GENERAL ANAESTHESIA AND SEDATION
FOR DENTAL PROCEDURES

An historical review, and the application of intravenous sedation to control patient anxiety and perception.

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'If a problem leads us into a new field in which we have no knowledge, we should acquire such knowledge. It is no excuse when working on a problem, to say "but that's not my field."'

NORBERT WIENER (1894-1964)
INTRODUCTION

General anaesthesia has had an association with dental treatment since its inception. Its use for dental purposes has had a controversial history and has been subject to factors often divorced from, and unrelated to, patient need. The dentist has come to rely increasingly on local anaesthesia for pain control, often to the exclusion of general anaesthesia altogether.

Studies of dentist/patient relationship (Ch. X) have resulted in an increasing awareness of the need for an intermediary zone of pain control short of general anaesthesia. This zone is concerned with patient concepts and responses to the dental environment evolving from the process of perception.

Perception is defined*, in this context, as involving 'interpretation of a stimulus and recognition of the object that produces a sensation. Perception is always based on earlier experience, and is the process by which one becomes acquainted with his environment, it implies that the stimulus creating a sensation has been registered, however unconsciously on the brain'. Perception simply implies recognition and interpretation.

Perception, then, has a psychological basis, and it is necessary to appreciate, in its application to the patient in the dental chair, that it is not synonymous with 'sensation'.

* Use the right word, Adelaide, Griffin, 1969. 725p. (p.520).
This latter term implies a physio-anatomical process, whereby the stimulus of a dental procedure is registered by sensory receptors, and transmitted by 'pain' conducting fibres. The sensory input however, which leads, although not necessarily so, to a pain response, is only the afferent limb of a complicated nervous system processing phenomenon (Kast 1968). Sensation cannot ever be 'pure' by the time it emerges in consciousness. Impulses set up by noxious stimuli are subjected to processing (Beecher 1959). Studies of the phenomenon of pain in particular by Wyke (1958), Sicher (1959), and Barker (1961), have stressed the importance of the emotional aspects of pain interpretation - described by Wyke as the 'affective reaction', or the 'suffering'. Thus, pain is considered by some, [Hardy et al. (1952), Beecher (1959), Batterman (1958), Monheim (1969)] to have two components, 'perception' and 'reaction', with the latter term implying the emotional phase. This concept is, however, erroneous. Firstly it involves a misunderstanding of the word 'perception' which is a processing element, and therefore has psychological implications. There is also an implication that 'perception' may be 'pure'. Pain threshold is not, however, constant from one individual to another, nor even in a given individual from one time to another (Beecher 1959). 'Reaction' is a word which often connotes motor behaviour - and yet is equated by these authors with emotional experience. There is a danger of confusing physiological and psychological events.
A more satisfactory way of understanding pain, in particular that of a dental procedure, is to talk of contributory causes, rather than components. Represented diagrammatically:

\[ \text{DENTAL PROCEDURE} \rightarrow \text{SENSATION} \rightarrow \text{PERCEPTION} \rightarrow \text{Response (Conception)} \]

This representation helps to clarify the purposes of pain control.

Now the sensation arising from the vast majority of dental procedures can be effectively eliminated by the appropriate use of local anaesthesia. This is a well established fact. The dental surgeon will recognise however, that many patients, nevertheless, are unable to accept dental procedures confidently and regularly even with the assistance of local anaesthesia. It must be realised that response to pain sensation depends to a greater or lesser degree on the individual's past experience and the meaning of pain sensation (Hardy et al. 1952). Pain perception may be affected by emotion and anxiety and as noted by Beecher (1959), analgesic agents exert their principal effect on the 'reaction component' rather than on the original sensation. Hitherto, the goal in the performing of a 'painless' dental operation has commonly been, to dull the original sensation.

In a state of complete general anaesthesia, where the patient is unconscious, both the sensation and the perceptual aspects are completely eliminated. By way of
contrast, the principle underlying all methods of perception control does not lie in the complete elimination of perception, but in acquainting the patient with dental procedures about which he is apprehensive, so as to condition his mind to their acceptance.

Perception control for the dental patient then, is not concerned with the control of the sensation which may arise in dental conservation or oral surgical procedures, but with the consideration of patient tolerance of these procedures, which is largely based on their expectation resulting from their previous dental experience. This in turn is equated with the level of apprehension which may be evident prior to the dental appointment.

Relative to any dental procedure, a patient may have three emotional or psychological phases:

(i) Pre-operative  (ii) Operative  (iii) Post-operative

It is the operative phase which is of special concern to the dental surgeon. Controlling perception in the operative phase will affect the post-operative phase, which in turn is identified with the pre-operative phase relative to subsequent procedures. Successfully controlled, the level of apprehension, as it relates to future dental procedures, should then decrease markedly. An important aspect is that the patient should know and feel that he has been to the dentist, if he is to feel more confident about future treatment.
A classical manifestation of the problem is the patient in the late teens or early twenties with a dentition showing extensive neglect, resulting from inadequate parental guidance or the failure to seek treatment because of the imprinted memory of an unpleasant dental experience in earlier years. It is vital that the dental surgeon understand fully the reasons for this neglect, because he seeks not only to accomplish the necessary dental treatment, but to re-establish the patient's confidence in his ability to accept treatment. Thus the treatment plan should include not only 'sensation' control, but also measures to control the perception which a patient has of dental treatment, so that his response to, and concept of the dental environment is modified.

A psychological study reported by Blass (1963) showed that dentists were unaware of the need to 'listen' to their patients. The implementation of perception control and relief of patient distress must however, be dependent on the appraisal of the patient's introspective report (Wyke 1958). Blass (1963) has noted further that '... the whole secret lies in understanding that human beings have psychological reactions from one end of the spectrum to the other, and that no technique or procedure can satisfy everybody'. It is necessary, if the dental surgeon is adequately to cater for this spectrum, that he similarly broaden his own spectrum
of pain control.

Historically, the control of perception has either been ignored altogether, or general anaesthesia has been used to accomplish the necessary dental treatment (usually exodontia). The need for control has long been appreciated, although not fully understood. General anaesthesia has thus had a close, though controversial, association with dentistry, and its history has not been in parallel with that of general surgical anaesthesia. Gradually, since the mid-1930's and particularly in the post-war period, the field of general anaesthesia has become the province of the medically trained, and more latterly of the specialist anaesthetist. Improvement of standards in anaesthetic practice has undoubtedly evolved from these developments. The problem of perception control in the case of the dental patient has, however, not been met; the specialist anaesthetist, generally speaking, does not give particular consideration to a dental patient as such. Appreciation of this problem, its study and its treatment must come from within the dental profession. Of particular significance is a concomitant change in emphasis in meeting patient treatment requirement. The old concept of and link between 'gas' and extractions, must give way to methods which allow better acceptance of conservative measures.

If patient attitude to dental treatment, and the
steps he is prepared to contemplate to undergo such treatment, can be affected then a betterment of communal dental health will result, and a greater appreciation of dental services follow.

Unfortunately the Australian dental surgeon lacks background, guidance and training for critical assessment in this field of study. Recognition of, and advancement in this field is dependent firstly on knowledge of the background to general anaesthesia for dental purposes; secondly on leadership; thirdly on the institution of a scientific approach and the establishment of clinical criteria for various methods of pain control.

It is, of course, most important also, that an active interest be taken by dental surgeons in general anaesthetic methods bearing in mind that -

(i) Dental work provides an excellent means for the clinical testing of new anaesthetic agents or techniques, on a co-operative basis with the specialist anaesthetist.

(ii) Dentists should be capable of critical assessment of the possible place which a new agent or technique may find in dental treatment.

(iii) It may be necessary to prevent, if possible, the introduction or continuance of restrictive legislative measures which could deny necessary advances in this field to the detriment of dental progress generally.

The aim of this thesis therefore is two-fold:
(1) To review the development of general anaesthesia and sedation for dental purposes, with particular reference to the Australian environment. The present day situation will be discussed, and some emphasis will be placed on philosophical aspects. The intention is to provide a background to this subject, to highlight the significance of certain developments, and to help clarify current interpretations and controversies.

(2) Within this concept, to discuss the nature of perception, and present means whereby perception control could be introduced into dental practice and teaching. For the purposes of this study, treatment methods involving 260 patients will be presented and discussed. The importance of recognition of patient apprehension, its assessment, and the incorporation into complete treatment planning of measures based on this assessment, will be stressed.

An understanding of perception, and methods for its control, represent one of the most significant and challenging studies in Dentistry today.
SECTION 1 - HISTORY AND DEVELOPMENT OF GENERAL ANAESTHESIA

I. EARLY HISTORY TO 1870

One hundred and twenty-five years ago, Horace Wells, dentist, emerged from the influence of nitrous oxide anaesthesia and cried, "It is the greatest discovery ever made! I didn't feel it so much as the prick of a pin!" (Colton 1886). A new era had begun in the practice of dentistry and of surgery, and yet it was an era rife with controversy; an era in which may be found parallels today. W.D.A. Smith (1968) says, 'There is a familiarity about many of these early discussions surrounding dental anaesthesia. It would be salutary to know the verdict of an historian of anaesthesia, writing in 2068 on present practice and controversies - assuming that our civilisation is extant'.

Of course, the story begins earlier - before anaesthesia was known. Early literature contains references to the use of sleep-producing potions. In Homer's 'Oddysey' is mentioned the use of a drug by Helen of Troy given to Menelaus and his guests -

Presently she cast a drug into the wine whereof they drank, a drug to lull all pain and anger, and bring forgetfulness of every sorrow. (Homer, Butcher & Lang 1965).
Opium, mandragora (mandrake) and hemp were the principal drugs used to produce stupefying effects on patients subjected to painful procedures. Surgeons depended on drugs to produce sleep while operations were performed. In 1540 Valerius Cordus described the synthesis of what came to be called ether. He noted its promotion of mucous secretion, and that it afforded relief from whooping cough. (Cordus & Tallmadge, 1925).

The term 'anaesthesia' is sometimes said to have been coined by Dr. Oliver Wendell Holmes and suggested to W.T.G. Morton (Warren 1847; Armstrong Davison 1965; Monheim 1970b). However according to J.B. Robinson (1948) the word 'anaesthesia' is found in Natham Bailey's An Universal Etymological English Dictionary (1721), defined as a defect of sensation, as in paralytyck or blasted person. The word is derived from the Greek ana 'without' and aesthesia, 'perception by the senses'. Sykes (1960) recounts:

Wendell Holmes believed that he had invented the term, as he described aesthetic as coming to him meaning sensitive, and in consequence anaesthetic as being insensitive easily followed.

Modern anaesthesia had its foundation in Chemistry, particularly in the work of Priestley, who discovered
the properties of oxygen and in 1772, nitrous oxide (Priestley 1772).

At the Pneumatic Institution (Clifton, Glos., England) founded in 1798 'for the purposes of investigating the medical powers of factitious air or gases (Gwathmoy 1914), Humphry Davy made his notable observations on the properties of nitrous oxide:

As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place. Modification of the powers of nitrous oxide by mixture of this gas with oxygen or common air, will probably enable the most delicately sensible to respire it without danger, and even with pleasurable effects.

(Davy 1800)

In 1799 Davy apparently inhaled the gas himself 'when cutting one of those unlucky dentes sapientiae', and the pain diminished after 3-4 doses. An account of his observations was published in 1800 in a substantial volume entitled, Researches, Chemical and Philosophical; chiefly concerning Nitrous Oxide.

Europe at that time was emerging from the 'Age of Enlightenment' (Gay 1966) when man began to understand his own nature and the natural world by methods of science. And yet, in spite of this new awakening, almost half a
century passed before Wells proclaimed 'a new era in tooth pulling'.

**Discovery**

The years which followed Davy's published volume in 1800, to December 1844, were not notable in the progress towards the utilisation of gases for anaesthetic purposes. Rather, they were applied towards public entertainments and student ether frolics. Ether was frequently used to illustrate inebriation and insensibility, and yet there was no record to 1839 on its ability to obtund surgical pain. In 1818, Faraday, a student of Davy's noticed the similarity of effects of ether and nitrous oxide. 'By the imprudent inspiration of ether, a gentleman was thrown into a very lethargic state, which continued with occasional periods of intermission for more than thirty hours'.

During this period there was considerable interest in 'mesmerism' which created a divergence between the 'first and second chemical stage.' (The history of anaesthetic discovery, 1870). The link between mesmerism and the inhalation of narcotic vapours was apparently forged by Robert H. Collyer, from Liverpool (England) who lectured extensively in America in 1839. He noted a similarity of effect between mesmerism and that produced by narcotic
vapour, and in 1842 claimed to have administered 'the fumes of his alcoholic mixture' to a Mrs. Allen of Philadelphia while a tooth was extracted without pain (The history of anaesthetic discovery, 1870, quoting The Liverpool Mail of Sat. Oct. 14, 1843).

The frivolous use of ether led, however, to its first use as a dental anaesthetic of which there is record (Lyman 1882).

William E. Clarke, a young student of chemistry in Rochester, New York, was in the habit of entertaining his companions with inhalations of ether. At the Berkshire Medical College in the winter of 1841-42, Clarke propagated this convivial method among his fellow students. Emboldened by these experiences, in January 1842 having returned to Rochester, he administered ether from a towel to a young woman named Hobbie, and one of her teeth was then extracted without pain by a dentist named Elijah Pope.

Horace Wells, assisted by John M. Riggs and Gardner Q. Colton were associated with the first dental anaesthetic of consequence - December 11th 1844.

Wells, having observed the apparent pain-killing effects of the inhalation of nitrous oxide at a public entertainment the previous night by Colton,
a chemical lecturer, tested its surgical possibilities on himself, allowing Riggs to extract a third molar, after he had inhaled enough nitrous oxide to produce insensibility. By mid-January 1845, he had extracted teeth for about 15 patients by the same means. Wells had the impetuous desire to make known widely and freely the great humanitarian benefits, as he foresaw them, of general nitrous oxide anaesthesia, and at the end of January 1845 went to Boston, to Harvard, to demonstrate his discovery (Aldrovardi 1948). Although the preliminary procedures took place without obvious distress, just as the tooth was separated from its attachments the patient groaned. The experiment was considered a 'humbug', and the 'groan' became a turning point in anaesthetic history. It was the beginning of the downward trail of disappointment and disillusion for Wells, and for nitrous oxide. The difficulties of handling the gas (not then a commercial product), the apprehension caused by the ashen appearance of the face, and by the accompanying cyanosis of the lips, and the spreading comments on the 'failure' of Well's public demonstration - and the related implications that nitrous oxide was not only ineffective, but also dangerous, discouraged general tests of the utility of the gas. Wells never again
attempted a demonstration of this type. He administered his gas at intervals and visited Paris in the Winter of 1847, but the honours arising therefrom, arrived too late. On January 23rd, 1848 he took his own life having sunk to the very depths of depression and despair.

It appears that Wells had used ether as far back as October, 1844, but had not communicated his results for several months to Morton and Jackson (subsequent claimants of the 'discovery' of anaesthesia) (Dorr 1847; Bennet 1847). He had, however, preferred nitrous oxide.

Nitrous oxide gas . . . is much less liable to do injury, and is more agreeable to inhale, producing at the same time insensibility to all painful sensation. It may be taken without the least inconvenience by those who become choked almost to strangulation with ether, in fact I have never seen or heard of a single instance where this gas has proved in the least detrimental . . . The only question to be settled is, which exhilarating agent is least likely to injure the system.

(Wells 1847)

Wells' opinions were supported by Marcy (1847), who predicted that 'for the performance of operations, the nitrous oxide gas will be found more valuable than any other agent'. Nitrous oxide, was, however, generally considered to be 'useless for surgical operations' as in most instances the exhilaration and excitement rendered the patient 'uncontrollable and very unfit from muscular contraction and convulsion. . . .' (Dorr 1847).
Present at Wells' nitrous oxide demonstration was W.T.G. Morton, a former pupil and partner of Wells', but of differing personality. Whilst in Boston, Wells confided in him, together with Dr. Charles T. Jackson. 'Both of these gentlemen admitted that it was entirely new to them. Dr. Jackson expressed much surprise that severe operations could be performed without pain' (Archer 1944). July 1845 saw Morton in Hartford. Wells wrote, 'he requested me to instruct him how to prepare the gas which I had been giving so successfully in Hartford, stating that he wished to make a trial of it in Boston. As this interview was in Hartford, I told him to request Dr. Charles T. Jackson (with whom we were both acquainted) to prepare him some of it, as he was a chemist'.

Jackson advised Morton that nitrous oxide was not easily available, and that it would be far less trouble if he tried 'sulfuric ether', which would be readily obtainable (Jackson 1861).

September 30th, 1846 saw the administration of sulphuric ether for a dental extraction by Morton in his office. Publicity attended the success of this occasion. The Boston Journal detailed an account of the operation the next day: '. . . an ulcerated tooth was extracted from the mouth of an individual without giving him the slightest pain'.
(Langa 1968). (It would appear that Morton himself must have given the journal this detail) (Keys 1963).

Then on October 16th, 1846, Morton gave a public demonstration at the Massachusetts General Hospital in Boston, when a small neck tumour was excised painlessly for a patient by Dr. John C. Warren under the influence of ether, which Morton attempted to disguise under the name Letheon. Morton used a newly designed inhaler (Fig. 1) and after administering the anaesthetic, he calmly remarked "Dr. Warren, your patient is ready". Warren, a prominent surgeon of the day, on completing the operation turned to his audience and employed the very word that they had hurled at the Hartford dentist, "Gentlemen", he said; "This is no humbug". Warren's account of the operation, (Warren 1846); notes that the patient 'did not experience pain at the time', although he was 'aware that the operation was proceeding'.

Fig. 1 - The Original Morton Inhaler
Morton was quick to publicise, and so establish his 'etherization', by means of circulars, pamphlets and publications, the last in May 1847, entitled *A Voice from Europe*, proclaiming European success of ether. These arose from Morton himself, and from an employed agent, Edward Warren, who published pamphlets entitled *Some Account of the Letheon* (Fulton 1963).

The foundations of anaesthesia in Australia arose from news and reports which emanated from Boston at this time. Ether was thus acclaimed, and nitrous oxide was considered discouraging.

Morton's successful administration of ether, contrasted to Wells' failure, said Clark (1938), meant the attainment of momentum for ether which swept away opposition - an 'all or none' effect.

There has been much controversy surrounding the rightful claimant of the discovery of anaesthesia. Wrangling and disagreement between Morton and Jackson and the right to claim $100,000 which U.S. Congress in 1849 agreed be paid to the rightful claimant is described by J.B. Robinson (1948). Probably the most searching and critical evaluation of these claims has been that by Raper
(1945), who attested that 'a discoverer must be able to recognise his discovery, and try to reveal it to others'. In this, he respects Wells' claim to priority. Letters and testimonials supporting Wells' claim, are also presented by Archer (1944) and Faulconer & Keys (1965).3

The word 'discovery' can have two connotations. The first implies an accidental gaining of knowledge, while the second implies intentional effort. Prior to 1844, the fact that these gases and vapours produced stupefying effects was well known, as evidenced by the ether frolics and exhibitions of 'laughing gas'. The 'discovery' was: that this effect could be applied with advantage in surgical operations. Wells undoubtedly made this discovery and attempted to demonstrate his theory. It cannot be claimed that Morton 'discovered' anaesthesia, but rather that he developed, and successfully demonstrated a means which gave it practical application in surgery.

Gardner Colton, in 1863, after a period of varying fortunes, found himself once again lecturing on nitrous oxide. Among his audience was J.H. Smith, a dentist, and subsequently Smith and Colton extracted 1,785 teeth in 23 days, using the almost forgotten nitrous oxide. The Colton Dental Association was established in New York with its aim -
'the painless extraction of teeth under nitrous oxide'.

Branch Offices were opened and it was estimated that Colton administered nitrous oxide 25,000 times without a fatality (Colton 1868). Later, in personal correspondence to Lyman (1882), Colton claimed to have administered nitrous oxide to 121,709 persons without a single death, to March 14th, 1881.

Less than a month following Morton's successful demonstration of his *Lethane*, H.J. Bigelow, who had been present on that occasion, delivered the first paper on 'etherization' (November 9th, 1846) (Bigelow 1846). He described the operation on October 16th, and 'a few of the operations in dentistry in which the preparation has been chiefly applied . . .', and apologised for restricting by letters patent, the new agent. His reasons were given as follows:

First, it is capable of abuse, and can readily be applied to nefarious ends.

Second, its action is not yet thoroughly understood, and its use should be restricted to responsible persons.

Third, one of its greatest fields is in the mechanical art of dentistry, many of whose processes are by convention, secret, or protected by patent rights. It is especially with reference to this art that the patent has been secured.
The text of Bigelow's paper was printed in the daily press, and a copy of the *Boston Daily Advertiser* with this article, was sent on November 28th, 1846, by his father Jacob Bigelow, to Dr. Francis Boott of Gower Street, London, an old friend. Bigelow described the painless extraction of a molar tooth for his daughter by Morton (J. Bigelow 1847), and also enclosed a copy of his son, H.J. Bigelow's paper (H. Bigelow 1847).

Boott immediately wrote to *The Lancet* presenting these details, and then his own experience:--

On Saturday the 19th a firmly fixed molar tooth was extracted in my study from Miss Lonsdale, by Mr. Robinson . . . without the least sense of pain or the movement of a muscle. The whole process of inhalation, extracting and waking was over in three minutes (Boott 1847).

Robinson and Boott subsequently collaborated on the design of an ether inhaler which was constructed by a Mr. Hooper of Pall Mall, and subsequently demonstrated at a number of London hospitals. (*Lancet*, Jan. 16, 1847). This apparatus was also featured in the *Illustrated London News* for January 9th, 1847. It was these journals and diagram of the apparatus which found their way to Australia. (Pugh 1847a). It consisted of the bottom part of Nooth's apparatus (used originally by Nooth in Chemistry experiments) having a glass funnel filled with sponge soaked in pure washed ether in the upper orifice, and a
flexible inhaling tube in the lower. (Fig. 2).

Fig. 2 Modified Nooth’s Apparatus

1. Pad.
2. Horizontal valve for expired air.
3. Vertical Flap valve
4. Stop-cock.
7. Glass vessel and sponge saturated with ether.
8. Sectional view.

The story of discovery and eventual acceptance continues to 1868, when an important link was forged in Anglo-American anaesthetic development. At this time concern was becoming evident in Britain, with respect to the administration of chloroform for dental purposes.

The credit for the introduction of chloroform is usually accorded to James Young Simpson of Edinburgh, a popular figure and prolific writer and worker in the field
of Obstetrics, a subject at that time still fighting for recognition. Simpson published the first paper on chloroform on November 20th, 1847 (Simpson 1847) in which the efficacy of chloroform as compared to ether for dental extraction ('tooth drawing') was noted. The difference lay in the extent to which perception was affected:

Ether: '... I did not feel the least pain, yet I was conscious of the operation being performed, and was quite aware when the crash took place'.

Chloroform: 'I was so completely dead this time, that I was not in the very slightest degree aware of anything that took place...'

It should be noted that Simpson, although given the credit, was not the first to be recorded as making use of chloroform. Chloroform had, according to Waldie (1847) been introduced in Liverpool as early as 1838-39, and its medicinal properties known (Cogswell 1847). Waldie, when he was visiting Edinburgh, claims to have suggested that Simpson 'try it'. William Lawrence and Holmes Coote of St. Bartholomews' had, during the summer of 1847, made extensive trials of chloroform, which had been suggested to them by a surgical pupil, Michael Funell, and were about to undertake exhaustive investigations of its properties when Simpson published his paper (Lyman 1882).

Reports on the successful use of chloroform for dental procedures soon followed - one week later (Nov. 27) in fact, G. Buchanan (1847) reported having extracted two
superior molars and 'cut across and destroyed the nerves of the upper incisors' in three minutes, using chloroform anaesthesia. In 1848, the famous dentist John Tomes lectured on the "Superinduction of Anaesthesia in dental operations". He dealt chiefly with chloroform (Tomes 1848). Clendon (1849) presented 100 cases, in 64 of which there was unconsciousness, insensibility and loss of motor power. Clendon complained of difficulties in controlling blood and saliva, and in keeping the mouth open.

Much of this early surgery was conducted in the analgesic state - the patient was said to be aware of the instrument grasping the tooth, and yet felt little or no pain sensation. By 1848, in Britain, chloroform had supplanted ether, and enthusiasm also waned in America. There was fear of narcotic influence, indiscriminate advertising, and a growth of charlatanism. The use of "Letheon" in cities other than Boston, had been abandoned by 1849. (Archer 1958).38

Development

Notable of those who sought to progress, was John Snow, who, in spite of the skepticism mistrust and conservatism of his fellows applied himself with great enthusiasm in study and research in this field. Snow attempted to bring anaesthesia on to a scientific basis, and by 1858 had collected reports of 50 cases of death through
chloroform (Snow 1858) - the first being Hannah Greener - January 28th, 1848 (Snow 1849). The Lancet was prominent in supporting Snow. In reporting a death in 1858, it said, (Chloroform in dentistry, 1858): - 'no dentist has any right to risk the life of a patient during an extraction by using chloroform. This time it was a servant girl; the next time it may be a duchess'. In a later issue it repeated warnings which had emanated from Snow - 'that 5 per cent of vapour is the maximum which can be inhaled, and the rag and bottle method cannot guarantee constant strength'. Deaths from chloroform administration were frequently reported. (Chloroform deaths, 1858).

The use of an analgesic state short of surgical anaesthesia for dental work was mentioned by Snow (1858):

... I have not always been able to keep the patient quite insensible throughout the operation. He has sometimes struggled or cried out, but there has been hardly any case in which the patient afterwards remembered any considerable part of the operation.

Another who sought to progress was Samuel Lee Rymer, who drew the attention of a meeting of the Odontological Society of Great Britain in December, 1863, (Rymer 1863) to the fact that nitrous oxide gas was being employed in America to produce anaesthesia. His comments were treated with some degree of scorn, and it was said that this was 'no novelty, but its failure on some occasions had led to
the introduction of ether'. Rymer's results were indecisive, and he was perplexed by Colton's claims. It appears that his problems lay in his apparatus, and he was discouraged further by "authoritative" opinion.

Fig. 3 - The Method of Administering Nitrous Oxide

used by Samuel Lee Rymer, in London, during a few trial administrations in 1863. The patient is seen inhaling from a rubber bag containing the gas while an assistant pinches his nostrils shut.

In 1867, Colton came to Paris for the Universal Exhibition, and here met up with Thomas W. Evans, a fashionable American dentist practising in Paris. He was greatly impressed by Colton's work (Colton 1868), and wrote enthusiastically of the 'superiority of the protoxyde of
nitrogen gas over other anaesthetics in dental surgery, particularly in operations which may be promptly effected. (Evans 1869) Evans visited London briefly at the end of March 1868, with a mission. He offered to administer nitrous oxide at the Dental Hospital. This he did and those present were quick to appreciate its value. (Trans. Odont. Soc., Apr. 6, 1868). The patient's appearance gave them concern however - 'There was a general asphyxiated condition, the whole countenance and lips presented a most fearfully livid appearance.'

Among those present was dentist, Alfred Coleman, who was a prolific writer and worker in the development of dental anaesthesia to the turn of the century. He, together with J.T. Clover, pioneered nasal inhalation in dental work - initially preferring to use chloroform. (Clover 1868, Coleman 1868).

Clover introduced a nasal cap shaped like a miniature facepiece for maintaining anaesthesia:

I merely exchange the face-piece of my inhaler for a nose-cap provided with valves and apply it over the nose. It is retained in situ by a strap which goes round the back of the head, and thus the chloroformist has his hand at liberty to watch the pulse or to afford assistance to the dentist in managing the gag, or in sponging the gums in those cases where much difficulty is experienced in extracting roots. (Clover 1868).

Coleman also adopted the idea of using a miniature
facepiece to fit over the nose (Coleman 1881). (Fig. 4).

Chloroform Apparatus with a Miniature Snow's Type of Facepiece, used by Coleman for Nasal Administration.

Fig. 4

The graduated drop-bottle containing chloroform either hung down from the tube, into which its mouth opened, or it could be inverted (as shown) so that chloroform fell on to a sponge within the tube. The end of this tube was covered by a wire-mesh cap through which air was drawn in by the patient's inspiration.

Clover was responsible for the first inhaler which attempted to measure the percentages of chloroform and air, thus allowing for more accurate regulation than hitherto. His nitrous oxide apparatus marketed by Coxeter and Son in 1868 included a two-way stopcock which allowed for the breathing of air or nitrous oxide as the administrator wished. (Fig. 5).

Coleman made the first clinical use of carbon dioxide absorber in anaesthesia. 'He takes a gallon of gas into a bag and makes the expired gas pass over slaked lime contained in a glass tube before it reaches the bag again' (Coleman 1871). Coleman used this absorber at the Dental Hospital, London, and for many years hoped that the principle of conserving anaesthetics exhaled from the
Fig. 5 - Later Model, c. 1890, of the Type of Nitrous Oxide Apparatus.

First put on the market by the firm of Coxeter & Son in August 1868.

-su. single union to cylinder of compressed gas.
-t. narrow-bored rubber tubing leading the gas into
-B. Caitlin's reservoir bag; the gas then passed through wide-bored tubing to
the inhaling apparatus the three main parts of which were:

TS. two-way stopcock (Clover's),
-FP. facepiece (Clover's), and
-b. Clover's 'supplemental bag'.
-h. air-hole in two-way stopcock, so that air or nitrous oxide might be breathed
by the patient as the administrator wished.
-ac. air cushion (in the 1868 model): the facepiece was rimmed with rubber,
covering padding (cf. Fig. 71).
-sc. stopcock for inflating rubber rim.
-is and en. inspiratory and expiratory valves, 'two circular horn valves working
upon delicate spiral springs'.
-SC. stopcock opening or closing the mouth of the rebreathing bag, b.
lungs would eventually be adopted, particularly in hospital practice where the expense of anaesthetic drugs was such an important factor governing their use. (Fig. 6).

Fig. 6 - Coleman's 'Economising Apparatus'

for absorbing carbon dioxide from the patient's exhalations during to-and-fro breathing in nitrous oxide anaesthesia.

k. frame which supported the 'economiser' on the top of the gas cylinder.
c. point of junction between apparatus and gas cylinder.
h. wide-bored tubing leading to the facepiece.

Narrow-bored tubing led the gas into the lower reservoir bag. The only inspiratory valve in the apparatus was situated in the tubing between the two bags so that gas passed from the lower to the upper bag but could not return.

The 'economiser' itself consisted of a round tin box divided internally by a vertical diaphragm half the height of the box and attached to its lid. The box was filled with small pieces of lime, dropped into it through two holes in the lid closed by: cap 1, into which opened one end of the angle tube connecting with the upper reservoir bag; cap 2, from which wide-bored tubing led to the facepiece.

The reservoir bags were first filled with nitrous oxide, then the facepiece was applied and the patient was allowed two or three breaths which he exhaled through an expiratory valve in the facepiece. Then the valve was held down by the administrator and the patient breathed to and fro, from and into the upper reservoir bag, the diaphragm compelling the mixture to pass through the lime. As gas was lost from the circuit the pressure in the lower bag raised the inspiratory valve and allowed fresh gas to flow into the upper bag until the pressure was again equalised.
By the autumn of 1868, two firms Coxeter and Barth had succeeded in compressing nitrous oxide into metal cylinders, and an efficient commercial service for supplying and refilling cylinders was gradually established. By 1870 nitrous oxide was available to almost all dentists who wished to use it. Coxeter and Barth were producing 6,000 gallons of nitrous oxide per annum, enough for 15,000 administrations. This was due almost entirely to its popularity among dentists, the gas having received little encouragement from the surgeons; being both cumbersome and expensive, compared with chloroform.

Mention also should be made of Edmund Andrews. He had observed the use of nitrous oxide by dentists, and wished that in some way it might be made available in general surgery. He proceeded with the conviction that if free oxygen were added to nitrous oxide, the mixture might anaesthetise for indefinite periods without asphyxia and thus render nitrous oxide available for prolonged operations of surgery (Andrews 1868). Although armed with insufficient data, Andrews, in 1868, predicted that a 20 per cent oxygen and 80 per cent nitrous oxide mixture would prove to be the pleasantest and safest anaesthetic known - provided pure gases could be obtained, and dilution with air avoided during its administration. (Such foresight was remarkable, and yet the practical use of the mixture, had to wait forty years, and even then its adoption was slow.)
II. BEGINNINGS IN AUSTRALIA

The first half of the 19th century was the period of the foundation of this new country. It saw the gradual emergence from a penal settlement, to a colony of free men with the encouragement of free immigration. The first major settlement outside New South Wales was Van Diemen's Land, (the name 'Tasmania' did not come into existence until 1856), which took place in 1803. It was a colony with many problems, not least, the large convict population. The free settlers were much encouraged during the period of Governor Sir John Franklin (1837-43), when efforts were made to attract to the colony men of intelligence and study; he sought to found a 'college or university for that part of the world', and 'for a few years Tasmania was the scientific centre of Australia'. (Jose 1917.)

Into this environment came the first administration of an anaesthetic to be recorded in Australia. The date — June 7th 1847. The place — St. John's Hospital, Launceston. Dr. William Russ Pugh, assisted by Dr. William Benson administered ether for purposes of dental extraction, and removal of a tumour of the lower jaw. This took place only eight months after Morton's Boston demonstration, the news of which spread with great rapidity. The Launceston Examiner played a notable role in preparing the public for
its adoption. On June 2nd, full reports of the use of anaesthesia in London were published, as well as the wide acceptance by leading surgeons of the principle of anaesthesia by inhalation. The June 8th issue reported the successful use of ether in these terms:

Dr. Pugh has constructed apparatus similar to that figured in the "Illustrated London News". It consisted of two glass vessels, one placed on the other, and both containing pieces of sponge saturated with ether. Connected with the lower vessel is a flexible tube provided with a stopcock, terminating in a pipe which is placed in the patient's mouth. The upper vessel is fitted with a glass stopper which is removed when the patient inhales, so that the air he breathes passes through the saturated sponges and becomes saturated with the ether they contain. The nostrils being compressed, the process of breathing is precisely as if a person inhaled and expressed the atmosphere through a tobacco pipe. The first patient was a young female, who for upwards of two years had been suffering from a disease of the lower jaw. In a few minutes the hands fell powerless, and the tube having been withdrawn, two double teeth were extracted after which the tumour was removed and a caustic applied to the bleeding. The operation under ordinary circumstances would have been excruciating. The patient intimated that the pain was not nearly so great as she had anticipated. She walked home shortly afterwards. (Fig. 2).

Dr. Pugh's notes of this operation describe the lesion as an 'epulis involving the posterior bicuspid and the anterior molar teeth'. Inhalation took place for five minutes before the operation was carried out. Dr. Pugh wrote that day to the Australian Medical Journal. (Pugh
1847a) He enclosed details of his cases, three in number, in which ethereal inhalation had been used, and expressed the opinion 'that a large amount of suffering hitherto experienced by patients may be superseded'. Ten days later, however, a letter from Dr. Pugh appeared in the Examiner in which he expressed disappointment with his further experience of ether. 'I have found that its effects on individuals are as variable as the constitution of those by whom it is inhaled.' He found favourable effects on those of 'feeble frame', but not so with the 'hearty and robust'. He wrote:

The brain remains confused, and the stupor of the drunkard is experienced for long subsequent to the application which occasioned it. I have seen sufficient to create alarm in my mind, and would therefore caution the profession against applying of the inhalation of ether, without special reference to the individual case. The remedy, like its twin brother nitrous oxide gas is, I feel assured, to enjoy a short lived notoriety. Their objectionable qualities are of similar character, having alike a tendency to produce congestion of the brain. Therefore those circumstances which occasioned the removal of nitrous oxide gas from the list of remedial agents in which, for a short time it held a high position, will in all probability deprive sulphuric ether, of portion of the credit it has recently received.

By 18th June 1847, Dr. Pugh was moved to again write to the Medical Journal:
...having made the public through your journal acquainted with my success, I shall by the first opportunity disclose the extent of my failure. I would now desire to caution the profession against the employment of ether inhalation in persons in any way disposed by apoplectic disease or even to those of a full habit of body. I have arrived at the conclusion that if the effect be not immediately induced, a continuation of the inhalation cannot be pursued without danger of serious consequences. (Pugh 1847b)

Meanwhile, news of ether had reached Sydney too, in fact, it is extremely unlikely that Pugh's administration preceded the first in Sydney. In fact, by June 15th of 1847, just one week later, Mr. John Belisario, dentist, of Spring Street felt confident enough in this new agent and in apparatus for its dispensing, to insert the following advertisement in the Sydney Morning Herald:

Painless Dental Surgery

Mr. Belisario is happy to inform the public that he is enabled by means of the recent discovery, ethereal inhalation, to perform the most difficult operations in dental surgery, with perfect freedom from pain or subsequent inconvenience to his patients. Mr. Belisario's apparatus was constructed by himself, in conjunction with an experienced medical gentleman of this city, who was also kind enough to superintend his first operations. Mr. Belisario continues to operate as hitherto on such patients as may not wish to make use of the ethereal vapour. (Belisario 1847.)

Study by the present writer, of the Sydney Morning Herald earlier in 1847 clarifies the controversy.
The first report of the use of ether as an anaesthetic appeared on Monday May 17th as a news item: 'It is ascertained that the inhalation of sulphuric ether renders a patient insensible to pain, and it is now employed with decided advantage in surgical operations.'

The next day (May 18th) a report contained a dental reference: 'the drawing out of his teeth becomes an agreeable excitement which is so delightful ...'. A further report, in the same issue said: 'Guy's Hospital ... was crowded to excess by members of the medical profession from all parts of the metropolis ... to witness the new process of inhalation of ether.' The report named Mr. Robinson (to whom reference has been made earlier) as the inventor of the apparatus.

On May 21st the editorial was devoted to the subject of 'Painless Surgery', and quoted a letter from a Dr. John Ware of Boston:

The number of operations of various kinds, especially those in dentistry has been very considerable, and I believe that few persons resist the influence of this agent. The effect is not exactly the same on all. In some the insensibility is entire, and the patient is aware of nothing which is going on; in others a certain degree of the power of perception remains; the patient knows what the operator is doing; perceives him for example take hold of a tooth and draw it out, feels the grating of the instrument, but still has no pain.
Ware also noted:

It was brought into use by a dentist and is now chiefly employed by that class of practitioner.

This same editorial contained descriptions of apparatus used by Bigelow and in more detail that used for the operation performed by Liston, which was of design previously mentioned (Fig. 2).

Dental operations were described:

He inhaled for two minutes and slept three minutes during which time the tooth, an inferior molar was extracted. At the moment of extraction the features assumed an expression of pain and the hand was raised. Upon coming to himself, he said he had had 'a first rate dream ... but had not the slightest consciousness of pain'.

Another patient, a girl of sixteen:

When force was applied she flinched and frowned and raised her hand to her mouth, but she said she '... knew nothing of the operation.'

Belisario and Nathan were undoubtedly impressed by these reports, and a letter published on June 10th indicated that by this date Belisario had had experience with a number of cases. This letter signed CHIRURGICUS, and written on June 9th, said that it was written 'for those who had not had an opportunity of marking its effects in Mr. Belisario's
numerous operations on the teeth'. Cases were reported:
'Many would not believe that they had lost their teeth.'
'One said that she knew we were taking her teeth out but experienced not the slightest pain.'

On June 15th (1847) the correspondence column of the Herald carried a letter from Charles Nathan, surgeon, of Elizabeth Street North. This letter read as follows:

Gentlemen, it having been asserted and by some persons believed, that the inhalation of the vapour of ether is dangerous, and that the surgeon who permits its use is careless of the welfare of his patients, allow me through your columns to state that I have, within the last few days witnessed nearly 40 painless operations from it, having myself inhaled, before I experimented on anyone, and in no instance did mischief or unpleasantness follow. In experimenting for surgical purposes I had one gentleman 22½ minutes in a state of perfect insensibility to pain, and his observation on recovery was that he would never have a tooth drawn again without first undergoing the same process. I would advise those who have any doubt, and feel an interest in the subject, to pay a visit to Mr. Belisario who will be happy to give them an opportunity of forming their own opinion.

{John Belisario was born in 1820 in Cheltenham, England of Spanish parents. He served his apprenticeship in England, and during his pupilage 'walked the wards of St. Thomas's Hospital, London'. He arrived in Australia in his early twenties, and in 1844 moved into practice in Spring Street. His name became well known to dentists in U.S.A. and England, and he received the Doctor of Dental Surgery degree in 1854 from the University of Baltimore,
and was subsequently honoured in numerous ways. (Fig. 7) (Blackwell 1907). His grandson John C. Belisario is, at time of writing, a practising dermatologist in Sydney.

Fig. 7. John Belisario, 1820-1900.

The day following Belisario's advertisement, (June 16th), the Herald editorial was devoted to the new discovery. It is worthwhile quoting this in part:

We were present a few days back when Mr. Nathan and Mr. Belisario, the dentist of Spring Street, applied the ether in two cases with results sufficiently surprising in each ... another patient stepped in (a younger brother of Mr. Nathan's), who had 2 stumps of decayed teeth in
his head, which were to be pulled out that morning. We saw the stumps, which being nearly level with the gums, required to be punched out, and if the reader has ever had or seen a stump punched out, he need not be informed that it is one of the most painful operations in the history of human torture. The patient, having on a previous occasion undergone the operation of painless surgery with extraction under the ether application took the chair for the second operation. He inhaled for about five minutes when he fell back apparently unconscious. Mr. Nathan held the patient's mouth open, whilst Mr. Belisario with a quiet rapidity that almost eluded observation drew forth one of these stumps and as quickly extracted the other, the patient the while reclining back, and breathing easily as if in a calm and deep sleep. In 3 or 4 minutes he woke up, rubbed his eyes and smiled. He was not aware until he was told so, that he had undergone the operation at all. Dr. Richardson counted the pulse which became very rapid and intermittent in the first case reaching as high as 120.

On Monday morning we met Dr. Cox in Pitt Street smelling particularly strongly of ether. On investigating we found he had just surrendered under the new method, 'a molar' to the skill of Mr. Belisario, and he seemed highly delighted at the reminiscence of having ejected so disagreeable a tenant, in so agreeable a manner. He stated that he felt, after inhaling, as if he had just taken a bottle of very good wine — that he was perfectly conscious and comfortable during the operation — that he thought he could, if he had tried, have lifted his arm, but he did not try, because it was altogether delightful to repose motionless and passively indulge the luxurious condition to which he had been reduced ...

The precise nature of the effect produced by the inhalation upon the nervous system and the brain is of course as yet, mere matter of scientific speculation, and opinions differ thereupon, but all are agreed that this new agent will be of incalculable value in the more critical operation of the surgeon. The experiments we ourselves witnessed are almost sufficient to show that tooth-drawing itself is converted into a luxury — even to the patient.
On June 22nd, Mr. Belisario respectfully informed gentlemen of the medical profession that his apparatus for the inhalation of the vapour of ether will be at their service whenever a cupital* operation may render it desirable'. This offer might well have been noted by the surgeons at the Sydney Infirmary, but apparently was not, as on June 28th the *Herald* carried another editorial where it was observed that on the occasion of an amputation a few days back (? approx. June 25th), there was obvious suffering on the part of the patient. 'The technique' (that is of anaesthesia) 'had been faulty', and the editorial noted that:

...the apparatus used at the Infirmary wanted a part which Mr. Belisario's instrument possessed, viz., a piece to fit around the lips, to prevent the escape of ether by the mouth, which, with most patients, especially ignorant ones, will be unavoidable unless the apparatus is so constructed as to ensure uninterrupted inhalation by means of the natural action of the lungs.

(This latter mentioned operation was performed by a Dr. McEwan, and the anaesthetist is given as a Dr. McCrae).

*The Word 'cupital' is not to be found in Oxford English Dictionary or Webster 3rd Intl. Dict. It would seem to have been a misprint. The correct word should have been 'capital'.
Potter (1938) and E. Gandevia (1954) regard this as the first use of ether by a New South Welshman, although it was obviously not a complete success. It appears however, that possibly previous to this a Dr. C. Buchanan of Port Stephens had administered ether for operations on popliteal aneurism. Buchanan wrote as follows (C. Buchanan 1847) (letter to Capt. King of Australian Agricultural Company):

I wrote to you on the 21st ... not being sure of the kind of apparatus used for the inhalation of ether, I tried the simple bladder with mouth-piece similar to what is used in the inhalation of nitrous oxide, or laughing gas, which answered the purpose admirably ... the operation ... took about five minutes ... Upon being questioned as to how he felt during the operation, he said he knew perfectly well what we were doing but he did not suffer the slightest pain.

Potter (1938) in a study of the early days of Australian anaesthesia, is at considerable pains to ensure that Dr. Pugh and not Mr. Belisario receives credit as being the first to administer ether. Dunlop (1927) states that 'It was in the Spring Street house that ether was first administered in Australia in 1847'. Potter however, felt that Dunlop, when using the term 'Australia', did not include Tasmania. Potter further is of the opinion that an 'accident of geographical position' arising from the fact that ships usually called at Van Diemen's land before reaching Sydney, gave to Dr. Pugh 'some days priority in the matter'. The present writer considers that this point
could not be valid. The letter written by 'Chirurgicus' which appeared in the Sydney Morning Herald of June 10th (1847), was written on June 9th. This indicates that Belisario had had experience of ether administration at least 'a few days', prior to this. This would indicate that in all probability Belisario's administration of ether preceded Pugh's, and most certainly would have no bearing on the time taken for ships to travel from Hobart to Sydney. The first reference to the use of ether for anaesthetic purposes abroad had, as mentioned, appeared three weeks previously (May 17th) in the Herald.

Nathan and Belisario had obviously collaborated on apparatus construction, and quietly carried out 'numerous operations' by June 10th, in order to gain confidence in the technique. It is obvious that they were sensitive to criticism, and Nathan mentions that some persons had asserted that it was 'a dangerous procedure', and it is unlikely under these circumstances, that they would immediately make their work public. It was also a time when practitioners were jealous of their own abilities, unwilling to readily share their knowledge with colleagues.

Pugh on the other hand was described as a 'frequent contributor to the medical press' (Dunlop 1927) and wasted no time in communicating his operations, and wrote to the
Medical Journal after three cases, only to find himself amending his ideas ten days later. The fine point seems to rest on drawing a distinction between the first administration, and first recorded documented case. The honour for the former belongs to Dr. Nathan and Mr. Belisario; for the latter to Dr. Pugh.

All of those who have recorded the details of these early days, seem completely concerned with the introduction of ether, and later with chloroform. The administration of ether, be it by Pugh or Belisario is taken to be the first anaesthetic. It appears that the use of nitrous oxide has been completely ignored, and yet certain comments made at the time indicate that it must have been known for its anaesthetic properties, and in fact used for this purpose. Pugh mentions nitrous oxide in his letter as enjoying a 'short lived notoriety'. Buchanan described his ether apparatus as 'similar to what is used in the inhalation of nitrous oxide'. It is clear therefore that before the advent of ether, nitrous oxide anaesthesia had been utilised, but this remains unrecorded. Searches by the present writer have failed to elicit any reference to the use of nitrous oxide for surgical operations, prior to 1847. The reasons could be listed:
(a) There were no medical journals published in Australia until August 1846, dependence for information and guidance was on English journals. Reports would probably tell of failure abroad.

(b) Suspicion and jealousy was rife amongst members of the medical profession at the time (evidenced by correspondence in Sydney Morning Herald March 31, Aug. 14, 1846).

(c) Duration of anaesthesia was too short to be considered of value surgically.

(d) Difficulty of preparation, and presence of impurities, in nitrous oxide.

(e) The name 'laughing gas' added little to its reputation in a medical sense (an exhibition of 'laughing gas' was given by Colton type 'chemical lecturer', J.S. Norrie, at City Theatre, Market Street, Sydney on July 23, 1845). (Syd. Morning Herald — pers. study).

The introduction of ether anaesthesia was not, as may have been expected greeted with enthusiasm by the medical press, in fact, to the contrary. In the June 1847 edition, The Australian Medical Journal launched its first attack on ether. These are the terms of the leader:
There is a fashion in medicine, as in other less important matters, and the rage just now seems to be after the means of rendering the use of the knife and other formidable instruments in the armamentum chirurgicum free from pain and therefore and thereby less dreadful and dreaded by those whose fate it is to be obliged to submit to their 'sharp medicine'. While we applaud a rational search after such means if they do exist, we would warn our professional confrères from too hasty adoption of any measure for this purpose, which may be offered for their acceptance ... it is still inebriation, and it does not appear to us of much consequence, if the operatee must be drunk, what the intoxicating medium may be. We have no hesitation in predicting for this process a transient popularity; it will have its day, ultimately to be abandoned as useless or injurious.

History must accord praise to the Herald for its sound thinking and approach, at this time, undeserving of the rebuke which followed in the Medical Journal. This editorial comment (June 28th, 1847) is as true today as it was then:

In the application of a new agent like this, it is much better to err on the side of over-prudence than on the side of rashness. It is far better that they should proceed cautiously along the steps of safe experience and by many trials — even with the certainty of some apparent failures — endeavour to ascertain how far they may trust this extraordinary new agent in surgery, with which as yet they have had so short an acquaintance, than by impatience and precipitation run the risk of raising the town by some scientific manslaughter.

When the July issue of the journal was published, Dr. Pugh's second letter appeared on the front page under
some editorial comment headed 'The Ethereal Humbug', which referred to the above article (see photocopy).

The editorial comment however, in view of a considerable number of reports of ether inhalation that had been received in the interim, was obliged to 'straighten its line', in fact in conclusion finds itself unwittingly agreeing with the Herald.

It has been asserted that all are agreed that this new agent will be of incalculable value in the more critical operations of surgery - which assertions we deny - and are so far from giving assent to the proposition (and in this we are not alone), that it is precisely in those more "critical operations" in which the state of the patient's pulse and countenance are the required indices of the effects of haemorrhage or of the shock of the operation on the system, that we would not use it.

Do not let us be misunderstood. We do not say that it ought entirely to be eschewed; all we contend for is, that it should be used not indiscriminately, but with caution, and only by or under the superintendence of medical practitioners, who, instead of allowing themselves to be run away with by the novelty of the process, should use it and investigate its effects coolly and philosophically, so that it may not, if calculated to be really useful come as many other therapeutic means have come to a premature end, through the discredit thrown upon it by its abuse.

Again, these words used more than one hundred and twenty years ago with respect to ether, could well apply to newer agents and methods today.
no further notice of so ridiculous a production, except to advise the Editor of that publication to "sick to the last." I am assured that occasionally when they step beyond their legitimate province they only make fools of themselves.

To the Editor of the "Australian Medical Journal."

Launceston, June 28, 1847.

Dear Sir—The perusal of the various public journals in which the successful application of Ether in surgical operations has been described, induced me not to think of the time to make trial of its efficiency, and in my first essay I was much pleased with the result. I have, however, from my subsequent experience been induced to view the proceeding less favorably, and having made the public, through the agency of my acquaintance with my success, I shall be the last opportunity of appreciating the extent of my failure. I was inclined to advise the general adoption of the recently discovered principle, and would now desire to caution the public against the employment of Ether in persons suffering from any diseased condition, or even to those of a full habit of body. I have arrived at the conclusion that if the effect be not immediately induced, a continuation of the inhalation cannot be pursued without danger of serious consequences.

The departure of the Savings will be immediately and therefore unable to write you at greater length.

Yours truly,

W. PUGH.

TO CORRESPONDENTS.

Dr. PUGH is thanked for his communications of the 5th and 18th insts. but we must request that he will find some means of sending his letters free of expense to us, as, under no circumstances can we afford to be taxed with postage.

The Newspaper Dr. F. mentions has not been received.

Our country subscribers are requested to take notice that Mr. Baker ceased to have any connection whatever with this Journal. The third part of April last, and all communications must be addressed to the direction prepaid.

ERRATA.—In our last number, p. 12, line 8, read "Port Nicholson" instead of "Port Egmont."

CHEMICAL LABORATORY,

DISPENSARY & FAMILY MEDICINE WAREHOUSE.

125, GEORGE STREET, SYDNEY.

G. F. POOLE.

DEARS most respectfully to apprise the

Inhabitants of the Sydney and District, that he has commenced business as CHIMIST AND DRUGGIST, in the premises lately occupied by Appleyard, late

425, George street. 

OPPOSITE FATHER AND SONS.

Handsome new and well-constructed drugstore has been erected, and well-furnished with all sorts of medicines and druggists' goods. The business is conducted in a regular and scientific manner. Having made arrangements for a regular supply of drugs and chemicals from one of the first houses in London, the present stock is equal to any in this colony.

G. F. P. feels confident that in the good and reputable characters of all sorts of medicines and medicinal; and having made every arrangement for a regular supply of drugs and chemicals from one of the first houses in London, the present stock is equal to any in this colony.

Established A. D. McCULLOCH.

A. FOSS.

WHOLESALE AND RETAIL

CHEMIST, DRUGGIST.

In Pitt street.

SYDNEY.

Physician's Prescriptions accurately filled, and Horse and Cattle medicines, Ointments and Powders, Made to order, New or Refined on the richest terms.

Authorized A. D. McCULLOCH.
By July 15th, 1847 ether inhalers were commercially available in Sydney (Gravely 1847). The features of these were that only air which had passed through the ether vase was inhaled, and the mouth piece was made exactly to fit the lips. A stop-cock regulated the supply of vapour.

Dr. D.J. Thomas is credited as being the first to administer ether at Port Phillip (Melbourne) August 2, 1847. Thomas also has the distinction of reading the first scientific paper before a medical society in Victoria On the Inhalation of the vapour of Aether, with cases (Thomas 1847). He wrote: 'From all I have seen and from cases I have read in which it has proved injurious, I am convinced they are the result of improper administration'. His paper made a plea to practitioners to be 'discriminating in the use of the anaesthetic, and be guided by the physical conditions and temperament of the patient'. His cases illustrated situations in which differing reactions had occurred with ether. His descriptions included the effects 'on patients exhausted by shock, haemorrhage, pain and sepsis, and on four others of temperaments -sanguineo-nervous, bilious, sanguineo-melancholic, and sanguineous' (Potter 1938). These reports are significant as they appear to have been the first 'case reports' surrounding dental anaesthesia. Thomas advised as to the depth of anaesthesia, desirable for tooth extraction.
Chloroform

As with ether, early administrations of chloroform in Australia were for dental purposes. This appears to have been five months from the date of Simpson's paper (Simpson 1847).

The date of the first instance of chloroform being employed was April 11th 1848 which was at Sydney Infirmary. Credit is given by Potter (1938) and E. Gandevia (1954) to McEwan, the surgeon, who had been associated with the unsatisfactory ether administration at the Sydney Infirmary the previous year. It would seem however, that the major credit should be accorded again to Charles Nathan, as he was the anaesthetist on this occasion and the operation 'normally tedious, difficult and excruciating' was performed under 'very good' anaesthesia. This was recorded in the Sydney Morning Herald of April 12th 1848, which then listed the advantages of chloroform over ether:

(a) Inhalation is not disagreeable to anyone.

(b) There are none of the symptoms of intoxication which sometimes appear with ether.

(c) No odour or taste afterwards as all traces of chloroform 'immediately pass away'.
The first recorded in Launceston was June 19th, 1848 for tooth extraction. The use of chloroform for dental purposes was evident also in June 1848 in Melbourne. (Potter 1938.) The first administration in Brisbane is not however recorded until 1854 when Dr. William Hobbs administered it for a cancer operation (Jackson 1923).

In Dunlop's study (1927) he was not able to find an earlier chloroform administration than 1852, at the Sydney Infirmary by Dr. H.G. Allayne. Potter (1938) attempted to 'fill the gap' between 1847 and 1852, and his paper details 24 operations during the period April 11th 1848 to February 14th 1849. These reports also included the first death resulting from the use of chloroform — at Windsor, N.S.W. on July 19th 1848, the operation being 'ligature of the common carotid.' In actual fact the operation was one for cancer of the mouth (Sydney Morning Herald, July 22nd 1848). Death was inevitable, but operation gave hope for some respite. The patient succumbed in less than five minutes from the first application of chloroform.

This early period is described by Dunlop (1927) as the 'period of enthusiasm, when the limitations of the drugs were unknown; results, remarkable results were obtained. Then there was the period of doubt. Finally, there was the period of unbelief'. Ether began to suffer
in reputation, and from 1852 and for some years thereafter was superseded by chloroform.

The reasons for the decline of ether are given by E. Gandevia (1954) as:

(i) Dr. Pugh's letter to the Launceston Examiner (17th June 1847).

(ii) The editorial comment of the Australian Medical Journal (1st July 1847).

(iii) Letter by a medical practitioner to a London paper which said that ether affected the blood and tended to produce pulmonary tuberculosis.

Dunlop (1927) records that 'Dr. Belisario apparently gave up the use of ether'.

Gradually the subject lost its novelty and soon faded from the public interest so that newspaper reports disappeared. Most, if not all, subsequent references in the journals were to chloroform. It appears that the tendency to favour chloroform was maintained until the mid-1870's.

E. Gandevia (1954) in his observations on these early days concludes:

It would be invidious to compare the results of the first generation of anaesthetists with the results of our own generation, in view of the vast advances in physiological and pharmacological knowledge and the development of new techniques.
Nevertheless, it would be most unwise to underrate the skill of the early exponents of the anaesthetic art.

He suggests that the following lessons can be learnt:

(i) the value of careful, accurate clinical observation;

(ii) the value of independence of thought and practice without recourse to reliance on the reports of others;

(iii) the value of a critical approach to a new method, drug, or appliance.
III. GENERAL DEVELOPMENT 1870-1900

The period which led up to the turn of the century was one in which progress in anaesthesia was notably slow. Magill (1966) felt 'that much of the delay could be blamed on the surgeons of the time . . . so engrossed in the development of their craft, with the aid of newly found advantages of operating on unconscious patients, they failed to realise that the anaesthetic was an integral part of their success'. These years whilst considered slow from the point of view of progress, were of great significance as a period of transition, orientation and organisation.

As more workers entered the anaesthetic field, so the picture became more confusing. Ether and chloroform were popular in general surgery, whilst nitrous oxide was used in dental surgery to an increasing extent - the work being carried out after removal of the face piece. Ethyl chloride had some trial also. During this period we see attempts to improve existing methods, attempts to explain anaesthesia, attempts towards greater safety, and attempts too, to prolong the anaesthesia for given periods of time.

In England, the first Dental Act became law in 1878. The Odontological Society of Great Britain, mentioned earlier, had been formed in 1863 as a merger of the then two societies (Campbell 1921). This society, with monthly
meetings, papers presented, and views exchanged, was able, at an early date, to study developments in the anaesthetic field as a unified body. On December 12th, 1868, a joint committee of the Odontological Society and the Dental Hospital, issued an important report. (Report of joint committee, 1868). This report set out to consider in detail to what extent nitrous oxide was an efficient anaesthetic, and whether as an anaesthetic in man, it was as safe as, or safer than those in general use. They also queried the physiology of its actions, with a view to obviating, if possible, any serious results which might follow its administration.

The advantages they listed as -

(i) Rapidity of its effects.
(ii) Rapidity of recovery.
(iii) Agreeable nature.
(iv) Tasteless, and less irritating.
(v) Freedom from nausea.

The disadvantages -

(i) Unsuit for long operations.
(ii) Rapidity of recovery.
(iii) Difficulty of making and transporting.
(iv) Twitchings render it unsuitable for delicate operations.

The Odontological Society and the Dental Hospital
were largely responsible for guaranteeing the worth of this agent to the cautious British medical profession. Notable for his efforts in this regard was Coleman (1871). On the question of prolonging the anaesthetic effect of the gas, a second committee in 1872 advocated that in operations on the mouth, the administration should be continued by means of a nose piece. (Report of joint committee, 1872). Dentists using nitrous oxide at this time received it in cylinders from Barth's or Coxeter's, and it was then emptied into a receiver standing in the surgery.

The revival of the use of ether in England did not begin until 1872. B. Joy Jeffries from Boston spread the information about American methods of 'etherization' among British and Continental chloroformists (Jeffries 1872). As a body, the chloroformists were not easily transformed into 'etherists', despite the obvious success of the American methods, but it was suggested that ether be given a trial (The administration of ether, 1872). C.S. Tomes, the prominent English dentist of the time visited the United States in 1873, and on his return described and praised the safety of American etherization.

An important outcome of the popular use of nitrous oxide was the development of a mouth gag which could be easily and speedily inserted. Mouth props were made from cork, boxwood or vulcanite. In 1868 Francis Mason was
working on the original of his now famous gag; at this time the type of gags used, were spring or swivel gags. The most popular type was the swivel gag devised by dental student, S.J. Hutchison. It consisted of a horse-shoe form of spring, to the extremities of which were attached pieces of metal guarded with gutta-percha, which, when the instrument was used, were adapted to the incisors of the upper and lower jaws. The tooth plates were attached to the arms of the spring by swivels, so that the spring portion of the instrument could be moved to either side of the mouth, and quite out of the way of the operator (Coleman 1871).

The 1870's
The major developments during this decade were -

(1) The early physiological work of Claude Bernard.
(2) J.T. Clover's nitrous oxide - ether apparatus (1876).
(3) The production of the analgesic state by Thiersch using morphine in conjunction with chloroform (1877).
(4) Paul Bert's use of a nitrous oxide - oxygen mixture.
(5) Glasgow committee of the B.M.A.

Claude Bernard
Bernard endeavoured to seek a scientific basis for anaesthesia. He did not believe
the then popular theory 'that anaesthesia was merely asphyxia'. In this he was supported by Evans (1869). Bernard (1869) and Evans (1869) proposed the theory that anaesthetics acted by 'elective affinity upon the sensitive cells of the nervous system' - although Evans was at variance with Bernard in disagreeing that chloroform actually altered the 'properties of the blood'.

Bernard later studied the effects of chloroform on muscle and nerve. Nerves, he found, became opaque, and if the action was not 'pushed too far', the nerve would return to its original state when the anaesthetic agent was eliminated and would again be able to conduct nerve impulses. Accordingly, Bernard developed the theory that anaesthesia was caused by reversible coagulation of the constituents of the nerve cell. (Bernard 1875). Bernard may also have been the first to suggest pre-anaesthetic medication (noted in (3)).

(2) J.T. Clover's nitrous oxide - ether apparatus (1876)

Clover attempted to combine the two gases - nitrous oxide and ether, and so utilise the advantages of each at the expense of the disadvantages. The patient was induced by the more pleasant nitrous oxide, and then maintained with ether subsequently. Clover at first administered nitrous oxide, and then exchanged the inhaler for an ether apparatus. He worked on the problem many years before he perfected his combined gas and ether apparatus. (Fig. 8) (Clover 1876).
Fig. 8 - Clover's 'Combined Gas-and-Ether Apparatus' (1876)

A. Stand for nitrous oxide cylinder.
B. Cylinder, actuated by foot-key, f.
  g. Union between cylinder and tubing, h.
  m. Stopcock.
When the administrator wished to administer nitrous oxide alone, he set the regulating stopcock, O, behind the facepiece, E, for 'gas'. The stream of gas then passed into the inhaling bag, D, and so to the facepiece. The exhaled gas escaped through the expiratory valve, p.

When he wished to administer a mixture of nitrous oxide and ether, he set O accordingly and turned the tap, k, on top of the ether reservoir, C. The stream of gas then circulated through C before passing down the flexible tube, n (within the bag, D), to the facepiece.

By turning the stopcock, m, the supply of gas was shut off and the patient could then breathe ether alone, to and fro through the inhaling bag, D.

The principle used was to gradually, but increasingly, mix ether with the gas without admission of air too early - not until the 'patient is stertorous' - when one breath was given. The patient continued to breathe a mixture of nitrous oxide, ether and air, until the usual signs of deep ether anaesthesia appeared, when the gas bag was detached, and the patient continued on ether inhalation. Hewitt (1893) recommended this procedure for dental practice when longer operating time than that obtainable from nitrous oxide alone was desired, and adapted a portable ether inhaler of Clover's design, for this purpose. (Fig. 9).

(3) Karl Thiersch (1877) - Mixed narcosis

Of considerable significance was the employment by Karl Thiersch of the combination of morphine and chloroform. This followed from previous work of Labbé and Guyon, who first administered morphine before chloroform in surgical practice (Labbé & Guyon 1872). This idea in turn
Fig. 9 - The administration of nitrous oxide and ether by means of a Clover's portable ether inhaler, a special form of stopcock, and a detached gas-bag.

had derived from Claude Bernard's experimental work on dogs, recorded in 1869 in Lancet. By this means 'the excitement stage of chloroformisation was considerably lessened and when once anaesthesia had been produced, extremely small
doses of the anaesthetic were needed to maintain insensibility to pain. Thiersch employed this method 'in several operations about the mouth; and found it possible to maintain an analgesic state in which the patient, although unable to feel pain could aid the operator by coughing out blood etc., when requested to do so'. (Thiersch 1877). This appears to be the first reference to the utilisation of an analgesic state for dental treatment using drugs, other than nitrous oxide.

(4) **Paul Bert (1878)**

Bert was sensitive to the shortcomings of anaesthesia as then practised, and sought an anaesthetic agent which was safe, and yet whose administration could be prolonged. Bert used a mixture of three-quarters nitrous oxide, and one quarter of oxygen, with the mixture breathed under increased pressure, and thus introduced into the blood of the experimental animal the quantity of oxygen necessary to maintain respiration and of nitrous oxide to maintain anaesthesia. Unfortunately Bert's methods lacked practicability. Bert felt that nitrous oxide was superior to chloroform for the reasons -

(i) Absence of usual period of excitation.

(ii) Tranquility it gives to the surgeon.

(iii) Instantaneous return to sensibility.

(iv) Absence of discomfort, nausea and vomiting.
(v) Harmlessness.

(Bert 1878)

(5) The Glasgow Committee of the B.M.A.

This committee conducted the first official physiological research into ether and chloroform in 1879, (Preliminary Report ... 1879; Report ... 1880). It was found that blood pressure and cardiac action were distinctly lowered under chloroform. Whilst admitting that although in deaths from this anaesthetic, respiration generally ceased before cardiac action, it asserted that the reverse might occur. These conclusions arose:—

(i) Lowering of the blood pressure is due to the weakening of the heart's action.

(ii) This effect is given by chloroform, not by ether.

(iii) Death may occur any time during chloroform inhalation by sudden stoppage of the heart.

This view was opposed to the principles of Syme of Edinburgh, a dominant and influential figure in anaesthesia of the day, whose word was accepted unquestionably in Scotland and much of England. He taught that chloroform never produced primary action on the heart - 'watch the respiration, never mind the pulse!' (Rowell 1896).

The 1880's

The principle advances of this decade were -

(1) Early attempts with endotracheal anaesthesia.
(2) The Hyderabad Commissions.

(3) New agents and methods on the scene -
   (a) Cyclopropane
   (b) Ethyl Chloride
   (c) Bromide of Ethyl
   (d) Ethylene
   (e) Chloroform and Oxygen
   (f) The A.C.E. mixture
   (g) Vinyl Ether
   (h) Trichlorethylene
   (i) Nitrous Oxide/oxygen (Schlafgas)

(1) Endotracheal Anaesthesia

William Macewen of Glasgow is given credit for pioneering endotracheal anaesthesia. Macewen in 1880, devised a curved metal tube which he inserted into the trachea by way of the mouth using a finger to guide the tube through the larynx, which was then packed off. (Macewen 1880). Macewen also advised the use of the laryngoscope to ascertain the precise state of the parts. (Chloroform was administered). Also in the 1880's, Joseph O'Dwyer whose interest was in the battle against diphtheria, invented a set of intubation tubes 'for the relief of asphyxia caused by laryngeal obstruction'. (O'Dwyer 1887). These were later adopted for anaesthetic work. J.T. Glover in 1881 at the International Congress of Medicine in London, showed new instruments for prolonging anaesthesia in operations in the mouth - especially a bag with a nasal screw adjusted and firmly fixed into the nostril with a screw movement; also funnel shaped India rubber tubes for
conveying the anaesthetic to the back of the mouth during operations on the jaw. Gorgas (1889) noted: 'The administration of anaesthetic through the nose has been suggested by Dr. B.C.A. Windle of England, a peculiar instrument being employed for pumping the vapour of the anaesthetic through a tube which passes into one nostril'.

Hilliard (1898) suggested the use of a 'soft gum elastic silk tube' 6 inches long, passed into the nose. With this tube in place, he replaced the face-piece so that 'the stream of gas deviated from it to the nose piece'.

Disadvantages noted with intranasal tubes were stenosis of the nostrils and haemorrhage (Buxton 1898).

(2) The Hyderabad Commissions

These impressive Commissions were of considerable significance, as chloroform was placed 'on trial'. The erroneous findings were eventually questioned, and disproved by Edward Embley of Melbourne in the early 1900's (Embley 1902).

Ten thousand dollars was spent by the Nyzam of Hyderabad in experiments on anaesthetics. There were two Commissions - one in 1888, in which 141 dogs were killed by chloroform inhalation, and results made (Turnbull 1896). The first Commission was organised by Surgeon Major Lawrie, whose views had long been with Syme and the Edinburgh School (Lawrie 1890). Lawrie said that in a series of
45,000 cases where the respiration had been watched, no deaths had resulted. Where the pulse was taken as a guide, deaths amounted to 1 in every 1236 cases (Williams 1890).

The medical world did not support these findings and a second Commission was organised in 1890. This was directed by Lauder Brunton, and employed about 600 dogs.

The second Commission found the following -

(i) Failure of respiration is the only means by which the heart's safety is jeopardised.

(ii) The heart never stops before respiration.

(iii) Chloroform does not directly injure the heart substance.

(Report of the Second Hyderabad Commission, 1890)

Physiologists throughout the world protested against these findings and showed that there were numerous fallacies in the technical work and that many of the tracings were capable of quite different interpretation. (Brown 1939), Kirk (1890) advanced a 'two force' theory that chloroform acted not only on the blood, but on the pulmonary mucous membrane, and stressed the importance of a sufficient atmosphere of chloroform. A second committee of the B.M.A. studied reports of 26,000 cases in hospital and private practice and concluded that no method of using chloroform was free from danger (Gwathmey 1914). Turnbull (1896) reports on his own findings which were that:
'During the protracted use of chloroform as an anaesthetic, the blood changed in character, lowered in pressure with weakening of the action of the heart and changes in its structure. Dilatation of the heart occurs under the use of chloroform at all stages and the heart muscle is weakened. In spite of all these findings chloroform anaesthesia persisted, although to a gradually lessening degree, until the 1930's, and even into the 1940's.

In reviewing the history of chloroform Kindschi (1948) notes that too high a concentration and lack of understanding of warning signs, based upon incomplete knowledge of the direct effect on the heart and circulation, resulted in deaths. By current standards most patients were probably underventilated. There is evidence also that early in induction there is increased vagus activity which may result in cardiac slowing or arrest. (Morris 1963).

(3) **New Agents on the Scene**

(The development of these was not confined completely to this decade).

(a) **Ethyl Chloride**

Guillaume Francois Rouelle is credited with the discovery of ethyl chloride in 1759 (Faulconer & Keys 1965), and in 1847 French physiologist Fluorens drew attention to its anaesthetic properties (Gwathmey 1914; Clark 1938). In 1848,
Heyfelder used the drug for general anaesthesia (De Ford 1912). There was little clinical application of ethyl chloride over these years, although Turnbull (1896) says that Glover made extensive use of it, after commencing inhalation with nitrous oxide.

The use of the agent was apparently abandoned until 1895, and in 1902/3 was introduced into England notably by McCardie (1903 and 1906) who studied the value of the drug in 620 cases, and it gained rapid favour in dental work. The return to ethyl chloride in the mid 1890's was possibly subsequent to the work of Carlson, a Gothenburg dentist, and Thiesing, a Hildesheim dentist, as subsequently it came into general use in German hospitals (Archer 1958; Faulconer and Keys 1965; Markovitch 1968). They noticed that when spraying ethyl chloride for regional anaesthesia, that several patients became unconscious. This observation prompted Thiesing to make experiments on animals, and then employ ethyl chloride as a general anaesthetic. In 1896 it passed from the dental chair to the operating theatre (Archer 1958). By the turn of the century ethyl chloride had become firmly established as a useful agent (Faulconer and Keys 1965).

(b) Cyclopropane

Discovered by August von Freund in 1882, (Keys
1963; Markovitch 1968) this agent was destined not to reappear for another fifty years.

(c) **Bromide of Ethyl**

First used in 1880 but quickly discarded. G.V. Black gave a practical clinic in 'Bromide of Ethyl as an anaesthetic for dental purposes or any very short operation'. This demonstration resulted in failure. (Archer 1958). During 1888 and 1889 there was a sudden vogue for ethyl bromide - particularly as advocated by Silk (Silk 1890/1891).

(d) **Ethylene**

Called originally 'olefiant gas', and later 'ethene', it was discovered in 1799 by Ingenhouss (Keys 1963). Notably investigated by Thomas Nunneley of Leeds who published results in 1849 and concluded that chloride of olefiant gas was a most valuable anaesthetic and 'completely successful in the small number of patients to whom he administered it'. (Nunneley 1849). B.W. Richardson had investigated it in 1865, and reported it a good anaesthetic, but inconvenient being a gas. Recovery was rapid without bad effects (Gwathmey 1914). Lüssem in 1885 anaesthetised animals successfully, but was unable to accomplish a like result on himself.

(e) **Chloroform - Oxygen**

Attempts to overcome the disadvantages of chloroform
resulted in trials of combining it with oxygen; Neudorfer in Vienna in 1886 introduced this concept (Gwathmey 1914). It did not however gain favour because of the lack of a device for regulating proportions. Junker's inhaler was introduced as an attempt to achieve a percentage method; Kreutzmann of San Francisco in 1887, used the Junker inhaler (Fig. 10),

**Fig. 10 - Junker's Inhaler**

The case containing the chloroform (or bichloride of methylene) bottle was suspended by the hook from the lapel of the administrator's coat,
A. Cap for covering the valve when the instrument was not in use.
B. Valve with feather indicator.
C. Pharyngeal tube for injecting the anaesthetic mixture into the mouth when it was inconvenient to use the facepiece (This was an addition to the apparatus made after 1867).

![Fig. 11 - Chloroform Anaesthesia by Junker's Mouth Tube](image)

Mouth tube introduced between blades of mouth gag.

(Kindschi 1948) and found greater rapidity, lack of marked excitement, quicker return to consciousness and fewer unpleasant after effects. The combination was used extensively in one hospital in Pittsburg in the early part of the 20th century. (Gwathmey 1914). In the Junker inhaler a stream of air was driven through
a length of narrow tubing into a graduated glass flask
not more than two thirds filled with liquid anaesthetic.
From the flask, another length of tubing led the
anaesthetic - air mixture to a vulcanite face-piece.
This inhaler was found very convenient in dental
surgery, as by means of a mouth tube the administration
could be continued after removal of the face-piece
(Coleman & Hilliard, 1912). (Fig. 11) Subsequently,
the disadvantages of Junker's inhaler were described by
Godfrey (1903). In 1895, Northrop suggested that
chloroform be combined with oxygen. He was anxious to
determine why chloroform kills, and to find a safer
method. He considered that as chloroform was very
heavy (4 x atmospheric air), when administered,
atmospheric air was partially excluded and the amount
of oxygen absorbed was diminished. (Turnbull 1896).

(f) The A.C.B. Mixture

This was 1 part alcohol, 2 parts chloroform and 3
parts ether, and was also described by Nunneley, and
was a widely used agent in the middle and latter parts
of the nineteenth century. (Keys 1963). A.C.B. was
recommended by the committee of the London Medical and
Chirurgical Society in 1864, with the advantages of
more perfectly sustained action of the heart, and
respiratory centre (Lyman 1882).
(g) **Vinyl Ether**

First mentioned by Semmler in 1875 (Brown 1939; Leake 1963) it was apparently first used for a dental operation in 1933 (Markovitch 1968).

(h) **Trichlorethylene**

Chemistry and properties were described by Fischer in 1864. (Faulconer & Keys 1965).^s5^

(i) **Dutch Liquid**

(chloride of hydrocarbon 1.2 dichlorurethane C\textsubscript{2}H\textsubscript{4}Cl\textsubscript{2})

This was given by Snow in 1849, in trials of which dental extraction formed a part, following the suggestion of Nunneley, that irritations previously experienced were due to impurities. He used his chloroform inhaler for the administration, but failed to agree with Nunneley in his praises of Dutch Liquid. He noted that it had a slower action, more persistent effects, and greater cost. (Snow 1858).^s6^

(j) **Amylene (C\textsubscript{5}H\textsubscript{10})**

Amylene was discovered by Boland in 1844, but it was not until 1856 that Snow experimented with its anaesthetic properties (on animals). He found that while little was required to produce insensibility, it was poorly absorbed. His first clinical administrations were in November, 1856, and were for dental extractions.
He noted that the effects were 'so favourable as to encourage a further trial'. It is notable that amylene apparently produced an ultra-light anaesthetic effect - the patient was apparently awake, although not really conscious of surrounding objects. This usual absence of coma in the employment of amylene cannot be looked on otherwise than as an advantage . . . often regardless of the surgeon's knife whilst the edges of the eyelids retain their full sensibility.

(Snow 1858)

In April, 1857, on his 144th case Snow had his first fatality using amylene, and another death followed in July, in his 238th case. Snow endeavoured to restrict the percentage of amylene which it was possible to breathe, by altering his apparatus, believing that the fatal cases were due to a 30 percent concentration. Soon afterwards it was agreed by members of the Académie de Médecine in France that the use of amylene be banned, in view of the deaths in Snow's hands. In 1893 a purified form of amylene called 'Pental' was attracting some attention.

(Hewitt 1893)

(4) Nitrous Oxide and Oxygen/Schlafgas

In 1887, Hewitt devised a machine for the administration of nitrous oxide and oxygen. This apparatus had a regulating mechanism for the increment and decrement of oxygen, although in Hewitt's words it was impossible to
give any reliable averages, 'owing to the variations which must to some extent occur in the bags during the administration'. He did however state that 'when the bags were partially distended and one hole open, 3½ - 6 per cent of oxygen came through', and each additional hole allowed for additional oxygen, (Hewitt 1893) (Figs 12, 13).

Fig. 12 - Hewitt's apparatus for nitrous oxide/oxygen.

Hewitt, who was a man of undoubted foresight and a vigorous worker in the anaesthetic field, had a particular interest in dental anaesthesia. His influence was considerable, his ideas basic, and yet acceptance was not
immediate. Writing in his text book *Anaesthetics and their administration* published in 1893, he states:

There is no form of anaesthesia at present known which is so devoid of danger, as that which results from nitrous oxide when administered with a sufficient percentage of oxygen, to prevent all asphyxial complications. In 2000 cases, of which I have kept careful notes, I have never detected the slightest sign of respiratory embarrassment or cardiac depression.

The mixture was in all respects 'the safest and most satisfactory agent for minor surgical operations', (Turnbull 1896) and was soon used in dental surgery. Case reports illustrated 60-110 seconds administration time, while the average available period of anaesthesia was 44 seconds.
(the longest - 90 seconds, the shortest - 21 seconds).

Hewitt still felt however, that nitrous oxide alone was the best anaesthetic for dental surgery. He wrote: 'It is true that the resulting anaesthesia is very short. It is far better for a patient to inhale nitrous oxide on two or more occasions, and have comparatively little done at each sitting, than for him to experience the discomforts of partial anaesthesia'. For longer cases he recommended ether preceded by nitrous oxide (Clover method). (Hewitt 1893)

At the same time as Hewitt was expounding his theories, Hillischer, an eminent dentist of Vienna read papers and demonstrated successfully the administration of nitrous oxide and oxygen at ordinary atmospheric pressure and was the first to do so. (Hewitt 1897). He reported 5000 cases with no failure. He termed his mixture 'Schlafgas' and commenced with 1 per cent oxygen gradually increasing to 20 per cent (Marks 1909).

Another prominent anaesthetist of the time was D.W. Buxton, who wrote an important text book, Anaesthetics: their uses and administration, first published in 1888. He attempted to raise the standard of anaesthetic practice to its former level, and also developed an improved apparatus for nitrous oxide. (Fig. 14) Buxton also added a trigger-action to Mason's gag, and devised a mouth-spoon
'to catch teeth or roots which may fall out of the forceps'. The spoon was held below the seat of the operation by the anaesthetist, acting as the dentist's assistant. (Fig. 15).

Fig. 14 - Buxton's Apparatus for Nitrous Oxide.
In use during the eighteen-nineties.

Fig. 15 - Mouth-spoon for catching teeth.

In 1889 was published Dental Medicine by Gorgas, where is found emphasis on the use of the horizontal position for dental operations in the chair, recently strongly advocated by Bourne (1967).

Gorgas makes this observation -

when ether or chloroform is administered for the extraction of teeth, the operation should be performed in a dental chair so as to admit of the patient being placed in as horizontal a position as possible to operate successfully, and every instrument it is necessary to use should be within the reach of the hand of the operator. Any considerable change in the position of the patient should be avoided until recovery has taken place.

Rules for the administration of chloroform as given by Professor J.J. Chisholm in Gorgas' text included:

Only administer chloroform in the recumbent posture, body prefectly horizontal and
Should loud snoring occur, force up the chin. This manipulation by straightening the air passages from nose to larynx makes easy breathing. While operating I have constantly in view the colour of the face, and the respiration of the patient, which I consider even more important for the surgeon to observe, than to feel the pulse.

1890 - 1900

As the nineteenth century drew to a close chloroform began to be discarded; the first devices for delivery of nitrous oxide/oxygen were marketed and, 'Somnoform' came into being.

In 1898, the S.S. White Company patented their nitrous oxide/oxygen machine (Armstrong Davison 1965).\textsuperscript{33} Acceptance of this form of anaesthesia for general surgery had to wait, as at this time there were two major disadvantages -

(i) Muscular relaxation was frequently inadequate.
(ii) Capillary bleeding was frequently increased.

(Brown 1939)

Relaxation was superior with ether.

A most significant development in this decade from the dental aspect, was the advent of 'Somnoform'. Somnoform was the innovation of George Rolland, then director of the Bordeaux Dental School. It was a combination of 60 per cent ethyl chloride, 35 per cent methyl chloride and 5 per cent ethyl bromide. Rolland presented an essay and clinical demonstration on Somnoform at the Congress of the
Association Francais pour l'Advancement des Sciences, in 1901, and to the British Dental Association in 1902 (Rolland and Robinson 1902).

Reports from 100,000 cases showed that:

... the respiration, pulse and blood pressure are at first intensified. They however very soon return to normal. The methyl chloride produces the anaesthesia, the ethyl chloride prolongs the period, and the ethyl bromide doubles the length of time, during which the patient is apparently conscious and yet you can operate a little longer without pain to the patient.

(Prytz 1908)

Gwathmey (1914) reported on the American anaesthetic death statistics for 1892 which showed 1 death in 2,800 administrations. Results of these statistics showed:

(i) Nitrous oxide and oxygen was the safest anaesthetic known.

(ii) Nitrous oxide should not be used alone.

(iii) Ethyl Chloride should not be used as a terminal anaesthetic.

(iv) Chloroform should not be used except in emergencies.

(v) Ether alone was the most commonly used, comprising nearly half the administrations reported - but, ether alone was not as safe as generally believed - it was materially safeguarded by oxygen.

(vi) Sequences and combinations when properly used were safer than any known single anaesthetic.

In London, the Society of Anaesthetists was founded in 1893, and in 1896 the jubilee year of anaesthesia was celebrated. This jubilee gave men a cause to pause and consider. Hewitt posed the question -
With all these additions to our storehouse of knowledge, why do not deaths from anaesthetics show signs of diminution? The reply is that the responsibilities involved in administering anaesthetics are not yet fully realised; that the administration is too often placed in the hands of comparatively unskilled men . . . the first step should be an educational one. By sending out into practice men who have a proper appreciation of the responsibilities and requirements in anaesthetising, an improved position of the subject and a notable saving of human life will inevitably result.  

(Hewitt 1896)

From 1847 onwards the English alone had persisted in asserting that anaesthesia was a task for the expert, and that his knowledge and his skill were far more important factors in successful anaesthesia than the drug and the method of administration which he chose to employ. For this reason the medical student in England had been given little opportunity to try his hand at administration. Although it was only in England that the profession of anaesthetist was generally recognized, specialization in anaesthesia almost invariably took place some years after qualification. More often than not an anaesthetic practice was combined with general practice, as in Clover's case, or with dental surgery, as in Coleman's case.

It was not the potential specialist anaesthetist who occasioned the outcry for better education, but the potential practitioner who would not specialize and yet who, from the very nature of his profession could scarcely avoid
giving an occasional anaesthetic. It was recognized, during the eighteen-nineties, that the only way to make such a man into a reasonably efficient anaesthetist was to inculcate upon his mind during his student days the essentials of anaesthetic theory and practice.

Turner (1896) asked: 'Should dentists administer anaesthetics?'. The British Medical Journal answered -

Anaesthetics should be administered only by duly qualified men. There is no law upon the subject, but only those who are able to perform tracheotomy in the event of asphyxia ought ever to administer nitrous oxide gas. Ether and chloroform should only be administered by medical men experienced in the use of anaesthetics. If a death were to occur in a dentist's chair the magistrate might consider it culpable negligence on the part of the dentist if he had no medical assistant present at the operation. The only safe rule is always to have a second person present, and, when possible, that person should be a doctor, or, better still, a skilled anaesthetist. (Administration of anaesthetics by dentists 1898; Dental Business 1899).

This correspondence on the subject of dentists acting as anaesthetists was reopened from time to time during the remaining years of the nineteenth century. It was complicated in 1898, by the further question: should unregistered dentists administer anaesthetics?

The need for the specialist anaesthetist was indeed greater than ever before; but although the demand outstripped the supply an acute shortage was not anticipated. There was, however, evident, anxiety, in the low average degree of skill shown by the non-specialist
practitioner, when forced to act as an anesthetist. It was considered desirable that he should reach at least a reasonable standard of proficiency in the simpler routine anaesthetic procedures; be able to satisfy a surgeon or dentist performing a minor operation, and himself be prepared adequately to deal with an anaesthetic emergency. Moreover, and this was particularly stressed, he ought to possess sufficient knowledge to recognise his own limitations in the field of anaesthesia.

In 1898, in a paper read at a meeting of the Society of Anaesthetists, Coleman revived an idea which both he and Clover had put into practice thirty years earlier, namely, the administration of nitrous oxide through the nose with the object of prolonging unconsciousness during operations on the teeth (Coleman 1898) (Fig. 16). His apparatus consisted of a nose-piece made to loosely cover the nose and fit accurately to its base, and which was connected with a very flat tube also adapted to fit accurately over the forehead. To the latter was attached a piece of stout rubber tubing having at its further extremity a very lightly constructed two-way stop-cock which was connected with the ordinary gas-bag.

**Intravenous Anaesthesia to 1900**

The first genuine attempt at intravenous anaesthesia was in 1665. Sigismund Elsholtz injected opiate to produce
Fig. 16 - Coleman's Apparatus for Maintaining Nitrous Oxide Anaesthesia through the Nose during Dental Operations (1898)

The patient is shown leaning back, his head supported by the head-rest of the dental chair (seen behind his ear). The nose-piece is held in place by a strap passing round his head. From the nose-piece a flat tube passes back over the crown of the head to the reservoir bag, a small stopcock being interposed between the two.
insensibility (Keys 1963; Buxton 1967). In 1841 Jayne patented his syringe which had a tapering nozzle down to a sharp point. In 1843, Alexander Wood used a crude syringe with which he injected morphine, and in 1853 developed the modern type of metallic hollow needle (Wood 1855), while Pravaz attached a hollow needle to a specially constructed syringe - the hypodermic syringe (Keys 1963). The first syringes were made commercially in the United States in 1856, and were of sterling silver, glass, rubber celluloid or German silver. The pistons had leather tips (Archer 1958).

Pierre-Cypriene Oré advocated the intravenous use of chloral hydrate in 1872 for surgical anaesthesia. He applied this technique experimentally at first and then reported (1874) to the French Academy of Sciences -

Immediately after the second injection the patient fell into a deep tranquil sleep; respiration at first accelerated became calm and regular, The pulse 90 before injection, fell to 70. (Oré 1874)

Chloral hydrate was at a disadvantage in that its action was slow in disappearing, and the required dosage was close to the toxic dosage.

In 1899 Dresser in Germany, introduced Hedonal (methyl propyl carbinol methane). (Adams 1944).

**Analgesia, Hypoalgesia and Twilight Sleep; Premedication**

Analgesia is that state where pain is eliminated without loss of consciousness; as opposed to anaesthesia
where all sensation is lost. Hypoalgesia (Relative analgesia) means a diminished sensation or heightened tolerance to pain. Many operative procedures, particularly in the field of dentistry can be performed with the patient in analgesic states.

It is notable that anaesthetic agents were so often used and tried first in the dental field. This was attended with success which was not always translated immediately into general surgery. It was obvious then, that the requirements within the two spheres differed. It was possible to carry out much of the dental work in analgesic stages of anaesthesia. There was often no recourse to full surgical anaesthesia, and generally no maintenance of the anaesthetic state over a prolonged period.

Jorgensen and Hayden (1967) note that John Tomes said 'On many occasions the patient has been perfectly aware of the steps of the operation, has felt the instrument grasp the teeth . . . and yet has felt no pain', and this observation has been noted herein on previous pages. This was particularly so with nitrous oxide, and ether but chloroform analgesia also was reported. De Ford (1912) described the use of chloroform to produce analgesia for dental procedures by Hewett, who in 1893 and 1895 presented papers on this subject to the Iowa State Dental Society. This society elected a committee to investigate Hewett's
methods. Hewett stressed that 'under no circumstance is a dentist justified in fully anaesthetising a patient for the extraction of teeth; the obtundent influence is ample. Hewett's method involved a very gradual induction with chloroform vapour deliberately avoiding deep narcosis. Excellent results, and a high level of safety, were recorded. It is of interest that Pittinger et al. (1960) in comparing the affects of anaesthetic agents on 'tooth pulp thresholds' in rabbits noted the very marked analgesic effect of chloroform.

'Twilight Sleep' is the name that has been applied to a state of semi-narcosis, and has been a term applied in the main, to obstetric practice. It applies to the combination of morphine and scopolamine administered either hypodermically or by mouth, and was first recommended by Korff of Germany in 1899 (Fülop-Miller & Paul 1938).

The concept of premedication was extremely slow in its development, and slower still in becoming widely accepted. Claude Bernard carried out researches and recommended the clinical use of a preparatory dose of morphine before chloroform inhalations. (Faulconer & Keys 1965).

Guibert (1872) testing the combined action of morphine and chloroform noted the two distinct states of analgesia and anaesthesia. The analgesic state he
described - 'consciousness and voluntary movements are maintained, but this state is sufficient to blunt sensibility to pain during parturition and minor surgery'. This was produced when 1/6 - 1/2 gr. of hydrochloride of morphine was given as a premedicant.

In 1872 Labbé and Guyon (sometimes Goujon) noted that morphine before chloroform lessened the excitement stage of chloroformisation, and extremely small doses were needed to maintain insensibility.

In 1883 French surgeon Aubert was using this premedication -

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<td>Morphine hydrochloride</td>
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<tr>
<td>Atropine Sulphate</td>
<td>5 mg.</td>
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<tr>
<td>Distilled Water</td>
<td>10 g.</td>
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1/2 gm. of this solution was injected 20-30 minutes pre-operatively,

During the 1890's Julliard of Geneva adopted the practice of preparing all his patients for ether anaesthesia with a preliminary injection of atropine-morphine. Julliard noted that premedication was important because the patient thereby came to the theatre in a greater state of mental and physical tranquility than he otherwise would have done. (Julliard 1891).

The injection of morphine combined with scopolamine (hyoscine) was introduced into anaesthetic practice in 1900 by Schneiderlin of Emmendingen, who had previously
used this combination as a sedative in treating mental patients. (The preparatory pharmacological work on scopolamine had been carried out chiefly by Merck of Darmstadt, during the years between 1895 and 1899). (Duncum 1947).
IV. DEVELOPMENT IN AUSTRALIA 1860-1900

Throughout these years there was little formal organisation of the dental profession in Australia. 1900 marked the beginning of dental legislation in New South Wales, although moves began earlier in Victoria.

First moves to form a Medical Association began in May, 1844 (Syd. Morning Herald, May 15 1844), and the last quarter of the nineteenth century saw the medical profession in Australia of high standing and greatly respected, well organised in groups and societies (B. Gandevia 1967).

The first Dental Act was passed in 1887, and in 1888 the Dental Board (Victoria) was gazetted. In 1897 the first teaching centre of Dental Science was established in the Australian College of Dentistry, by the private efforts of dentists themselves. (Gillies 1941).

The most commonly employed anaesthetic in Australia throughout this period was chloroform; this was however, to be challenged.

In 1862, the Australian Medical Journal published an extract on "Chloroform in Dentistry", from Dr. Charles Kidd of London.
Chloroform is much used and with great safety, though as a rule, it is not desirable to push the anaesthetic action as far as complete insensibility; deep narcotism is indeed to be avoided, as the patient should be partially conscious at least as regards the special senses, so as to hear the spoken directions of the operator when he directs the mouth to be opened, the mouth to be washed with water etc., such patients will often cry out most terribly too, especially nervous females; they have the apprehension of pain vividly before them, yet when asked afterwards they say they felt nothing, they express utmost amazement that 5 or 6 or 10 hideous stumps, old enemies, are all out, but such is the fact. I have administered chloroform to persons sitting upright, and believe there is not much risk attending to it. If faintness occurs however, the patient should be at once let down on the floor. (Kidd 1862).

Further editions of the *Australian Medical Journal* to the mid-1870's contain numerous records of deaths following chloroform administration. This journal, published from 1856, emanated from Melbourne (the previous *Australian Medical Journal* had been published in Sydney from 1846 to 1847). It was rivalled from a brief period by the *Australian Medical Gazette* (not to be confused with the later publication *Australasian Medical Gazette*) and it was in this journal in 1869, that Murray drew attention to chloroform deaths, and noted evidence of heart pathology at post-mortem. He felt that the probable cause lay in impurities and advised thorough testing of samples. He also warned against indiscriminate use of chloroform and stressed the importance of its effects on the heart.
In 1870, McGregor reported failure in his attempts to freeze the gum with ether spray to produce a local anaesthetic for tooth extraction, and so 'do away with the necessity of giving chloroform.'

Benjamin Ward Richardson contributed an authoritative article on "Death from Chloroform" in 1871. This article was a most comprehensive study, and concluded —

In reviewing the past of chloroform, I see nothing to lead me to assume that any of the deaths which have followed the administration, have been due to absence of skill, want of special knowledge, quality of the specimens of chloroform, or in the operative surgery. We must therefore look for the cause of death in some inherent fault in the chloroform itself.

Crooke (1871) endorsed Richardson's remarks and described the self-administration of chloroform for a dental extraction 'I felt neither pain, sickness, headache nor any other inconvenience after it was over'. Sansom (1871) writing on the 'Administration of Anaesthetics' summarised the current views of nitrous oxide —

If an operation of short duration is to be performed, the administration of nitrous oxide is probably the most indicated. This has the properties of quick action, induction of sleep insensibility with rapid recovery. The use of this agent requires, however, apparatus and time for arrangement; it cannot be a measure for the many and for the moment. Yet, largely used as it is by dentists, it takes away from the general
dangers of anaesthesia, by withdrawing from the greater risk of the other anaesthetics, a large class with was proved to be in afore-time peculiarly prone to danger. Certain conditions should, however, in my opinion, preclude the administration of nitrous oxide; these are pulmonary congestion, cardiac affections, and cerebral affections. When an operation of uncertain or of long duration is to be performed, the chief agents are ether, bichloride of methylene, and chloroform.

Writing with respect to chloroform, Sansom said —

Especial care should be taken at the early stages of the administration of an anaesthetic, whatever that anaesthetic may be. There is no doubt that the emotional disturbances which occur at such a time may induce dangerous and even fatal effects. Sudden death at the moment of commencement of an operation, when no anaesthetic whatever has been employed, is far from uncommon.

Clover's apparatus was shown to the Medical Society of Victoria on October 2nd, 1872, but it was considered that the ingenuity of the apparatus hardly compensated for the simplicity of chloroform administration ... 'which as the result of much experience was now adopted.'

1875 saw the most important contribution in anaesthesia in Australia of the period. This was a most exhaustive study by J. Davies Thomas, then senior house surgeon at Adelaide Hospital. His paper was entitled "A Consideration of the respective merits of Chloroform and Vinic Ether as General Anaesthetics". Thomas noted —
Of all the mishaps that a medical man may experience in the practice of his anxious and responsible profession none can exceed in painfulness the occurrence of a death under chloroform. I found from my own experience and that of others that though nitrous oxide was a very convenient and safe anaesthetic for petty operations occupying but little time, yet it was practically valueless for the more serious operations of surgery.

He further noted that the recorded deaths under ether were absolutely smaller in number than under chloroform.

In lower animals the respiration seemed to fail before the heart, but not so in man. With ether we have only to guard against danger from apnoea ... with chloroform we not only have the risk of apnoea but also ... an instantaneously mortal syncope.

He listed the 'usual objections' to ether,

(1) Ether is more disagreeable in odour.
(2) Ether is disagreeable to take.
(3) It takes longer to get a patient unconscious.
(4) Ether causes more excitement.
(5) Less economical.
(6) An inhaler must be used.
(7) Inflammability.

Thomas then countered each of these objections, and protested that the commonly held theory that deaths were due to carelessness did not hold. In November, he presented
statistics to support his contentions. He noted that deaths were due to sudden paralysis of the heart, which he thought was incapable of happening under ether. He listed the types of operations where deaths had occurred and noted that 48 per cent of deaths had taken place before the operation had even commenced. It is also salutary to note that thirteen deaths were for extraction of teeth of a total of 166, the largest number for any single operation. In 1876, Thomas again wrote on chloroform versus ether, and detailed and analysed a number of case reports. He found of fourteen cases of supposed ether deaths, only two could be directly attributed to ether and these administrations did not follow twenty rules — which he then gave. In spite of this detailed and illuminating work condemning chloroform and seeking its replacement by ether, chloroform retained its popularity. In 1889, Lempriere sought an explanation. The reasons he gave were portability, easy application, cheapness, less cumbersome apparatus, and anaesthesia more quickly produced.

Ether inhalers of various type notably Hawkeseley's inhaler,* were exhibited at medical meetings during these years, and no doubt a fresh interest gradually began to be taken in ether. It was not easy for it to overcome its

*Described by Duncum (1947), P.321.
disadvantages in the minds of the medical men of the day — Gillbee (1880) having just heard a paper on 'Chloroform Deaths' (Hearn 1880) did not doubt the greater safety of ether, but thought its administration was 'more tedious' and he thought 'chloroform would never be altogether superseded'.

In a discussion on Anaesthetics at a meeting of the B.M.A. (Victorian Branch) on 31st October 1888, Springthorpe made an interesting observation: 'In dental operations ... stimulation of the 5th nerve such as was then produced ... was a cardiac excitant.' Hence in such cases he 'aimed at getting the patient only into a state of cortical anaesthesia, when pain was unfelt and yet ordinary reflexes not abolished. Then the local operation might be performed with advantage and perfect safety ... the patient rallied quickly'. For major operations, he advocated complete anaesthesia.

Throughout the years, 1880 to 1900, there were frequent reports of deaths following chloroform administration, and in November 1884, details of a death after ether inhalation was recorded. (Poulton 1884). When a death occurred in Sydney Hospital in July 1884, the inquest jury advised the presence of a second medical man if chloroform was to be again administered in Sydney Hospital.

In March, 1889, the B.M.A. (N.S.W. Branch) published resolutions relating to anaesthesia —
(1) That, in the present state of medical knowledge, no one anaesthetic is the best drug to use on all occasions.

(2) With regard to the responsibility — this falls on both operator and anaesthetist, but varies in time and degree ...

(3) Heart diseases, ... are no bar to the administration of anaesthetics.

(4) ... present knowledge does not allow us to diagnose with certainty the existence of a fatty heart; but its presence does not forbid the use of an anaesthetic.

(5) In certain cases operations without an anaesthetic may be more dangerous ... than with an anaesthetic.

(6) In the event of collapse being induced by an anaesthetic artifical respiration is the most reliable measure to be adopted. (Resolutions ... 1889).

Todd in 1889 attempted to classify and analyse the causes of anaesthetic deaths. He explained the method of supporting the mandible in order to maintain the post-oral airway, and eliminate 'stertor', discussing the anatomical aspects.

J.S. Darton claimed to have pioneered the introduction of nitrous oxide/oxygen into N.S.W. in 1890. He described the problems which attended this, in particular the imperfect and cumbersome apparatus, and the difficulty of obtaining compressed oxygen in the early years. Darton felt
that the disadvantages were of small weight, when measured against the assured safety and the lengthened operating time. (Darton 1905).

In concluding this section reference is made to the editorial in the *Australian Medical Journal* June 15, 1891. In noting that deaths from chloroform had been unduly frequent at Melbourne Hospital the editorial asked –

Is it wise to rely solely on one anaesthetic for all cases? Do the students at Melbourne Medical School get all the practical experience possible, compatible with the safety of the patients in the hospital? The customs of other schools, especially Edinburgh, show that they do not. Students should be practically trained in all methods, and learn also to use their own judgement in the selection of particular anaesthetics for particular cases. It has been recommended that a special anaesthetist should be appointed to administer anaesthetics personally in all cases. But is this practicable? An anaesthetist cannot be always available for emergency cases. But, if the students were trained by a specialist to give anaesthetics themselves while students, they would when they graduate, be competent to administer them either in hospital or private practice.
V. **PROGRESS TO WORLD WAR I PERIOD**

(Subsequent review will emphasise Australian development)

This period, one of great importance, began with the passing of the first legislation dealing with the affairs of Dentistry in N.S.W., in 1900. It ended with the War of 1914-18 which was an event which greatly affected the progress of anaesthesia - Australian medical practitioners began to re-direct their attention to anaesthesia, and the first concentrated invasion of medical practice by the specialist followed in its wake. (Blackburn 1951).

Throughout these years Dentistry became firmly established as a profession, with the opening of the Sydney Dental Hospital (1900), and later a Dental School (1902).

Anaesthesia at this time was a branch of medicine seeking recognition. In 1901, the Society of Anaesthetists in Britain, pointed out to the General Medical Council that:

(i) there was no compulsory training in anaesthesia in any hospital or teaching centre in the whole of Great Britain and Ireland,

(ii) There was no examination in this subject.

(iii) The giving of an anaesthetic involves risk to life.

(iv) Every doctor is liable to be called upon to give one.

The Education Committee of the Council replied that they fully appreciated the importance of proper teaching in the subject of anaesthesia but they were of the opinion that it was not expedient for it to be compulsorily included in
the medical curriculum. (Sykes 1960).

Development in this period will be discussed under the following headings:

(1) Edward Embley of Melbourne.
(2) Somnoform and ethyl chloride.
(3) Nitrous oxide/oxygen.
(4) Analgesia.
(5) Intravenous anaesthesia.
(6) Premedication - Anoci-association,
(7) Endotracheal anaesthesia.
(8) The problem of dentists general anaesthetics.

(1) **Edward Embley of Melbourne**

Embley was born in 1861; pharmacist 1882, he matriculated in medicine in 1884 and graduated 1889. In 1896, he announced that Scottish surgeon Syme, and the Hyderabad Commission were wrong. (Embley 1896). His greatest contribution was however, in 1902, when he published the results of his researches carried out at Melbourne Hospital. He showed that heart muscle was very sensitive to chloroform poisoning; that the drug raises the excitability of the vagus; that deaths in the induction stage of anaesthesia are syncopal, and unconcerned with respiration; that failure of respiration is mainly due to fall of blood pressure, and that in post-induction stages of anaesthesia there is general depression of all activities,
and no longer syncope through excited vagus action. (Embley 1902).

Embley endeavoured to add scientific research to clinical observation. He also studied ethyl chloride and showed, in 1906, that this drug produced much the same effects as chloroform, but in less degree. Ethyl chloride had one quarter the action of chloroform on the vagus, and 1/19 on the heart muscle. It is on this difference that the relative safety rests, he said.

Embley made other important contributions throughout this period. In 1910 he described how ether was safer than chloroform. His investigations showed that in the percentages used for anaesthesia, chloroform depressed the heart’s capacity 51 times more than ether. He concluded that 'ether is in every way much safer than chloroform'. (Embley 1910).

In 1912 and 1913, Embley reported on the use of narcotics with ether and nitrous oxide/oxygen (mixed narcosis). The use of morphine, scopolamine and atropine injections allowed nitrous oxide to be used instead of ether. Greater use of nitrous oxide eliminated a great deal of 'post-operative wretchedness'. Embley later showed that chloroform affected the muscular activity of the arterioles as well as the heart itself, and summarised his results on the cause of anaesthetic deaths:-
(i) Syncope
(ii) Excessive intoxication
(iii) Shock (a) nervous (b) adrenal
(iv) Pathological
(v) Accidents such as flooding of the bronchi

He gave the treatment which each required.

Embley's work meant the final defeat of the Hyderabad Commission. Brown (1939), notes that Embley's contributions pioneered scientific research and teaching of anaesthesia in Australia.

(2) Somnoform and Ethyl Chloride

In 1902, Rolland and Robinson read a paper on 'Somnoform' to the British Dental Association conference. They recommended Somnoform administration utilising a 'linen handkerchief conically folded around a piece of paper. At the bottom of the cornet cotton wool was placed which is then sprayed with Somnoform. The nose and mouth were completely covered by the cornet. (Fig. 17).

Somnoform was introduced into Victoria by Philpots and Gray in 1904. (Gray 1906).

The following are figures published in the Australian Journal of Dentistry in 1906 for general anaesthetic cases at Melbourne Hospital,
The charges are also given, which may have been of significance in influencing the relative frequency of administrations, and it cannot be considered that these figures fully indicate clinical preferences:

(Gas - 3/-, chloroform - 5/-, Somnoform - 3/-, Gas by nasal inhalation - 5/-).

The figures do however show one marked influence in the very notable gain in popularity of Somnoform at this time.
Gray (1906) wrote:—

During the past eighteen months, Somnoform has been used absolutely to the exclusion of nitrous oxide in 1500 cases, all of which have been carried out under my personal supervision, and I can say unhesitatingly that in not one single case have I had the slightest anxiety as to the patient's safety, nor have I seen any alarming symptoms, beyond struggling on the part of alcoholics, and retching in a percentage of the cases.

Gray found hysteria in some female patients and in thirteen per cent retching and vomiting. He advised that anaesthesia could be expected in 5 seconds.

So much did I like it, that it very rapidly supplanted nitrous oxide in my private practice. It is a very long time since I administered the latter, and my apparatus is dying its death behind the door of my surgery.

Prytz (1908) indicated that 1 million administrations had been given with few deaths; one being due to fatty degeneration of the heart, and one due to shock. He further noted that anaesthesia induced by Somnoform differs from that induced by nitrous oxide, in as much as the induction period is very short and the duration quite long. Somnoform anaesthesia was entirely lacking in asphyxia, cyanosis, suffocation, jactitation, while nausea was extremely rare, said Prytz.

Fetherston (1909) described how he had become 'an ardent Somnoformist', and no longer used his gas machine. Fetherston was impressed by the great simplicity and portability of the apparatus; also by the short induction
and long anaesthesia, and the total absence of after-effects. He averaged an extraction of six teeth at each administration; his largest number being eleven.

Somnoform was the subject of a further paper, by J.L. Smith (1914), who felt that this agent met requirements more than any other anaesthetic. He listed the new formula (83% ethyl chloride; 16% methyl chloride; 1% methyl bromide) and its properties, and compared its safety with nitrous oxide. He felt that its superiority lay in the longer analgesic stage following the anaesthesia which allowed for 'double the work without having your patient struggle or hurt'. It is of interest that he made considerable use of the analgesic stage, and noted that using a De Ford inhaler, (Fig. 18) continuous analgesia would be maintained without removal of the inhaler from the face. 'In the stage between sleeping and waking you can usually cut the most sensitive dentine without the slightest pain'. The popularity of Somnoform was more concentrated in Victoria than N.S.W. at this time, (interest was not evident in N.S.W. until 1917) and its popularity was due to a great extent to previous condemnation of ethyl chloride. Philpots (1908) was of the opinion that 'ethyl chloride in its modern form had been condemned as dangerous too early'. Somnoform represented a resurrection of ethyl chloride, which use involved 'but little risk'. Philpots described
in detail the administration of ethyl chloride for dental operations. Normally 5cc. dosage had been used although results were reported utilising a 50cc. capsule with tap, which allowed for small dosage, until sufficient anaesthesia was obtained for the requirements of the case.

For longer periods of anaesthesia Philpots suggested a nitrous oxide and ethyl chloride sequence. Nitrous oxide was given until the patient had had four or five gallons and cyanosis was just appearing; the three-way stop-cock was then moved to allow admittance of ethyl chloride. Experiments were also being conducted in combining oxygen with ethyl chloride, when the only difference noted was more rapid recovery. Ethyl chloride
was held in favour as being cheap, portable, causing no cyanosis, and requiring a very simple technique.

A further advocate of mixing nitrous oxide with ethyl chloride was Holland (1909). He gave as reasons for its use:

(i) Safety
(ii) Duration
(iii) Uniform results
(iv) Absence of distressing after-effects.

Adding to the confusion which had become evident at the time, came an article by Hornabrook in 1911, who described the advantages of 'open' ethyl chloride over the closed method - 'the extreme unpleasantness of the closed method, and also the feeling that the patient has, that the closed inhaler, especially if it has a rubber mouthpiece is unclean'. Other advantages listed included the 'rapid elimination of ethyl chloride from the system, and after a few minutes, the patient is quite fit and free to go home . . . ' 'Vomiting is rare; the swallowing and coughing reflexes are retained and any blood which is swallowed is soon brought up'. The advantages of open ethyl chloride over Somnoform were said to be:-

(i) Safer - (Hornabrook listed 3,500 cases without a moment's anxiety; nor had he had to use artificial respiration).

(ii) More pleasant.
'With open ethyl chloride, the conjunctival reflex is lost only, and the breathing of the patient becomes stertorous or snoring. If ethyl chloride is over-administered or over concentrated, twitching movements come on in the arms and legs; the patient becomes rigid'.

Foremost among American advocates of Somnoform was De Ford (1912, 1913), who claimed that:

Somnoform is the easiest of all anaesthetics to administer. Men who make most dismal nitrous oxide failures, experience little or no difficulty in inducing somnoform anaesthesia and analgesia. The appliances used are very much less complicated than nitrous oxide appliances. With somnoform, anaesthesia and analgesia can be induced without the admixture of oxygen, air dilution being all that is necessary.

De Ford (1912) stressed that a stage of analgesia was sought rather than anaesthesia, which he said provided better operating conditions than with the equivalent stage using nitrous oxide. Stressing the value of general anaesthetics to the dental surgeon, De Ford noted the importance of overcoming conceptional aspects of dental treatment and avoiding 'dental fatigue' in the patient. With regard to safety he claimed not to have witnessed a dangerous symptom in 8 years and 6,000 anaesthesias.

(5) Nitrous Oxide/Oxygen

Promotion of the use of nitrous oxide/oxygen in dental practice was largely due to the efforts in the United States of Teter, Heidbrink and McKesson.
Teter was a dentist from Cleveland, Ohio, who produced a machine for the administration of nitrous oxide/oxygen in 1902. This machine was well accepted, and led to wider use of this method. Teter also perfected the nasal inhaler (Terry 1912), and advocated the warming of the gases. In describing his apparatus (Fig. 19) Teter (1910) said:

![Diagram of Teter's apparatus with a vapour warmer, note attachment which allowed for ether supplement.]

The gases should be under a slight pressure in the inhaler if the best results are to be obtained. This is accomplished by a delicate spiral spring on the expiratory valve. The two gases should not be mixed in the bags, but just
before entering the inhaler. A transparent face-piece is advisable, so that the features of the patient may be always visible. If there is retching it can be seen if vomit comes from the mouth without raising the inhaler. If a mouth-prop is being used it can be seen whether it is in place or not. Such an inhaler is more easily kept aseptic. There should be means for nasal inhalation for all work in the mouth or throat, so that nitrous oxide and oxygen can be continued any length of time. There should be an attachment so that varying percentages of ether can be administered in combination with nitrous oxide and oxygen. The advantages of this anaesthetic are that it is not unpleasant to the patient; anaesthesia is soon induced; any position of the patient can be utilized; the cough reflex is maintained, preventing inhalation of blood and tissue; quick recovery from the anaesthetic state without nausea and vomiting, unless blood and tissue have been swallowed, and above all, the safest anaesthesia known.

Teter concluded:

My object in presenting this subject before a section of the American Medical Association is to encourage the professional anaesthetist to take up nitrous oxide and oxygen as a general anaesthetic and develop it to a science. It is essential that great advancement must be made along the line of anaesthesia to keep pace and to the forefront with other branches of medicine and surgery, and this can be accomplished only by the efforts of the medical man as a professional anaesthetist.

Heidbrink, a dentist from Minneapolis, (U.S.A.), had experimented with the Teter machine, and built an entirely new machine for nitrous oxide/oxygen anaesthesia in 1906. He provided a third bag for rebreathing. Later in 1910, he produced his model 'T', a continuous flow machine, which made use of a reducing valve as a flow meter.
He was the best known exponent of 'timed anaesthesia', (Keys 1963), another being Wright (1908) from Western Australia. Wright demonstrated the use of ethyl chloride as an adjuvant to nitrous oxide. The nitrous oxide was breathed into a one gallon bag for 4-5 inhalations, then the ethyl chloride was tipped in, and after 25 seconds, the face piece was removed and the operation proceeded.

McKesson was a physician from Toledo who became interested in anaesthesia in 1906, and in 1910 perfected the first intermittent flow* nitrous oxide/oxygen machine. (Armstrong Davison 1965). McKesson introduced the principle of fractional rebreathing and found it possible to save the first part of each expiration for rebreathing. (McKesson 1915)

In Australia, the use of nitrous oxide/oxygen was advocated by Marks (1909), who outlined conditions for the successful administration of the combined gases.

Marks claimed up to 15 minutes anaesthesia with a slow (4-5 minute) induction, and occasionally re-applied the face-piece during a difficult extraction. Men with beards, as a rule required less oxygen, as there was an admission of air through the beard.

* (Continuous flow; Intermittent flow. See Page 278.)
Marks' paper helped to inspire moves to introduce a course in 'Dental Anaesthesia' at the Second Australian Dental Congress in Melbourne, 1909. Several clinical demonstrations in anaesthetic technique were given at this Congress. 'Crank on 'Nitrous oxide and ether';'Nasal administration of nitrous oxide' by Parker and Sagar; 'Nitrous oxide, ether and chloroform' by Kiel (Nitrous oxide and one per cent ether for long dental operations was shown and thought excellent, one patient having 21 teeth extracted), 'Continuous anaesthesia using nitrous oxide and air' by McClinton. 'Somnoform' by Hemmons. 'Nitrous oxide/oxygen' by Marks). It is obvious that there was intense interest at this time by dentists in anaesthesia, although the diversity of agents and methods, without clear policy or central authority meant a lack of unification in this field, and elements of confusion.

In 1912, in conjunction with the 3rd Australian Dental Congress in Brisbane, a report was issued as a result of a circular sent to '400 ethical dentists in Australia'. This report indicated that nitrous oxide was the anaesthetic chiefly in use, but in Southern States, Somnoform and ethyl chloride had their advocates.

McClinton presented a paper at this Congress on 'Continuous anaesthesia by Nitrous Oxide'. He said, 'In my opinion, nitrous oxide is as safe as cocaine, if not safer,
and yet is not generally used in prolonged anaesthesia'. He had not at that time administered oxygen in conjunction with nitrous oxide, because he was unable to get an apparatus to his liking. His technique was to keep a steady stream of gas blowing in the patient's face, and then after induction, the mask was placed on the nose, the mouth being covered with a towel, excluding all air. 'After 12-13 breaths, they go under', he said. If they showed signs of recovery, he would stop operating and replace the nose piece, giving pure gas for 2-3 breaths.

Meanwhile, nitrous oxide was dismissed by medical men in a few words as being clumsy and requiring apparatus too heavy to carry about. (Sutherland 1913). Throughout these years, however, many attempts were made to administer nitrous oxide in a continuous manner for prolonged extractions and for surgical operations. This work was attempted with nitrous oxide anaesthesia kept up by the intermittent administration of gas by ordinary apparatus. It was not until 1913 that interest in nitrous oxide/oxygen for general surgery began. (Page 1913). Luke and Ross (1919) noted however, 'it will be obvious to those associated with the ordinary phenomena of nitrous oxide anaesthesia, and the quietness of breathing and muscular flaccidity essential to the performance of the majority of operations of surgery that the gas is by no means adapted
for such use'. The maintenance of the supply of nitrous oxide by means of a nasal tube as suggested by Harvey Hilliard (1898), Luke and Ross considered objectionable, on the grounds of it being apt to cause considerable epistaxis.

It was during World War 1 that nitrous oxide/oxygen anaesthesia acquired an importance and a degree of recognition, which was anticipated only by those few who in England and the U.S.A. had been working for some years to perfect its administration. (Luke and Ross 1919).

The various methods which existed in Britain, for its administration at this time were:

(i) **The Hewitt System**
Which utilised a double bag system, each gas having a separate bag and fitted with a regulating stop-cock. The relative percentages of nitrous oxide and oxygen which the apparatus was capable of furnishing, depended on the degree of distention of the bags during the inhalations. (Fig. 20).

(ii) **The Teter System**
This introduced a resistance to the expiration which meant that gases were applied under positive pressure, which deepened the anaesthesia. A definite amount of oxygen was constantly being mixed with the nitrous oxide.

(iii) **Clark System**
The maintenance of constant pressure in the bags
Fig. 20 - Hewitt's gas and oxygen apparatus.

was attempted. A central valve with a slot for each gas was supposed to proportion the gases.

(iv) Guy-Ross Method

Allowed for a more ready percentage of oxygen. (7¾ per cent).

Variations of method involved the use of ethyl chloride or ether as adjuvants.

Of importance at this time was the contribution by Hart and Minshall (1914) who drew attention to the impurities in commercial nitrous oxide for dental use and their injurious effects by inhalation. They recommended 98 per cent pure
nitrous oxide content as a minimum standard.

Gwathmey (1914) said:

With the nose-piece in position a great many surgical operations especially dental work may be done with ease during the analgetic stage of nitrous oxide/oxygen anaesthesia. It is now an acknowledged fact that dentists can do their work more acceptably to the patient, and with greater satisfaction to them-selves when using nitrous oxide and oxygen for painful dental work, than without this help or with only a local anaesthetic.

(4) **Analgesia**

Godfrey (1903) indicated the differences in technique for dental and other operations. He said that it was inadvisable 'to abolish, except for a very short time, the coughing and swallowing reflexes ... it is sufficient to carry the stage of anaesthesia just to the abolition of the corneal reflex'. According to Raper (1945), self-administered nitrous oxide was first introduced into dental practice by Guedel in 1912, with an inhaler held to the nose like a 'longnette'. This had followed Guedel's earlier work with obstetric analgesia (Guedel 1911). Other early contributors were Mann (1912) and De Ford (1913). De Ford (1913) defined the state of surgical analgesia as 'a state or a condition of the patient, in which, without complete loss of consciousness, certain surgical procedures may be accomplished without inducing pain; or the pain incident to the operation as ordinarily performed, is held in abeyance to such an extent as to elicit no objection on the part of
the patient'. He also noted that 'to be successful in
inducing surgical analgesia one must be masterful and must
completely dominate the patient'.

The first mention of analgesia in the Australian
literature came from Taylor (1913). Taylor, writing from
America, thought that the subject would 'prove of exceptional
interest to the dental fraternity of progressive Australia'.
He felt sure that it would come into general use 'very
shortly', and the field of the dentist be 'greatly widened'.
Taylor wrote:

With all ordinary anaesthetics the sense of feeling
pain is lost before unconsciousness or general
anaesthesia is reached, but the patient passes so
quickly from the stage where no pain is felt, to
anaesthesia, that the former state is of no use
whatever to the operator. What we really have to
do, is to get our patient on that narrow margin
between sensitiveness and anaesthesia, and to keep
him in this stage for a sufficiently long enough
time to allow an operation to be performed. It has
been found and proved possible to maintain this
condition, and the patient is entirely without the
pain derived from the operation, while he is still
in possession of his mental faculties. Just
imagine a patient undergoing an operation and being
able to see, hear and talk to the operator, and yet
in a state of insensitivity to pain, then you have
ideal analgesia.

So far nitrous oxide has been chosen for this
purpose. Now, nitrous oxide produces analgesia,
but it carries the patient on into anaesthesia so
quickly if used alone. So another important item
is to decide the right diluent, either oxygen,
air, or a mixture of both... the apparatus to be
used is arranged so that pure oxygen can be used in
conjunction with the nitrous oxide and ordinary air
also, if need be, perfect results of analgesia can
be obtained for an almost indefinable length of
time.
The patient is first given pure nitrous oxide for a few seconds until the analgesic state is reached, then the percentage of nitrous oxide, being cut down slightly, a quantity of oxygen, or oxygen and air, is admitted to the mixing-chamber and inhaler in sufficient proportions to prevent anaesthesia, but to maintain analgesia, the proportions being about 75 per cent nitrous oxide, and 25 per cent oxygen.

The inhaler itself is a small piece of apparatus which fits snugly over the patient's nose, and can be strapped in position, or preferably held there by the patient. In the latter case the patient himself becomes the anaesthetist - and a safer one could not be found - for even if complete anaesthesia is induced, caused by too great a percentage of nitrous oxide (and if carried too far, resulting in cyanosis), the inhaler will be pushed away from the nose by a spasm, and recovery will quickly occur, thus relieving the operator of all anxiety regarding the safety of the patient.

With regard to the cases in which analgesia can be used, there is no end to them. It can be used to the greatest advantage and success when drilling or excavating sensitive dentine, and cavities on the gingival margin, when filling with gold, preparing roots of teeth for a crown or bridge, exposing, and even when extracting pulps; in fact, in all operations where it is necessary or preferable to have the patient conscious, and yet insensible to pain.

Taylor finally quoted 'an American expert' to conclude his article:

Analgesia is here, and will remain forever. Once a patient is treated in that stage the dentist's chair to him appears a veritable throne, and the operation a pleasant diversion, instead of a tortuous necessity. I predict that within two years, every progressive dentist in this country will be using nitrous oxide and oxygen analgesia in his practice.

I trust that this short reading will be acceptable and that the subject will arouse as much
enthusiasm among the dentists of my own country, Australia, as it is at present doing here, although still in its infancy.

A subject 'in its infancy' in 1913, has it seems, taken considerable time to mature; the enthusiasm hoped for, was not realised. Langa (1968) in his text devoted to 'Analgesia' in the modern context, notes that at this time the gas machines were not finely calibrated, and the gases were impure. This lead to a great deal of nausea, vomiting and excitement - stage symptoms. Success came to relatively few. A revival did however ensue in the first half of the 1930's. (Fig 21).

Fig. 21 - The Gregg Inhaler - illustrating a type of inhaler used for nitrous oxide/oxygen analgesia 1912-1913 period.

Somnoform as an analgesic agent retained its popularity in the hands of certain operators. J.L. Smith
presented a paper in 1914, which drew attention to the
analgesic stage, and its advantages to the dentist. He
described the state as allowing of the 'painless cutting of
dentine', the patient after which will be 'rested and
refreshed'. He felt that Somnoform was superior to nitrous
oxide, and indicated that a great number of nitrous oxide
analgesia cases are 'absolute failures . . . because an
operation is performed when the patient is not surgically
anaesthetised'. With Somnoform the patient did not
'struggle', nor were there any symptoms of 'cyanosis,
jactitation or stertorous breathing',

A.F. Smith (1914), and Ziele (1915), further
discussed analgesia. Smith said:-

Pain caused by cutting sensitive tooth structure is
quite different from the pain inflicted upon
sensory nerves in other parts of the body. This
can be accounted for because the fibrillae in the
dentine is not real nerve tissue. Many patients
can be placed in the analgesic condition and a
tooth excavated or hyper-sensitive dentine cut with
a bur absolutely painlessly, while the patient in
the same state and under the same conditions can
feel pain when pinched upon the skin.

Ziele, speaking to the Odontological Society of
N.S.W., claimed that many dentists 'excused themselves to
their patients by condemning the use of nitrous oxide for
tooth extraction', and urging them to accept 'local'. The
'aversion to the use of nitrous oxide', said Ziele, 'by the
general practitioner in dentistry, indicates a lack of skill
and training or confidence. I am convinced more than ever of the belief that to extract every tooth that calls for such treatment with local anaesthetics, is wholly wrong practice'. Ziele condemned the use of local anaesthesia in the presence of infection, and noted that post-operative complications at the extraction site were less when general anaesthetic was used.

As so few dentists were using nitrous oxide here as a general anaesthetic, or received any worthwhile training in its use, it was scarcely to be expected that they should become converts to analgesia, as a means of relieving pain in cavity preparation. The use of the analgesic state received considerable support in the United States, but attracted little attention in Australia. McKesson (1914) gave an account of his experiences:

The state of analgesia is made possible by the fact that in the development of general anaesthesia, the first special sense to surrender is the sense of pain, leaving the other special senses less influenced.

The technique for giving nitrous oxide for analgesia consists in diluting the gas with enough air and oxygen to prevent loss of consciousness, on the one hand; and yet of sufficient concentration for the relief of pain, on the other. . . it is necessary to recognize the limitations of analgesia; nor to attempt the removal of a live pulp nor an extraction under its influence; nor to expect that analgesia unaided by suggestion will make a fearless patient out of a fearful one.

The safety, and the necessity for 'positive
suggestion were stressed by Feltus (1915).

(5) **Intravenous Anaesthesia**

Fischer and von Mering in 1903, introduced barbital (veronal). This first barbiturate was a long-acting drug, slow in its effects, and left patients in a deep sleep which disappeared after 24-28 hours.

The period 1909-1912 saw the reintroduction of intravenous methods of anaesthesia:-

(a) **Ether**

Burkhardt of Germany in 1909 aiming to produce a form of anaesthesia which would be safe in unpractised hands, experimented with intravenous chloroform, and then turned his attention to ether. He used a 5 per cent solution of ether in a sterile physiologic salt solution. At the Berlin Surgical Conference in 1910, six surgeons of prominence corroborated the success of Burkhardt and satisfactory results were reported in practically every country (In Britain, Rood 1911; Napier 1912).

Gwathmey (1914) and Blomfield (1918) described the use of intravenous ether, which was preceded by the subcutaneous injection of morphine sulphate 1/6 gr., atropine 1/100 and scopolamine 1/1000 gr. A 5% - 7½% per cent solution of ether was used in
Ringer's solution at 85°F. The technique involved the surgical exposure of the vein under local anaesthesia (cocaine). A cannula was then introduced and tied in the vein. The solution was first administered full flow after which a 40-60 per minute drip was set up. Adams (1944) considered that the apparent disadvantages of intravenous ether could possibly be refuted, and the technique could be worthy of further consideration.

(b) **Hedonal**

Hedonal (methyl-propyl-carbinol-urethane), was the first of the barbiturates to be used intravenously. The early work with this agent was done by Fedoroff of St. Petersburg, and in 1912 he reported the results of 580 cases with no deaths. Its use in England was reported by Page (1912) with 75 cases. Australian reports on Hedonal came from Latham (1913) and Moore (1913) and the advantages of intravenous anaesthesia were first described by these contributors. Moore, whilst praising the method, expressed doubt in view of reported deaths under Hedonal in Britain. Blomfield (1918) said that the use of Hedonal involved so much risk as to be impractical. Mennell (1935) described the
fate of Hedonal, supplies of which became
unobtainable at the onset of war, and so it fell
into disuse.

(c) **Isopral** (Trichlor-isopropyl-alcohol)
Graef in 1913 reported 359 cases in which isopral
induction and ether maintenance had been used.
This combination he maintained, produced a more
lasting deep narcosis than ether alone. It
permitted smooth induction and less excitement,
and thus more even maintenance.

(d) **Paraldehyde**
Paraldehyde as an intravenous agent was reported
by Noel and Souttar in 1912. It was not a great
success as an anaesthetic except in combination
with ether.

(e) **Magnesium Sulphate**
Three cases were reported in 1916 by Peck and
Meitzer, with reasonable anaesthesia produced.

(6) **Premedication**
The psychological importance of premedication was
not fully stressed until 1909, by Buxton. Prior to this,
Korff in 1901-3 had tested various combinations of morphine
and scopolamine, and proposed: a total dosage of 0.001g.
scopolamine hydro-bromide and 0.025g. morphine hydrochloride
in 10.0g. distilled water. This was to be given in three
equal injections, the first two and a half hours, the second one and a half hours, and the third half an hour before operation.

In 1903, Hartog, recommended the injection of 0.0005g. scopolamine and 0.01g. morphine half to three quarters of an hour before operation, as a routine preliminary to ether anaesthesia.

G.W. Crile developed a method of combining local anaesthesia with general anaesthesia in 1908. This was known as Anoci-association. The nerve supply to the field of operation was blocked off by local infiltration before the general anaesthetic was administered. This was a most important development when considered in modern context.

Crile worked on the problem of shock from 1897, which research notably yielded the ideal treatment - 'the direct transfusion of blood'. Finally, researches led to the 'kinetic theory of shock' - that shock was the result of excessive conversion of potential into kinetic energy in response to adequate stimuli (Crile and Lower, 1915).

The concept of anoci-association (Crile 1911) arose from the desire to develop in the patient freedom from noci-association. Every adequate stimulus awakens an ontogenic or phylogenetic memory, or association, and the nerve mechanism evolved by countless similar experiences in the life of the individual or of his race makes the
appropriate response. These associations may be injurious to the individual - *nociceptive associations*. (Crile and Lower, 1915)\(^6\)

Crile stressed that the treatment of shock involved:

(i) Haemorrhage must be checked.

(ii) Relief of pain.

(iii) Removal of anxiety and distress.

Premedication with morphine 1/6 gr. and scolopolamine (1/150 gr) was recommended one hour before operation, and local anaesthesia (novocain 1/400 solution) used routinely. (Fig. 22)

**Fig. 22 - Anoci-Association.**


11. Patient under inhalation anaesthesia in whom traumatic noci impulses only reach brain.

111. Patient under complete anoci-association. Traumatic impulses blocked by novocain.
Crile studied the influence of the inhalation anaesthetics upon shock production (Crile and Lower 1915) and laid down these important findings:

(i) Under approximately equal trauma, changes in the brain cells were approximately three times as great under ether anaesthesia as under nitrous oxide/oxygen anaesthesia.

(ii) That the fall in blood pressure was two and a half times greater under ether than under nitrous oxide/oxygen.

(iii) The condition of the animal was worse after trauma under ether than after equal trauma under nitrous oxide/oxygen.

(iv) The excitation due to the feeling of suffocation while inhaling ether causes a certain amount of exhaustion from which the patient taking nitrous oxide/oxygen is spared.

Nitrous oxide/oxygen should be the inhalation anaesthetic of choice.

Crile's ideas were given support in Flagg's text *The art of anaesthesia* (Flagg 1919) who said:

... all necessary manipulations are done under cover of this nerve blocking, and if all unnecessary trauma is avoided, then a light anaesthesia becomes the method of choice.

The desire to overcome the unpleasant feature of general anaesthesia - that of the fear of the patient being put to sleep, led Collins in 1910 to use scopolamine and morphine as a preliminary to general anaesthesia, which he described as a 'rational procedure'. The use of scopolamine - morphine had been applied to obstetric practice by von Steinbächal (1903) and so was established the concept of
'twilight sleep' for the relief of obstetric pain.

Gilbert Brown (of Adelaide) has made a number of important contributions to the literature. In 1911 he presented notes on 300 cases where general anaesthesia had been combined with narcotics. He used ether (open and closed), chloroform, A.C.E. mixture and ethyl chloride anaesthetics with morphine usually combined with atropine, scopolamine, or veronal. He attributed the following effects to the narcotics:

(i) The patient is more tranquil and may become slightly amnesic,

(ii) The anaesthetic is not dreaded, and therefore taken better,

(iii) The induction is quicker (although occasionally the patient becomes too placid).

(iv) The amount of anaesthetic used is much less (especially open ether).

(v) Salivation and excess of mucus in the throat was very rare.

(vi) Post-anaesthetic vomiting was rare.

(vii) Shock seemed to be lessened.

(viii) Post-operative pain minimised.

The narcotic combination which he found most satisfactory was:

\[ \frac{1}{4} \text{ gr. Morphine} \]
\[ \frac{1}{100} \text{ gr. Hyoscine} \]
\[ \frac{1}{100} \text{ gr. Atropine} \]

and 'open ether' the best anaesthetic. (Brown 1911).
(7) Endotracheal anaesthesia

In 1902 Fransz Kuhn of Germany, presented a paper on nasotracheal intubation, and pointed to its advantages, and its maintenance of a patent airway in every condition. Kuhn said:

To the satisfaction of such an arrangement for operations inside the mouth, is added the fact that nasotracheal intubation permits the anaesthetist to remain outside the surgical field. The mask is far removed from the face, and it is possible to deepen the anaesthesia quickly if desired. Further, is the abolition of reflexes originating in the upper airways, and security and maintenance of a patent airway, even if laryngospasm, bleeding or vomiting occur, (Kuhn 1902).

To Kuhn may be said to belong the credit for pioneering endotracheal anaesthesia as it is employed today.

In 1909 Meltzer and Auer published results in which it was demonstrated that if air was blown into the trachea of an animal whose respiratory mechanisms had been paralysed, full oxygenation of the blood could be maintained. In 1909-10 Elsberg made clinical application of this work; and in 1912 Peck demonstrated the application of this principle to clinical anaesthesia. In the meantime Cotton and Boothby advocated the endotracheal insufflation of mixtures of oxygen and nitrous oxide, (Cotton and Boothby, 1911)

In 1913 Chevalier Jackson considered one of the world's leading laryngologists, presented a technique of insertion of intratracheal insufflation tubes. He described
the use of the laryngoscope and the placement of the endotracheal tubes. The patient to be 'fully under the anaesthetic by the open method, first, so as to get full relaxation of the muscles of the neck'.

(8) The Problem of Dentists Administering General Anaesthetics

This problem was to the fore in Australia in 1909, stimulated by discussion in Britain. On January, 20th, 1909 there was a move by the Section of Anaesthetics of the Royal Society of Medicine to restrict the administration of anaesthetics to legally qualified practitioners. (Proposed General Anaesthetics Act 1908; 1909) They ruled: 'Dentists have always been recognised as proper persons to administer nitrous oxide gas, and this right should not be taken from them, but they should be prohibited from administering the more dangerous anaesthetics, unless they possess a medical qualification'.

In the discussion, Hilliard said that 'most of the objections to gas would disappear if every doctor and dentist were taught how to administer it'.

Hewitt said: -

To entrust anaesthesia, whether nitrous oxide or more potent agents to those without medical training was a retrograde act . . . He had records of six cases of death from nitrous oxide in the last twenty one years in the hands of persons with no medical qualification.

Finally, it was moved that the opinion of the
Section of Anaesthetists be forwarded to the Royal Society of Medicine. (The motion was carried 14 to 7).

This proposed legislation was viewed with interest in the *Australian Journal of Dentistry* which reported on a paper subsequently read by Hewitt (1909). "The proposed legislation in regard to Anaesthetics, and the advantages it would confer upon the dental profession." This paper was a most important one in dental anaesthetic history, and obviously had far-reaching effect.

Hewitt believed that the dental student should be educated in the administration of local anaesthetics, and of nitrous oxide, and have 'plenty of experience' and be examined on the subject. He hesitated to say it was advisable that the dentist should give chloroform or ether, and said that he would confer no statutory powers upon dentists to administer these. The report continued:

There was no doubt that the last few words of Dr. Hewitt's paper contained a lesson for all - that the man successful in practice was the man who studied above all things the welfare of his patient, who sacrificed very often his convenience, his rest, and his health. He often said to his medical brethren who wanted legislation for this, that, and the other, that if every individual member in the profession would make himself valuable to his individual patients, he would have far more influence than he would ever attain in any other way.

There was considerable discussion on the question, and the main thoughts against dentists giving anaesthetics were twofold:
(i) Whether the dentist was competent to meet emergencies, although admittedly competent to do the work.

(ii) The question of the dual function of one man performing the operation and giving the anaesthetic.

Hewitt in his concluding remarks noted that he had been unable to find record of a 'death from a local injected anaesthetic in the hands of a registered dentist', and 'if danger did arise under a local anaesthetic there was always time to call in a medical man... under a general anaesthetic, by the time the medical man arrived the patient was usually dead'.

The attitude of the British Dental Association to the proposal was then expressed. They protested in a 'most emphatic manner against any legislation which would make it illegal for registered dentists to administer anaesthetics for dental operations'. The proposed legislation was thus withdrawn from the House of Commons, and has never again been put forward. The dental surgeon in Britain came very close at this time, to relinquishing his right to administer anaesthetics. The bill was apparently not re-introduced due to the advent of World War I. These discussions took place at the British Dental Association Conference in May, 1909. In October of that year the Second Australian Congress was held in Melbourne, and the British views were noted and endorsed. The motions put, and some of the discussion is of
considerable interest in the light of present day controversies.

Prytz put the following motion which was carried unanimously:

This Congress is most decidedly agreed that dentists have a perfect right to administer certain anaesthetics for dental operations by virtue of their training being so thorough; and also on account of the fact that they have done so for many years; and would strenuously oppose any effort to deprive them of such rights.

Earlier that day, and following a paper read by Marks on "Nitrous oxide/oxygen anaesthesia", an important motion was put by Springthorpe. It read as follows:

That on the question of anaesthetics for dental purposes, it would be wise to have a certificate of skill and experience to be given after suitable theoretical training, and also a suitable course, and a paper examination. And to attain that purpose, the question should be referred to the various Dental Boards of the States of the Commonwealth, the Dental Board of Victoria to take the initial step in the matter with a view of the safeguarding the vested rights of dentists already qualified to practise the administration of anaesthetics for dental purposes.

Prytz moved an amendment - 'that the question be referred for discussion to the business meeting of the Congress this afternoon'. This was carried.

And so that afternoon, the President put forward Springthorpe's proposal and asked for an endorsement by Congress. Morrison seconded the motion and said:
... our status in the matter has never been definitely set forth; and in the event of any serious mishap, I think our position in a court of law would be a very critical one; more especially would that be the case where the operator was also the person who had administered the anaesthetic, thereby fulfilling two capacities at once. There is an opinion prevailing in some quarters that the administration of general anaesthetics belongs more to the province of the medical man; and the view is also held by some that dentistry is a specialty in general medical practice, and that, therefore, general medical practitioners should take over the administration of general anaesthetics. I differ very emphatically from those ideas.

... assuming that we have the right to administer anaesthetics, the point might be raised as to whether we should be permitted by law to administer certain anaesthetics, and debarred from administering others... we must make our position unchallengeable and unassailable in the administration of general and local anaesthetics to our patients. To do that, the best course would undoubtedly be to follow the recommendation made by Dr. Springthorpe, that dental practitioners be provided with certificates which would prove that they had received special instruction as part of the dental curriculum in these subjects, and that they had passed a satisfactory examination, and shown themselves experts capable of administering anaesthetics. While we are all convinced, I think, and all of one mind on this point, it is not so much a matter of educational difficulty, because the dental curriculum can easily be adapted to meet requirements, but it is a very definite legislative need.

Speaking against the motion, Lewis said:

... even if a certificate were obtained, as suggested, showing that the holder, being a dentist, is a fit and proper person to administer anaesthetics, I doubt very much whether the possession of it would relieve one from the necessity of appearing before the dreaded coroner if an accident should happen.
Having to appear before him in certain events, whether we have the certificate proposed or not, I am perfectly sure that the credentials we all now have are quite sufficient.

... the only credentials a dentist or a medical man needs to possess are a sufficient knowledge of that branch of his art that he has been practising, and the use of ordinary care. That being so, we who are practising the administration of anaesthetics now, are sufficiently protected ... if the suggestion is made that the teaching of anaesthetics be embodied in the college curriculum, I would support it.

Clarke also spoke against the motion ... 'If you have a certificate as suggested, and anything unfortunate happens, the law is going to say you have no right to make a mistake'. The President seemed disturbed by the train of thought evident in the words of those opposing, and pronounced that the motion was designed to get the voice of the dentists as to the necessity of further improving the course of education in anaesthetics. The opposition was increased however, Stevens even claiming that, 'Those who get certificates may possibly feel that they have obtained licences to kill', and noting that, 'Dentists have been administering anaesthetics with very few bad results'.

The motion was then put and lost by a very large majority.

Had this motion been carried the history of anaesthesia for dental purposes may well have been different. Unrecognised at the time, this vote was undoubtedly of
considerable significance. An opportunity was lost at this very early stage, to establish 'Dental Anaesthesia' as a serious course of study in this country. Had this course been established at that time, the next fifty years of history would no doubt have been different.

Philpots, following the paper by McClinton (1912) mentioned earlier said:

We as dentists have evolved certain anaesthetics which we claim as ours - handed down, by our ancient brethren - whereas our medical confreres have looked down upon us, waiting for us to have fatalities and simply pounce on us. In Australia, we have been most successful in doing away with medical assistance, I have told you before that I have got no time for chloroform. It should be made a criminal offence for chloroform to be administered for dental operations.

Personally, I think that dentists should administer anaesthetics for one another. Of course if we had a medical man who was a specialist and patients would pay a fee, I would certainly give up administering anaesthetics, but until I can get a medical man who will look upon the matter as I do, I am going on my own.

We as dentists have had a very hard fight, but we have held up our end very well, and the time has come when we can show to medical men that we do understand anaesthetics.

McClinton, in reply said: 'I believe in having a man trained to give anaesthetics for the dentists; but what about the country districts, where you may be 100 miles away from a specialist? I believe in the dentists generally training themselves to give their own anaesthetics as far as possible'.
And so, three years after the 'lost' motion, the problems were still apparent.

In 1913, Bret Day lectured to the Dental Graduates Society of South Australia on "General Anaesthesia in Dentistry". He drew attention to the fact that certain techniques worked well with one man, while with others the same task would not be performed equally well. The anaesthetic should be chosen as each particular case warranted, he said. Further, he stressed the importance of an adequate history and thought that patients always appreciate honest, solicitous enquiries. He mentioned certain types of patients who required careful handling.

This lecture and subsequent article, constituted the soundest common sense that had been recorded in this sphere in the Australian dental journals to that time.

No clear policies had yet emerged with respect to anaesthesia, and even chloroform continued its popularity in some quarters. In fact, some surgeons insisted on the use of chloroform and regarded the anaesthetist simply as a 'nuisance'. The anaesthetist was at this time fighting for recognition. Sykes (1960) notes some comment of the time: 'It is strange that so many attempts have been made to either dispense with his services altogether, or to dispense with or discourage his adequate training. Non-anaesthetists seem particularly liable to make dogmatic statements on a subject they seem to know little about'. Sykes (1960) further
records a 'hard hitting indictment' from Hewitt in 1907: 'It is difficult to see any reason why the administration of the most powerful agent in the British Pharmacopoeia should be placed in the hands of medical men whose qualifications, and professional attainments are, as a general rule, inferior to those of other officers'.

When new 'gas' machines became available these were purchased in the hope that better anaesthesia would result. Instruction in anaesthesia for general surgery in Australia at this time was given to junior resident medical officers, by a senior resident medical officer, who had become 'expert' as a result of perhaps two years' experience, with the help of other graduates or perhaps with little help. Ether was generally given by the closed method, and chloroform sometimes used.

The clouds of war were gathering in Europe - a war which provided a call for anaesthesia to an extent never hitherto known, and which stimulated fresh thinking in every branch of medicine.
VI. 1914 - 1929

The First World War stimulated fresh thinking in every branch of medicine, with the unprecedented number of severely wounded men calling for something more than ether and chloroform, or an open mask. Nitrous oxide and oxygen gradually became more popular for general surgery at this time. (Magill 1966). Following in the wake of the War came the first concentrated invasion of medical practice by the specialties, many Australian medical officers being given the opportunity to study abroad pending their discharge (Blackburn 1951).

Over this period (1914-29), nitrous oxide with oxygen became more firmly established as the basic general anaesthetic for the dental surgeon. Brockway (1915) noted a 'return' to general anaesthesia for the extraction of teeth and queried why nitrous oxide was not more generally used. Ethyl chloride almost displaced nitrous oxide however for a period.

To this time, anaesthetic duration of 30-40 seconds had usually been the order, and the necessity for the actual surgery to be prompt. Cyanosis normally accompanied the administration - considered by some with 'amusement' (Luke & Ross 1919). It was however, recognised as a problem, and the concept of the concomitant use of oxygen with nitrous oxide gained momentum.
Development, 1914-29, is considered under these headings:

(1) Wartime history
(2) Nitrous oxide/oxygen (before 1920)
(3) Endotracheal methods
(4) Ethylene
(5) Ethyl Chloride/Somnoform
(6) Intravenous anaesthesia
(7) General review
(8) The problems of dentists administering anaesthetics
(9) The contribution of A.J. Arnott.

(1) **Wartime History**

At the beginning of the War of 1914-18, the only dental appliances in the Australian Army were a set of forceps carried by the R.M.O., and this officer was the only 'dental practitioner' officially provided for the army in the war. By the close of the war however the importance of the dental service had become recognised. The reason for military neglect of dentistry was an historical one. The Army Dental Service of the A.I.F. was in a very high degree special and peculiar. It was created 'de novo', and its organisation and methods were wholly independent of the British Army or any other precedent. The Medical Service of the A.I.F. was under British direction. 15,773 Australians were rejected for the A.I.F. on dental grounds. Prior to
May 1915, the responsibility of the dental care of Army personnel had relied upon voluntary effort.

By August 1915, the 3rd Australian General Hospital had arrived in Lemnos, 60 miles from Gallipoli, and 117 general 'dental' anaesthetics are recorded over the next four months, while 764 are reported as given by the Dental Service between January 1917 and June 1919. Ether and chloroform were commonly used, although the great advantages of nitrous oxide, particularly in cases of bad shock-haemorrhage, became recognised. Apparatus used were a 'Coxeter sight-feed apparatus', and one constructed 'in the field' by a Capt. Wellman, A.A.M.C. This apparatus could be used with 'complete success for O+E, N₂O, N₂O+O, N₂O+E, N₂O+O+E, and also for giving oxygen only ...' (Butler 1940).

Foremost exponent of the use of nitrous oxide/oxygen in Britain at this time was Boyle (1917), responsible for the first Boyle's anaesthetic machine. (Fig. 23) Not until the end of 1917 did nitrous oxide/oxygen become widely used in battle clearing stations where it proved brilliantly successful. The practicability of the method was first demonstrated by Marshall (Marshall 1917; 1919).

There were however, during World War I, few experts in the use of nitrous oxide anaesthesia; in fact a general shortage of people capable of giving chloroform, ether or ethyl chloride. Although nitrous oxide expertly
administered to the morphinized patient had many advantages, in the long run ether bore the load, for there were few situations in which the expertise demanded in nitrous oxide administration was available. Shock was a perplexing problem. Much was known of its aetiology and pathology, but treatment was still in its infancy. The necessity of restoring circulating volume was well known, but means of doing this were never very satisfactory. (Davis 1968a)

(2) Nitrous Oxide/Oxygen (before 1920)

Nitrous Oxide alone
(i) **Face-piece.**

Nitrous oxide was administered by means of a face-piece connected to a three-way stop-cock, which allowed for three positions -

A. 'Air' - patient would breathe air only.

B. 'Valves' - inspiration drew in gas; expiration closed this valve and opened the expiratory valve to allow escape.

C. 'No valves' allowed for rebreathing from the bag. (Fig. 24).

The stop-cock was attached to the upper end of the bag made of impervious rubber, and allowing a 3 gallon capacity. Rubber tubing connected the bag to the cylinders (4 feet x ¼").

![Fig. 24 - Barth's three-way stop-cock and face-piece.](image)

The procedure was to insert a prop initially, and then the face-piece applied with the stop-cock turned to 'air'. After a few breaths it was turned to 'valves' for 8-10 breaths, when the
pointer was turned to 'no valves' and to and fro breathing permitted until anaesthesia was induced.

Operating time on removal of the face-piece was 30-40 seconds, following an average induction time of 55-73 seconds. (Luke & Ross 1919)³⁷⁰.

(ii) Nasal administration

In order to prolong the anaesthesia, apparatus of the design of Paterson was recommended (Fig. 25). To the bag was attached a 2-way stop-cock from which passed two narrow flexible rubber tubes passing to a metal nose-piece fitted with a rubber air-pad to admit accurate adaptation. A stream of gas was allowed to pass through the nasal passages and expired through the mouth. It was noted that usually some pressure on the gas supply was necessary. This method allowed of 10 minutes anaesthesia. (Luke & Ross 1919)³⁷¹.

Nitrous oxide/oxygen

³⁷² Luke and Ross (1919) describe four methods:

(a) Hewitt's original method

(b) Teter's method
(The American Clark machine was similar - the mixture delivered was rich in oxygen and delivered at low pressure.

(c) The Guy-Ross method
This made provision for a measured percentage of oxygen, and the mixed gases would be given on the rebreathing system - rebreathing time averaging
two minutes. In 1916 Bellamy Gardner indicated the advantages of prolonging dental anaesthesia and abolishing the need for haste. Gardner used Paterson's nose-piece (Fig. 25) with tubes leading to a mixing chamber. 10 per cent oxygen was used after a lapse of 1 minute, (Gardner 1916). (Fig. 26).

(d) Sight-feed machines
These consisted of a glass chamber roofed in by a metal plate perforated by three pipes - two of entry and one of exit. Each gas was led through its appropriate pipe into the chamber which was filled three quarters full with water (Fig. 27). The anaesthetist trained his eye to judge, from the deepest level at which he could observe bubbles from each of the tubes of entry, at what pressure each gas was escaping.
Fig. 26 - Diagram of Bellamy Gardner's nasal gas-oxygen method.

Fig. 27 - Sight-feed Machine.
Nitrous oxide was practically abandoned at Melbourne Dental Hospital at the end of 1915, in fact there were only 145 cases in which it was used over the three years from 30th June 1912 (Hornabrook 1918).

(3) **Endotracheal Methods**

In 1915 D.H. Jackson published a revolutionary paper (Jackson 1915) on a new method for the production of general anaesthesia and analgesia, with a description of the apparatus used. His apparatus was too awkward to find a place in the operating room, but his idea was destined to revolutionise the administration of inhalation anaesthetic agents. He showed how anaesthetics are almost totally excreted by exhalations from the lungs, and by means of constant circulation of the air within the machine, the exhaled anaesthetic could be simply carried around, washed through with sulphuric acid and sodium hydrate solution, and again returned to the animal for rebreathing, thus the degree of anaesthesia could remain constant. He kept dogs anaesthetised for period of time extending to 5½ hours, and the animals were in excellent condition at the close of anaesthesia.

During World War I, I.W. Magill and E.S. Rowbotham, working as anaesthetists with the British Army Plastic Unit, for patients undergoing plastic facial surgery, developed the insufflation endotracheal method. Two tubes were often
used, passed orally, the second tube being for the return flow of the gas. For operations involving the mouth, they learned to pass the tube through the nose into the pharynx and thence by the help of a guiding rod or forceps into the trachea. Inhalation endotracheal anaesthesia eventually followed when it was realised that one wide-bore tube inserted into the trachea could allow breathing in both directions. (Rowbotham 1920).

In 1921 Rowbotham and Magill presented their experience of over 3000 anaesthetics for war injuries. They used direct vision to guide their catheters into the larynx, and Magill (1920) described his forceps for guiding the nasally introduced catheter into the trachea.

The next few years saw some increase in the use of intratracheal insufflation, but it was still reserved for special situations. In fact in 1928, Magill deplored the unnecessary use of intratracheal insufflation, and mentioned operations of a trivial nature, or short duration as being a contraindication. He emphasised the anaesthetization of the larynx and fauces by 20 per cent cocaine spray. Also, in 1928, the superiority of the single large bore tube suddenly became apparent. It became apparent too, that these large tubes properly curved would quite frequently find their way into the trachea when inserted through the nose, rendering laryngoscopy unnecessary.
J.S. Lundy brought the "news" of these British methods to America via the Mayo Clinic and intratracheal anaesthesia was utilised 85 times at this clinic in 1928. The use of an inflatable cuff on the outside of the tube was proposed by Guedel and Waters in 1928. (Davis 1968b).

Prominent in the teaching of anaesthesia in Sydney at this time was Mark Lidwell, who introduced endotracheal insufflation anaesthesia at Royal Prince Alfred Hospital, Sydney. According to Lidwell (1929) Thomas Piaschi, one-time surgeon to Sydney Hospital had been the first to use the method in Sydney. Lidwell spoke to the Congress of the Society of Dental Science in 1921, on the subject of the intratracheal method of administering ether for dental operations. (Lidwell 1921). He indicated the advantages, which he said were:

1. Continuous anaesthesia for any length of time.
2. Less danger from the anaesthetic.
3. Practically no danger of foreign bodies passing into trachea.
4. The patient may be placed in any desired position.
5. No salivation.
6. Any form of dental operation may be undertaken.
7. The anaesthetist is right away from the patient, and in no way interferes with the operator.
8. Hardly any post-anaesthetic vomiting.
(4) Ethylene

Luckhardt and Thompson in 1918 established experimentally the anaesthetic and analgesic qualities of a mixture of 80 per cent ethylene and 20 per cent oxygen. (Luckhardt & Carter 1923).

In 1922 Luckhardt, working with Carter further experimented with the properties of ethylene, and later gave a private demonstration at the University of Chicago. The demonstration was most successful and in March 1923, ethylene was administered for surgery by Isabella Herb. 106 case reports were subsequently presented by Luckhardt and Carter, and Herb also published a clinical study (Herb 1923). Monheim (1968) claims that ethylene more closely approaches the ideal anaesthetic for dental and oral surgery, than any other agent. It is the flammability and explosability hazards which are against its general use, although Monheim says that some oral surgeons advocate ethylene as the anaesthetic of choice for treatment of patients in the office.

In Australia, there was obvious interest in the work of Luckhardt and Herb in the United States. At first it was hoped that it may be the answer to the search for an anaesthetic giving relaxation combined with rapid recovery (Daly 1956).

There were two notable contributions in Australia
in the 1920's with respect to Ethylene - by R.A. Aird and by Gilbert Brown. Aird (1926) described the administration as being similar to nitrous oxide, except in the percentage of oxygen required, which varied from 8 to 35 per cent, averaging 15 per cent. He found anaesthesia to be rapid with no struggling, patients passing off into a deep sleep. 'Relaxation is marked, and often teeth may be extracted without the use of a mouth gag, the jaw being manipulated as easily as if the patient had a local anaesthetic'. Colour varied under ethylene; cyanosis was not usual, patients having often an ashen colour which cleared up as the anaesthetic was prolonged, sometimes reaching a bright red colour. The recovery was quick and quiet.

The advantages (summarised) were:

(i) Quick anaesthesia.
(ii) Good relaxation.
(iii) Absence of sweating.
(iv) Experience had shown that ethylene was ideal for patients suffering from diabetes, pulmonary tuberculosis and cardiac diseases.

Disadvantages were:

(i) Odour.
(ii) Inflammability and explosibility.
(iii) Lack of portability.

Brown's (1927) contribution was more comprehensive,
He described different techniques for children (under 14), and adults. For children, he advocated 15 per cent oxygen to commence, increasing to 24 per cent, and the use of a nasal inhaler and mouth-cone. For adults an 8 per cent induction increasing to 15 - 20 per cent oxygen was used. The use of mouth packing was emphasised for the first time in the Australian dental literature.

Brown's article is of further significance in that his method described anaesthesia for continuous administration. 'One dose' ethylene and oxygen did not appear to be very satisfactory, as the recovery was so rapid.

I have used it in twenty-three cases, with good anaesthesia, varying from twelve seconds to one minute and forty seconds. But surely the time has come to abandon "one dose" anaesthesia, and substitute continuous anaesthesia, when the work may be done easily, carefully, and with the least amount of trauma. The struggles to extract teeth against time are neither pretty, nor good surgery.

Brown also listed the advantages. To Aird's list he added -

(i) Non-toxic.

(ii) A high percentage of oxygen may be given throughout.

(iii) Anaesthesia may be maintained for an indefinite period.

(iv) Rapid recovery and vomiting rare.

Disadvantages -

(i) High cost of gas.

(ii) Must use large cylinders as cylinder valve may freeze using small cylinders.
(iii) Robust patients may require the addition of ether.

(5) **Ethyl Chloride/Somnoform**

Hornabrook (1918) summarises the situation existing to that time as to anaesthetics administered at the Melbourne Dental Hospital. Speaking of the period July 1st, 1906, to June 30th, 1918, he said:

All the administrations have been given in the upright position, the patient sitting in the dental chair. There has not been one fatality, and it is extremely rare to have any sign of collapse. Of the total number of 32,236 administrations, 30,435 were cases in which ethyl chloride or Somnoform was used alone or in conjunction with other anaesthetics. The present method is to use 2cc. of ethyl chloride in conjunction with 5cc. of Somnoform, in the majority of cases. We found that 5cc. of Somnoform by itself did not always give a sufficiently long enough anaesthesia when a large number of teeth had to be extracted. The following is the complete return from July 1st, 1906, to June 30th, 1918, in detail, and speaks for itself. It is a record of which any hospital might feel proud:

<table>
<thead>
<tr>
<th>Anaesthetic</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrous oxide</td>
<td>1,654</td>
</tr>
<tr>
<td>Nitrous oxide and ethyl chloride</td>
<td>3,778</td>
</tr>
<tr>
<td>Ethyl chloride</td>
<td>14,969</td>
</tr>
<tr>
<td>Somnoform</td>
<td>13,859</td>
</tr>
<tr>
<td>Ethyl chlor., chloroform and ether</td>
<td>51</td>
</tr>
<tr>
<td>Ethyl Chlor., and ether</td>
<td>91</td>
</tr>
<tr>
<td>Ethyl chlor., and Somnoform</td>
<td>485</td>
</tr>
<tr>
<td>Ethyl chlor., and oxygen</td>
<td>197</td>
</tr>
<tr>
<td>Nitrous oxide and oxygen</td>
<td>138</td>
</tr>
<tr>
<td>Chloroform</td>
<td>11</td>
</tr>
<tr>
<td>Nitrous oxide and Somnoform</td>
<td>5</td>
</tr>
</tbody>
</table>

(*mostly prior to 1912*)

Charlton (1917) in Sydney, spoke on the use of ethyl chloride, which at that time (as noted) was used
extensively in Melbourne, particularly by the 'open method', but little in Sydney. Both open and closed methods and nitrous oxide sequence administrations were described. Charlton did not see any superiority of the latter method to Somnoform, which he said, gave a similar period of complete anaesthesia. 'There is no unwieldy apparatus' and 'before rebreathing commences, vapour mixed with air has been gradually absorbed into the blood, with the result that consciousness is lost with a minimum of discomfort'.

Ethyl Chloride gradually became the principal anaesthetic agent in Melbourne until in 1924, the annual report of the Australian College of Dentistry, and Melbourne Dental Hospital (Pooch 1924) showed 3662 general anaesthetic cases, and the report said that 'Somnoform and ethyl chloride had been used exclusively.' It was regretted that a death had occurred under Somnoform, but considered that 2 deaths in 80,000 administrations, and an average of 13 cases daily, 6 days a week, year after year, was a proud record, and that every precaution was taken. The local anaesthetic cases totalled 2,434. By way of contrast, the Annual report of the Queensland College of Dentistry noted:

Local Anaesthetics (1924-5) - 8,863
General Anaesthetics (1924-5) - 43

(Jones 1924)
At the 5th Australian Dental Congress held in Sydney in 1924, Chauvel demonstrated his inhaler for ethyl chloride. (Fig. 28).

![Diagram of Chauvel's Inhaler]

**Fig. 28 - Chauvel's Inhaler.**

A. Tap  
B. Bag  
C. Small gauge tubing  
D. Larger bore of capsule  
E. Slender neck  
F. Air-way

Chauvel had apparently shown his ethyl chloride apparatus to Charlton, then Superintendent of the Dental Hospital, Sydney, and says Chauvel 'it, or a modification of it had been adopted there'. (Chauvel 1925).

(6) **Intravenous Anaesthesia**

**Dial**

In 1924 Ludwig Bogendorfer published a paper on the first soluble short-acting barbiturate (Soluble Dial)
(di-allyl-barbituric acid). This paper opened a decade of investigation of many barbiturates which might be used in an injectable form. This barbiturate has been used orally, but it has had little use by the intravenous route. **Pernocton (Pernoston)**

This was the first barbiturate used for general intravenous anaesthesia, introduced in 1927 by Bumm of Germany (Adams 1944). Pernocton is sodium - 2 - bromallyl - barbiturate (contains a bromine atom) and was given in 10 per cent solution - 3 cc. - at the rate of 1 cc. per minute. Its action was quicker than dial.

**Ethyl Alcohol**

Marin of Mexico used ethyl alcohol intravenously in 1929, and this was tried out by Constantin in Britain, who found it useful for patients suffering severely from shock or loss of blood. A light anaesthesia was produced, but muscular relaxation incomplete.

**Avertin**

This was a trade name for tribromethylalcohol (CBr₃ CH₂ OH). It was first used by Eichholtz in 1926. Avertin produced a quiet induction, but its disadvantages were:

(i) depression of respiratory centre.

(ii) lowered blood pressure.
(iii) prolonged period after operation with depressed reflexes and shallow breathing.

When avertin was first marketed it was claimed to be a general anaesthetic, but it was soon recognised that if given in doses sufficiently large to produce general anaesthesia, it was unsafe. Some observers noted that avertin produced toxic changes in the liver. (Hewer 1932). Kirschner in 1929 reported results for 150 cases in which the agent had been administered intravenously.

**Sodium Amytal (Sodium iso-amy1-ethyl barbiturate)**

Sodium Amytal was used more frequently in the United States from 1929 to 1933 than any other intravenous anaesthetic agent. The introduction of Sodium Amytal into the United States kindled nation-wide enthusiasm, which eventually gave way to a more sane appreciation of its value and usefulness.

Zerfas et al. (1929) of Indianapolis, demonstrated the intravenous use of Sodium Amytal, and reported excellent results from 300 cases in doses of 20-25 mg. per kilo. Its use was recommended in conjunction with other local or general anaesthetics, in particular the intravenous injection of 12-20 mg. per kilo, prior to the administration of ether and nitrous oxide and oxygen. The injection at a recommended rate of 1 cc. per minute was continued until the patient became drowsy and lost consciousness (usual dose
was 0.2 - 0.6 gm.

(7) General Review

Analgesia

The enthusiasm noted in the previous chapter by some workers for the use of analgesia was not maintained, in fact analgesia was actually condemned. Dalton (1918) claimed:

To operate on sensitive teeth of nervous patients (and these are the ones for whom analgesia is supposed to be such a boon), is a most dangerous practice.

He stressed the possibility of shock if painful operations took place in the analgesic stage, and suggested surgically anaesthetising patients for cutting retentions and otherwise shaping cavities.

The Twenties

There were no specialists who devoted their full time to anaesthetics at this time, in Australia, although there were anaesthetists on the honorary staffs of the larger hospitals who combined these appointments with their general practice. The general practitioner who sought to specialise was largely self taught.

Nitrous oxide/oxygen anaesthesia was used little in general surgery, being considered the province of the dental surgeon. Few medical men knew how to use it (Daly 1956). Daly recalls that -
The only surgical gas and oxygen machine was a Heidbrink at Sydney Hospital, and I recollect it was shown there at a clinical meeting of the British Medical Association about 1920. It was said to be used for only the worst surgical risks. I asked to be informed when it was being used, but apparently no one was interested in it...

Nitrous oxide was not found ideal for general surgical practice, and acceptance was not forthcoming. (Cowen 1921) said that the greatest disadvantage was the lightness of the anaesthesia it produced. The defects were not readily overcome by attempting to obtain greater depth, and ether, morphine, scopolamine, and local anaesthesia were used as supplementary agents.

The disadvantages of nitrous oxide were summarised (Anaesthesia 1921): Muscular rigidity, rapid recovery and thus post-operative pain, cost and 'cumbrousness' of the apparatus. Ether, although described as repulsive (Anaesthesia 1921), was considered safe and simple, and thus was the choice of the majority.

Significant papers presented during the 1920's in the Australian literature were:

(a) McElhone (1922) discussed the choice of anaesthetics for dental operations. He listed:—

Nitrous oxide (35 seconds)
Ethyl chloride (1-2 minutes)
Nitrous oxide/ethyl chloride (1-2 minutes)
Somnoform (1-2 minutes)
Ether (ad lib)
(b) Newton (1922) drew attention to the action of anaesthetics on the respiratory, circulatory, glandular and nervous system. He considered nitrous oxide to be the safest anaesthetic known — but limited in scope as 'deep and prolonged anaesthesia is impracticable'. Concluding his paper he said, 'The interests of the patient are not safeguarded to the fullest extent unless thorough preliminary examination and treatment are, where possible, carried out'.

(c) Black (1923) opposed the use of general anaesthetics for dental work. He stressed aspects of safety, success of the operation within the time allowable, and conditions of operation. He said that the 'fear of being unconscious was greater than any horror of an operation performed on a conscious patient, and then made particular point of likely damage to brain cells from transmission of stimuli from the injured part in the unconscious patient (anoci-association).

(d) Brown (1924) discussed the examination of the patient, and choice of anaesthetic which should be considered along with the type of operation, health of the patient, the extent and difficulty of the operation, and also the operator. He explained the methods of administration favouring Parret's inhaler for Somnoform, and Heidbrink's apparatus for nitrous oxide/oxygen. He also
administered 1/100 gr. atropine to reduce salivary secretion. Brown said, in answer to questions following his Paper:

Speaking as a medical man and an anaesthetist, that except for cases of short duration under nitrous oxide or Somnoform, I am of the opinion that the longer cases should be given by an experienced anaesthetist . . . If a dentist did undertake cases requiring extended duration of anaesthesia, the dentist should make more careful inquiries into the patient's condition than were usually made.

A further questioner said, he 'had found great difficulty in many instances of getting medical men to give any other anaesthetic than ether by means of the Clover apparatus; this was often undesired by, and inconvenient to the dentist'. Brown in reply said he thought most medical men were scared of nitrous oxide, and felt that the dentist could probably administer it much better than they. Also many of the older generation of medical men had been 'brought up' to chloroform and the Clover-ether apparatus. 'If the dentist considered this undesirable, he should endeavour to obtain another anaesthetist for the case'.

(e) Carroll (1925) sought an anaesthetic suitable for cavity preparation. He said that those in use were 'hardly practicable'.

Ethyl chloride and Somnoform without a sequence are of too short duration for adequate cavity preparation, besides which the prone position and
the nausea which sometimes accompanies their administration are objectionable features.
Nitrous oxide, held for some years back in the same regard as our grandparents had for patent medicines, has proved the bubble with the inevitable end. With its normal posture it would seem the ideal anaesthetic, but it is very expensive, especially for country practitioners, and like other general anaesthetics it requires the attendance of an anaesthetist. So one actually looks for some other method . . . the panacea for all our troubles - local and regional anaesthesia.

These few comments probably well summarised the feelings of the majority of the dental profession at that time, and even to the present day, on the use of general anaesthesia for cavity preparation, and indeed even in exodontic work.

Dodds (1927) drew attention to carbon dioxide and rebreathing in anaesthesia. He contended that anaesthesia was a form of asphyxia in a modified, regulated form. He also noted that nitrous oxide affected the serum, and not the haemoglobin which continues to carry oxygen in the usual way. He described and advocated the concept of rebreathing - with rebreathing the carbon dioxide tension was increased, ventilation of the lungs leading to increased oxygen tension followed, and the percentage of oxygen properly dissociated at the capillary area, and then usefully employed in the tissues. The stimulating properties of carbon dioxide in the
physiology of respiration, were noted and rebreathing at all times considered desirable, provided the oxygen supply to the lungs was maintained in sufficient quantity. The result, he said, was that the respiratory movement is strengthened and maintained.

(8) The problem of dentists administering anaesthetics

Discussion of this problem continued, and the confused situation which had had its roots in the 1909 Congress rejection of the provision of training in general anaesthesia for dentists became more apparent through these years. Local anaesthesia advanced and the use of general anaesthesia by dentists began to decline. Improvement in local anaesthetics contributed to this decline, although fear of possible fatal consequences with general anaesthetics was probably the main cause. This in turn, was associated with the accompanying uncertainty as to how the dentist stood in regard to the law in the case of a death under general anaesthesia.

Nicholson (1918a) deplored and regretted the decision taken by the 1909 Congress, and criticised the inadequate training which the students were then receiving at the Australian College of Dentistry. He felt this inadequacy particularly with respect to the use of the stethoscope. He felt that it was important that the student be 'taught to ascertain in a scientific way whether
a patient is in a fit condition to have an anaesthetic administered'.

Tuckfield (1918) however was of the opinion that the opposition at the Congress had been against the granting of a diploma, not against a course in anaesthetics. The granting of a certificate was designed to give some protection to the dentist; it did not imply that anaesthetics were improperly given by dentists. Tuckfield claimed that the use of the stethoscope by dentists had little support.

Nicholson (1918b) replied, and said that 'the motion was lost because a great many in that audience had no heart or desire to undertake a course in anaesthetics, or anything else'. Nicholson noted that ethyl chloride (requiring no special apparatus) had displaced nitrous oxide. He said:

... one can only come to the conclusion that these gentlemen consider the dental curriculum is not yet sufficiently advanced in the subjects of physiology, anatomy, and general pathology to warrant the introduction of stethoscopy at the present time ... the statistics of Great Britain show that in the administration of ethyl chloride the fatalities are 1 in 13,000 compared with nitrous oxide gas 1 in 100,000.

He then quoted numerous authorities which suggested that ethyl chloride administration could be hazardous, and asked 'are we forever to remain in ignorance of the danger signals revealed to the ear of the medical man?'
Nicholson suggested a five year dental course with greater emphasis on physiology, anatomy and pathology.

In 1920 medical opposition to the administration of anaesthetics by dentists was voiced. This notably related to ethyl chloride (Stertor 1920; Corlette 1920):

I have seen cases of ethyl chloride which were on the verge of proving fatal, but for the presence of a skilled anaesthetist . . . Are we as a profession to recognise them (i.e., dentists) as equals in the field of general anaesthesia? If so, what is the use of our special training, which they do not receive?

(Stertor 1920)

Ziele (1920a) put the dental viewpoint that 'anaesthesia was necessary and desirable' for many patients and an essential part of the proper training of a dentist. Ziele indicated that distinction should be drawn when speaking of ethyl chloride between the open 'unmeasured' method which he deprecated, and the enclosed measured method, both alone and in sequence with nitrous oxide. He concluded:

(i) That all dentists should be trained in the use of anaesthetics suitable to their practice.

(ii) Ethyl chloride by the measured method is safe.

(iii) Impressions that ethyl chloride was dangerous indicated a lack of acquaintance with the safe method.

Medical editorial comment (The administration of anaesthetics, 1920) asked:
whether a dentist without medical qualifications should be allowed to administer a drug for the purpose of inducing a state of unconsciousness during an operation. If dentists or other persons who have not passed through a complete course of training in medicine, and who have not become qualified and registered as medical practitioners, are allowed to administer one, they must be allowed to administer another anaesthetic. It is therefore redundant to discuss the relative safety of ethyl chloride in this place, although it is necessary to recognise the general principle that the safety of the condition of general narcosis by chloroform, ethyl chloride, ether and the like is dependent on the skill, knowledge and experience of the person administering the drug. The law does not interfere with any person who chooses to administer any drug in the treatment of disease, provided that the patient places himself voluntarily under the care of this other person and provided that the person undertaking the treatment not being a medical practitioner, does not lead the patient to believe that he is duly qualified or registered. In many cases it is essential or expedient for the patient to be rendered unconscious or anaesthetic during the performance of a dental operation. The dentist has the option of employing local anaesthesia or general anaesthesia. The public, however, is satisfied to trust the dentist to carry out the injection of the local anaesthetic. This confidence is based on the fact that many dentists have acquired considerable experience in the manipulation and carry it out with skill and care. Accidents are rare. We doubt whether it would be wise or necessary to warn the public against this common practice. The patients would probably not be safer in the hands of a medical practitioner, especially when the latter has not the same manipulating dexterity in dental operations as an experienced dentist.

The question of a general anaesthetic, however, is a different one. It has been laid down by the General Medical Council that a medical practitioner who allows a dentist to administer a general anaesthetic for the purpose of a surgical operation, is guilty of covering. Save under conditions of emergency a medical practitioner may not delegate the administration of drugs to induce general narcosis to anyone who is not registered as a medical practitioner. The reason for this unwritten rule is that a patient must not be subjected to a dangerous condition unless the person
bearing the responsibility is competent and skilled. Before the drug is administered, the patient should be carefully examined. It is not only essential that the anaesthetist should be aware of the condition of the heart and respiratory organs; the condition of the excretory organs should be investigated and an endeavour should be made to ascertain the state of the nervous control of the ductless glands and of the lymphatic system. The medical anaesthetist takes every precaution to safeguard the life of his patient. Should an accident occur in spite of these precautions and in spite of the skill manifested in the administration of the drug, he cannot be held personally responsible. It is the opinion of all who have administered ether and chloroform on thousands of occasions that these measures, together with a long experience in the art of giving the anaesthetic, contribute to the safety of the patient. The public should therefore be warned against the practice of allowing dentists to administer a general anaesthetic. As long as the law does not forbid unqualified practice, we are powerless to prevent dentists from taking this considerable risk. The matter is one between the public and the dentist.

Hornabrook who, as has been noted, was intimately concerned with dental anaesthesia at the time replied

(Hornabrook 1920a):

I would far rather have the well-trained dental student administer a dental anaesthetic to me than I would the average medical man. Taking us all round, the medical man is not, as a general rule, good at dental anaesthesia, especially in the handling of such drugs as ethyl chloride or Somnoform ... the dentist goes through a very careful and scientific course, not far behind our medical training in stiffness.

In the case of our dental students in Melbourne, their anaesthetic course is a very practical one; ... In his third year, besides having to attend lectures in anaesthesia, each student has to give 40 general anaesthetics, and in his fourth year 60, making 100 in all. These anaesthetics are either ethyl chloride or Somnoform, and the record of the Melbourne Dental Hospital is over 36,000 Somnoform or ethyl chloride administrations in the last 14 years without one
single death. In every case the anaesthetic is administered in the upright position.

... We have to advance with the times and the dental profession and training are not what they were some years ago. The dentist's calling is a highly scientific one today, and he has to go through a very stiff course (at any rate in Victoria), before he obtains his degree, and that course includes a by no means inferior one in dental anaesthetics.

Hornabrook wrote a second letter but this was not published in the Medical Journal (Hornabrook 1920b):

... the proper commonsense scientific course to take is to train your dental student in the proper administration of general anaesthetics of the character of ethyl chloride and Somnoform for dental work ... the medical profession will have to get over the idea that they are the only persons capable of administering general dental anaesthetics ... train your dental student and train him properly in the use of dental anaesthetics, and the man who does so will be doing a duty to the public and the profession ... we are only training our dentists for these drugs and for dental anaesthesias, and I have not the least doubt in my own mind that our course is the correct one, both for the patient and dentist.

Aird (1921) who was Superintendent of the Melbourne Dental Hospital at the time, stressed that the 'giving of an anaesthetic was not mere mechanical skill' - it was rather the 'becoming familiar with the laws governing administration; and 'developing the ability to properly correlate and apply these laws'.

Aird re-echoed Hornabrook's sentiments, and then said:

This introduction to the subject actually makes one think that a general anaesthetic is used for extraction of teeth entirely, but such is not the case. By
modifications in the technique of using the anaesthetic, degrees of anaesthesia may be obtained from the light analgesia to the deepest anaesthesia, and hence cutting of sensitive dentine, cementing, opening of abscesses, etc., etc., may be performed quite painlessly and without interference to the local physio-pathological conditions, a matter of no mean importance and frequently quite overlooked by those who have given over their practice to the unlimited use of the hypodermic syringe.

The Australian Journal of Dentistry of October, 1922 gave its editorial comment to "The administration of anaesthetics by dentists". This was prompted by the death of a woman under the influence of an anaesthetic, (Somnoform), at the Melbourne Dental Hospital. The Report of the Inquest has concluded 'there does not appear to have been any negligence. The operation was necessary, and the anaesthetic was properly administered'.

The editorial noted that certain conclusions could be drawn from the result of the Inquest:

1st. - The right of dentists to administer anaesthetics such as nitrous oxide, ethyl chloride, and Somnoform is established.

2nd. - That for these anaesthetics it is not necessary that a physical examination be made, provided that reasonable care is taken to ascertain the general condition of patient's health by judicious questioning.

3rd. - That a dental student receiving a training at the Dental Hospital, is quite justified in administering these anaesthetics under official supervision.

The one great thing that the Coroner needs to be satisfied with is that proper precautions were taken, and that no
carelessness was established. And we feel that as a result of this case dentists should have much more confidence in the future in regard to the administering of anaesthetics. Enthusiasm for the use of general dental anaesthesia was shown by Ziele (1920b). He called for more attention to be 'paid in Sydney, to this absolutely essential part of a dentist's training'. He felt that many dentists had more experience 'in the administration of those anaesthetics suitable to dental practice than the majority of medical practitioners'. In this respect he mentioned nitrous oxide, ethyl chloride and Somnoform, whilst stressing that with ether and chloroform, a specialist in anaesthetics should be called in. Further pertinent comment at the time came from Ash (1925) who supported the training in, and administering of, general anaesthetics by dentists. Arnott (1928), discussing the use of anaesthesia in routine practice said:

The risk of fatality has led many to avoid a general anaesthetic wherever possible, and the decision is undoubtedly correct when such a lethal drug as chloroform is contemplated as the administrative agent. Nowadays, the skilful administration of nitrous oxide plus oxygen has demonstrated that general anaesthesia should not be overlooked by the dental surgeon. It can be definitely asserted that nitrous oxide plus oxygen is a good and safe anaesthetic to administer.

(9) The contribution of A.J. Arnott

In August, 1929, the first edition of The Dental Journal of Australia was published, together with the
Doctoral thesis of A.J. Arnott: "General Anaesthesia in Dental Surgery" (Arnott 1929),

He described four methods of anaesthesia which he had employed:

(1) Nitrous oxide + oxygen.
(2) Nitrous oxide + oxygen + ether.
(3) Ethyl chloride (closed) induction followed by nitrous oxide/oxygen.
(4) Ethyl chloride (semi-closed) for young children.

Of these methods Arnott said they have 'proved successful with other 6,000 patients, whom I have anaesthetised for various dental operations'.

Arnott's work was notable in its comprehensive treatment of the subject, and no comparable work has been published in the Australian dental literature since that time. The basic principles which were laid down in this thesis have, in the main, also stood the test of time. There were omissions, - no reference to analgesia, conservative dentistry, or premedication for example. He dealt with anaesthesia firstly from the physiological aspects, discussing absorption and carriage of the drug, the action of anaesthetics on the circulation and respiration - with special reference to shock and asphyxia. He described the onset and symptoms of laryngeal spasm, and the treatment of this and mechanical obstruction. No previous author had given such profound attention to these important complications.
His next section dealt with 'the preparation of the patient and preliminary examination, and the apparatus needed, which lead on to discussion of accidents, under the headings of respiratory failure, circulatory failure and vomiting. These were discussed under causes and treatment. The advantages of nitrous oxide/oxygen anaesthesia were listed, and the safety was stressed, the quick recovery noted, and the 'indefinite length' of anaesthesia time, as opposed to nitrous oxide pure.

Arnott used and described three types of apparatus:

(a) The Clark Machine

Cylinders connected to rubber bag which connected to a mixing chamber, and from this a tube lead to the face-piece. This machine allowed for an indication of the oxygen percentage.

(b) The Heidbrink Machine (Fig. 29)

This had the following advantages - ease of control, visible gauges, ease of obtaining rebreathing, oxygen under force, and positive pressure of gas, and the case of addition of ether vapour.

Describing the induction, Arnott administered 93 per cent nitrous oxide, 7 per cent oxygen until at the end of one minute the patient was receiving 99 per cent nitrous oxide, 1 per cent oxygen - on
Fig. 29 - Heidbrink Hospital Unit.

C. Cylinder  M. Mixing chamber
E. Ether tap  P. Pressure gauge
EC. Ether container  R. Reduced pressure gauges
H. Hand wheels  T. Thumb screws

Signs of cyanosis the oxygen percentage was then increased until a 'dull pink colour' was obtained. 'I have even given as much as 20 per cent oxygen . . . and the patient has been evenly anaesthetised'. He described nitrous oxide/oxygen as the 'ideal, safe and efficient anaesthetic'.

(c) The McKesson Machine

This was not described as it was similar to the Heidbrink,
Ethyl chloride was then discussed and distinction drawn between the closed method for adults, and the 'semi-closed' method for children. It was found that ethyl chloride was invaluable as an induction agent for nitrous oxide/oxygen nasal sequence.

The apparatus consisted of:

![Diagram of apparatus](image)

Fig. 30 - Ethyl Chloride Apparatus.

- B. Barth 3-way tap
- E. Expiratory valve
- F. Face-piece
- GT. Gas cock
- MT. Metal tubing
- RB. Rubber bag
- RF. Rubber inflated cover
- RT. Rubber tubing
- Z. 5 or 3 cc. ampoule

The stages of ethyl chloride anaesthesia were described, and it was noted that 'attention to the respiration is one of the most important considerations;
any embarrassment to the respiration will produce alarming and serious symptoms' - he advised 'watching and listening with vigilance to the respiration' - the means of controlling respiration was obtained by the introduction of carbon dioxide direct from a cylinder to the rebreathing bag, simultaneously with the ethyl chloride vapour.

For children the method used involved dropping a few drops of ethyl chloride on to a face mask and then stimulating respiration with 5 per cent carbon dioxide, 95 per cent oxygen mixture for a second or two, followed by more anaesthetic. As soon as deep anaesthesia was reached the mask was removed, and the nasal sequence of nitrous oxide/oxygen resumed (with particular care to avoid a low percentage of oxygen).

Of Somnoform Arnott said, 'I have found no distinct advantages over the use of ethyl chloride pure'. He had used it on 1500 patients. It is notable that the Somnoform formula was given as:

60 per cent Ethyl chloride  
35 per cent Methyl chloride  
5 per cent Ethyl bromide

as this was not the 'new' formula.

At about the same time, Buttle (1929) reported considerable success with Somnoform in out-patient work, particularly children. Buttle was working in Manchester, (England), having been encouraged by the 'excellence of
this agent as used in Australia' (presumably Melbourne). He stressed that for successful administration, the use of the new formula (83 per cent ethyl chloride, 16 per cent methyl chloride, 1 per cent ethyl bromide) was necessary.

Thus the agent, which in Melbourne had been regularly used for many thousands of cases, was received with little enthusiasm in Sydney.

In the final section of his thesis Arnott discussed other methods and of intra-tracheal anaesthesia he said:

The intra-tracheal method of administration of nitrous oxide oxygen and ether is very commendable in major dental operations. The object of my thesis, however, is to demonstrate safe general anaesthesia methods, which can be practised by trained dental anaesthetists for usual dental operations, e.g. extractions. Intra-tracheal anaesthesia is usually practised by 'skilful medical anaesthetists'.

In retrospect, Arnott (1970) states 'prior to 1929 general anaesthesia for minor dental operations (e.g. extractions) was a usual procedure. The methods then used were considered safe, but did not completely eliminate the possible complication of the inhalation of foreign material',
VII. 1930 - WORLD WAR II PERIOD

The thirties were an important decade in the matter of the revival of nitrous oxide, and of the introduction of practical methods of intravenous anaesthesia. It was also the decade of the foundation of Anaesthesia as a medical speciality as it is known today, while controversy continued with respect to the dentist's right to administer general anaesthesia.

Discussion is under the following headings:

(1) Nitrous oxide/oxygen
(2) Cyclopropane
(3) Divinyl Ether (Vinesthene)
(4) Ethyl Chloride
(5) Intravenous anaesthesia/sedation
   (a) Evipan (Evipal)
   (b) Sodium Thiopental (Pentothal)
   (c) Pentobarbital Sodium (Nembutal)
(6) Trichlorethylene (Trilene)
(7) Ether
(8) Endotracheal anaesthesia
(9) The contributions of:
   (a) S.V. Marshall
   (b) Noel Heath
   (c) Geoffrey Kaye
(10) Anaesthesia - a speciality.
(11) Anaesthetic administration by dentists.
(1) Nitrous oxide/oxygen

In 1930, Seldin contributed a treatise on 'Nitrous oxide/oxygen in Dental Surgery' making these comments:

As dentistry has been presented in the last 20 years, that is with the instructor doing all the anaesthesia and the student merely watching, it has become impressed upon the student's mind that block and gas/oxygen anaesthesia is a specialist's work. The foundation of good and humane dentistry was not in the student's curriculum. Even though the students are anxious to avail themselves of every opportunity to become acquainted with the administration of anaesthetics, none was ever offered them.

In discussing the choice of anaesthetics, Seldin referred to the high safety record of nitrous oxide, and discussed its physiology. He then described technique, and drew attention to the importance of throat packing and the forward position of the chin. Another American contributor was Ruth (1930), whose technique and experience echoed that of Seldin.

Somnoform had been discredited in 1928 by a report of the National Pharmacological Commission of the U.S.A. Mead (1935) reports the Council of Dental Therapeutics' attitude to Somnoform:

The Council declared Somnoform inadmissible to A.D.R. because the absence of acceptable evidence of exceptional safety and value makes the claim unwarranted, (Rule 6); because the name is not descriptive of its composition (Rule 8), and because it represents an irrational mixture of well-known products (Rule 10).
Thus, Somnoform ended its thirty year long popularity. Amies (1930), was one of the first in Australia to indicate the preference of nitrous oxide to Somnoform and ethyl chloride. These, he said, had disadvantages, particularly where a long anaesthesia is required. He had been using nitrous oxide/oxygen 'for practically every case for 18 months, occasionally supplementing with ether'. His method was identical with that of Seldin. Disadvantages he gave were:

(i) Cost - (17/6d for 100 gallons).

(ii) Cost of machine.

(iii) Skill necessary to use machine.

The advantages were:

(i) Safety of anaesthetic.

(ii) Indefinite length of anaesthetic.

(iii) Quick recovery without nausea.

(iv) Patient remains in sitting position throughout.

(v) If necessary, can be given within an hour or two of food.

(vi) Not contra-indicated to the same extent as ethyl chloride, ether or Somnoform.

(vii) Pleasant from the patients' point of view.

(viii) Non-explosive.

Beckwith (1931) strongly advocated the policy of never using a local anaesthetic for the removal of a diseased tooth or any form of impacted tooth. He had
used nitrous oxide/oxygen anaesthetic in 42,000 cases in his exodontic practice including expectant mothers, and in particular with children. He hoped that the rule would soon be 'the longer the operation, and the more exacting the surgical technique, the more the need for nitrous oxide/oxygen'. He considered that the safety of nitrous oxide/oxygen was proportionate to the knowledge and confidence of the anaesthetist in recognising the symptoms of anaesthesia. Beckwith described his methods: an upright position commencing with a face-piece and a little oxygen. As soon as the eye reflex was lost he changed to the nose piece, and packed the throat by drawing the tongue forward and placing a large gauze pack in the posterior part of the mouth.

Fig. 31
(A) Face inhaler;
(B) pressure drums;
(C) control valve for anaesthetic mixture;
(D) delivery tube;
(E) ether vaporizer;
(F) pressure regulating screw.
In September of 1931, Amies drew attention to the new 'Austox' anaesthetic machine for nitrous oxide/oxygen. Amies said:

It incorporates many modern improvements such as automatic feed whereby gas only flows from the cylinder as the patient inhales. This, of course, effects a considerable saving in nitrous oxide. The anaesthetic can be given at any given pressure by adjusting the pressure control which is graduated in mm. of mercury. A purely Australian product, the machine calls forth no little praise, and its moderate cost - 35 Pounds, should help popularise nitrous oxide/oxygen anaesthesia in dental surgery.

The 'Austox' was an intermittent flow machine similar to the American McKesson Dental Naragraf apparatus, and was used for many years for dental anaesthetics in Australia. There were four machines available in Australia at this time. (R.A.C.S. Anaesthesia Museum, Melbourne - Personal visit).

(a) **AUSTOX** The percentage of gases was not measured. The anaesthetist regulates the supply of gas or oxygen directly from the cylinders in accordance with the clinical condition of the patient.

(b) **NEW AUSTOX** The percentage of gases was indicated by the displacements of columns of water in calibrated tubes. Each gas had an individual column, and was controlled by a separate needle valve.

(c) **DENTAL AND MATERNITY AUSTOX** Incorporating many features of the McKesson. Flow of gas discontinued functioning only during inspiration.
(d) **SAFETY GAS MACHINE** Gas percentage is measured by water flow meters and the flow of each gas controlled by an individual screw valve.

Referring to the use of nitrous oxide/oxygen for conservative work, Amies (1931) listed two disadvantages:

(i) The anaesthetist generally wants the patient semi-supine

(ii) The patient should be in a private hospital for twenty-four hours after, for observation, and the work cannot therefore be done in the dental surgery.

Aird (1933), spoke to the Anaesthetic Section of the British Medical Association, and on the subject of choice of anaesthetic said 'the use of nitrous oxide and oxygen has become so general that this agent is not difficult to obtain. This anaesthetic is, in my opinion, preferable to ethyl chloride or Somnoform for the average practitioner'. He said that there was a 'swing back to nitrous oxide and oxygen again, because it is safer, and the recovery is so much better, and the patients get away quicker. This facilitates handling a greater number of patients per morning'. For longer cases he thought chloroform a pleasant, safe and speedy anaesthetic in capable hands. He advocated the use of the upright position for operating provided the chair could be 'quickly dropped to permit the prone position',.
Aird also spoke strongly in favour of the use of endotracheal methods:

If the time required for the operation exceeds a few minutes then the endotracheal method is saved of time, for once the patient is intubated the operator can go on almost indefinitely. I am satisfied that there is less risk in this type of anaesthesia of after trouble, from swallowed blood and certainly fillings, blood, etc., entering the lungs. The operator can work with less hurry, and so there will be less trauma to the tissues. This is the ideal anaesthetic for the prone position, and it is equally so for the upright or almost upright position in the dental chair.

Rothwell (1933), spoke to the N.S.W. Branch of the Australian Dental Association on "Nitrous Oxide Anaesthesia" and was the first contributor to record indications for general anaesthesia, as opposed to local. He noted that general anaesthesia was suitable for highly neurotic and nervous patients, and there was less chance of dry socket, post-operative pain and haemorrhage, tissue necrosis and syncope.

Rothwell's paper presented clearly the most important aspects of nitrous oxide anaesthesia including details of the 'signs'. He concluded that the three most vital factors were:

(i) Knowledge of the various symptoms presented in the different stages of anaesthesia.

(ii) Knowledge of the physical condition of the patient and of resultant conditions to expect.
(iii) Absolute knowledge of all the details of operation, of the anaesthetic apparatus, and accessories used.

Archer (1935), contributed further, with his discussion of "Nitrous Oxide/Oxygen Anaesthesia". Archer called for 'conscientious and intelligent administration' - the anaesthetist should have a 'thorough understanding of his subject, well informed on allied topics, possessed with the power of thoughtful rational application of knowledge'. Three subjects, he said, had militated against conscientious intelligent anaesthetisation:

(i) Lack of knowledge concerning general anaesthesia.

(ii) Failure to examine the patient adequately.

(iii) Ignorance of necessary treatment in major emergencies.

Archer stressed the necessity of physical examination of the patient, which included temperature, blood pressure, breath holding test and medical history, together with an examination of the oropharynx. The physical examination should, he said, include a study and decision as to the need for premedication.

Profound psychic disturbances result from fear, excitement and apprehension, and not a few cases are on record in which the resultant mental shock has resulted fatally. Many operators are deceived by an outwardly calm patient, who actually is quaking within. These seemingly impassive patients are missed, if routine preanaesthetic examinations are not made.

On emergencies he said: 'In any office where
general anaesthesia is administered, the dentist should have complete knowledge of all emergencies which might arise and have the drugs and instruments to meet them'. He felt it most important that the indications of a progressively increasing anoxemia, and those of respiratory failure be known and recognised.

The emphasis during this period was thus on the abandonment of the unscientific and anoxic "quick" nitrous oxide or Somnoform, to the more considered approach, where the length of anaesthesia could be controlled and prolonged if necessary, utilising a constant percentage of oxygen.

Most of the contributions to the Australian dental literature were from overseas. Roberts (1937) and Mackay (1938) were such contributors - Roberts considered nasal gas/oxygen the method of choice and he had carried out 25,000 cases, some of which had lasted over an hour. - 'There is no possibility of the anaesthetic finishing before the operation. Inversely, should the operation prove a short one, there has been no prolonged and protracted induction for the patient to recover from'. Mackay said that prolonged anaesthesia with nitrous oxide may be dangerous, and stated that recent studies had shown that death or neurologic injury may result from nitrous oxide anaesthesia.
The damage results from the fact that nitrous oxide and carbon dioxide require a state of deep asphyxia before they produce anaesthesia. Asphyxia and anoxaemia produce serious brain damage when prolonged, and especially in persons whose cerebral circulation is already impaired, as by congenital or acquired heart disease or any chronic lung disease.

F.W. Clement - From Toledo, Ohio, Clement was a pupil and colleague of McKesson, and published in 1939 the first edition of his book *Nitrous Oxide - Oxygen Anesthesia*. Clement devoted a section of this book to dental anaesthesia and analgesia, and felt that the chief reasons why nitrous oxide/oxygen was not used routinely in all dental offices was the time, effort, and experience necessary to achieve proficiency in its administration. Patient evaluation and classification, premedication and patient preparation were discussed. The Clement-McKesson methods involved induction with 100 per cent nitrous oxide at pressure of 5-7 mm. on the pressure control dial, until the first evidence of 'oxygen want' was shown in change of rate and character of respiration. At this stage 4 to 5 per cent oxygen was added.

Rebreathing was recommended in longer cases, and the McKesson machine allowed for adjustment of this factor - to within 100 to 200 cc. of the tidal air. The 'resistant group' of patients Clement said, could be successfully anaesthetised by attention to 'pressure, minimum of oxygen, and a disregard of cyanosis'.
The Clement-McKesson principles while no longer tenable, nevertheless had considerable impact and influence in dental anaesthesia for many years. Amies (1970) considers that McKesson's views were 'ahead of his own time'. Clement discussed analgesia as a state where pain was dulled or obtunded. Fear and apprehension were said to be obstacles to successful administration. A 30 per cent oxygen mixture was used by nasal inhaler,

Puterbaugh (1939), revived interest in the analgesic state:

The effect of analgesia upon the patient is to produce a condition of stupor without loss of consciousness in which the perception of pain is distinctly lowered, and the memory of painful
sensation is practically lost when the anaesthetic is withdrawn.

Puterbaugh noted the similarity between the sensations of inhalation analgesia and barbiturate sedation, but felt the latter offered more advantages, inhalation anaesthesia being more expensive and causing at all times nausea, prostration and post-operative depression, and being accompanied by frightening apparatus. Both, however, he regarded as 'valuable adjuncts to our armamentarium'.

Demonstrations of the use of nitrous oxide/oxygen with the Austox machine were presented at the 10th Congress of the Australian Dental Association in Melbourne, August, 1939. Aird and Walsh presented 34 cases. Features were the quiet rapid induction, the prolonged period of anaesthesia due to the continuous administration via the nose, and the careful use of mouth packs. Recovery was quick and without nausea. The technique involved induction with nitrous oxide and introduction of 8 per cent oxygen when slight cyanosis of the lips was seen.

(2) Cyclopropane

Lucas and Henderson in 1928 found cyclopropane to be a potent anaesthetic gas (animal experiments), and this agent was first administered for surgical anaesthesia in 1930 (Waters and Schmidt 1934). In 1933, anaesthetists witnessed the results of this work, which was carried out
under the direction of Ralph M. Waters at the University of Wisconsin, (Stiles et al 1934).

With the introduction of cyclopropane and the almost obligatory use of a closed system and the relatively quiet and shallow breathing produced by cyclopropane, various anaesthetists learned that it was easy to take over breathing by intermittent compression of the bag, and thereby 'control' respiration. (Davis 1968 a).

In Australia, Marshall (1937), advocated cyclopropane/oxygen anaesthesia by the use of the carbon dioxide absorption technique, and described it as the 'ideal form of general anaesthesia for the prolonged and difficult operations of dental and oral surgery; pleasant, safe and free from after effects . . . '.

(3) Divinyl Ether (Vinethene, Vinesthene)

This agent grew out of the study of the relationship between chemical constitution and biological action, which studies accelerated during the 1930's. Leake devised the idea from studies on ether and ethylene that it 'might be of interest to determine whether or not the characteristic unsaturated carbon atom of ethylene would improve the anaesthetic properties of ether if it were part of the ether molecule'. After meeting some difficulty in the synthesis of the divinyl oxide, Leake teamed with Chen and Knoefel working in California, and they predicted that
'divinyl ether would be the most satisfactory of the unsaturated ethers for inhalation anaesthesia', (Leake & Chen 1930).

Rugh and Major at Princeton, in 1930 discovered an improved method of preparing and stabilizing divinyl ether, and patented it under the name "Vinethene". Gelfan and Bell (1933), demonstrated its safety as an anaesthetic, and it was first used clinically in 1933. West Australian, Troup (1935), had observed the use of Vinethene during a visit to the United States and reported in these terms:

Vinethene does not irritate the upper air passages, but increased salivation suggests the use of atropine as a preliminary injection. The muscular relaxation that it produces equals that of ether. Recovery is rapid, and is comparable with that from nitrous oxide. Relaxation is good. Liver inefficiency is the only contraindication. Beach, at the Pennsylvania University Hospital in Philadelphia, has supervised its administration to some 5,000 patients. During a very short visit to this centre, I saw it used only for induction, by the ordinary drop method, as a preliminary to ether. The induction was quick and the patients appeared to have no discomfort, Indications for its use may be as follows:
(i) As a substitute for ethyl chloride, both induction before ether and for short periods of anaesthesia,
(ii) As a substitute for ether in operations not lasting for longer than half an hour.
(iii) As an adjuvant to gas administration, instead of ether.

Middleton (1937) was the first in Australia to describe the use of Vinesthene for dental purposes. He felt that this drug had a 'definite value in producing a greater
relaxation' and allowed a larger percentage of oxygen to be given with nitrous oxide/oxygen administration. Disadvantages he listed were:

(i) Increased secretion of saliva
(ii) Unstable when exposed to air

Brown (1939) described Vinethene as useful for short operations, and said that in 'some of the dental clinics in England, it has supplanted nitrous oxide for children'.

Vinethene thus offered a better alternative to ethyl chloride in dental anaesthesia, and in fact came to be used in this capacity.

(4) Ethyl Chloride

This agent continued to find favour in some quarters - particularly in Pedodontic work. Newgarden (1931) advocated the use of ethyl chloride for this type of work, and stated that it deserved a definite place in dentistry. He felt that unfamiliarity with its use was the main reason for more not having tried it. He summarised:

Anaesthetisation of children is often a problem for the dentist. He may or may not have a nitrous oxide machine; an injection is often out of the question. In these cases ethyl chloride will prove a boon to the operator. Cyanosis, stertor, pallor or irregular respiration show that the patient has been carried too deep.

Ethyl chloride as an anaesthetic agent for the
extraction of deciduous teeth was popularised by the Forsyth Dental Infirmary at Boston (U.S.A.), where by the mid-1930's it had been used successfully for several hundred thousand patients (Jacobs 1933). The use of this drug allowed for removal of deciduous teeth in different parts of the mouth and provided a inexpensive, simple and painless method of handling children. 'In neglecting the use of this drug the dental profession is overlooking a valuable aid.' said Rowe Smith (1938).

Jacobs (1938) reinforced these contentions. He stressed that the operator should aim to give the 'least amount of ethyl chloride and the greatest amount of air' and sought to produce the analgesic state. This was achieved utilizing gauze placed over the child's mouth and nose, the spray being directed on to the open mouth whilst the nostrils were pinched. Operation commenced 'as soon as the eyeballs became fixed or rolled up or down'.

Fig. 33. Technique of administration of ethyl chloride.
(5) **Intravenous Anaesthesia/Sedation**

(a) *Evipan (Evipal)*

The introduction of evipan represented a considerable advance in the practical use of intravenous anaesthesia. Weese and Scharpff reported in 1932 on its pharmacological and clinical effects, and in 1933 Weese reported on an improved compound Evipan-natrium (*Evipal-sodium*). Evipan (*Evipal in U.S.A.*), 'because of its rapid destruction in the body was found to produce very safe anaesthesia for minor operations of short duration'.

Jarman and Abel (1933) reported on the clinical use of Evipan:

> We have used 2 - 3.5 cc. of evipan giving 3 to 5 minutes complete anaesthesia and allowing ample time for dental extraction or extractions, opening of abscesses . . .

They reported 100 cases, eight of which were dental, and concluded, 'The drug should never be used single handed, since it is essential that the patient's airway be continuously maintained'.

Bunyan (1934) in Australia, described the preparation of this drug and its injection. White and Collins (1935) employed Evipal in 100 cases and kept accurate records of its action. Their data indicated that the drug had a 'great field of usefulness', and they did 'many minor and several major operations under the effect of Evipal:'
They found that patients who had taken this anaesthetic asked for it a second time — 'They stated that the sensation of going to sleep is a pleasant one, and waking is without delirium or excitement.'

An extract from the Council on Dental Therapeutics of the American Dental Association, September 1931, is of interest:

Within the last five years several derivatives of barbituric acid, which possess more toxic properties, and consequently require smaller amounts to bring about hypnosis, have been introduced to the medical profession for anaesthesia by intravenous injection. Many reports have appeared in praise of such agents for anaesthesia, partial or complete, by this method. These may be dismissed with the remark that very little controlled evidence was submitted in these publications to show the dosage which may be employed with safety and the margin of safety between effective and toxic doses, the clinical signs by which the untoward effect of such anaesthesia may be recognised and more important the adequate antidotal measures to be instituted in the case of accident; nor is there any evidence that intravenous administration presents advantages over oral. The history of the introduction of other newer derivatives is likely to be repeated in the present instance. Invariably the trend of such knowledge has been that, with the introduction of each of these new derivatives of the barbitals, a group of supporters has made special claims for the anaesthetic value of the derivative, later to be followed by less enthusiastic reports based on intensive observation by the more cautious.

Following a short dissertation of the possible toxic effects of barbiturates the report went on:

When a drug of this type is injected intravenously,
it is beyond reach as far as the anaesthetist is concerned. He may hope that the patient has not received too much, but as far as effective treatment is concerned in case he has given too much, there is little he can do. Since the barbitals are well tolerated by, and readily absorbed from the intestinal tract, and other satisfactory methods of anaesthetic (ethyl chloride, nitrous oxide-oxygen, ethylene-oxygen, procaine, etc.,) are readily available, the dentist should guard himself against over-enthusiastic reports and uncritical advocacy of this method of drug administration. In view of the inherent dangers of intravenous injection, the Council cannot condone this type of medication for dental practice except in very special or emergency cases when other methods are contra-indicated or have failed. (Council on Dental Ther. 1931).

In Australia, Williams (1934) reported on two cases where extractions had been undertaken using evipan and the duration of anaesthesia was 28-30 minutes. He used a 10 per cent solution, and listed the advantages as - absence of stertor and coughing, the general quietness of the patient, and reduced haemorrhage. Holburn (1934) described evipan anaesthesia as a 'pleasure'. He said:

First, there is no elaborate apparatus or mask to frighten an already nervous patient. A slight prick in the arm as the needle is inserted in the vein, and the patient, counting slowly, may reach fifteen or so, before he falls quietly asleep, and he remains peaceful and relaxed during the entire operation. The duration of anaesthesia, which can be controlled and may be as much as twenty minutes, gives ample time for the most careful operator to clear an entire mouth. The patient, on coming round, feels well, and there is an entire absence of the nausea and bad taste some-times very persistent with inhaled anaesthetics.

Drummond-Jackson, who has been a notable exponent
of intravenous techniques in Dentistry in Britain since
the early 1930s contributed his experiences with evipan.
(Drummond-Jackson 1935). After discussing apparatus and
patient preparation, on dosage he said: 'the dosage is
best determined by recognition of physical signs of stages
of anaesthesia and reaction in individual cases'. The signs
and symptoms of evipan anaesthesia were described together
with contra-indications and minor complications (tremors,
delayed recovery, and vomiting). In his summary Drummond-
Jackson made these points:

If only one tooth remains to be extracted and
anaesthesia is passing off, secondary adminis-
tration may be dispensed with, and the following
procedure adopted in suitable patients: When
the patient becomes coherent he is asked to
open his mouth and sit still, and the extract-
ion is quickly performed. No memory of this is
retained afterward nor does there seem to be
severe pain experienced at the time of extract-
ion. Bleeding is less with Evipal than with
other anaesthetics, and the clotting process
more rapid.

In my own practice I use Evipal only for about
50 per cent of my short general anaesthetic
extraction work, but am using it more and more
for multiple fillings and other prolonged
conservative work, where the long semi-anaesthesia
it can produce at one's hands after getting
thoroughly conversant with its action makes the
visit almost a joy to the patient, as well as a
boon to the operator.

It is worth recording at this point that Drummond-
Jackson (1962) reported 40,000 intravenous anaesthetic cases
since 1932 without severe complication:
It is sad to consider the barrage of attack which this pleasant technique has so unfairly suffered through the years from those who have little knowledge of its potential safety and flexibility. In 1933 I wrote: 'This method or an improvement on it, will undoubtedly come into general use in future dental practice'.

Mennell (1935) wrote of evipan:

The same old whisper is going around: all is not well with the barbiturates, their use is not devoid of danger, especially when used intravenously, and the same old word 'idiosyncrasy' is cropping up. What is put into a vein is irrecoverable. Why should evipan, which is by far the quickest and easiest to give, be free from the same dangers as the others of the group? It most certainly is not, which is only to be expected, and I believe the whisper which is already heard will soon become a roar when some of the dangers are brought home more forcibly to the surgeons.

Wyckoff (1938) felt that local anaesthetics had gained in popularity because of the 'frequent contraindications to the use of general anaesthetics, and the expense of training necessary', and drew attention to intravenous anaesthesia, which he noted had been used in England and Germany much more than in the U.S.A. He described a technique for the use of Evipal similar to Drummond-Jackson (1935) and summarised:

(i) It produces complete amnesia; therefore it is excellent for the apprehensive patient.

(ii) The patient goes to sleep quickly and quietly; there is no sensation of suffocation.

(iii) No post-operative nausea is encountered.

(iv) In fracture work it is especially advantageous.
In retrospect, an editorial in 'Anesthesiology' in 1943, said:

One has only to scan the literature of the first two or three years following the introduction of evipal to realise the disappointments through which knowledge of the potential hazards and contra-indications was won. As a result of this difficult experience, the pendulum swung and evipal was classed by many writers as a dangerous, toxic drug and an unsatisfactory anesthetic agent. It now is known that the drug was not dangerous, but the method of administration was, and often the danger consisted in the type of patient to whom the drug was administered. The lessons learned from the early use of evipal were, in the main, thoughtfully considered by those who began to use pentothal sodium.

(b) Sodium Thiopental (Pentothal Sodium)

Introduced by Lundy at the Mayo Clinic in 1935. Troup (1935) having visited the United States in 1935, first reported to Australian anaesthetists on Lundy's new barbiturate tentatively called thio-nembutal, and the technique of its use was described. It is of interest that an intermittent method was originally recommended -

. . . about two to three cubic centimetres are given intravenously fairly rapidly. The needle is left in the vein and subsequent amounts of about half a cubic centimetre are injected when the patient shows signs of coming out, until the operation is completed. It appears to be more effective in its action than 'Evipan', relaxation is better, and jactitation in the induction stage, which sometimes occurs with 'Evipan', appears to be absent.

Pentothal sodium has remained in popular use for the induction of surgical anaesthesia to the present day, and
further reference is made in the next chapter.

In the United States in the late 1930's and through into the 1940's outstanding workers in the field of intravenous anaesthesia were Lundy and Adams from the Mayo Clinic (Lundy et al 1939), and dental surgeons Wyckoff and Hubbell. There were no Australian dental contributions.

Anaesthetists Brown and Troup (1937) in Australia, had used thiopental in 56 cases for minor operations. Of these 56 cases, 17 were dental (the largest single group). In 51 cases a 10 per cent solution was used and in 5, a 5 per cent solution, the longest period of anaesthesia being 25 minutes, this operation being completed under nitrous oxide/oxygen. The following comments were made:

(i) Induction was quicker, quieter and less tendency to jactitation.

(ii) No post-anaesthetic vomiting.

(iii) 5 per cent solution recommended - but the larger syringe (20 cc.) was clumsy to handle when given by repeated dosage method.

(iv) Excessive salivation in one patient.

(v) The indications for intravenously induced anaesthesia are necessarily very limited.

(c) Pentobarbital Sodium (Nembutal)

The clinical application of Pentobarbital Sodium was first reported by Fitch, Waters and Tatum (1930), and also by Lundy (1930). The therapeutic value was quickly recognised, and during the early 1930's many investigators
studied the pharmacology of this agent. Lundy (1931) advocated its use as a hypnotic and reported experience in more than 2,300 cases. He described the action as 'sustained'.

Pentobarbital was combined with Scopolamine to produce obstetric amnesia and analgesia in 1934, although restlessness was evident in a high percentage of cases (Irving et al., 1934).

The use of premedication for general surgery, and the drugs best suited, was a controversial subject amongst anaesthetists at this time. Intravenous pentobarbital and scopolamine were however, much in favour (Black 1935, Mennell 1935).

(6) Trichlorethylene (Trilene)

In 1935 Striker et al. reported on clinical experience in 300 cases utilising Trichlorethylene. Their early work was with dental cases:

... we produced analgesia without anaesthesia, and it was possible to extract one or two teeth under this procedure. But later we produced complete anaesthesia and as many as fifteen teeth were removed. The dental cases ranged in age from eight to sixty-five years. There were a total of twenty cases. The induction period ranged from three to eight minutes with a mild excitement stage, then good relaxation and a recovery period of two to nine minutes. In one instance fifteen teeth were removed from a man sixty-five years old. Within fifteen to thirty minutes all these dental cases returned home.
Ether

Many dental surgeons now lacking both surgery facilities and training in general anaesthesia were as a rule offered 'open ether' anaesthesia by the medical man. Scott (1935) decried the use of the 'open ether' as being the worst method ever designed for dental work, and sought to define the ideal anaesthetic:

(a) It should allow the operator to work in his accustomed surroundings - his surgery, with the patient . . . sitting in the chair.

(b) It should allow for the whole job to be completed.

(c) When completed the patient should recover promptly, so that he does not swallow the blood.

(d) Pleasant, safe and quickly eliminated.

The first moves to provide a new role for ether by anaesthetists began in 1935, when Brown (1935) noted an 'enormous increase' in the use of gaseous anaesthetics abroad. The methods were of three main types:

(i) Pure nitrous oxide/oxygen, little premedication, no ether. Relaxation was produced by secondary saturation.

(ii) Heavy premedication, nitrous oxide/oxygen, little ether.

(iii) Large amount of ether, with the gases used as a vehicle.

Mennell (1935) an anaesthetist of 34 years standing presented a paper "Ether is not dead" and regarded the eclipse of ether as only temporary. He felt that this eclipse was due to:-
(i) slowness of modern surgical procedures.

(ii) lack of skill and knowledge in its use (particularly the Clover Mask).

(iii) attempts to use the open method of giving ether after induction with chloroform.

Ether was however, to continue as the anaesthetic of choice for teaching purposes through to 1960. Probably one of the main reasons for this was its usefulness in illustrating to students the 'signs' of anaesthesia - these had been laid down by Guedel (1937).

![Diagram](image)

Fig. 34
Guedel's signs and stages of anaesthesia.

The stages were: 1st analgesia; 2nd delirium; 3rd surgical anaesthesia and 4th respiratory paralysis. The surgical stage was divided into four planes. Guedel's observations were made when administering ether by open mask.
The analgesic state was defined as the 'loss or obtundation of the sense of pain without loss of consciousness or the sense of touch'. The signs of nitrous oxide anaesthesia measured against this chart indicate that if the patient is receiving sufficient oxygen to satisfy basal metabolic needs, then nitrous oxide can only depress this patient a certain amount - at best just below stage III, phase 1. Guedel's classification was fairly accurate and advantageous from a teaching viewpoint, when ether was used on an unpremedicated patient.

(8) **Endotracheal Anaesthesia**

Thus, the use of open ether persisted, and endotracheal anaesthesia remained the choice of the few. Its advocacy in dental surgery first came from Brown in 1930, who described its use with ethylene/oxygen. He said:

> The advances in dental surgery during the last ten years have markedly increased the number of major operations. The type of anaesthesia has had to be altered to suit the new conditions, and to provide a narcosis which may be lengthened at will.

Brown had used ethylene and oxygen for 1,300 dental operations and presented four case reports. His technique consisted of:

(a) Premedication of 1/6 gr. morphine 45 minutes before operation.

(b) Throat spray with 10 per cent cocaine solution.

(c) Chair tilted horizontally and Ethylene/10 per cent
oxygen administered by face mask; ether was added after the first minute.

(d) Endotracheal tube passed and connected to gas supply.

Gutteridge and Walker (1930) inserted a lubricated nasal catheter connected up to an anaesthetic machine, following induction with ethyl chloride and ether, and mask; they recommended this method as ideal for longer dental operations as there was no time limit. Endotracheal techniques for dental work were further advocated by Marshall (1937) and Heath (1939).

(9) The contributions of:

(a) S.V. Marshall

S.V. Marshall was closely associated with the teaching and practice of general anaesthesia for dental purposes in Sydney for over twenty years.

In 1937 he presented a comprehensive paper before the 9th Australian Dental Congress in Sydney. He drew attention to the fostering of nitrous oxide/oxygen anaesthesia by dentists, and said that 'dentists shall continue the application of such methods and agents'; it is 'rendered inevitable by the circumstances and exigencies of their working conditions'. Marshall stressed the importance of preventing oxygen deficiency, and then discussed the available methods:
(i) **Perhalation and Closed techniques**

Perhalation or 'open' techniques should only be used in short procedures or in emergency. He thought 'open' ethyl chloride, ether or chloroform unsuitable for dental work. For closed techniques he suggested nitrous oxide/oxygen - ethyl chloride combination, although drew attention to the use of Vinyl ether which he reported as 'excellent for children'. 'Risk of oxygen deficiency is greatly reduced, and temporary complete obstruction of the airway is permissible', he said.

(ii) **Intravenous techniques**

'Single shot injections' he said, 'especially if given by the operator himself, are to be condemned. Inexperienced administrators are apt to conclude that the indication with a syringeeful of solution is to inject it, and act accordingly, with most alarming results. The patient's reaction should be the criterion of dosage'. He preferred Pentothal sodium to evipan, suggesting 'slow injection of 1 cc. (5 per cent solution) every 3 seconds'.

(iii) **Endotracheal techniques**

These he described as 'par excellence' and the ideal method of anaesthesia for prolonged and extensive operations in and about the mouth cavity. Two types were described:
(a) Insufflation

(b) Inhalation

The inhalation method was preferred, using the Magill endotracheal tube. This provided 'absolute control . . . variations in depth are possible, and in emergency the lungs may be inflated with oxygen . . . Passive respiration effected by intermittent compression of the rebreathing bag may be readily performed. Protection against entrance of fluids and solids into the larynx and trachea is absolute . . . .''

(iv) Carbon dioxide absorption techniques

'The anaesthetising mixture is contained in an entirely closed system . . . with oxygen run in continuously in amounts sufficient to meet metabolic requirements'. He advocated cyclopropane/oxygen anaesthesia by the use of the carbon dioxide absorption technique.

(b) Noel Heath

Heath (1938 & 1939) wrote a doctoral thesis within the University of Melbourne on "Anaesthesia and Analgesia in Dental Surgery". He said:

It is the duty of the dental surgeon to weigh up the clinical and physical examinations, and taking into consideration the psychological conditions of the patient, to select the best anaesthetic or analgesic for the particular operation. Ether is used, particularly in Australia in a greater percentage of cases than is any other anaesthetic. One of the main reasons
for this is that the majority of medical practitioners who administer anaesthetics for dental surgeons have not the equipment or training to administer nitrous oxide/oxygen. It is not surprising to find that the dental surgeon is tempted to use local anaesthesia for operations that could be performed with greater advantage under a general anaesthetic. There is no doubt that if dental surgeons were to demand the types of anaesthesia which they required, instead of passively and without question taking what they are given, the medical profession as a whole would respond. Until the dental profession does begin to demand the benefit of these modern advances it must take its share of the blame for the present state of affairs.

Heath studied and surveyed dental anaesthetic deaths 1926-36, and stated that chloroform should be avoided unless directly indicated, and that 'the means of intubing the larynx and of insufflating air or oxygen should be at hand whenever an anaesthetic is administered'.

He further discussed the criteria of the selection of local and general anaesthesia; and then 'post operative respiratory sequelae' - with special reference to the incidence of pulmonary abscess following operation. He presented an analysis of cases of pulmonary abscess treated at Alfred Hospital (1922-36) and Melbourne Hospital (1922-7), and also included 21 post-operative dental cases from Melbourne Hospital (1922-32). Fatal results had occurred in 34 per cent of the cases at the Alfred; 40 per cent at the Melbourne and 28.6 per cent at Melbourne Hospital.

Questionnaires were sent to all members of the
dental profession in Victoria to ascertain how many practitioners had encountered cases of respiratory sequelae. Questionnaires were also sent to 900 patients of Melbourne Dental Hospital who had had multiple extractions with nitrous oxide/oxygen anaesthesia by intra-nasal method (10-32 extractions). 7.7 per cent reported post-operative respiratory sequelae and of these 5 per cent were cough and chest symptoms, 34.5 per cent cough only. In 40 per cent of cases a medical practitioner was consulted.

Heath then discussed possible modes of infection and said that there were two theories:

(i) Aspiration

(ii) Embolic

The Aspiration theory contended that infected matter was inhaled from the mouth, throat or sinuses during or immediately following operation. The Embolic theory contended that an infected embolus was freed from the field of operation. Heath endeavoured to simulate the production of respiratory sequelae in dogs but the results were inconclusive. He also studied the effect of the position of the patient, and found that in nitrous oxide/oxygen anaesthesia and short cases of light ether, the position of the patient has little effect on the circulatory compensating mechanism.

In comparing the various techniques of anaesthesia
he described nitrous oxide/oxygen by the intra-nasal method as being the most suitable for short dental operations, this to be supplemented with a little ether should the requisite depth of anaesthesia not be obtained. 'In long cases however the danger of inhaling blood, mucous, etc., is greater . . . and the use of endotracheal anaesthesia is indicated'.

(c) Geoffrey Kaye

Geoffrey Kaye was a dominant figure in general dental anaesthesia in Melbourne over the period of the thirties and forties, being Instructor and Senior Lecturer in Anaesthetics at the Melbourne Dental Hospital, from 1937 to 1957.

The association of Kaye with the Dental Hospital in Melbourne meant a pre-eminence over these years in Melbourne, of dental anaesthesia, in its academic and scientific aspects. (Amies 1970).

Kaye (1935) drew the attention of anaesthetists to the use of 'positive pressure' nitrous oxide/oxygen anaesthesia, using the McKesson or Austox machines which enabled the gases to be delivered at any desired pressure from 0-40 mm. mercury. This he felt an advantage in 'minor dental operations' although 'major procedures required endotracheal anaesthesia'.

Kaye was the chief adviser in anaesthesia to the Australian army throughout World War II. The Australian Army's
gas apparatus (1938) was devised hurriedly to meet the approach of the war of 1939-45. It had to be simple, robust and easily produced. Hundreds were produced at 35 Pounds a piece. They offered minor problems in maintaining the water level in having no regulators and in being for two gases only (R.A.C.S. Museum, Melbourne - Personal visit).

(10) Anaesthesis - a speciality

The first scientific meeting of the Australian Society of Anaesthetists took place in September 1935, under the presidency of Gilbert Brown. 1937 is however regarded as the year of the birth of the speciality, when a Chair of Anaesthetics was established at Oxford with Dr. R.R. Macintosh as first Professor. This foundation through the generosity of Lord Nuffield, ensured the attraction of a team of outstanding men and women, and led to the first thorough, practical, and simple text books; scientific testing, and development of equipment and techniques; invaluable experiment over a wide field, and in due course and almost by direct influence, to the upgrading of the speciality as we now know it (Bryce-Smith et al. 1963).

In the United States in 1937 the American Board of Anesthesiology, Inc., as an affiliate of the American Board of Surgery Inc., was formed. (The purpose of these Boards is to improve the standards of graduate medical education, and training) (Keys 1963).
(ii) Anaesthetic administration by dentists

The continuing problem of the administration of general anaesthetics by dentists was the subject of a paper by Ash (1932). Ash, as editor of the Dental Journal of Australia and Lecturer in Dental Jurisprudence, University in Sydney, spoke with some authority, and his statements were undoubtedly influential. He found that none but a 'qualified' person should give a general anaesthetic, but asked 'who is qualified?'. He felt that the term referred to the possession of 'scientific and technical ability', and that the dentist has the right, 'so long as he has the necessary knowledge and skill'. Ash, however, contended that it was sound advice to have a medical man present to give the anaesthetic because,

(i) The dentist has no power to sign a death certificate.
(ii) Evidence of medical man was more readily accepted in court.

His article concluded: 'A man should not, however, undertake to do a work of skill unless he is fitted for it, and it is his duty to know whether he is so fitted or not'.

Ash's article had a sequel, in the form of an editorial in December of 1932 which queried:

whether, at the present time, when local anaesthetics are so very much in favour the cost of installing an apparatus for the administration of nitrous oxide and oxygen would be warranted.
There are many dental surgeons who will have nothing to do with general anaesthesia, simply because they regard it as the work of specialists, and even though the death rate under nitrous oxide is practically nil, they do not desire to take any risks.

Also in 1932, Amies presented an important paper on this problem.

As far as the actual technique of administration of anaesthetics for routine dental extractions is concerned, the dental graduate could never be accused of lack of adequate training. His University degree implies that he has undergone the requisite course and shown the necessary skill. However, a charge of gross negligence might be proved against him if he anaesthetised a patient who was obviously ill without having the subject's general condition medically investigated before hand, and receiving the doctor's sanction for the anaesthetic. With what cases is a dental surgeon competent to deal? I should say all "good risk" subjects where an anaesthesia of no more than three to four minutes is required, and where a second induction is never contemplated.

He then distinguished between good, bad and intermediate risk patients, and asked:

Now, what anaesthetics should a Dental Surgeon use? Obviously only those he has used as a student, or those in which he has received special postgraduate training. The dental graduate is usually therefore restricted to ethyl chloride and Somnoform, and he should be very wary about giving more than ten cc, of either drug. Because he can remember giving forty cc, to a hospital patient is no argument that he should do the same in private practice. Hospital routine and private practice are two entirely different things.

He recommended the presence of a second graduate for the short dental case, or, if the patient was a child, a competent nurse.
Somewhat less emphasis was placed on the teaching of general anaesthesia to dental students in Sydney, than was the case in Melbourne. In Sydney, A. J. Arnott became Dean of the Faculty of Dentistry in 1934, and became closely associated in matters of policy with H. R. Kemp, Dental Hospital Superintendent (1934-46). Kemp had a particular interest in the subject of local anaesthesia, and the policy was encouraged that the latter was adequate for most minor oral surgery procedures performed by a general practitioner, and that for major oral surgery the use of general anaesthetics administered by anaesthetists who had enjoyed post-graduate training in this specialised field was desirable. This view was reinforced by concomitant progress in premedication, anaesthetic solutions and advances in surgical skills (Arnott 1970).

In Melbourne, Amies, who took up the Chair of Dentistry in 1937, had trained in anaesthetics under McKesson at Toledo, Ohio, and consequently was more orientated to and identified with general anaesthesia - particularly the Clement/McKesson methods. He appointed Geoffrey Kaye as his senior lecturer in anaesthetics, who was also a trainee of McKesson's. Thus, under the direction of Amies and Kaye general anaesthesia received greater priority in the Melbourne dental curriculum than was the case in Sydney (Amies 1970).
In the late 1930's dentists were made acutely aware of the risks and dangers attendant upon general anaesthesia for dental surgery. Downie (1938 & 1939), a physician, presented an account of some of the possible dangers facing the dentist in the contemplation and administration of a general anaesthetic. He mentioned the undiagnosed diabetic, or tuberculous patient, and also discussed the heart case:

The majority of cases, with whom trouble is experienced during anaesthesia can be grouped into those to whom the anaesthetic has been too rapidly administered, and those who have suffered some obstruction to their airway, with consequent anoxemia. The substances commonly used in anaesthesia do not all carry the same risk. By careful selection of anaesthetic, slow induction and attention to the provision of an adequate airway, much anxiety during anaesthesia can be prevented.

He then drew attention to the danger of inhalation of foreign material: 'I would remind you that the very existence of light anaesthesia with the attendant retention of the cough reflex is exactly that state of anaesthesia in which irregularities of respiratory excursion are most likely to be experienced. Under these circumstances gagging and breath-holding occur, and are often followed by exaggerated inspiratory efforts which are capable of carrying a foreign body further into the bronchial system than a cough can dislodge.'
VIII. WARTIME AND POSTWAR DEVELOPMENT, 1940-69

Developments during this period have been considerable, notably in the establishment of endotracheal inhalation anaesthesia, muscle relaxants, the discovery of halothane and methoxyflurane, shorter acting barbiturates, the ataraxic drugs, and a renewed interest in premedication and analgesia. There had been a notable increase in research and in scientific studies. Post graduate diplomas became a pre-requisite for the aspiring specialist anaesthetist.

In 1940, the first edition of *Essentials of General Anaesthesia, with special reference to dentistry* was published. This text, written by the Nuffield Professor of Anaesthetics at Oxford, Professor R.R. Macintosh, and his assistant Freda B. Pratt (later Bannister), became the authoritative text in general dental anaesthesia in Britain for many years. This text had a strong dental bias, and case histories cited were 'from the field of dental surgery, since the art of dental anaesthesia is often much neglected', and, in their opinion, 'a mastery of the difficulties encountered there, will help the anaesthetist to understand and overcome many of the problems he is likely to meet in anaesthesia for operations on other parts of the body'.

The text dealt with the then current theories of anaesthesia, and on the subject of 'cyanosis', it was observed
that nitrous oxide was a weak anaesthetic, and its qualities
had to be reinforced deliberately by a reduction of oxygen
intake to such a level that some degree of cyanosis was
usually noticeable. 'Cyanosis is here unavoidable, and not
of serious import. It exists in the presence of a free airway,
and the light anaesthesia of nitrous oxide does not depress
the respiratory centre,'...

In a later edition (1943), the Oxford Vaporiser
was described. This was used for the administration of any
liquid anaesthetic, but was particularly applied to ether,
and was the fore-runner of the modern vaporiser. (Fig. 35).

Fig. 35
Oxford Vaporiser.
S - hand-bellows or
spring bag.
H - control handle.

The figures on the scale represent closely the
volumes per cent of ether vapour in the ether/air
mixture delivered.

H.S. Seldin from New York, presented the second
edition of his text *Practical Anesthesia for Dental and
Oral Surgery* in 1942. Representing an American viewpoint,
there was however no marked departure from the principles of Macintosh and Bannister. Distinction was, however, drawn between continuous and intermittent flow machines, and the Heidbrink model well described (Fig. 36) as an example of the former type.

Fig. 36 - Heidbrink gas machine, dental outfit Model 5T. Has automatic pressure regulators with safety valves, centre valve for governing, measuring and proportioning the gases. Emergency valve which delivers direct to the patient up to 100 per cent pure emergency oxygen or nitrous oxide with bag open or closed.

This machine was designed to induce anaesthesia and analgesia by the 'standardized time technique', and flow meters were provided with gauges to read the percentages of oxygen, rather
than volumes or velocities. Seldin's advocacy of the continuous flow principle and the Heidbrink machine, represented a significant departure from the Clement/McKesson principles.

Both these texts had chapters on 'Analgesia', with suggestions for the utilization of nitrous oxide/oxygen for the production of this state, to allow for cavity preparation. Seldin, in fact, indicated the advantages which analgesia possessed as compared to local anaesthesia. Complete insensitivity of dentine was obtained, and the associated bur noise and vibration became more pleasurable to the patient.

John Lundy of the Mayo Clinic, published a comprehensive text *Clinical Anesthesia*, in 1942. The difficulties of office dental anaesthesia as opposed to hospital practice were discussed. Nitrous oxide/oxygen and Vinethene were considered suitable for the former. He described single dose pentothal sodium for one or two extractions, and an intermittent technique where the period of anaesthesia was as long as five minutes or more.

**Headings in this section (1940-69)**

(1) Thiopental Sodium (Pentothal).

(2) World War II.

(3) Endotracheal anaesthesia.
(4) Curare (Intocostrin).
(5) Trichlorethylene (Trilene).
(6) Succinylcholine (Scoline).
(7) Review of the Australian literature.
(8) Halothane, Methoxyflurane.
(9) Intermittent and continuous flow inhalation.
(10) Inhalation analgesia.
(11) Intravenous anaesthesia/sedation:-
     (a) Methohexital
     (b) Propanadid
     (c) The Jorgensen Technique
     (d) Pentazocine
     (e) The Ataractic drugs
         (i) Diazepam
         (ii) Hydroxyzine
     (f) Ketamine
(12) Renewed interest

(1) **Thiopental Sodium** (Pentothal Sodium)

Hubbell and Adams (1940), suggested intravenous administration of Pentothal sodium for cases in which the patient might be difficult to manage under nitrous oxide/oxygen anaesthesia, and in those in which local anaesthesia was not well tolerated.

The advantages were said to be:

(i) absence of much excitement.
(ii) ease of administration.

(iii) simplicity of equipment required.

(iv) absence of post-anaesthetic nausea.

The recumbent position was recommended, and an initial dose of 4 - 6 cc. of 2.5 per cent solution injected, which when not sufficient, additional doses of 2 cc. were administered until anaesthesia ensued. The importance of the onset and observation of respiratory depression was emphasised, and the danger of over-dosage stressed.

Hubbell and Adams said:

In dental surgery, light anaesthesia has some advantages. When the jaw is not completely relaxed, the cutting of tooth or bone is made much easier. Although the anaesthesia may become sufficiently light to result in movements on the part of the patient or even an outcry, there is usually no recollection of pain after the return to full consciousness.

... in dental surgery it is not objectionable to wait for the first sign of muscular reaction. As the end of the operation is approached, it is desirable to allow the anaesthesia to become light so that, when the operation is completed, the patient may have sufficient control of the laryngeal reflexes to expelorate blood and mucus. Postoperative effects of anaesthesia, such as nausea and headache, are seldom encountered. In some instances, laryngeal spasm is severe, and is often accompanied by marked cyanosis. When this condition is more than transient, the administration of the intravenous anaesthetic should be discontinued, and oxygen with 5 per cent carbon dioxide should be administered.

Intravenous anaesthesia was not recommended routinely in the dental office, unless a competent anaesthetist was in charge, satisfactory equipment available, and a place
available for watching the patient during recovery.

Bullard (1940) discussed the use of intravenous Pentothal or Evipal anaesthesia for exodontia and oral surgery. An intermittent technique was described. The average recovery time was one and a half hours. Laryngeal spasm was said to be the most distressing emergency and had occurred in 1 per cent of cases. (Bullard had had experience of 946 cases - 718 Pentothal, and 288 Evipal - all of the 'good risk' type). The types of operation involved were impactions, cysts, abscess incision, fracture reduction and root recovery from the antrum.

Hubbell (1941) reported his further experience, and had, by 1944, recorded 13,000 intravenous administrations for dental procedures, with 2.5 per cent Pentothal. Present indications for Pentothal sodium in ambulant dental work are few. For hospitalised patients it is used as an induction agent. Monheim (1968) indicates that it may be used for short procedures of less than five minutes, Allen et al (1968) have noted prolonged cardiovascular and respiratory depression with thiopental which contra-indicated its use as the sole adjuvant in nitrous oxide/oxygen anaesthesia, for dental operations.

The American military services early in World War II equipped their medical departments with large supplies of intravenous anaesthetic agents, which were supposedly complete,
compact and non-inflammable. The early experience was favourable. However, 'disaster struck', and Pentothal sodium came very close to being discarded altogether. Experience at Pearl Harbour and in North Africa, seemed to indicate that Pentothal was the cause of fatalities. (Davis 1968 a).

A foremost critic was Halford (1943):

A number of patients were given evipal by competent anaesthetists only to have respiratory failures, some of which ended in death. After several such fatalities, pentothal sodium was used, and again respiratory failures occurred, and, as in the case of evipal, death ensued in enough cases to cause us to abandon it as too dangerous. The injuries we were attending were all severe ... we were attending patients in severe shock.

Halford said that intravenous anaesthesia was the 'ideal method of euthanasia'. Open drop ether was felt to 'retain the primacy'.

Adams and Gray (1943) however, attempted an explanation, and said:

Pentothal sodium can be administered safely, provided the administration is carried out very cautiously, and provided much smaller fractional doses of the drug are used than would be necessary if the condition of the patient more nearly approached normal.

Adequate supportive oxygen therapy was stressed.

This was echoed in an editorial comment in Anesthesiology (1945):

It is of the utmost importance that one who administers, or supervises the administration of, pentothal sodium as an anaesthetic preparation,
keep in mind the following facts: (1) that the agent is powerful; (2) that it is a potent depressor of respiratory function, even in small doses, when rapidly administered; (3) that the effects of any single large dose, rapidly injected, are reversed with difficulty; (4) that individual tolerance to this and other derivatives of barbituric acid is most variable and cannot be accurately pre-determined; hence, attempts to set down certain dosages have been found to be unreliable and unsafe; (5) that a patient's tolerance to a barbiturate will vary with his physical condition and that certain states, such as extreme debility, toxemia, dehydration, loss of blood and shock, may markedly lower the threshold of tolerance of the individual from what his normal tolerance would be.

R.C. Adams of the Mayo Clinic was a foremost authority on intravenous anaesthesia during the 1940's. His comments with respect to Pentothal are pertinent today. He said (1945):

The general tendency has been either to regard the method as the answer to most of the anaesthetic problems, or to look on its use with distrust and skepticism. Despite its widespread use, a better general understanding of its intricacies and its correct application is needed by the medical profession in general. The broad principles of its use are not thoroughly understood. Intravenous anaesthesia is linked closely to both the principles and practices which govern the administration of anaesthetic agents in general. Most of the difficulties and fatalities associated with intravenous anaesthesia have arisen from failure to appreciate this fact.

Induction should be slow - this is the only way in which a desired depth of anaesthesia can be maintained without producing untoward or undesired effect. This will also determine the optional level for a particular patient. Most importantly ..., the patient's tolerance to the drug is lowered by shock.

It is often said that one of the advantages of intravenous anaesthesia was, that little or no equipment was necessary for its successful administration. Such statements are not only misleading,
but have resulted in many unfortunate experiences in the hands of those who believed them. Complications need not be any more serious under intravenous anaesthesia than under inhalation anaesthesia, provided the equipment for taking care of such difficulties is available.

The use of Pentothal sodium in 'office' dental surgery was described in 1950, by Millhon. Observations on 3,434 cases were presented, all being for extractions, in 96 cases impacted teeth. 2.5 per cent solution was used, and an intermittent injection technique was described. Recovery time was three to five minutes, before removal to a 'recovery room', the patients being allowed to leave the office when 'steady on their feet'.

Millhon made a particular plea:

. . . to recognize the fact that dental surgeons' needs in general anesthesia are different from those of the general surgeon. This is substantiated from the data of the cases reported, in which it is observed that it is not necessary to use large amounts of sodium pentothal anesthesia for dental surgical procedures.

(2) World War II

The experiences in the United States Army in the early days of the war, with Pentothal have been noted. Ralph M. Tovell was appointed in July 1942, as a consultant in anaesthesiology in the United States Army, and progress from this time accelerated, until D-Day, June 1944, saw the Units well equipped with necessary items, such as endotracheal tubes and laryngoscopes. (Davis 1968 a).
McCulloch (1947) describing his experiences with the Australian Army, used ethyl chloride in minor cases in the early days of the war as 'pentothal was in short supply', as too were cylinders of nitrous oxide/oxygen. The Army regarded cyclopropane equipment as 'extravagant and unreasonable nonsense'. Pentothal sodium gradually 'came into its own' being 'invaluable for battle casualties' - on occasions three adjacent theatres being used simultaneously by one anaesthetist.

Walker (1952) noted that 'anaesthetic methods chosen depended not only on technical indications, but also on the local conditions, the agents to hand, and in particular the anaesthetists available. Thus, dental officers frequently gave admirable service as anaesthetists in time of stress and difficulty, and so lightened the responsibilities of operations in forward surgical teams'.

Geoffrey Kaye was adviser in anaesthetics to the A.I.F. in the Middle East, and in 1942 wrote a Manual of Army Anaesthesia Apparatus, which was circulated to all medical units. This publication was intended as a purely 'ad hoc' production, to introduce untrained or semi-trained occasional anaesthetists to the limited range of equipment available to the A.I.F. in the field. (Kaye 1970). It helped greatly in the understanding of the various forms of apparatus, and their maintenance. Chloroform was used frequently, and
induction difficulties with ether were encountered. Late in 1942 an Oxford Vaporiser (Fig. 35) was supplied to the 2/6th A.G.H. in the Middle East, which had a great virtue in requiring little attention for safe and efficient operation. Trilene was extensively used at 115th (Heidelberg) Military Hospital.\textsuperscript{62}

Extensive preparations were made for the use of nitrous oxide/oxygen anaesthesia, but it did not receive widespread acceptance or use. Anticipations were based on World War I experience with respect to haemorrhage, shock, sepsis and toxaemia, which made anaesthesia a grave and often fatal hazard. Nitrous oxide/oxygen was expected to show superiority over ether. The 'Austox' field service apparatus was intended to fulfil the heavy demands envisaged, but despite the qualities of the apparatus, its utility in practice was limited, partly because a high degree of skill was required for its successful operation, and also because other methods (intravenous in particular) were more simple and effective. Nitrous oxide and oxygen anaesthesia was not used extensively, as under field conditions it was not worth the trouble which its provision and application involved. Cyclopropane was readily available in Australian base hospitals but not used extensively, although later in the war it was used in cases of extensive facio-maxillary surgery.

Intravenous anaesthesia with Pentothal sodium
appeared to have a great many advantages, and was invaluable in battle casualties. Major L.G. Morton reported on 1,000 cases of Pentothal anaesthesia in the 2/4th A.G.H. in Tobruk. (Walker 1952). 20 cc. of 5 per cent solution gave the surgeon 20 minutes to work. In Tobruk, care was taken not to give Pentothal in cases in which blood might enter the pharynx and cause laryngeal spasm. There were few complications and sequels of anaesthesia - respiratory sequels being the most common which were experienced in over 2 per cent of cases. The work of specialist anaesthetists under service conditions, enhanced interest and raised standards, in anaesthetic practice.

(3) **Endotracheal Anaesthesia**

Although, as noted in the previous section, endotracheal or intratracheal intubation techniques had been introduced into the United States in 1928 from their origins in England some years earlier, the advantages were not quickly realised. Twenty years later 'open ether' was still recommended as being the most satisfactory for student teaching (Watson 1947). There was controversy over the oral route for the tube as opposed to the nasal, and difficulty was encountered in desensitising the larynx prior to insertion of the tube.

According to Davis (1968 b) few utilised the cocainization of the larynx, as recommended by Rowbotham
and Magill (1921). Other methods used were:

(i) Nitrous oxide 90 per cent, oxygen 10 per cent, sometimes with ether supplement and face mask. Insertion of the tube had to be very rapid following removal of the mask.

(ii) Carbon dioxide 5 - 10 per cent, which produced vigorous movements of the vocal cords.

(iii) Pentothal.

(iv) Cyclopropane, which provided jaw relaxation for some time after discontinuing administration.

Lundy (1945) used 5 per cent butyn, or metycaine spray.

Whilst popularity of the endotracheal technique increased gradually, it was not until the mid-1950's that its use became general, due in large part to the introduction of Succinylcholine.

(4) Curare (Intocostrin)

This drug was known for centuries by South American indians and its physiological properties familiar to 19th century clinicians - Evans (1869) for example, noted - 'Curare possesses the property of paralyzing the motor nerves, without impairing the functional potentiality of the nerves of sensation'.

Adams (1945) reported its use along with Pentothal sodium to improve the relaxation which was sometimes not adequate with the latter. The amount of Pentothal required was thus reduced. Adams reported that curare acted by peripheral action, the diaphragm being spared. However,
larger doses came to be used to produce paralysis, and controlled ventilation became a necessity. Beecher & Todd (1945) in their extensive investigation of anaesthetic deaths, reported that an uncommon number of patients were being 'killed' by curare.

The first reported use of curare in Australia was by Marshall and Daly on August 11th, 1945, at St. Vincent's Hospital, Sydney. 'We embarked on this adventure with much trepidation... The start was finally made... under dental auspices, a circumstance somewhat reminiscent of the introduction of general anaesthesia just one hundred years ago. Confidence was soon established...' (Daly & Marshall 1946).

Troup (1947) discussed curare and concluded that it was a useful adjuvant to general anaesthesia with the gases and barbiturates. Marshall (1949) described the neurophysiology and pharmacology of curare in greater detail. The use of curare (d-tubocurarine) in anaesthetic practice associated with controlled ventilation, established its place. Physiological investigation had reached a degree where respiratory acidosis was evident in many surgical patients. Adequate oxygenation with adequate carbon dioxide elimination was essential. Thus, controlled ventilation was evolved; the anaesthetist aids inspiratory effort by a synchronized artificial rhythm, or takes complete control of the patient's respiration, after the abolition of all voluntary efforts,
by a combination of narcosis, hyperventilation and curare.

(5) *Trichlorethylene* ('Trilene')

As noted in an earlier section case reports were originally presented on the use of trichlorethylene anaesthesia in 1935. It was not, however, until 1941 that interest was again shown in this agent. Its reintroduction was to a large extent due to the interest and efforts of a chemist - Chalmers, who carried out a series of experiments and self-administration, subsequently contacting the then secretary of the Anaesthetics Committee in Britain, C.F. Hadfield, and also Imperial Chemical Industries, who were, it transpired, already manufacturing 'Trilene' without reference to its anaesthetic properties. (Hadfield 1941). Hadfield with Hewer (1941), undertook a preliminary investigation of 127 cases. Galley (1943) was the first to have recorded its adaptation to dental work, while Hill (1944) described a technique for using Trilene as an auto-analgesic during conservative dental work.

Galley (1945) reviewed his experience of 'Trilene' for all types of dental surgery in 2,000 cases. Three techniques were used:

(i) Single dose method.

(ii) Nasal nitrous oxide/trichlorethylene.

(iii) Endotracheal nitrous oxide/trichlorethylene.
It was found with method (ii) that higher percentages of oxygen were possible and venous congestion avoided. A minimal amount of 'Trilene' was used and then switched off, thus giving the advantage of the rapid recovery of nitrous oxide/oxygen. Endotracheal administration proved a useful method of anaesthesia for major dental surgery, recovery was rapid compared with nitrous oxide/ether, and vomiting was almost unknown. Cartwright et al. (1945) said that its use solved the difficulty of the 'tough' dental patient.

The use of Trilene to produce analgesia for dental procedures was reported by various workers. Williams (1946) described a method of auto-analgesia whereby the patient administered to himself a mixture of air and Trilene vapour. Williams carried out cavity preparation, pulp removal and abscess drainage, under Trilene auto-analgesia without pain. (Fig. 37).
Scher (1946), in a lengthy paper discussed aspects of Trilene analgesia, its advantages, and its contraindications. The advantages were: quick induction and effects rapidly reversible and predictable, easily controlled, portability and economy.

Scher used a different apparatus (Fig. 38).

**Fig. 38** Scher's apparatus for Trilene analgesia.

N : Nose hood (acrylic)  A : control pin  
E : Adjustable clamp  H : Higginson bulb
HB : Headband  L : Liquid
T<sub>1</sub>, T<sub>2</sub> : Conducting tube  GT: Capillary bore glass
V : Vapouriser  tube
C : Glass connector  O : Aperture
VP : Vinyl Portex rim  J : Jet
CA : Clear acrylic

The method was fully described, and the results of 521 cases discussed:
Nine per cent of cases were considered as failures, and completely resistant, and the method was not practical for children under 13 years. The 'most frequently appreciated applications, from the patients' viewpoint was the fortification of a previously injected local anaesthetic'. Scher found that 43 per cent preferred trichlorethylene analgesia to 34 per cent local anaesthesia, whilst 23 per cent were undecided.

Adverse effects he found were excessive salivation (73 per cent), giddiness (9 per cent), nausea and vomiting (1.5 per cent) and headache (2.5 per cent). There was some discussion of the effects of Trilene on pain, and possible affinity for the sensory fibres of the fifth nerve queried. Amnesia was a notable feature of the technique with respect to pain sensation.

Dormer (1948) stated that 'the advantages of Trilene over local anaesthetics in conservative dentistry were:

(i) Trilene has a definite sedative effect, so marked, that under its influence the most restless patient becomes a perfect subject to operate upon.

(ii) The patient apparently loses 'will power'; he is a thoroughly co-operative and ideal patient.

(iii) The patient recovers from the effects of Trilene in a few minutes.

(iv) There is not the discomfort of the long period of anaesthesia with local anaesthetic.

(v) Trilene, within the first few minutes of application appears to disperse fear.
Australian dental publications carried frequent advertisements for 'Trilene' at this time, (Fig. 39), but general acceptance was not evident. In the United States acceptance was delayed because of an adverse report of its undesirable effects on the cardiac mechanism by Waters et al, in 1943. (These were associated with deeper phases of anaesthesia). Sadove et al (1953) attempted to revive interest and described the use of trichlorethylene for analgesia, which differed from the previous contributions in that it was not self-administered. It was found 'particularly valuable for cavity preparation and sealing'. Extremely apprehensive patients were found to be poor subjects for analgesia, and proper selection of cases was essential. As opposed to nitrous oxide analgesia, that with trichlorethylene was found to be deeper, and amnesia more pronounced.

Iasella (1969) has recently recommended Trilene as being ideal in out-patient paediatric anaesthesia, indicating its potent analgesic action plus the limited degree of other properties. Love (1970) considers that Trilene could perhaps be 'rediscovered', and find fresh application in dental analgesia. W. Allen (1970) reports the successful application of Trilene adjuvant in paediatric dental anaesthesia, using a McKesson Trilene vaporizer. A 75/25 per cent N₂O/O₂ mixture was employed. Cost was said to be a great advantage of Trilene (one-thirtieth that of halothane). (Ball and Allen 1969).
(b) **Succinylcholine (Soline)**

In 1949 Balthasar and Sara presented a preliminary report on 'Decamethonium Iodide C10 in anaesthesia'. This agent they found 'readily adaptable to short procedures without the fear of post-operative respiratory depression. It was miscible with thiopentone, and there was less risk of bronchospasm. In a further report (1950) they found that excellent relaxation was achieved and greater ease of intubation.

Consequently in 1952 Balthasar and Sara reported on Succinylcholine chloride. This they found to be an ultra-short-acting muscle relaxant, which was an excellent aid to
intubation. Less thiopentone was required and the drug was 'non toxic to most tissues and organs'.

Orton (1952) recommended 0.5 gm. thiopentone followed by 75 mg. of Scoline to produce full relaxation of the jaw muscles, and loss of laryngeal reflexes. 'Scoline', he said, 'has proved particularly valuable in dental cases in which endotracheal anaesthesia is to be followed by the rapid extraction of a number of teeth. The full benefit of rapid induction and intubation can then be followed by the rapid return of the cough reflex, and voluntary respiration without the use of neostigmine'.

Muscle relaxants are at present commonly employed in general surgical anaesthesia. In addition to curare and Scoline should be mentioned relaxant gallamine triethiodide (Flaxedil) a synthetic agent, and the antagonist neostigmine (Prostigmin) which are in popular use.

(7) **Review of the Australian Literature**

The Wartime period marked the end of an era in Dental General Anaesthesia, and the subject has received scant attention from contributors to the Australian dental literature since that time. Progress in anaesthesia which might have had dental application, was poorly reported.

Harms (1941) said that:

Most of the new improvements in general anaesthesia have been largely stultified by improvements in local anaesthetic techniques, and by the increasing
use of staged extractions ... we have, in 1941, a somewhat different background of anaesthetics and methods of administration. There are men who specialise in the giving of anaesthetics, and of special anaesthetics. Their experience and skill, combined with the lowered toxicity of the new drugs, gives a much lower mortality rate than was experienced twenty years ago.

Throughout the War years articles and extracts were from overseas journals, there being no local contributions in this field:

Marcus (1941) sought anaesthesia which provided 'sufficient oxygen at all times'. To this end he recommended at least 10 per cent oxygen, which sufficed for the majority of patients. For the 'resistant' type of patient he advised premedication or hospitalization or intravenous Pentothal in the office. Ruffine (1941) noted some of the differing requirements of ambulant dental anaesthesia to that in hospital.

Steadman (1942) and Maidlow (1942) offered opposing views on the use of the throat pack. Steadman considered that the throat pack should be dispensed with in short cases; the pack he felt to be not infallible and could cause obstruction. Maidlow said that the pack should be used to guard against entry into the air passage of foreign matter, and to help in the economising of gases.

Jacobs (1943) revised the use of analgesia, with 10 - 20 per cent nitrous oxide for cavity preparation, or as an induction before local anaesthesia for nervous patients
undergoing extraction.

Heath (1945) discussed anaesthesia in children's dentistry, and in cases of extensive caries, suggested endo-tracheal inhalation with a wide bore catheter, using ether or nitrous oxide and oxygen.

Sealey (1946) discussed the choice of anaesthetic method for oral surgery, and listed three types of general anaesthetic:

(i) **Nasal administration of nitrous oxide/oxygen**

He stressed the supplementation of nitrous oxide/oxygen with pre-medication, and an agent such as ether or trichlorethylene, in order to avoid anoxia and increase the potency. This was the first mention of this type of supplemental anaesthesia in the Australian journals.

(ii) **Endotracheal Anaesthesia**

The advantages listed were:

(a) Full and adequate packing.

(b) Mouth is entirely free.

(c) Trachea may be aspirated at the end of the operation.

(iii) **Intravenous Anaesthesia**

This, he said, had disadvantages in oral surgery:

A marked fall in the blood pressure - hence it is undesirable to have the patient sitting up; respiratory depression which makes adequate packing almost impossible; and, pronounced susceptibility to a laryngeal spasm. The use of a pack, the presence of blood or debris in the pharynx, or attempts to intubate the larynx further activates such a spasm, which, was a serious
disadvantage. A further disadvantage, said Sealey, was the long period after the anaesthetic, before the patient has the full possession of his faculties.

Sealey listed and discussed the factors governing the choice of anaesthetic method which were:

(a) General health of the patient.
(b) Physical state of the patient.
(c) Age of patient.
(d) Type of tissues involved.
(e) Area of tissues involved.
(f) Length of operation.
(g) Surgical technique.

Rovenstine (1947) from New York, condemned anoxic techniques of nitrous oxide/oxygen administration. He said that the anoxic state had been the cause of deaths and psychoses, personality defects and impairment in circulatory and respiratory functions. The analgesic technique was, he said, safe, as this utilised 35 to 50 per cent nitrous oxide; the techniques which he condemned were those where pure nitrous oxide was used as the induction agent, particularly the saturation techniques.

Marshall (1946), who with Daly (1946), addressed the N.S.W. branch of the Australian Dental Association, noted that the emphasis in anaesthesia had been 'mainly on the requirements of general surgery, while those of dentistry . . . have tended to suffer a lack of proper appreciation.
... dentists have had frequently to put up with a decidedly inferior quality of general anaesthesia for their more extensive surgical procedures. ... dentists themselves have been culpable in this regard, in either not knowing of, or not insisting on, methods more appropriate to their requirements.

Marshall listed the essential principles of general anaesthesia for surgical operations, viz., Patient assessment, preparation, and pre-medication; skilful administration of appropriate agent, patent airway and competent after-care. The use of a Magill tube and endotracheal inhalation method of anaesthesia for longer oral surgical procedures was then advocated. For shorter procedures, Daly recommended nitrous oxide 100 per cent induction, with admission of 7 - 10 per cent oxygen 'when the eyeballs go off centre'. Anoxaemia, he said was 'necessarily involved' which could be dangerous if 'severe or prolonged'. Reference was made to ethyl chloride or ethyl chloride/ether, and intravenous Pentothal or Evipan. The latter he said, was suitable for short and easy procedures.

The most comprehensive contribution in the post-war years came from Geoffrey Kaye in 1948. Two years previously Kaye had collaborated with R.H. Orton and
D.G. Renton to produce a text, *Anaesthetic Methods*. This book claimed to meet the requirements of the 'non-specialist anaesthetist', and one chapter was devoted to dental anaesthesia. This treatise stressed 'the high degree of co-operation between anaesthetist and dental surgeon and the handling of the ambulant patient'.

Much of this material was restated in Kaye's 1948 paper. General anaesthesia, he said, while not to be used light-heartedly, may be employed in these circumstances:

(i) Major procedures for small children.
(ii) Apprehensive adults.
(iii) Extensive operations.
(iv) Complexity of block injection, e.g. double block.
(v) Sepsis.
(vi) Institutional practice.

He then classified dental operations as 'minor' or 'major'. With 'minor' cases he stressed:

(i) The surgical procedure must be capable of completion within five or ten minutes.
(ii) No great loss of blood or extensive removal of bone.
(iii) The patient should be able, soon after his awakening, to proceed home without hardship.
(iv) Patency of the patient's air-passage and protection of the bronchial tree.

In discussing ambulatory dental anaesthesia,
he felt that the choice was nitrous oxide, or ethylene/oxygen by nasal route and positive pressure. On the subject of intravenous anaesthesia, Kaye agreed with Sealey (1946), and said:

If they are to be considered as the sole anaesthetic, they must be combined with tracheal intubation so that the air-passages may be kept patent, and the bronchial tree protected from contamination.

After drawing attention to the necessity for satisfactory conditions and personnel, Kaye discussed the selection of anaesthetist, and summarised the situation:

General anaesthesia is being regarded, to an increasing extent, as the sphere of the professional anaesthetist. At the same time even were there enough professional anaesthetists to go round, not many of them would interest themselves in minor dental surgery. . . The dental surgeon may have to accept as his anaesthetist either a general practitioner of medicine or a brother dentist. . . From the legal standpoint, a dental graduate is probably entitled to practise any method of anaesthesia in which he has had formal and adequate training.

Kaye then described pre-operative care and care at operation. In this latter section he discussed certain aspects under sub-headings:

(i) Anoxia - which must be prevented, and 'the percentage of oxygen always sufficient to maintain a red colour in the blood'.

(ii) Volatile supplement - Melbourne Dental School was using Trichlorethylene.

Kaye noted:

This is certainly agreeable in smell, non-inflammable, and relatively free from nauseating effects; it is, however, not without hazard to the respiratory centre and to the heart.
The Hospital's present experience of a few hundreds of cases is insufficient for a decision as to whether the non-inflammability of this drug is a fair offset to its greater toxicity as compared with ether.

(iii) Packing.

(iv) Patency of the airways.

(v) Observation of the exhalation valve.

(vi) Suction.

(vii) Vomiting - 'no intra-oral manipulation should be performed until anaesthesia is brought to, or restored to, the middle of the first place of the third stage, at which the vomiting reflex is obtundened'.

(viii) The retained root - Unless this can be readily seen, termination of proceedings and later removal under local analgesia was recommended.

For major dental operations hospitalization was recommended, and it was to be expected that endotracheal methods would be employed.

In his summary Kaye stressed these three points:

(a) Correct patient assessment.

(b) Maintenance of the patency of the air-passages.

(c) Protection of bronchial tree against entry of blood or dental fragments.

Discussing the choice of anaesthetic in exodontic work, Arnott (1948) said, 'Today, intravenous pentothal sodium followed by laryngeal intubation with a Magill's tube and the closed circuit inhalational nitrous oxide and oxygen or ether/oxygen mixture is the type of anaesthesia for dental
operations within the oral cavity'. This he said, should be 'employed in all major dental operations where a general anaesthetic is considered essential'.

Helmore (1948) agreed with Arnott, but contended that nitrous oxide had a place. He listed three 'classes of case':

(a) One or two simple extractions plus 'needle phobia'.
(b) Patient with acute infection which requires simple treatment.
(c) Young child requiring removal of a few temporary teeth.

Helmore noted that the patient may be aware of an extraction, but feel no pain during light plane anaesthesia with nitrous oxide/oxygen, and he termed this Analthesia. He also reported satisfactory experience of several cases where trichlorethylene supplement had been used. Clark and Haymet (1948) supported Helmore, and also considered that overcrowding at hospitals and expense, precluded the use of the 'ideal' method on occasions.

The controversies and problems in dental general anaesthesia were admirably elucidated by Marshall and Shea (1949). Many of the points are particularly pertinent as there is an attempt to foreshadow future requirements in this area of study. 'Doctors' they said, 'had rather hazy ideas of the problems which confront dentists in their daily work... and... when general anaesthesia is
required. ... perhaps not fully cognizant of your difficulties'.

Most doctors receive a reasonably good basic training in general anaesthesia, but many are not specially instructed in the peculiar difficulties and dangers which accompany its application to dental and oral surgery. Many dentists too, do not sufficiently appreciate the risks involved. ... intravenous anaesthesia carries the added risk of the most persistent and dangerous laryngospasm. ... The inhalational and anoxic hazards are truly enormous.

Dentists are legally entitled to give general anaesthetics, but at present few are technically qualified to do so. In comparison with doctors, their basic training and practical experience with routine methods are insufficient. ... severe censure or worse will follow if serious trouble or disaster results. Queries are made about the reasons for its present comparative disrepute. ... the truth is, that the capabilities of the gas and its uses have been too frequently exceeded. ... Thus a valuable method is largely discarded, so that few doctors and dentists are really competent in its use today.

Nitrous oxide and oxygen anaesthesia in its proper application offers many great advantages in dental and oral procedures.

Marshall envisaged the following:

(i) Proper training especially of basic physiological factors.

(ii) Establishment of general anaesthesia clinics.

(iii) The award of a Diploma or its equivalent.

(iv) Restriction of training to post-graduates in either profession.

Dentists should not dabble in general anaesthesia he said, until their teaching and training have been very much improved. Nor should they rely on the average doctor for
adequate satisfaction in this regard.

Shea followed Marshall and spoke of "Methods and progress". On the subject of *Intravenous anaesthesia* (Pentothal, etc.,) he felt that a 'patent airway cannot be guaranteed', and that the 'difficulties and dangers of pentothal once they appear, snowball in a most alarming and dangerous fashion. Dentists who use pentothal themselves, perhaps without assistance of any kind, are indeed running grave risks. . . .'

Inhalation general anaesthesia, he divided into two groups:

(a) Agents and methods by which pharyngeal reflexes can be abolished.

(b) Reflexes are not definitely abolished.

This second group Shea listed as nitrous oxide/oxygen, or trichlorethylene for general analgesia or anaesthesia alone, or the combination of these, or nitrous oxide/oxygen/vinyl ether.

The anaesthesia they produce is very light, hardly more than analgesia combined with loss of consciousness and resultant amnesia. The safety and success of this method depend on a correct assessment of the job in hand, in the light of the skill and ability available. It is small wonder that nitrous oxide/oxygen alone is not a method enjoying extensive use here. It is by no means safe in unselected and often unprepared cases. Nitrous oxide and oxygen must involve some degree of sub-oxygenation, often severe. Thus some combination providing a wider margin of safety is very desirable. . . Trichlorethylene, combined with nitrous oxide/oxygen 'has overcome most of my objections to nitrous oxide/oxygen alone'.
Shea described two methods which he had used for dental work:

(i) Induce with N₂O/O₂ in usual way and add the Trilene as the administration becomes stabilised, then increasing the O₂ percentage.

(ii) Establish the analgesic effect of the Trilene first in 70 : 30 per cent N₂O/O₂.

... In very few cases have I felt that we should restrict ourselves in point of time... The need for a method and agent likely to facilitate office work is perhaps more apparent to you than to us. Venturing further will demand increased co-operation and understanding between all members of teams engaged in the performance of dental and oral surgery under general anaesthesia.

Kaye (1951) further studied the question of hypoxia and the likelihood of it doing harm to the patient during dental anaesthesia. His study included 336 patients of age range 2½ to 65 years. The average duration of anaesthesia was 7.7 minutes ranging from 3-21 minutes. Samples were withdrawn from the right bronchus during inhalation. Conclusions in this study were that 15 per cent oxygen was the critical figure, as below this figure a sharp decline in the saturation of the blood was shown. Important conclusions were drawn:

It would seem from this series that, under ordinary conditions of minor dental surgery, it is only the exceptional patient who enters surgical anaesthesia when receiving an atmospheric percentage of oxygen. The anaesthetist must then decide whether he will work at sub-atmospheric levels or, maintaining the atmospheric level, will resort to volatile supplement. The former course has been
adopted widely in the past. That harm has seldom accrued is testimony to the relative freedom of nitrous oxide from histotoxic effect. A minor degree of hypoxia will probably not harm a healthy subject provided that the percentage of oxygen supplied is 15, that no volatile agent is introduced, that the air passages are patent and that the duration of anaesthesia is limited to about five minutes. Such technique is, however, of a marginal nature. It seems more reasonable to give an atmospheric percentage of oxygen, making up any defect in potency by means of volatile supplement.

A strongly worded article, from an address given to the Australian Society of Anaesthetists by Spiers (1953) described general anaesthesia for dentistry as a 'hazardous field of practice'. The burden of his paper, he said, was that in cases in which, for paltry reasons, a general, rather than a local anaesthetic is administered for a dental procedure, the patient is in fact submitted to a risk of death or illness of which he and often his professional adviser are quite unaware. Anaesthetic death in its highest incidence is not common in the experience of any one individual, and the morbidity or the mortality following inhalation of infected material may never come to the notice of those present at the original operation, so that the possible consequences of a general anaesthetic do not often present themselves to the mind of the anaesthetist. Contact with coroners' records will remind one very forcibly that death is a possible consequence of general anaesthesia.

After lengthy discussion of 'anaesthetic death' in general terms, Spiers said:-

If there are safe techniques of anaesthesia for dental work, they ought to be capable of employment by the average practitioner, whether dentist or doctor, since there is no immediate prospect of the employment of skilled specialists for every dental anaesthetic: even if there were, it seems that we should expect a reduction in the risk rather
than its elimination. There must be few experienced anaesthetists whose practice has been entirely free from unexpected disaster to a patient who was apparently a 'good risk' for the procedure contemplated.

No technique has been discovered which is free from certain general hazards, such as asphyxia by vomiting; and the more complicated the technique of anaesthetization is made, the more the patient comes to be dependent upon the anaesthetist's skill and upon the efficient functioning of the various pieces of apparatus. Malposition or blocking of tubes, malposition of a cylinder on a machine, failure to remove a throat pack, intra-arterial or perineural injection of thiopentone... Very seldom, of course, but now and then, a new nightmare enters the lists, and the disadvantages of local analgesia were minor compared with those of general anaesthesia.

The Australian Society of Anaesthetists, in 1954, published views on dental anaesthesia. These views were prepared by the Dental School in Melbourne:

Whilst most patients are content to receive local analgesia for minor dental procedures, technical or psychological considerations may call for general anaesthesia. A dental operation is performed upon the upper respiratory tract; the ideal technique is, therefore, endotracheal anaesthesia, and this is the routine in many general hospitals. Intubation is, however, a severe procedure to impose upon the ambulatory patient undergoing a minor dental operation. The Dental School handles some 500 such patients, mostly children during each year. Neither hospital beds, nor trained anaesthetists exist in number sufficient for the handling of this volume of patients under endotracheal anaesthesia. A compromise with ideal safety is therefore necessary, and it is now proposed to describe the compromise adopted by the Dental School.

The School makes no attempt to train Dental students as anaesthetists; it aims only at giving them
practical acquaintance with the problems of anaesthesia, so that they may co-operate intelligently with the anaesthetists with whom they will work after their graduation. Whilst the dental graduate may legally administer these anaesthetics in the use of which he has been trained, the Dental School regards anaesthetic work as the province of the professional anaesthetist.

Requirements are met by the administration of nitrous oxide/oxygen, supplemented with trichlorethylene, and given by the nasal route under positive pressure. Adequate mouth-packs of Gamgee-tissue give reasonable protection to the bronchial tree. Their insertion requires a considerable amount of training. The patient's position in the dental chair is a semi-sitting one; the mouth can be more effectively freed of blood or debris in this posture than in the horizontal one, because foreign matter gravitates to the floor of the mouth, where it is readily seen and aspirated, rather than into the pharynx.

Endotracheal anaesthesia is not often used for "minor" cases, although the anaesthetist does not hesitate to pass an endotracheal tube should one be needed to maintain a patent airway, or should the operation prove to be of unexpected scope or duration. If the patient's secretions be copious, or should the merest suspicion exist that blood or vomitus has been inhaled, a nasotracheal tube is passed and the trachea is aspirated.

The induction was described:

Nitrous oxide, under a pressure of 5 mm. Hg., is given for about four breaths; oxygen is then introduced progressively, in advance of signs of hypoxia, until the atmospheric percentage of 21 is reached. A pause is then made whilst the signs of anaesthesia are evaluated. The School has found that, whilst an atmospheric percentage of oxygen is compatible with unconsciousness, it is attended by surgical anaesthesia in only about 4 per cent of cases. The classical technique, made familiar by McKesson, therefore called for reduction in the percentage of oxygen supplied, usually to a value between 15 and 20. This technique is not approved by the Dental School, which regards an atmospheric concentration as mandatory. Hence, if the early third plane of
anaesthesia be not gained with it, the student is taught to admit trichlorethylene gradually until the desired effect is obtained. The percentage of oxygen is then increased to 25, or even to 30. When the muscles of the jaw relax, a gag is gently introduced by the surgeon.

During the period of maintenance, the percentage of oxygen remains at a minimum of 25. The trichlorethylene, however, is reduced by successive deductions to the minimum compatible with quiescence: it is often scaled-out entirely by the middle of the operation.

The average duration of anaesthesia was found, in 336 cases, to be 7.7 minutes. Where student exodontists were engaged (480 cases), the average duration was 8.4 minutes. On rare occasions, surgical difficulties prolonged the operation time to thirty or forty minutes; nasotracheal intubation was in that event performed.

Heath (1954) contributed to the 13th Australian Dental Congress, 1953, and said:

It has been an accepted fact for a number of years that general anaesthesia has many uses in the practice of dentistry, however, it is not in routine use in conservative dentistry. I feel that there are many dentists who would make a great deal more use of this type of anaesthesia for selected cases, notably those combining surgery and conservative dentistry, if they could be convinced that there was a practical and not too complicated an approach to the procedure. There are very few medical practitioners who are expert anaesthetists with nitrous oxide and oxygen. The anaesthetic most widely used, and in the use of which most medical men are trained, is ether. I usually therefore use ether as an anaesthetic agent.
Woodley (1954) supposedly commenting on 'Modern anaesthesia for minor dental surgery', confined his remarks to intravenous anaesthesia (Pentothal). These remarks were in turn confined to a list of hazards, and finally to a nine point plan for the treatment of intra-arterial injection.

Lane and Belcher (1955) described their technique for anaesthetising young children for conservative work - in the dental surgery:-

(i) Induction with nitrous oxide/oxygen.

Off-the-face induction technique was used. Induction with 100 per cent nitrous oxide delivered at about 5 mm. Hg. pressure was rapid.

(ii) Upon attainment of stage I1 of anaesthesia, the mask was applied to the face.

\[ N_2O : O_2 = 80 : 20 \]

Trilene was introduced gradually until the vaporiser read 2\(\frac{1}{2}\)-3 (C.I.G. Type). On this mixture anaesthesia rapidly deepened to 'Stage I11'. Either of two procedures were now adopted: (a) intubation without relaxants or (b) intubation with intravenous Scoline. 3-5 minutes after induction the patient was considered fit for laryngeal intubation.

Heath (1957) was again active, and presented a clinical demonstration at the 14th Congress of the Australian Dental Association, in 1956. His technique and ideas had
changed, and ether was no longer indicated. The actual technique used was as follows:

(a) For very young children, induction with nitrous-oxide/oxygen. Anaesthesia was continued with nitrous-oxide/oxygen and Trilene supplement.

(b) Older children. Induction with nitrous-oxide/oxygen. Anaesthesia continued with nitrous-oxide/oxygen and Trilene supplement. If necessary, intravenous Scoline was included, before intubation into larynx. Some older children may have induction with intravenous Sodium Pentothal.

(c) For adults. Induction with intravenous Sodium Pentothal, and intravenous Scoline before intubation into larynx followed by nitrous-oxide/oxygen with Trilene supplement.

Christensen (1958) drew attention to the fact that in many country areas the dental surgeon was not being provided with modern anaesthesia, but rather was forced to operate under antiquated and dangerous methods. Christensen suggested that all general anaesthetics for dental operations be carried out in hospital, and that the dental surgeon be supported to the fullest extent in his requests for endotracheal or naso-pharyngeal anaesthesia for all operations in the mouth.

Clark (1958) read a paper which was somewhat in the manner of a reply to Christensen. Clark mentioned the long distances between centres and the minimum of apparatus available. He said that 'open ether was still the safest and most useful anaesthetic for the general practitioner.
Thiopentone induction was now universal and was expected by the patient. The sequence most normally taught in the medical schools was thiopentone-ethyl chloride-ether'.

Marshall (1958) in discussion which followed this paper stressed the importance of retaining 'open ether' for teaching purposes.

Eight thousand intravenous dental anaesthetics were reported by Leditschke (1959). He said: 'I am convinced that with reasonable care it is, for adults, the best form of dental anaesthesia at present available, and is eminently satisfactory as a sole anaesthetic in the vast majority of instances. He preferred Evipan which, he said, he had used since 1934. (This had to be specially imported). For dental anaesthesia, the main advantages of Evipan over Pentothal are, said Leditschke. (i) Respiration is much less depressed; (ii) Laryngeal spasm very much reduced; (iii) Less irritant to the tissues, (iv) less profound anaesthetic, producing less relaxation which is not so essential in dental operations. The keener retention of pharyngeal and laryngeal reflexes is an extra safeguard in cases when changing of the pack has been a little delayed and a little blood trickles past the pack.

Leditschke noted that the Executive of the Australian Society of Anaesthetists had said that, 'Generally
speaking Pentothal alone was unsuitable for dental anaesthesia', and had also stated, 'This is a sleep producing drug, and has little or no action in relieving pain or obtaining relaxation'. To this Leditschke replied:

When nearly half my patients refuse to believe they have been asleep, after having had a number of teeth removed under intravenous anaesthesia, I seriously question the above statement. It has not been unusual to find a patient convinced that he had not yet been unconscious.

Sara (1961) discussed the oxygen content of anaesthetic mixtures, and noted that discrepancy existed between the percentages of oxygen indicated on the dials of machines, and the actual percentage delivered. This however, was usually in favour of an increased oxygen percentage delivered. The optimum content of oxygen was discussed:

Whatever the concentration of oxygen delivered to the patient, the actual concentration reaching the alveoli and so absorbed will be less. This obtains in the normal physiological state; if the inhaled percentage is 20% oxygen, the alveolar content is 14%. Similarly, in anaesthetic practice in a semi-closed circuit administering 80% nitrous oxide and 20% oxygen, the alveolar concentration will be 80% and 10% respectively, when there is no extended dead space. This occurs with nitrous oxide given intranasally when each exhalation is expended and inhalation is made with fresh gases. With such a system and with percentages delivered as mentioned, there is no marked disturbance of arterial blood oxygen concentration. With further reduction to an inhaled oxygen mixture of 19%, desaturation of the haemoglobin commences, and at an oxygen inhalation of 18% (which gives an arterial oxygen saturation of 94%), the physiological reaction to anoxia can be observed. It is well known that
deficiency of oxygen, and not necessarily an anoxic mixture, produces irreparable cerebral damage or cardiac arrest. What is not realised is that the classical signs of hypoxia-cyanosis, loss of consciousness, tachycardia and hyper-ventilation - may be masked during an anaesthetic procedure, and the first evidence of such hypoxia may be a catastrophic event. In anaesthetic practice improvement of oxygenation is produced by an increase in the content of oxygen in the inspired mixture, and by the maintenance of adequate ventilation so that more alveoli are functioning to absorb the gas.

Bridges-Webb (1963) reviewed 300 anaesthetics in general medical practice. Of these, 38 were dental, which he said were an important group, in view of the danger of inhalation of foreign material, and the maintenance of a clear airway. Ether was employed in 27 per cent of cases, Trilene 30 per cent, Halothane 15 per cent, ethyl chloride and thiopentone being used in other cases. The complications listed included vomiting, obstructed airway, excess secretions, cough, difficult intubation, mishaps with equipment, trauma, difficult venepuncture, and insufficient premedication.

The Australian dental literature has been notable in the sparcity of contributions in the field of general dental anaesthesia over these years. The only voice raised in opposition to recommendations put forward with respect to general anaesthesia for dental purposes, by the Faculty of Anaesthetists, Royal Australasian College of Surgeons in 1964 (Appendix 1) came from an American, R.G. Taylor who saw the document as an intrusion into the right of
Dentistry to educate and practice. He stressed:

It would be complete folly for dentists to minimize the importance of this proposal on the basis that few dentists are involved. This may be true in Australia at the moment, but it ignores the fact that in the United States, many dentists and oral surgeons are receiving extensive general anaesthesia training by both dentists and medical anaesthesiologists in every dental school and major university affiliated hospital in the country. It also ignores the certainty that future research will change current anaesthesia practices and our profession may have cause to regret an ill-considered retreat from an important and necessary part of dental practice. (Taylor 1965).

The document did however receive an official reply from the Australian Dental Association, in particular from Dr. J.M. Wark. (Appendix 1). The Faculty of Anaesthetists elected to re-issue this document in 1970, and its contents are awaited with interest.

Burrell (1954) looked to the future of anaesthesia in Australia, and noted that specialization was a comparatively recent advance in this country, and discussed financial considerations which were a problem for the anaesthetist. The undergraduate training she felt had deteriorated, but as general practitioners were likely to be called upon to administer anaesthetics for some years to come, particularly in country districts, 'they must be taught in their undergraduate days certain basic methods, and taught them well'.

Marshall (1949) and (1954) discussed aspects of the teaching of anaesthesia and in the latter paper the
gradual change from the teaching of 'straight' ether, to thiopentone intravenous induction was noted. The tendency of practitioners (medical) particularly in country districts not to familiarise themselves with new techniques particularly intravenous methods, gas machines and muscle relaxants and the preference to conform with 'local custom and opinion' was noted. The process of change was slow, said Marshall, but meanwhile, 'students and new graduates should be given adequate instruction in standard methods, and facilities for proper training should be established for those wanting more detailed or special knowledge'.

Troup (1954) also discussed some of the current problems, the foremost of which he saw as 'that of teaching'. This, he said, was a greater need than research. The teaching of 'open ether' was giving way to intravenous induction. From a teaching point of view it was regrettable, that the 'stages and signs of anaesthesia' as a teaching basis was being lost.

In 1961 the Nuffield Foundation announced a grant of 25,000 Pounds for the establishment of a Chair in Anaesthetics within the University of Sydney, the first of its kind in Australia. Professor Douglas Joseph was appointed to this Chair.

Dwyer (1967) discussed some of the problems in the specialty of anaesthesia as he saw them at this time. He felt that providing an anaesthetic service was a crushing burden.
No doubt we brought this on ourselves when we adopted the British standards whereby only physicians were considered competent to administer anaesthetics, whether they were adequately trained for this or not. In this we have stood apart from America and Europe, where nurses or technicians have been trained to provide the bulk of the anaesthetic service. The first step in this is, I believe, a national survey of the community's needs and of the varieties of anaesthetic practice required in different areas. At the same time, the professional and economic security of anaesthetists must be guarded. To me, the nurse or technician anaesthetist or the futuristic concept of automated anaesthesia will remain always a compromise compared to anaesthesia practised by a physician.

Dwyer called for more stimulating undergraduate training and better experience at resident level. He also sought better relationship between anaesthetist and other scientific workers in the basic science departments.

The situation in anaesthesiology was again reviewed by Mackay (1968). She called for more Chairs of Anaesthesia. Of teaching, she said, 'Instruction to undergraduate students has rightly evolved to a stage where little, if any, technical training is given. Teaching should be concentrated mainly on basic principles of anaesthesia, much more instruction being given on intensive care. No medical graduate should be considered competent to administer anaesthetics without postgraduate training'.

Mackay called for an increased status in anaesthetic practice, and felt that one of the new horizons for anaesthetists lay in intensive care units. She also hinted at the
possibility of computer controlled anaesthesia in the future. 

(8) Halothane (Fluothane) and Methoxyflurane (Penthane).

Halothane arose from research carried out in I.C.I. laboratories in England during the 1950's, and its pharmacology was reported by Raventos in 1956, and by Burn et al (1957). The advent of halothane meant a positive end to anoxic techniques in dental anaesthesia.

Goldman (1959) first described its use in dental surgery together with the use of a vaporiser designed specifically for the administration of low concentrations of halothane in conjunction with nitrous oxide/oxygen. 'The technique employed was to induce anaesthesia with pure nitrous oxide for the first few breaths and then, to turn on the Fluothane vaporiser so that a minimal quantity of not more than ⅛ per cent is added to the nitrous oxide. After a few more breaths, oxygen is let in to about 12½ per cent', and then gradually increased to 20 per cent at the end of five minutes.

In a later paper Goldman (1960) introduced the halothane at the time of introduction of the oxygen, and gradually reduced it after the onset of surgical anaesthesia. Goldman found no significant decrease in blood pressure, the patient was more comfortable at the end of the administration, and recovery was reasonably rapid - patients could leave the chair in about two minutes and the building, in 20 to 30
minutes. No cardiac irregularities were observed. The rapid recovery and avoidance of risk of anoxia in young children when treated over long periods were also remarked upon. (each administration lasted a minimum of 25 minutes).

Sara (1961) noted that caution in the use of halothane should be exercised under Australian conditions, as the ambient summer temperature is often high, and this could affect the vapour concentration.

Wolfson (1962) reported similar results to Goldman in the use of halothane as an adjuvant, in more than 6,000 cases. He found it excellent for cases of prolonged anaesthesia associated with multiple extractions. The value of the agent with operations for the small child was stressed. Smooth maintenance could be produced on 20 per cent oxygen, for periods of 15 to 20 minutes if required.

Other British workers, Ayres (1960), Capstick (1961) Rickards (1961) and American, Gatewood (1962) all reported favourably on the use of halothane in dental anaesthesia. In 1962, Bourne presented 'a fresh approach' which represented a major turning point, in the history of dental anaesthesia. Restriction of oxygen could no longer be considered tenable, and the following principles were laid down:

We should have an apparatus that encourages the use, from start to finish in every case, of a standard 75/25 mixture. This would five 4 per cent
more oxygen than atmospheric air - a valuable contribution to safety with any anaesthetic; and the resulting concession in nitrous oxide is too small to make any difference that would be discernible clinically. The gases should be delivered through flowmeters, so that the anaesthetist can tell at a glance that the patient is getting the correct amounts - a safe-guard that his specialist colleagues in their day-to-day operating theatre work would not for a moment be without. A continuous flow system should be used, the advantages of the intermittent demand-flow system, with variable pressure-control, being largely, if not entirely fictitious. The gas mixture should be led to the patient from a reservoir bag, through wide-bore tubing and with an expiratory valve close to the patient's face, exactly like the set-up on an ordinary Boyle's apparatus. It is often an advantage to use an oro-nasal face mask for induction and then change over to purely nasal administration when anaesthesia is established. In many patients nitrous oxide alone is not enough to establish satisfactory anaesthesia. The apparatus should therefore have a vaporiser for adding halothane (Fluothane) because it is without doubt the best available inhalational supplement. This too, should be given in a fixed amount, large enough to be effective, yet without any possibility of overdose. These requirements are satisfied by 2 per cent halothane. Finally, the apparatus should provide oxygen in case of need.

These requirements are met by the Salisbury machine.

(Amalgamated Dental Co). (Fig. 40).
A new technique utilising halothane was described by Marrett (1964). This involved the use of the 'Medrex' apparatus (Fig. 41).

Fig. 40 Salisbury Anaesthetic Machine.

Fig. 41
Medrex apparatus.
The patient is anaesthetised by halothane and 100 per cent oxygen with the occasional use of nitrous oxide, instead of the conventional method of nitrous oxide and minimal oxygen as an anaesthetic with halothane as an adjuvant. The apparatus is designed so that the required halothane concentration needed for surgical anaesthesia is automatically self-regulated by the patient. The most resistant can always be mastered and the dangerous conditions of laryngeal spasm, cyanosis, collapse and induction vomiting have all been abolished.

The apparatus was described and then the technique, which method Marrett considered safer than the use of fixed percentages of halothane as 'it is impossible to forecast the patient's behaviour and requirements'. There was an in-built safety factor in the machine, namely that 'only the breath passes through the vaporiser'. Marrett stated that clinical trials had extended over 25,000 cases, without incident, but stressed that the technique described 'must be rigidly adhered to'.

The use of halothane for pedodontic work, was further illustrated by Goldman (1966), as practised at the Eastman Dental Hospital, London. Induction in small children was accomplished with intramuscular methohexitone, and maintained with nitrous oxide and oxygen in a mixture of 50 per cent and with the addition of approximately 1 per cent halothane vapour. This technique was again described but in greater detail by Rule et al (1967), and recommended as an out-patient procedure for very young frightened patients
or mentally or physically handicapped children. Data was presented from 225 cases.

American oral surgeon, Noble, evaluated the use of nitrous oxide/halothane anaesthesia in 5,800 patients during 6 years of oral surgery practice. (Noble 1967). He reported his results as satisfactory for both patient and operator. Work was carried out more rapidly and smoothly - few complications were reported: 6 per cent of the patients had an excitement stage; 2 per cent had vomiting. The cardiac irregularities encountered were usually easily corrected; 17 per cent of the patients had relatively insignificant transient nodal rhythm; 7 per cent had premature ventricular contractions, and 0.5 per cent had premature atrial contractions.

Another American oral surgeon (Trieger 1965) says of halothane:

It provided excellent relaxation, freedom from excessive salivation and secretions and reduced the need for large doses of barbiturate. It provided for rapid recovery. Since this agent is so potent, exact minute-to-minute observation is necessary during its administration. The experience gained from approximately 1,600 ambulatory patients treated by oral surgery in the office, favours the combination of an induction dose of methohexitol followed by maintenance with halothane to effect rapid onset, a smooth, relaxed anaesthesia and rapid recovery.

There has been some doubt on the association between halothane and liver dysfunction. Powell (1968) warned against its use with patients who have previously shown an 'unexplained
fever, bilirubinuria or jaundice after previous halothane administration. A national halothane study was instituted in 1963 by the U.S. Food and Drug Administration, and results involving twenty million patients in 34 institutions were reported. These fully supported the clinical use of halothane, and its high degree of safety. There was no evidence that halothane produced a harmful hepatotoxic product (Way and Cullen 1968).

The pharmacology of halothane was reviewed by Black (1965). In 1966, Forbes discussed the development of arrhythmias, particularly following the injection of adrenaline during halothane anaesthesia. In 13 per cent of patients studied, arrhythmias were found during light halothane anaesthesia in spite of adequate ventilation and high oxygen concentration. Forbes suggested that local anaesthesia acted as a vehicle for adrenaline and that the use of lignocaine for dental procedures could not be expected to obtund reflex sympatho-adrenal activity consequent upon dental extraction.

The relationship between cardiovascular function and halothane was reported by Goldberg (1968) -

Heart rate may be slowed due to its direct effect on the S.A. node and central nervous system (C.N.S.). Diminution of cardiac output as a result of reduction of stroke volume was said to be the major factor responsible
for arterial hypotension seen with this anaesthetic.

Katz and Bigger (1970) attempted to provide a 'proper perspective' and noted that arrhythmias requiring treatment were rare. They may be due not only to changes in the heart, but also to primary changes in C.N.S. or in the periphery.

The possibilities of cardiac irregularities during dental anaesthesia has been discussed twice in recent years in The Lancet (Cardiac irregularities, 1966; Dental anaesthesia, 1969). In the latter annotation it was noted that in patients under the influence of halothane, cardiac irregularities had been shown to be produced when the trigeminal nerve is handled during section of its root.

**Methoxyflurane**

Introduced clinically in 1959 by Artusio and Van Poznak, this agent has been the subject of some disagreement as to its place in anaesthetic technique. Abbott Laboratories (1968) are of the opinion that this has arisen from different anaesthesiologists having employed different techniques and levels of anaesthesia with methoxyflurane. 'With earlier anaesthetic agents many anaesthesiologists have accepted respiratory and circulatory depression or increased cardiac irritability, as a normal and inevitable part of anaesthetic procedures. They have become accustomed to managing their patients at these deep and potentially
dangerous levels. The principle property however, of methoxyflurane was discovered to be its analgesia, and with less than anaesthetic doses three levels of analgesia were described:

(i) Conscious analgesia.
(ii) Analgesia with unconsciousness.
(iii) Surgical analgesia or 'level of lightness'.

The suggested properties of this agent would seem to render it suitable for dental use. Abbotts say that oral surgery may be carried out with methoxyflurane. Induction may be by intravenous barbiturate. Immediately after the painful manipulation is begun the methoxyflurane is discontinued and the patient maintained thereafter on nitrous oxide/oxygen - 2/3 or 3/1 mixture. Emergence is prompt.

It is further said that 'sensation could be obtunded long before entering the level of deeper surgical anaesthesia, and that profound analgesia exists after only 2 to 3 minutes of 1 per cent methoxyflurane inhalation. Maintenance with methoxyflurane is usually smooth and relatively easy. Once induction is complete, concentration is reduced to approx. 0.5 per cent, sufficient to maintain the patient in the level of surgical analgesia. . . lightness'.

Tomlin (1965) noted that the most notable feature using methoxyflurane was the stability of cardiac rhythm.
Knoll and Stone (1963) used methoxyflurane as a supplemental agent in 52 patients undergoing prolonged restorative dental procedures. They did not find the slower rate of induction or prolonged recovery time as disadvantages. An important paper in the present context was that by Dragon and Goldstein (1967). Methoxyflurane was here used solely for its analgesic properties. It was administered by a Cyprane Inhaler to 262 patients for routine dental operative procedures or simple extractions. A 1 per cent concentration was used for a maximum of 3 minutes after which a local anaesthetic injection was usually made. The main purpose of the inhalation agent was as a 'mood modifying and a pre-injection analgesic'.

A later report on the dental use of this agent was by Callahan and De Leo (1969). They listed the advantages as:

(i) Nonflammable stability.

(ii) Excellent analgesia in light levels - 'single or multiple extractions can be performed on children inhaling methoxyflurane vapour and 2:1 or equal mixtures of N₂O and O₂, in a total time expenditure of less than six minutes... with satisfactory obtunding of salivary, coughing, and vomiting reflexes... without alteration of the patient's cardiovasular or respiratory response'.

(iii) Relative safety during induction - 'the likelihood of precipitous induction is remote'.

(iv) Ease of administration.

(v) Methoxyflurane tends to produce neither laryngospasm nor bronchospasm.

(vi) Cardiovasular stability.
(vii) Compatibility.

(viii) Decreased vomiting incidence.

The disadvantages were:

(i) Failure to manifest the Geudel eye signs.

(ii) Pallor.

(iii) Slow emergence on long cases.

Two techniques were described, with demand and continuous flow machines.

The advantages of methoxyflurane were also enumerated by Cole (1968). In particular he noted the lack of excitement and acute awareness of pain in the immediate post-operative period. Sydney anaesthetist, Jobson, has made extensive use of methoxyflurane (not dental cases) to the exclusion of nitrous oxide, and has designed an apparatus for its administration (Jobson 1968).

He maintained anaesthesia with 0.6 per cent methoxyflurane in air or air-oxygen, and found that patients could be maintained for several hours, leaving the operating theatres with reflexes present and usually conscious. The view advanced was that by means of such a system consistency and accuracy of ventilation are more easily obtainable than by circle methods and a closer approach to normal respiratory physiology during anaesthesia is facilitated.

Jobson made these points:
Methoxyflurane is non-inflammable and non-irritating, is a better analgesic than trichlorethylene, and is compatible with the use of adrenaline. It is potent in very low concentration. Another advantage of methoxyflurane is that the vapour pressure curve is so flat that little variation of concentration occurs over the usual room temperature range, and there is little loss of spontaneous evaporation between periods of use. The ideal use for such an agent is to use it in low concentrations for its hypnotic and analgesic qualities, thus obtaining an effect like that of nitrous oxide.

McDowell (1967) compared the use of halothane and methoxyflurane for dental surgery in series of 100 patients. The advantages of the latter were primarily its not sensitising the heart to epinephrine to the same extent as does halothane, and its economic advantages in longer procedures.

W. Allen (1970) has used methoxyflurane in 12,000 short extraction cases, and 100 long conservative cases, and he has found it a 'perfectly satisfactory alternative to halothane', although a special vaporiser was needed (Cyprane vaporiser) to achieve a one per cent concentration.

A portable unit which allows for small concentrations (notably 0,4 per cent) and oxygen supplement is now (November 1970) available in Australia, (Australian Anaesthetic Equipment Co) - (Bloom 1970) and the present writer hopes to report at
a later date on its dental application.

(9) **Intermittent and Continuous Flow Inhalation.**

**Intermittent (Demand) Flow.**

Intermittent flow machines are so called because the gases do not flow at a constant rate, but vary with the rate and depth of respiration, and cease to flow during expiration. The output varies with the patient's respiratory needs, and this machine measures only the proportion of the two gases and the pressures at which they are emitted. (Langa 1968)""

**Continuous flow**

Nitrous oxide and oxygen are led into a reservoir bag by separate flow meters. The proportions of the mixture in the reservoir bag are determined by varying the flow rate of each gas. The gases flow continually at the volumes and proportions set by the operator on the flow meters. The gases flow under lower pressures.

The Clement/McKesson principles mentioned earlier utilised intermittent flow machines.

Various British workers have stressed the inaccuracy, and in fact the hazard of intermittent flow machines. Hunter and Fraser (1959) discussed the inaccuracy of dental machines, and said that the successful and safe use allowed only a small margin of error, and the idiosyncrasies of the machine must be understood - the occasional anaesthetist was therefore
at a disadvantage.

Nainby - Luxmore (1967) surveyed all the anaesthetic machines believed to be in use by dentists in Southampton (Eng.). Fifty machines were tested - the 'Salisbury' machine with high-flow rotameters gave accurate gas mixtures at various flows. Latham and Parbrook (1967) drew attention to the drawbacks of intermittent flow machines, and recommended continuous flow machines or the use of a premixed gas machine. The use of this latter type they had previously described for dental anaesthesia (Latham & Parbrook 1966).

In 1968 the British Standards Institution adopted specification for anaesthetic machines of the demand-flow type. With respect to delivered oxygen at any dial setting from zero to 100 per cent oxygen and any minute volume from 4 to 30 litres per minute a tolerance of ± 5 per cent is the highest allowable error.

Allen et al (1969) studied demand-flow machines, which they found to be inaccurate and uneconomic when compared to continuous flow machines. In a further report, Allen, with Everett and Hornbein (1970) detailed the probable cause of a fatality involving the demand-flow machine, and drew attention to the hazards of rebreathing with the McKesson Narmatic machine.

The hazards then are:

(i) Possible restriction on patient's breathing.
(ii) Pressure against expiration can place a load on patient's circulation.

(iii) Unpredictable variations of function.

(iv) No provision for convenient or satisfactory ventilating assistance.

Bell (1969) sought the reasons why general anaesthetic procedures for dental out-patients were 'eschewed by most professional anaesthetists'. It was felt that association with older intermittent flow machines may have been responsible for open techniques falling into disrepute. With nasal mask connected to a Boyle type machine: gas flows are known precisely, vaporisers behave predictably, a rebreathing bag gives familiar induction of adequacy of tidal respiration and supplies a ready means of respiratory assistance. It is suggested that inhalation anaesthetic methods with re-appraisal of continuous flow machines for dental procedures, should now be made.

(10) **Inhalation analgesia**

As previously noted inhalation analgesia has been recommended with enthusiasm for dental procedures at intervals, notably (1913-18) and the mid-1930's. In recent years there has again been a revival of interest, with even a complete text-book being devoted to the subject. (Langa 1968).

Prominent advocates of the technique have been Klock (1951 and 1955) and Tom (1956, 1968). Klock describes
the state of 'Ammalgesia', which he said was a 'very precise and well-defined plane of general anesthesia in the first stage. It exists between... the analgesic stage and the excitement stage.' Ammalgesia was defined by Klock as:

...a state of general anesthesia induced by the administration of a minimal amount of a general anesthetic drug or combination of drugs in conjunction with local block or infiltration anesthesia of the operative field.

Klock and Tom have demonstrated that in about 1½ minutes (average of 40 breaths by the patient) a satisfactory state of analgesia, tranquility and amnesia can be obtained in all but the most resistant patients, and in these, irrespective of what operative procedure may be contemplated, full general anaesthesia under suitable conditions is required. The technique utilises 20 to 30 per cent oxygen with nitrous oxide. Favourable conditions are generally produced, although Tom (1968) recommends supplementation with trichlorethylene or divinyl ether if the patient will not settle. The safety of the technique has been stressed, together with the rapid recovery. It has also been suggested that ammalgesia is easy to learn, to use, and to teach.

The use of nitrous oxide/oxygen analgesia for dental work has been discussed by Trieger and Carr (1969). They describe Analgesia as providing an important adjunctive aid to the management of the dental patient. It helps to establish enhanced rapport by decreasing anxiety. It does
not substitute for either local or general anaesthesia.

Personal correspondence with Allen (1970) has indicated a considerable renewal of interest in nitrous oxide/oxygen analgesia in the United States. Purpose built analgesia machines are now available in the United States and in Britain. The Dentalgesic machine (Dentatron Corporation), and the Quantiflex R.A. Machine (Fraser - Sweatman Inc.) (Figs. 42, 43) are notable examples. Features of these machines are 'fail-safe' oxygen flow - an alarm sounding on the Dentalgesic if the oxygen flow is less than 2.5 litres/minute. Nitrous oxide flow stops automatically if the oxygen pressure drops below an adequate level. These machines are equipped with large colour-coded flow meters, and an immediate oxygen-flush push button (Fig. 44). Administration is by nasal mask (Fig. 45) or nasal cannula. (Fig. 42).
Fig. 42 Demonstrating administration of Nitrous oxide/oxygen analgesia with the Dentatron Dentalgesic machine. Note the use of nasal cannula.

Fig. 43 The Quantiflex R.A. Relative Analgesia Machine.

Fig. 44 Controls - Quantiflex R.A. analgesia machine.
The present writer has employed the Quantiflex R A machine (on loan) for twelve cases over the period (Nov. 24 - Dec. 4, 1970) - This method would appear to have definite application in the provision of short-term sedation.

(11) **Intravenous anaesthesia/sedation**

Intravenous methods for dental procedures are not new - the use of evipan and thiopental having been already described. In the past decade however, there has been strong advocacy in certain quarters for a definite place for intravenous agents and methods in routine dental practice. This advocacy has particularly concerned methohexital (methohexitone), but has also embraced propanadid and techniques which provide sedation and analgesia.

(a) **Methohexital** (Methohexitone sodium, Brietal)

The pharmacology of methohexital was first investigated in 1955 by Gibson et al., and the early form called Compound 22451. Subsequently, this was fractionated, and the
alpha-dextro-levo racemic mixture which came to be called Compound 25398 was given clinical trial. In 1957 Stoelting reported on its use in 285 cases, as an induction agent with dosage varying from 40 to 220 mg, utilising one per cent solution. He found that 'patients were relatively free of any serious complications', although apnoea was a common finding, if injection was too rapid.

Compound 25398 became methohexital sodium, and its first use for dental procedures was by Redish et al (1958), when it was compared as a 1 per cent solution to 2.5 per cent thiopental sodium, and 5 per cent methitural sodium. The results indicated the greater potency of methohexital and a more rapid recovery time.

Wyant and Chang (1959) made comment on the intermittent use of methohexital which they found unsatisfactory. The high potency with very short duration of the drug they found made it almost impossible to maintain smooth anaesthesia without causing either apnoea or awakening. Administration by a continuous intravenous drip was almost mandatory for any procedure lasting more than a very few minutes. This rendered the administration of methohexital somewhat cumbersome for the short procedures for which it is most useful.

A further study of the use of methohexital - with 'office oral surgery procedures' was undertaken by Recant (1960).
2,500 cases were involved - 'most procedures were of less than five minutes duration'. He concluded that 'properly employed by experienced anaesthetists, and used in conjunction with oxygen or nitrous oxide and oxygen and/or local anaesthesia, methohexital represents the closest approach to the ideal general anaesthetic for the ambulatory oral surgery patient'.

In Britain, the first clinical trials were carried out by Coleman and Green (1960), who used doses ranging from 50 to 220 mg. of 1 per cent solution, with an average of 70 mg. They said, 'Our main objects were to obtain quiet dental anaesthesia without hypoxia, and to achieve a rapid recovery...'. Methohexital was given intravenously as rapidly as possible. The dose, 5 mg. per stone of body weight, was the minimum which experience had shown consistently to produce sleep for two minutes. As soon as the patient was asleep, a mixture containing 15 per cent oxygen and 85 per cent nitrous oxide was administered with a nasal mask. 1½ - 3 minutes were required in the majority of cases to establish satisfactory conditions for operation. At this stage the oxygen percentage was increased to 20 per cent. Taylor and Stoelting (1960) reported the use of methohexital in 3,340 surgical patients. They used a 1 per cent solution and an average induction dose of 70 mg., and found the main disadvantage to be pain along the vein following injection,
while laryngospasm, hiccups and coughing occurred infrequently.

Further trials were undertaken in Britain in 1960, by Green and Jolly, using methohexital as an induction agent followed by nitrous oxide/oxygen. 500 dental outpatient cases were involved. The oxygen percentage was increased to 20, after a period of 1½ to 3 minutes. In 15 patients it was necessary to supplement with another agent (mostly trichlor-ethylene). Ninety-four per cent of patients were deemed fit to return home within half an hour. Patients' reaction was tested by means of questionnaire, and results were extremely favourable. Methohexital was considered to have, 'great promise in dental anaesthesia. . . .'

Throughout the 1960's various workers reported on the use of methohexital in dentistry. Hubbell (1960) used it in 2,500 cases for oral surgical procedures, by induction dosage followed by intermittent doses if indicated. He noted that 'most patients tolerated surgical procedures in very light planes of anesthesia, with the swallowing, cough and gag reflexes active. Half of the patients would tolerate surgical procedures after the induction dose was apparently completely spent, and the patient appeared to be awake. A few reported feeling the surgical procedure, but none complained of feeling pain. The lighter planes of anesthesia with active protective reflexes which are possible with methohexital sodium make this a safer general anaesthetic
agent for oral surgery.'

Lyon (1961) studied a series of 513 patients undergoing oral surgery procedures under methohexital anaesthesia, which was found to exhibit the property of producing amnesia in extremely light anaesthetic planes. Myers and Coltman (1961) analysed a series of 1,000 cases where methohexital was used as the sole anaesthetic in 78 per cent of cases, the remaining 22 per cent being supplemented with nitrous oxide/oxygen. These workers used a standard induction dose of 100 mg. They concluded: 'The 'single shot' method of anaesthesia, named by one of the writers as intrasthesia, which included necessary supplementations, represented an advance in modern dental work for use by the general practitioner dental surgeon in his surgery.

New Zealanders, Wilkinson and Wilkinson (1963), used methohexital as an induction agent in 96 cases with nitrous oxide/oxygen maintenance.

Goldman and Harris (1963) compared methohexital and thiopental as induction agents in a series of 1,025 patients. Comparison was also made between differing doses of methohexital. They concluded that 8 mg. per stone dosage gave 'smoother maintenance' and recovery was even more prompt than when thiopental had been employed. Goldman in a further study with Harris (1964) undertook clinical trials
on a series of 298 patients, and compared 1, 2 and 5 per cent concentrations. They found a 2 per cent concentration the most satisfactory, and summarised:-

(i) In this concentration methohexitone does seem to possess analgesic properties. It was possible to extract 1 - 3 teeth under very satisfactory operating conditions in all cases.

(ii) Induction of anaesthesia seemed smoother with this concentration of the drug.

(iii) Recovery and leaving times compared very favourably with those of the 1 per cent concentration.

(iv) A drop of blood pressure when it did occur was decidedly less than with 1 per cent.

(v) Operating conditions as a whole were more satisfactory, though twitching was more noticeable with this stronger concentration.

Possibly the most comprehensive study of the dental use of methohexitonal (as an induction agent) was by Young and Whitham (1964). They observed results from 2,000 patients undergoing dental surgery under general anaesthesia in the sitting position (in this respect the authors found the incidence of fainting to be 1 in 500, and said that 'providing the anaesthetist is quickly aware of this phenomenon and the patient immediately put in a horizontal position... no serious harm will result'). Their sequence consisted of a single dose of methohexitonal (mean male 10.8 mg/stone, female 7.5 mg/stone) followed by nitrous oxide/oxygen and in 30 per cent of cases supplemental halothane.
They found a 'still operating field' in 98 per cent of cases, while 97 per cent were Romberg steady, and fit to leave within 30 minutes. They said that 'immobility of the patient should represent a criterion by means of which the relative merits of various dental anaesthetic techniques can be assessed'.

The question of 'recovery' was raised by Hutchinson and McNeill (1963) who felt that many patients who had had methohexitol, were not as fully recovered as they or the anaesthetists may think. They may 'lapse into further sleep or amnesia for recent events after apparently complete waking, which could put patients in considerable danger if they are allowed to leave the hospital unaccompanied too soon'.

The practical application of methohexitol for dental procedures was reported by Wilkinson, Foreman and Neels (1965). Three methods were employed:

(i) Single dose method for simple extractions with dosage used being constant, viz., 80-100 mg. for females and 100-120 mg. for males. 3,404 patients were treated in this manner.

(ii) Intermittent dose method, where maintenance doses of 30-40 mg. were given 3-10 minutes apart. 3,300 cases were so treated.

(iii) Induction agent, followed by nitrous oxide and oxygen, or a combination of the intermittent method with inhalation for resistant patients. Atropine (1/50 - 1/100 gr.) was also given for any cases of longer than five minutes duration.
These workers found that metabolism was rapid, the cough reflex always present, there was no significant depression of respiration, and noxious effects were minimal.

The first report of clinical investigation of methohexinal sodium for other than dental use in Australia was by O'Leary (1962) at St. Vincent's Hospital, Sydney. The injection of 100 mg, was 'given rapidly'. Effects on respiration, blood pressure, pulse rate and cardiac output were recorded. O'Leary noted 'because of the ultra-short action of the drug, a smooth methohexital, nitrous oxide/oxygen and relaxant technique was found to be impossible'. He concluded that 'It appears to be a powerful respiratory depressant, but does not possess severe cardio-vascular toxicity. Its analgesic properties are poor... it does not appear to warrant any priority over thiopentone'.

Crankshaw (1962) however, in presenting a paper before Australian anaesthetists listed advantages as compared with thiopentone:

(i) Stable in solution for 6 weeks as compared with 48 hours for thiopentone.
(ii) More rapid onset, and more rapid recovery.
(iii) Post-operative nausea and vomiting rare.
(iv) Hypertension less frequently observed.
(v) Vasoconstrictor action lacking (no sloughing, tissue breakdown or thrombosis).

Slow injection was recommended.
Canadians, Simpson and Rondeau (1966) used methohexitol in three techniques:

(i) Short operations used alone,

(ii) Cases of moderate duration, 'Here, after an average initial dose of 150 mg. of 1 per cent methohexitol with atropine 1/100 gr., is injected fairly rapidly, a nasopharyngeal tube is passed and anaesthesia is maintained with nitrous oxide, oxygen and halothane'.

(iii) Cases of longer duration, in which 30-40 mg. of succinylcholine was added, and a nasotracheal tube passed. The aim stated by the authors was to provide optimum conditions for out-patient anaesthesia.

The following complications were noted: vein irritation, involuntary movements, hiccup, laryngospasm (4 per cent of cases), coughing, nausea (rare), post-operative pain, crying and restlessness.

The dental application of methohexitol has only once been reported in the Australian Dental Journal, by New Zealander, Foreman (1967). His article concentrated on the 'intermittent technique' to produce an 'amnesic - analgesic state in which all normal reflexes are retained throughout the operative period, which is unlike general anaesthesia'.

Foreman was at pains to point out that operating was performed only at 'light levels which do not cause loss of the eyelash reflex'.

The intermittent use of methohexitol as advocated, has met with opposition from anaesthetists. Brophy (1968) has presented 'considered' opposition. She claimed that barbiturates had no analgesic effects, and were actually 'anti-analgesic'. (She quoted Dundee, 1964, who showed that sub-
anaesthetic doses of methohexital produce increased sensibility to somatic pain.) She then discussed complications and effects - amnesia, she said, was not specific to the drug, lack of cumulation, she said, was not true; incidence of laryngospasm, lack of pulse monitoring, hypotension and hiccups; altogether presenting a highly critical review. In her summary Brophy states: 'The argument that millions of patients have been given intermittent methohexital in Britain, in no way enhances arguments that it is a safe technique'.

Shafto (1969) discussing the use of methohexital in paediatric dentistry has this to say:

Anaesthetists whose experience with methohexitone has been confined to its use as an induction agent prior to an inhalational anaesthesia, may be surprised at the type of anaesthesia reported in this series of cases in which it was used as the sole agent throughout the operation. The situations are completely different. When used only as an agent for the induction of anaesthesia it is administered to a patient who is not in receipt of painful stimulation and the picture is that of a drug producing a powerful hypnotic effect and respiratory depression. In the present series of cases, however, the patient was undergoing a painful operation while anaesthetized with a drug which is predominantly an hypnotic and amnesic agent. In these circumstances the stimulus provided by the commencement of the operation produced profound reflex effects.

The intermittent technique for methohexital has been primarily expounded in Britain by the 'Society for the Advancement of Anaesthesia in Dentistry' (S.A.A.D.). The technique is described as 'ultra-light anaesthesia'. It
is emphasised by this Society that 'ultra-light anaesthesia is a state of unawareness in the patient of his environment, or of minor stimuli. It is distinguished from conventional anaesthesia by the retention of the glottic and swallowing reflexes, and is the safest level of anaesthesia that can be produced. Methohexitone is known to produce this level, and is short in duration and free of side effects'. (Buxton 1967).

Fig. 46: Set up for Intermittent Methohexital advocated by S.A.A.D. 1965. Small increments of methohexital are injected according to reaction of patient to stimuli.
Fig. 46b: Intermittent Methohexital (1970). Patient now reclined and operator seated.

The number of dental practitioners who have been influenced by the teaching of this Society is considerable, and this has included many Australian graduates.

Criticism in Britain to date has been primarily from a Joint Sub-Committee on Dental Anaesthesia sponsored by the Ministry of Health (1967). This committee felt that methohexital depressed respiration, and 'with increasing dosage eventually produced apnoea followed, if recovery occurs, by a gradual return of respiratory function'. The barbiturates in general have little powers of pain relief or of abolishing the motor responses to pain, and if the patient is unconscious, so long as he is breathing adequately he is likely
to be reactive in varying degree to painful stimuli.

A second major criticism arose from physiological studies on patients subjected to intermittent methohexital by Wise et al (1969). In summary the points arising from this study were:

(i) Patients were repeatedly having surgical anaesthesia induced, recovering, and then being reinduced.

(ii) Laryngeal reflexes not active at all times.

(iii) One or two doses of methohexital cause no great physiological upset.

(iv) It was noted that if peripheral resistance was suddenly increased in response to pain the raised cardiac output into the rising resistance system caused quite severe hypertension.

(v) Normal circulatory reflex response to hypoxaemia obtunded.

Another like study has been conducted by Thornton et al (1969 and 1970) who found that, in their hands, the technique was 'inferior in almost all its aspects to the standard local anaesthetic technique'. Tests carried out on patients undergoing treatment under intermittent methohexital (I.M.T.) were E.C.G., pulse, blood flow, oxygen saturation and respiratory excursions. 0.6 mg. atropine was also given to the I.M.T. group. Some of the findings of this study when given careful scrutiny however, seriously question whether it was the agent or the technique which was the major influence.
The application of methohexital in dental anaesthesia was further discussed by Thornton (1970), who summarised the pharmacological properties which he said should be borne in mind when discussing its place in dental practice. He found that methohexital had a distinct place in dental anaesthetic practice, but should not be employed in situations where pharmacological properties which it does not possess are demanded from it.

Methohexital has more recently been advocated (Foreman 1970) and used as sedation, accompanying local anaesthesia. The technique is dependent on the administration of sub-anaesthetic levels of methohexital, with short (less than 20 minutes) procedures. This method would seem more in keeping with its known pharmacology and neurophysiological effects.

(b) **Propanidid (Epontol)**

A non-barbiturate short acting intravenous anaesthetic, propanidid is a phenoxyethyl oxyacetic acid derivative. Preparation was carried out in Germany in the Bayer research laboratories, and animal experiments conducted in 1960. Propanidid was first introduced into Britain in October, 1962, and first reported in a British publication by Dundee and Clarke (1964). The Bayer handbook (1965) reports on clinical experience of over 25,000 anaesthetics which indicate short duration, and rapidity of recovery. It is stated to be
suitable as a sole agent in 'small numbers of dental extractions, or incision of abscesses'. The rapid recovery time is said to make Epontol, 'an ideal anaesthetic for dental procedures'.

Goldman and Kennedy (1964) used propanadid on a number of patients requiring one or two dental extractions and found excellent operating conditions. Swerdlow (1965) described the use of propanadid in 302 patients undergoing dental extractions, 140 of which received it as the sole anaesthetic. The dose administered varied from 5 to 8 mg./kg. Resistance or resentment was noted in some patients, and three developed thrombophlebitis. In comparing propanadid with methohexital the author states that propanadid gives slightly better analgesia. The recovery of consciousness appears to be equally rapid, but the "going home time" was shorter with propanadid. The difference is more marked with larger doses of the two agents.

Australian experience with propanadid was reported by Gunner et al (1965) and Cole (1965). The former regarded it as useful for short procedures or electroconvulsive therapy, but at a disadvantage as an induction agent, while Cole regarded it as 'especially suitable for out-patient use'. He said that in therapeutic doses there was no appreciable analgesic effect.
Howells (1966) discussed the properties and operating conditions with propanadid. The main points were potency, non-occurrence of laryngospasm or bronchospasm, no known incompatibilities, and rapid breakdown.

Clarke and Dundee (1966) compared the cumulative effects of thiopentone, methohexitone and propanadid. They found that propanadid was rapidly destroyed in the body whereas the other agents are translocated into storage depots. Work of Doenicke and colleagues (1965) is quoted which indicated that complete electroencephalographic recovery after an anaesthetic dose of propanadid occurs in 5 - 10 minutes, whereas after methohexitone it takes many hours.

In a later paper Swerdlow (1967) felt that repeated injection of propanadid was dangerous due to the danger of depression.

In reports of dental cases carried out by members of S.A.A.D. (1967), the viscosity, and the need for a large needle were mentioned. Other points were:

(i) Patient selection to avoid thrombosis.

(ii) Larger dosage than methohexital.

(iii) Avoidance of patients with kidney deficiencies.

(iv) Little post-anaesthetic analgesia.

(v) No post-extraction amnesia.

Absence of pain on recovery was however, observed by Schofield and Jepson (1967). They also reported no cases of haematoma
or venous complications. The technique used by these writers was an injection of 1 ml. (50 mg.) per stone of body weight at a rate of 1 ml. per 1.5 to 3 seconds. 2 ml. increments are added if the anaesthesia appeared too light.

The use of propanadid intermittently was studied by Cadle et al. (1968). Diluted solution (5 per cent) was used and dosage calculated at 6 - 8 mg./kg. Increments of 3 - 5 ml. (75 - 125 mg.) were given if the patient showed signs of screwing up the eyes or a purposeful movement. 126 cases were treated, mostly for extractions with an average length of procedure of 6 minutes. Side effects were minimal. There was a low incidence of nausea and vomiting although the latter did occur in 3 cases (post-operatively). The authors considered the technique particularly useful as an agent 'for extraction where a good analgesic effect is required, if purposive movement is to be avoided'.

(c) The Jorgensen Technique

This technique, devised by Jorgensen of Loma Linda University, California in 1946, utilises for sedation purposes, pentobarbital sodium, pethidine hydrochloride and scopolamine hydrobromide. Jorgensen worked initially on methods of providing pain control for spastics and other problem patients. He found that nausea which attended the use of pethidine, could be eliminated by a preceding dose of pentobarbital which doses must be adjusted to an individual
level. The Jorgensen technique for dental treatment makes for the establishment of tranquil operating conditions for extensive conservative or oral surgical work over a prolonged period. Case reports using this technique are recorded in Section 2. The procedure, indications and contra-indications are more fully described by Jorgensen (1967), Drummond-Jackson (1967) and Jorgensen and Hayden (1967). Some clinicians have recommended modification, commonly with methohexital as an additional cover for the local injections, or extractions. (Attwood 1963).

Cass (1969) who has personally observed Jorgensen's work regards the methods and dosages involved as over cautious, light, and without hazard. Further discussion on this technique will follow in Section 2.

(d) **Pentazocine** (Fortral, Talwin)

Introduced in 1965, pentazocine is an analgesic being virtually free of the addiction possibilities of other similar agents such as pethidine. It is compatible with scopolamine hydrobromide and has no interaction with pentobarbital. As such, this drug represents an alternative to the use of pethidine in the Jorgensen technique. Its use for the relief of post-operative pain following dental surgery has been reported by Nasits (1967) and Versnel and Duncan (1966) whilst Kurland (1968) has presented dental
cases in which pentazocine has been combined with an intermittent methohexital technique.

(e) **The Ataractic drugs**

The modern era of Psychopharmacology began in 1952 when French clinicians discovered that chlorpromazine had the property of sedation without the usual hypnotic effect (Weintraub 1969).

Ataraxia is that state in which there is calmness and peace of mind and an ataractic, a drug which produces this state. In the context of this paper two will be mentioned - Diazepam (Valium) and Hydroxyzine (Atarax).

(i) **Diazepam (Valium)**

Was developed in 1961, and reported by Randall et al after which it was increasingly used to treat anxiety states. The first recorded intravenous use in dental surgery was by Davidaou of Paris, in 1966. In Britain, Main (1968) treated his first case in November, 1966. Subsequently 60 cases were treated, and a maximum of 10 mg. diazepam was used. Atropine 0.4 mg. was given, and methohexital 30 - 40 mg. while the local anaesthetic was injected. The results of this study showed that amnesia was readily produced, and recovery more rapid than from the Jorgensen technique. There was little post-operative disturbance. In 83 per cent of cases the results were ideal, 10 per cent of cases good, and 7 per cent poor.
Katz et al (1967) testing blood pressure relationship to diazepam administration, found no clinically significant pulse or blood pressure alterations on the injection of 10 mg. diazepam.

A symposium in October 1968, discussed the dental use of diazepam, the speakers being O'Neil, Fitzgerald, Main, Verrill, and Davida. (O'Neil et al 1968). O'Neil indicated that 'under general anaesthesia the accumulation of blood and saliva etc., necessitated air-way control', but if 'patients could be sedated, anaesthetic assistance may not be required and recovery problems simplified. O'Neil concluded that diazepam would have a useful future in helping nervous dental patients overcome their fears. Fitzgerald discussed the use of diazepam in general practice and suggested its use for 'the surgical case' or 'up to 90 minutes conservation'.

Main noted that further to his earlier report (Main 1968), in further cases he had reduced or eliminated the methohexital, but increased the diazepam. Main also reported results from 73 cases of diazepam and found the average dosage was 13.5 mg. Verrill noted that the observance of the level of the upper eyelid was a useful sign to determine the sedation level - the lid being at this stage half-way across the pupil.

Rattray (1968) reported his experience with diazepam in general dental practice in various operations, while Brown,
Main and Lawson (1968) described a further series of cases in which higher doses (up to 20 mg.) than in the earlier report of Main (1968) were used. It was noted that short-comings of intermittent methohexital and Jorgensen techniques were to a great extent overcome with intravenous diazepam.

O'Neil and Verrill (1969) used a diazepam sedation for oral surgery, commonly excision of impacted third molars. Results from 52 cases were reported. 'Very good co-operative sedation was obtained in 37 cases; 14 cases showed minimum stirring with phonation, but were controllable, two cases were unsatisfactory, and were completed under general anaesthesia with methohexital'. Amnesia was noted as a particular effect.

Khosla and Boren (1969) found intravenous diazepam to be very satisfactory premedication for patients undergoing oral surgical procedures under local anaesthesia. A second symposium reporting favourably on further clinical trials of intravenous diazepam was held in June 1969 (Laurence et al 1969).

(ii) Hydroxyzine (Atarax)

This agent has been used as a pre-operative tranquilliser for routine procedures and oral surgery, but principally by the oral route. There have been few reports of its use intravenously. Linenberg et al (1961) reported seven cases of 50 mg. intravenous administration prior to
nitrous oxide anaesthesia for extractions. The effects in all seven patients were rated 'good'.

Shane (1966 and 1968) described the use of hydroxyzine (dosage 25 - 50 mg.) in combination with alphaprodine hydrochloride, atropine sulphate and intermittent one percent methohexital. Shane claimed that 'the public should be offered a complete nonhospitalized dental service in one sitting'; and put forward this technique as a means of achieving this, with elimination of anxiety, and accompanying amnesia. Shane also employed 'intensive suggestion' before the administration of the intravenous agents, when the 'patient is led to believe that the operation will be performed and completed while he is asleep, and that he will be allowed to awaken during the final trimming and polishing phase'. Intravenous hydroxyzine is not marketed in Australia.

(f) Ketamine Hydrochloride (Ketalar)

This agent, the advent of which has aroused fresh speculation on the possible role of the intravenous route in dentistry, with its production of a dissociated state, was investigated by Corsenn and Domino (1966) and by Stöcker (1966). Ketamine could represent the first practical application of Neuroleptanalgesia produced by a single drug.

Neuroleptanalgesia is the name given (de Castro and Mundeleeer 1959) to a state of sedation and indifference to the environment combined with analgesia (plus the
protection of the organism against surgical pain by selective cellular blocking) - and the ability to co-operate if required. (Huguenard 1968).

Stöcker found cough and swallowing reflexes retained and respiration not influenced. Pronounced salivation occurred in the absence of atropine. Nausea and vomiting were not induced. 65 cases were studied undergoing 'surgery of the jaw'.

A more comprehensive study was by Langrehr (1969), who analysed results of 1,300 ketamine anaesthetics (678 as the sole agent) which included dental extraction, and as a result of the experience of this study, extraction and abscess incision were given amongst major indications, although it was not felt suitable for ambulatory anaesthesia.

Corsenn et al (1969) indicate that the drug is 'safe, effective and reliable' as an anaesthetic for short lasting surgical or diagnostic procedures. The advantages are said to be 'ease of administration, powerful analgesic action, and lack of respiratory and cardiovascular impairment'. Of considerable significance was the report that ketamine hydrochloride did not obtund protective laryngeal and pharyngeal reflexes, and because of the lack of relaxation of the muscles of mastication and the tongue, an unobstructed airway was maintained without artificial support of the tongue, or the need for endotracheal intubation. Their study included a series of 115 cases, mostly children, undergoing extraction.
Intravenously administered at a dose of 0.5 to 1 mg. per pound of body weight, ketamine hydrochloride produced surgical anaesthesia within 15 to 30 seconds, that lasted from four to ten minutes.

Given intramuscularly at a dose of 5 mg. per pound of body weight ketamine hydrochloride produced surgical anaesthesia in 2 to 3 minutes that lasted 20 to 40 minutes.

The selective dissociative action of the drug is characterised by profound analgesia combined with a peculiar state of unconsciousness - the patient appears disconnected rather than asleep. When entering anaesthesia the eyes are open, nystagmus is prominent, and after a few seconds the eyes become centered and appear in a fixed gaze. (Corseun et al 1969).

Nausea and vomiting during post-anaesthetic recovery were found to be rare, although undesirable psychomatic activity may be observed if the patient is awakened prematurely. This so called 'emergence phenomenon' has resulted in some condemnation of the usefulness of ketamine - at least with adults. (Hubbell 1970; Davidau 1970). However, Sweet (1970) reports results of a study of emergence reactions in over 12,000 patients, when the overall emergence phenomena incidence rate was a little over 13 per cent, only 1.6 per cent having had unpleasant dreams.

Further study would seem to be needed before the dental application of ketamine is clarified.
(12) **Renewed Interest**

In the United States in 1953, the 'American Dental Society of Anesthesiology' was founded. This society publishes a two monthly journal - *Anesthesia Progress*.

In Britain the Society for the Advancement of Anaesthesia in Dentistry (S.A.A.D) was formed in 1957. This society has been active in seeking better dental anaesthetic methods and had undertaken to the end of 1970 some 62 short post-graduate training courses. A quarterly journal, *SAAD Digest* is published.

In Queensland a branch of the S.A.A.D. was formed in 1961, although not particularly active, while in 1968 a group formed in Sydney named the 'Dental Sedation and Anaesthesia Study Group'. At time of writing this group numbered 60 members. On 16th June, 1970 the Group was renamed 'The Australian Society for the Advancement of Anaesthesia and Sedation in Dentistry' (A.S.A.A.S.D.)

An intense interest in intravenous and inhalation analgesia has been observed in the Western United States. Post-graduate courses have been over-subscribed. Allen (1970) states that the evaluation of intravenous and inhalation analgesia was 'the most critical need in this country (U.S.A.) at this time'. It is obvious that the undertaking of ground work, research, both scientific and clinical, and educational aims and policies must be given serious consideration by appropriate bodies in Australia.
IX. ANAESTHETIC DEATHS

A study of the Dental Acts of the U.K., the various Australian States and New Zealand will reveal that,

(a) Some acts define dentistry in the most broad and general terms — e.g. the U.K., Victoria, Queensland.

(b) Some acts set out in detail the various duties of the dentist e.g. New Zealand, South Australia and N.S.W. [The specific section of the N.S.W. Dentists Act 1934-1957 is Section 3(2)]. A standard clause in this group reads as follows:

'Practice of dentistry' includes:

(b) The giving of any anaesthetic in connection with any operation of the human teeth or jaws.

Recently the Dental Board of Victoria gave detailed consideration to the amendment of the Medical Act (1958) Part 11 (Dentists), and it decided to recommend the retention of this clause defining dentistry in the most broad terms. In arriving at this decision, the Board realised that with a specific definition, great significance might be placed upon any omission therefrom. (Wark 1969)

Scott (1935) made this observation, which could still hold true:
Our legal position seems to be that we are perfectly entitled to administer gas, until we kill a patient. Then we have to convince a coroner that we are competent. His decision is made largely on the evidence of medical men, who may not be in a position to judge if sufficient skill has been used. When a medical man has a death under an anaesthetic he may have an enquiry, but his right to administer an anaesthetic and his skill are not questioned. If that is our right also, then some provision should be made to give us a legal standing equal to that of a medical man, and sufficient to enable us to withstand the inferences made when Truth reports a "Death in a Dental Surgery".

Many dentists are uncertain as to their legal situation as it relates to general anaesthesia, and this uncertainty has been an important factor in deterring dentists from this field. 'Expert evidence' called would invariably be that of a specialist anaesthetist, and this may not necessarily favour the dentist.

Stated simply then, a dentist may administer an anaesthetic provided,

(a) That he has the patient's permission to do so — or in the case of a minor, permission from the patient or guardian.

(b) That in the case of misadventure, he can prove to the court that he had sufficient training and knowledge to administer the anaesthetic — and that he exhibited a reasonable degree of fore-thought, judgement and care.

Stephens (1966) has said that 'general anaesthesia,
for those in good health, seems safer than flying ... and can scarcely be counted per se as a significant hazard to life'! The problem of anaesthetic deaths has however, been concomitant with the history of anaesthetic administration. Some of the early experiences with chloroform, in particular, have been related in earlier chapters. Attention was drawn at the turn of the century to the dangers of chloroform (Embley 1902), and yet it continued to be used for at least another 50 years. The relationship between anaesthetic use and the demonstration of its hazards are an anachronism.

Hornabrook (1928) said:

I do not believe that deaths which arise when under the administration of anaesthetics are not preventable. I know they are preventable, and they are the result of an error of judgement. There is only one rule ... that the anaesthetist ... must learn ... never gamble. The mere fact that a man may administer an anaesthetic to a patient and produce in that patient a state of surgical anaesthesia does not necessarily make him an anaesthetist — not by any means.

Hornabrook believed that coroner's inquests were valueless and he doubted whether the 'whole truth' was obtained from these enquiries. He cast doubts with respect to the condition of 'status lymphaticus' which was said at that time to be responsible in numbers of anaesthetic
deaths, and he felt it a 'cover for ignorance and incompetence'. [The British Medical Council in 1931, reported that it was unable to recognise any such pathological entity — (Status Lymphaticus 1931).] Hornabrook called for the appointment of a medically constituted board to investigate every anaesthetic death.

It was 1938, however, before the first comprehensive survey of anaesthetic deaths was presented (Anaesthetic fatalities 1938). Thirteen hospitals were involved. These included the Melbourne Dental Hospital, where no deaths were recorded in the period 1932-6 in which 25,506 anaesthetics were administered for a total of 212,010 extractions. One patient was however, reported to have died five months later, from pulmonary abscess following inhalation of a tooth. In the final analysis the Dental Hospital presented the greatest number of cases, but the lowest mortality. (The caption to this table reads 'Note the low mentality at the Dental Hospital', which, it is hoped, was a misprint.) Overall there were 89 deaths in 193,977 cases.

Spiers (1953) attacked the use of general anaesthesia in dentistry, and stated that 'death does occur from time to time in association with dental operations under a general anaesthetic'. He quoted one death for 1951, and two in the first six months of 1952, in each case the
patient being in their early twenties. He said that the experience and skill of the anaesthetist were more important factors than the nature of the anaesthetic. 'Given a properly trained and qualified anaesthetist, morbidity and mortality fall, regardless of the agent, technique, or patient condition.'

In a personal request for a reconsideration of his views, seventeen years later, Spiers (1970) noted that as a 'higher proportion of anaesthetics would now be given by well qualified specialists, so the incidence of disaster attributable to the administrator would be reduced, and you will appreciate that I'd expect this to reduce the incidence of disaster'.

Spiers (1961) further discussed operating theatre deaths and their prevention. He claimed that two people die each week in N.S.W. as a direct result of having anaesthetics for operations!

In 1950, Brown reviewed 133 fatalities in anaesthesia for the period July 1936 to June 1950 occurring at the Royal Adelaide Hospital. The causes were varied but included deficient pre- and post-operative care, provision of atmospheres deficient in oxygen, failure to protect the bronchial tree against entry of foreign matter, and failure
to maintain patency of the air passages or to clear them when obstructed (Brown 1950).

Possibly the most comprehensive study ever undertaken into anaesthetic deaths was that by Beecher and Todd (1954). This study in the U.S.A., embraced a period of five years. Some of the observations are pertinent; for example, they found that when the muscle relaxants are employed death rate increased nearly six-fold. They found a 'sharp' indication of danger in the use of muscle relaxants — in particular curare. Data presented showed that death from anaesthesia was of sufficient magnitude to constitute a public health problem. In conclusion they stated that:

... in studies of this kind great interest attaches not only to the number that die under the circumstances being studied, but also to how many live, and in those who die, all cause of death must be examined. A study directed along these lines might be able to show that the over-all death rate was smaller when some agent or technique was employed than when it was not ....

Seldin and Recant (1955) studied records of deaths in the city of New York for a ten-year period in order to determine the mortality rate in patients undergoing anaesthesia in dental offices. They found an extremely low percentage of dental anaesthetic deaths, and reported on the enviable safety record of intravenous barbiturates for
dental procedures — no deaths with these agents were included in their survey. They said:

Deaths may occur, however, since the dangers of respiratory depression and laryngospasm are always present. In competent, trained hands, however, this kind of anaesthesia is no more dangerous than any other. The anaesthetist who can skilfully evaluate his patient, who can prevent laryngospasm, and who can manage a spasm should it occur will rarely, if ever, experience a fatality. Intravenous anaesthetics, as well as any local, spinal or general anaesthetics, are dangerous in untrained or insufficiently trained hands. Rather than condemn the agent, one must emphasize the importance of the skill and training of the anaesthetist.

Over one and a half million anaesthetics were given in dental surgeries in Britain, increasing each year according to Goldman (1958). He recorded a death rate of .0073 per 1,000 from these anaesthetics; which he felt was creditable, but could be improved upon. He found that when 'barbiturates' were used (he is unspecific — but it must be assumed that thiopental-sodium was most commonly used — methohexital not having been marketed at the time) the rate rose (0.26 per 1,000). Goldman considered that the non-intubated patient was 'definitely safer sitting up in the dental chair'. A study of blood pressure had indicated no significant drop, in fact rather a consistent but regular raising.
In 1960 Goldman revised his figures, reporting 21,896,909 dental anaesthetics in Britain for the years 1952-8 (over three million per year) (Goldman 1960). He recorded a total of 100 deaths from figures obtained from the Registrar-General's office which included hospital cases.

An editorial in 'British Journal of Anaesthesia' of May 1964, states:

The mortality rate in the United Kingdom in the dental chair is only about 1:300,000 which is perhaps as good as is ever likely to be achieved. One may speculate as to how much this is due to the simplicity of the methods employed, and as to whether an increasing use of complicated techniques by specialist anaesthetists would alter this figure.

In 1960 the State Minister for Health appointed a special committee to investigate deaths under anaesthesia in N.S.W. This committee had wide representation, (regrettably no dental), and for the purposes of deliberation death under anaesthesia was stated to include 'the death of a patient who, having had an anaesthetic, whether local or general, fails to recover fully or dies, either from the anaesthetic, or from any complication or incident associated with the administration of the anaesthetic. The definition is intended to include not only deaths resulting directly from the administration of an anaesthetic, whether immediate
or delayed, but also deaths associated with the administration of an anaesthetic from whatever cause, including such incidents as transfusion mishaps, resuscitation procedures, etc.'.

In New South Wales, a relevant section of the Births, Deaths, and Marriages Act 1899-1948, as amended 1960, provides that:

A medical practitioner ... shall not sign a certificate ... in respect of any person who, in the opinion of such medical practitioner ... has died whilst under or as a result of the administration of, an anaesthetic ... but shall as soon as practicable after the death, report the death to the Officer-in-Charge of the police station nearest to the place where the death occurred.

All anaesthetic deaths should be reported therefore to coroners, but the committee noted that some cases in which the anaesthetic probably played a major part, are not reported to the coroner.

One finding is of significance:

'23 out of the 55 deaths attributable to anaesthesia occurred in the "good" and "fair" risk groups, and in 15 of these, the subjects were unqualified "good" risks. This would seem to be an inordinately high proportion.' and another:
'of a total of 55 deaths, 15 occurred in specialist hands, and 40 in other groups'.

The errors of management are shown in this table:

<table>
<thead>
<tr>
<th>Error of Management</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overdose</td>
<td>27</td>
</tr>
<tr>
<td>Inadequate management of crisis</td>
<td>24</td>
</tr>
<tr>
<td>Inadequate pre-anaesthetic preparation</td>
<td>22</td>
</tr>
<tr>
<td>Wrong choice of anaesthetic</td>
<td>22</td>
</tr>
<tr>
<td>Inadequate ventilation</td>
<td>18</td>
</tr>
<tr>
<td>Inadequate resuscitation during the anaesthetic</td>
<td>11</td>
</tr>
<tr>
<td>Inadequate observation of the patient during anaesthetic</td>
<td>6</td>
</tr>
<tr>
<td>Hypoxic gas mixture</td>
<td>5</td>
</tr>
<tr>
<td>Technical mishap</td>
<td>5</td>
</tr>
<tr>
<td>Inadequate reversal of muscle relaxant</td>
<td>2</td>
</tr>
<tr>
<td>Inhalation of vomitus</td>
<td>1</td>
</tr>
</tbody>
</table>

These errors were discussed in greater detail, and the committee summarised:

Individual anaesthetists must therefore satisfy themselves that their training equips them with a proper knowledge of the principles involved, and having achieved this, they must at all times adhere to these principles without distraction. Even if it is not possible to realize the ideal situation in which no deaths at all due to anaesthesia occur; this should nonetheless be our aim. In achieving it, the Special Committee believed that nothing can be more useful than a conscientious and critical inquiry into the mistakes of the past, so that they may be avoided in the future.

One of the findings of the committee is of particular
dental interest:

'Nitrous oxide enjoys a well-deserved reputation for lack of toxicity, and provided the mixture administered to the patient at all times includes a concentration of 20% oxygen or greater at the mask, no deleterious effects from the agent as such, need be anticipated.'

McCarthy (1961) and Mandel (1963) both stressed that mortality associated with dental anaesthesia should not be related to that for general surgery. The differences were discussed and the greater safety level of dental anaesthesia demonstrated. Some of these differences were:

(i) Better physical status of the ambulant dental patient.

(ii) Avoidance of depressant pre-anaesthetic drugs.

(iii) Short procedures.

(iv) Oral surgical procedures represent a comparatively mild surgical insult to the body.

(v) Deep levels of anaesthesia not necessary.

(vi) Use of muscle relaxants not necessary.

(vii) A satisfactory method of resuscitation may be employed in the dental office.

McCarthy (1961) said — ' ... when I feel that the patient is a poor candidate for general anaesthesia, I utilize local anaesthesia, usually with other agents to
control the patient's apprehension.'.

The Special Committee investigating Deaths under Anaesthesia in N.S.W., presented its second report in March, 1970. One factor which emerges from this report is that 'the anaesthetic agents are not themselves responsible for a fatal outcome, but rather the choice of agents or technique and their misuse'. The Committee considered that in 60 per cent of 'true' anaesthetic deaths the incorrect choice of anaesthetic or technique was made.

Further points of dental interest are:

(i) Overdosage with the general anaesthetic agents figures as a factor in about 40 per cent of true deaths — the commonest agents being thiopental and ether.

(ii) Inadequate ventilation is one of the 5 major causes of disaster and it is noteworthy that the muscle relaxants were significant in contributing to half the true anaesthetic deaths in which they were used.

(iii) It is now rare for the Committee to review a death in a healthy individual due to major errors of anaesthetic management.

(iv) The Special Committee believes that the proceedings of the coroner's court seldom succeed in establishing the real cause of an anaesthetic fatality.

(v) There were 12 'true' anaesthetic deaths in which the technique was of a regional nature. In 6 of these cases death was due to overdosage and in 5 of these the agent used was lignocaine.
(vi) Anaesthetic agents themselves are not lethal except when they are misused.

Of particular interest was this comment:

(vii) Some operations are readily carried out under regional methods. It should not be uncritically assumed that 'locals' are always less risky than 'generals'. Although there are times when this is clearly true 'restlessness and non-cooperation can be managed by the judicious use of sedation, with the preservation of consciousness'.

Robinson (1970) maintained that prompt but simple measures would retrieve cardio-respiratory arrests in dental practice, and that almost all deaths which occur as the result of cardiac or respiratory arrest in dental surgery, must be regarded as avoidable.

Methohexital

The safety of methohexital used according to well defined methods and principles has been notably championed by the 'Society for the Advancement of Anaesthesia in Dentistry', in London. The editorial of the British Medical Journal of May 31, 1969 raised some doubts, in view of a study into the physiological effects of methohexital administered intermittently and conducted at Birmingham University. (Wise et al 1969). These authors stated that 'several deaths associated with this technique have been reported in the press, but it is difficult to gauge the number of patients at risk with the drug'. They made no
attempt to be more implicit in their statement nor to specify the deaths, or to give more details as to their circumstances.

It must be regarded as consequential that writers be specific with respect to use and misuse; whether an agent or method of using this agent should be condemned on the grounds that it can be misused. The relative importance of drug, method, operator, patient and anaesthetist should be accounted for in the assessment of the degree of hazard involved.

Official figures in Britain show 1 death only as attributable to the use of intermittent methohexital in the period 1959-1968. (Hansard 22 July 1969, written answers, Col. 366 — Drummond-Jackson 1969). A survey involving 445,386 cases of 'minimal increment methohexital, showed nausea/vomiting to occur in 1 in 968 cases, and laryngeal stridor or spasm 1 in 1065. (SAAD 1968).

The question of anaesthetic deaths is one deserving of closer analysis than can be given in a statistic. The old idea of showing mortality rates for anaesthetics as number per thousand nowadays must be considered unacceptable. Any anaesthetic death should receive careful study and analysis such that the causes and circumstances are as fully
documented as possible. Statements concerning anaesthetic deaths can then be stated unemotionally and with scientific foundation.

Further, there is need for a good deal more clarification as to the hazards represented by certain techniques and certain agents. Almost invariably, early enthusiasm shown for a new agent is dampened by later work demonstrating possible hazards which may result from its employment. The end result is one of confusion.

Patient position for dental anaesthesia would appear to be a factor of great importance. The use of the supine position has been strongly advocated by Bourne (1957, 1966, 1967) and also by Boulton (1970). Bourne (1966) analysed deaths of 37 dental patients anaesthetised in the upright position whose first sign of 'trouble' was when they collapsed. There would certainly seem to be scope for research into anaesthesia for dental purposes - this is well illustrated for example by the observations of Kaufman (1965) who noted marked electrocardiographic (E.C.G.) changes in patients undergoing dental extraction under general anaesthesia. These changes were found to be predictable. Local anaesthesia supplement was found to prevent arrhythmias during extractions in the upper jaw, but less so in the lower. E.C.G.'s of patients undergoing dental extraction under local anaesthesia showed tachycardia and ventricular systoles in normal subjects.
'when the needle pierced the gum' These arrhythmias may explain some anaesthetic fatalities, said Kaufman, and he emphasised the additional care required in anaesthesia for dentistry.
X. THE DENTIST/PATIENT RELATIONSHIP

The study of clinical anaesthesia both in medicine and in dentistry has come to be interpreted as a specialised post-graduate field, 'a highly complex ritual dependent on many drugs and much equipment' (Johnstone 1962). This has resulted in the provision of little or no training in anaesthetic method at undergraduate level. As the majority of practitioners carry out dental practice on the basis of their undergraduate training, it follows that few patients are offered ambulant general anaesthesia as an alternative to local.

Three surveys have been undertaken in Australia which have sought information as to the relationship between general anaesthesia and the practising dentist.

Jackson (1967) reported the results of a study conducted in Queensland. 695 dentists were approached, but only 126 replied, and these were predominately from the country districts. In view of the poor response, a modified questionnaire was later sent to 100 random practitioners.

Jackson concluded:-

Whether or not dentists should give general anaesthetics to patients in their own offices is a question beyond the scope of this article, but comments can be made on the practicability of alternative arrangements. The existing hospital facilities would have difficulty in accommodating the number of patients involved, and it is possible that, at present, there are not enough doctors
trained in this type of anaesthesia to take over the work in dentists' offices. There would seem to be a definite need for more facilities for post-graduate training in dental anaesthesia, whatever the professional designation of the anaesthetists might be.

In the latter part of 1968, a questionnaire relating to a proposed course in general anaesthesia for dentists (12 months) was circulated by the post-graduate committee in Dental Science within the University of Sydney. 1790 questionnaires were sent, and only 478 replies (32.8 per cent) received. Almost 30 per cent of these replies indicated some interest in the proposed course, while the need for training in the administration of general anaesthetics by dentists was the most frequent comment.

A South Australian survey (Feb. 1969) concluded that:

(i) a definite need existed for general anaesthesia in dentistry, and

(ii) there is an increase in this need for conservative work.

(iii) anaesthetics will have to be carried out in dentists' rooms for many years to come, because of a lack of alternative facilities.

Surveys of this type, while of value, should account for, and relate to, practice type and location. The city dentist might be expected to encounter differing problems to the suburban man or the country practitioner. Level of
patient education, patient affluence and racial origin, and the availability of specialist facilities are important variable factors. Questionnaire answers would also tend to reflect dentists' present training and experience, rather than giving an assessment of the role which general anaesthesia, or more particularly sedation, might have if practitioners were equally confident in their use, as with regional methods.

The surveys have tended to stress 'anaesthesia,' and overlooked 'sedation,' and they have not accounted for the importance or otherwise of the relationship between general anaesthesia and the emotional aspects of dental treatment. The use of anaesthesia and sedation must be considered to be closely linked with the question of the dentist/patient relationship.

Waterson (1967) discussed anaesthesia as a dental problem, and said:

Any improvement in techniques for pain control in dentistry must come from the profession itself. Until more dentists are educated in general anaesthetic procedures no such improvements are likely, because it must be acknowledged that the dentist is the person best qualified to judge the value of any measure designed to render more efficient dental treatment.

In his practising of general dentistry, the dental surgeon encounters certain problems, which often find him wanting for a satisfactory answer.
The modern dental practitioner undergoes extensive and intensive undergraduate training, and is well grounded in biological sciences and the technical skills of modern dentistry. He is found wanting in three important spheres:

(1) A full understanding of the 'human' problems associated with his work.

(2) The ability to prepare the patient psychologically to accept necessary treatment.

(3) The ability, in his surgery, to offer to his patients treatment under circumstances other than using local anaesthesia.

Many practitioners are able, of course, by virtue of personal attributes to overcome (1) and (2). Epstein (1964) and Raginsky (1968) are of the opinion in fact, that a warm understanding personality in the dentist is more effective, or just as influential as the placing of emphasis on tranquillisers or pre-medication.

Unfortunately, not all dentists are naturally possessed of these attributes. Martin (1965) undertook a most comprehensive and important study of dentist/patient relationships on behalf of the Dental Health and Research Foundation. He notes:

Dentists who participated with us in this study have themselves freely expressed dissatisfaction with the fact that there seems to be limited opportunities for practising dentists, and for the dental students who are the future members of the profession, to break out of the circle; to obtain skill and experience and training in the ever present problem of inter-personal relations.
Many dentists expressed a sense of despair in the ability of their professional organization and the dental schools to provide appropriate training.

The conscientious practitioner may also develop a sense of frustration in his work. He may feel that he is 'overtrained' for procedures much as cavity preparation or denture construction, and yet is unable to impart his sense of ideals to his patients. This very problem can, and in fact has, lead to degrees of mental breakdown in some dentists. (Newland 1969).

It is clear that if the process of dental health education is to progress, then the general practitioner needs to be better equipped to meet 'human' problems, and this must be a prime consideration. Dental health programmes, as have been mounted in the past can have but limited impact.

Rowntree (1961) in discussing dental health education programmes said that 'before it was possible to get to the basic personality, and re-create or produce new habit patterns, the fear barrier had to be broken down. An atmosphere full of fear, anxiety or tension can be quite detrimental to communication. (Weiss and Swearingen 1969). Bulman et al (1968) in an extensive study of dentist/patient relationships found that 'fear clearly emerged as a factor keeping people away from the dentist'.
Lovett (1965) has stressed the importance of practitioner confidence. He described the need for: 'a competent diagnosis, prescribing an efficient plan of treatment, showing the patient what modern dentistry can do for him by being informal, specific, sincere, patient, enthusiastic, and a friendly adviser'. Undoubtedly many of the problems which appear to block effective treatment are overcome by these very factors, and it is vital indeed that they be not overshadowed. Doubt has been expressed (Phillips 1970) as to whether, in fact, sedation techniques could become an excuse for 'not making a personal relationship between the dentist and his psychologically needful patient'. The decision to utilise sedation, or in fact any method of pain control, should however, largely derive from the dentist's assessment of the patient's introspective description of the dental environment. It is therefore essential that he exercises the art of 'informed listening'.

The need for dentists to practice the art of listening has been emphasised by Blass (1963), Ewen (1967), and Jaffe and Kutner (1967). Modern studies in preventive psychiatry (Caplan 1964) have shown the practical value of helping patients confront crises by lending support, talking it over, finding the facts and realising the danger, pain or trouble, and to speak of unspoken fears. False reassurance is to be avoided.
Walsh (1956) has said that the patient derives from the dentist an 'understanding of his needs and a sense of security arising from the feeling that the dentist will place the welfare of the patient above all other consideration'. He further noted '... the memory of past experience is often the basis of a patient's fear. Painful or unpleasant experiences may lead to a non-co-operative attitude. For example, a patient may prefer to have teeth out under a general anaesthetic rather than be subjected to conservative procedures involving the use of the handpiece. Once the confidence of the patient is gained, and the harmful effects of past experience are corrected, the patient's gratitude and change of behaviour is often striking'.

Martin (1965) has observed that 'patients are very resentful that the dentist will not relate to them in an understanding way'. Dental patients have a need for emotional support. When the need is unfulfilled or frustrated, an unsatisfactory relationship results. (Collett 1969). The responses of the patient will depend on his motivation, his attitudes, and consequently his reactions and conceptions will be either positive or negative, depending to a considerable degree, on the information he has acquired. This information may be either factual or fictional, biased or unbiased. (Collett 1969). Egbert et al (1963) have demonstrated
that pre-medication alone cannot allay pre-operative apprehension. Those who face an anxiety-generating situation look for emotional support.

Martin (1965) in presenting his findings of patient attitudes said:

Patients of all kinds expressed a simple and direct opinion of dentistry as painful and frightening and, as such, sufficient in itself to discourage one from seeking treatment. For many, there is nothing that dental service or treatment can offer that can offset the terrifying aspects of dental attention, and they are frankly not prepared to subject themselves to the terrifying experience.

It was strikingly apparent to the research team that the failure of the patient to understand the real basis of his concern and anxiety about dental treatment was responsible for most, if not all, of the strange and disproportionate reactions and behaviour in relation to dentists and dentistry. It became increasingly clear that there was a tremendous amount of exaggerated fear concerning the dental situation.

The relationship between dentist and patient is crucial to the effective advancement of communal dental health. The patient must be greeted with an acute understanding not solely of his dental problems biologically, but psychologically, as well. He must be allowed to express his anxieties and idiosyncrasies as they apply to the dental situation, for him a temporary crisis situation.

Martin (1965) says:

It seems to be primarily his (i.e. the dentist's) task to understand fully the anxieties and fears
operating in both the patient and himself. When he understands his own need to combat anxiety, he will more readily accept that the methods he uses might cut across some of the most fundamental needs of the patient in the situation. The nature and significance of the problems pointed to in this report should not be minimized, nor should the difficulty of developing practices designed to cope with them.

Sedation then, is not a replacement for the dentist's understanding relationship to his patient—it is dependent on, and supportive to, this relationship.
XI. DISCUSSION OF DEVELOPMENT, AND THE PRESENT DAY SITUATION

A study of the historical development of general anaesthesia for dental purposes has been presented. The subject has always been controversial, involving conflicting views and opinions. Opinions form as a result of historical background and influences, and as a result of his being subject to certain influences a man forms his opinion. Further, as noted by Harris (1945) - 'There are many, who in their enthusiasm to sweep clean, overlook the basic principle that man is governed by his emotions far more than his capacity for logical reasoning'. General anaesthesia in dentistry has been strongly subjected to emotional influences. The time has come for a logical, unemotional and scientific approach to its problems.

The unfolding story of the development of dental general anaesthesia reveals certain considerations and lessons.

Although axiomatic, it must never be forgotten that anaesthesia or sedation in any form are not ends in themselves, but are means which allow a dental procedure to be performed more acceptably. Now, while it would be considered barbaric to perform exodontic procedures without any form of anaesthesia nowadays, it must be stressed that many patients undergo cavity preparation, without any form of anaesthesia or analgesia. What is it that allows one
patient to undergo treatment this way, while for another
even regional analgesia is inadequate? Little thought or
attention has been paid to this question. It is clear that
neurophysiological and psychological factors are involved
rather than regional anatomical factors. A local anaesthetic
injection will exert an 'anatomical' effect in the blocking
of neural pathways and hence potential pain sensation impulses
from the area involved.

There should be little logical reason therefore,
to employ general anaesthesia simply for the control of pain
sensation. Local and general anaesthesia then, accommodate
different needs - in the former the patient is conscious,
in the latter he is not. This lack of consciousness in
general anaesthesia accounts not only for the elimination of
sensation, but also eliminates all perception throughout the
operative phase. We may think of full consciousness as being
the result of the synchronisation of certain neuronal pro-
cesses, and complete loss of consciousness as complete
depression of cortical and subcortical centres.

Neurophysiologists have found 'consciousness'
difficult to define. Brodal (1969) regards the problem as
insoluble, as any attempt to explain how nervous impulses
can be translated into mental experience is an impossible
attempt. It is clear, however that consciousness may be
affected as a process (Brain 1962), and something of which
there may be more or less activity.

When we speak of 'control' we mean being 'selective' of components of consciousness or regulating the level of consciousness or temporarily desynchronising the neuronal activity referred to above.

It is important firstly to recognise and clarify certain concepts:

`Anaesthesia` means loss of all feelings or sensations. General anaesthesia infers concomitant loss of consciousness (complete). Local/Regional anaesthesia confines the loss of sensation to one part.

`Analgesia` means the loss of all pain sensation without loss of consciousness.

`Hypalgesia` or 'relative analgesia' means a diminished sensation or heightened tolerance to pain - the patient will be less aware of his surroundings.

`Sedation` means a diminution of activity, excitement and apprehension. This involves a calming process with the patient remaining conscious.

Nitrous oxide is notable as an agent which has application in the production of the hypoalgesic state. It will be remembered that Horace Wells' patient uttered a 'groan' when his tooth was separated from its attachments, which groan produced scepticism amongst his medical audience. The patient is reported to have been satisfied with the result,
and to have felt no pain. It must be noted also that the extraction was successfully completed. It was clear, and it soon became established, that dental extractions could as a rule be accomplished with nitrous oxide, to the satisfaction of the patient, in the presence of reflex activity. It will also be clear, and an observation of a series of extraction cases using nitrous oxide by inhalation methods will reinforce the contention, that reflex activity is exhibited by many of these patients - indicative that cortical impulses are still being received. It is the control of the perception of these impulses which allows the extraction to be completed.

Nitrous oxide came to be popularly used for dental cases, and was attended by much success, which however was not readily translated to general surgery. Dental work was performed rapidly on removal of the mask, during the emergence from the nitrous oxide effects. Lighter anaesthetic planes than were tenable for general surgery were utilised. Nitrous oxide was however at certain disadvantages in the early years of anaesthesia, but was kept 'alive' by the dental profession, and better apparatus was developed for its administration.

Disadvantages were:

(i) Complex apparatus was required.

(ii) Induction necessitated oxygen restriction.

(iii) Prolongation of the anaesthetic was not possible,
The last two factors were destined to be overcome although the question of apparatus has always been a disadvantage when compared to the simplicity of a syringe. This disadvantage militated against nitrous oxide, to the point that questions of simplicity, facility and economics overshadowed it, and Somnoform, ethyl chloride and intravenous agents became popular. It was evident however that nitrous oxide, administered with an adequate percentage of oxygen was the safest anaesthetic known, and the question arises whether other agents and methods represented a compromise or whether they had a place in their own right.

With nitrous oxide, the question of induction without accompanying cyanosis was not quickly solved, and 'dental gas' acquired a stigma which was not to be readily absolved. The techniques of McKesson which necessarily involved the production of some cyanosis, and the non-reliability of his intermittent-flow principle were so to the fore that dental 'gas' anaesthesia became associated with these principles. This stigma must not be allowed to cloud modern methods and concepts.

In 1929, Arnott distinguished between those techniques considered safe and suitable for 'dental anaesthetists', and those for 'medical anaesthetists'. (p. 182). This distinction was however, belated. In 1909, an opportunity to establish 'dental anaesthesia' as a subject deserving of
special study was lost, (p. 141) and progress to 1930 was highlighted by lack of unification, and a dispersion of opinions, methods, and techniques. This was set against an ever-present background of doubt and controversy as to the dentist's role as an anaesthetist. Dentists found it difficult to justify the expense of an anaesthetic machine. The dangers of the inhalation of foreign debris were strongly stressed.

It thus became the logical step for local anaesthesia to be used by dentists for minor dental work and anaesthesia administered by specialist anaesthetists the order when a general anaesthetic was required. Anaesthesia was to be the province of this man only - 'nurse' anaesthetists for example, were not to be contemplated. Dentist anaesthetists became fewer; practical, and even theoretical undergraduate training was reduced. In the early 1950's Diploma courses and examinations were established for the medical specialist, strengthening his position and status even further.

In the decade 1960-70 however, new agents and methods have appeared which have aroused a renewed interest by dentists, in this field. Halothane, methohexital, propanadid, diazepam, methoxyflurane and 'continuous flow' machines may all be mentioned. Further, the present day dental graduate has reached a standard of education higher than ever before. This certainly applies in the technical and biological aspects - but there would still appear to be deficiencies notably in
what might be termed the 'human' aspects. (Ch. X). The
dentist who is but slightly sensitive to his patients' needs
and attitudes, as they affect the attainment of treatment
ideals, will readily recognise a problem. How to transfer his
ideals into practice? He will recognise that for a great
number of patients dental treatment has an awesome stigma.
This stigma continues to persist in spite of his apparent
ability to control 'pain' with local anaesthesia. The new
interest referred to in Ch. VIII (12) is becoming increasingly
evident as dentists sensitive to this problem, seek to expand
their methods of pain control. This may be construed by some
as an 'invasion' into the field of general anaesthesia - the
prerogative of the specialist anaesthetist. Is this inter-
pretation correct?

Historically, dentists and dentistry have had an
active participation in the development of general anaesthesia.
This must be seen as more than a proud memory; it is relevant
for today. It is illustration of a continued realisation of
the often unpleasant nature of dental treatment and the need
at times to eliminate all 'perception'. As evidenced by the
history and development presented in preceeding chapters,
dentists have sought methods which best cater for their needs,
and this has not always been in parallel with methods for
surgical anaesthesia. Have we lost sight of some of the simple
problems where general anaesthetics were found useful? (Helmore
1948).
(i) 'Needle phobia'.

(ii) Patient with acute infection which requires simple treatment.

(iii) Young child requiring removal of a few temporary teeth.

Have we ensured that the dental surgeon retains efficient methods of dealing with these problems? Above all have we the means to meet and overcome patient apprehension, where it exists as a barrier to efficient effective treatment and the subsequent maintenance of dental care?

The dental surgeon needs a broader approach in treatment programming than to merely be able to offer his patients local anaesthesia. His seeking this broader approach must be seen as an attempt to make a positive effort to overcome the stigma referred to above. A better understanding of the dentist/patient relationship (Ch. X) and of the nature of pain will result in turn in a better understanding of the problems and their solutions.

The specialist anaesthetist is unquestionably a highly trained competent practitioner. As applied to dental treatment, however, and bearing in mind that anaesthesia is but a 'vehicle' for the accomplishment of the treatment, certain questions arise:

(i) Are dental operations of a nature to demand the services of a specialist anaesthetist whenever local anaesthesia alone is deemed inadequate.
Some dental operations would demand the services of a specialist medical anaesthetist, while others do not. Classification is necessary.

(ii) If so, are these services always readily available to the dental surgeon?

By careful and selective case assessment the number of dental cases requiring the services of a specialist anaesthetist may be limited, such that these services should always be available.

(iii) Does general anaesthesia as practised by the specialist satisfy the dentist's needs?

Much conservative work and oral surgery can be accomplished with better advantage to dentist and patient, utilising an intermediate form of pain control based on local anaesthesia with the patient conscious. (Ch. XII, A). Using this, the dentist may exercise perception control and, at the same time, practice in his customary surroundings with all its implications. Patient conceptions of the dentist and dental treatment relate specifically to this environment. To be effective in meeting these conceptions, control methods must apply in this environment. The aim is control of perception, not elimination.

(iv) Is there any justification for lesser trained anaesthetists in dentistry?

There is no justification for two levels of anaesthetist - first and second class, but there could be a medical anaesthetist, and a dental anaesthetist, the latter confining himself to dental work. This poses the question as to whether dental anaesthesia is in any way different -

A precedent has been set, notably at the University
of Pittsburgh, U.S.A, where dentists may receive post-
graduate training in general anaesthesia for dental work
(Monheim 1970 a). It is considered by Monheim that other
demands of the specialist medical anaesthetist are such, to
justify the existence of a dental anaesthetist. This individual
would usually practise in a group practice or clinic and
apply his skill whenever a general anaesthetic was deemed
necessary. His training should include physical diagnosis to
permit patient evaluation, and determine under what conditions
a general anaesthetic can be given (Monheim 1969).

The existence or otherwise of a 'dental anaesthetist'
would seem then, to depend on the availability and demands of
the 'medical anaesthetist'.

(v) Is in fact it necessary to use general anaesthetics
for dental operations at all?

Criteria commonly given (e.g. Windeyer Report, 1970)
are briefly:

(a) Spastics.
(b) Those known to react adversely to local anaesthesia.
(c) Mentally subnormal.
(d) Poor psychological attitude.

A further reason has been given (Saunders 1970),
(e) In patients where much work is required to produce
dental fitness and is unlikely ever to be achieved
by the usual course of repeated treatments under
local anaesthesia.

(a) and (c) could well be questioned. Healey et al (1970)
found diazepam/local anaesthesia an 'effective alternative to general anaesthesia during dental extractions in the severely mentally handicapped patient', while some success is also reported using 'relative analgesia' (Langa 1968). Jorgensen and Hayden (1967) report the successful use of the Jorgensen technique for two patients suffering cerebral palsy. (d) and (e) need not apply as illustrated by case reports in the following section, while (b) must be considered extremely rare. I have encountered only two (mother and son of one family) in 13 years of practice. The strict use of general anaesthesia as a clinical necessity for dental treatment using these criteria, must be considered rare.

(vi) Why does the average specialist anaesthetist show little interest in dental anaesthesia? (Fact?)

Some anaesthetists have expressed concern in this area. Moore (1968) for example, feels that: 'where the practice of dentistry calls for the introduction of new concepts and new methods, the initiative for solving these problems must come from the specialist anaesthetist. If this is not provided by them as part of their service to the dental profession, the dental surgeon, admittedly a craftsman anaesthetist, will try as best he can to introduce innovations'. The editorial of British Journal of Anaesthesia of March, 1968, says 'that there is much to be said for the organisation of sessions in general dental practice, where the specialist anaesthetist will give instruction to post-
graduate students'.

Brophy (1970), says that 'anaesthetics for dentistry should be given by medical graduates with post-graduate training in dental anaesthesia'. This is the era of the specialist anaesthetist and many dentists who at one time administered anaesthetics are no longer prepared to do so. However, the specialist anaesthetist is not the whole solution, the members of this group are often not available, or are unwilling to work in a dental surgery. Economics or the 'double fee' problem should not be considered as a barrier, in view of the benefit schemes now available.

There has developed in Melbourne a number of medical practitioners who limit their practice to the giving of general anaesthetics for dentists. These doctors have no higher qualifications in anaesthesia - they are not members of the College of Anaesthetists, nor are they regarded as specialists by that Body; but they give a very good service to the public and the profession'. (Wark 1969).

The question of what anaesthetics a general medical practitioner should administer has arisen on two occasions in recent years:

The first was a plan of Graded Privileges for General practitioners in Public Hospitals. They were to be graded 1 - IV depending on competency. This over simplifies the situation as the problems are related to the general state of the patient, the
operation as well as the knowledge of a particular anaesthetic technique. The Society of Anaesthetists and the Faculty would not agree to the introduction of Graded Privileges. Again, during discussion on the Federal Government's Proposed Health Plan the question arose as to what distinction should be made between services carried out by General Practitioners and Specialists. The Society of Anaesthetists unanimously agreed to the following motion: 'It is not possible administratively to distinguish between those anaesthetics which could be given by general practitioners and those which should be given by a specialist'. (Roden 1970).

With anaesthetists militating against the general practitioner anaesthetist, it is hardly surprising that they should adopt the same, or even a stricter approach to the question of dentist-anaesthetists.

Throughout the latter part of 1969, through to mid-1970, I have had the opportunity of serving on a working party initiated by the Faculty of Anaesthetists, R.A.C.S., to investigate and report on 'general dental anaesthesia'. This has brought me into contact with professional anaesthetists and their views. Many are quite vocal on the subject, but much opinion expressed will tend to be based on the experience and degree of dental orientation of the person concerned.

Anaesthetists tend to present various shades of viewpoint -

Commonly however, over the question of dentist-anaesthetist, doubt is expressed on two main factors:

(i) Ability of the dentist to carry out pre-operative assessment,
(ii) Ability of the dentist to cope with emergencies. These factors are those encountered most frequently, some stressing the one as opposed to the other.

In the performance of a dental procedure the dentist's aim should be three-fold:

(i) The procedure is performed pain-free, and with safety.

(ii) To account for the patient's attitudes and emotional outlook as they relate to dental procedures.

(iii) The encouragement of confidence in the patient's ability to accept dental treatment, and the furtherance of the dental care and welfare in that patient.

'Controlled conscious' techniques can more closely satisfy his requirements, those of the patient, and those of a legislative nature, than do 'unconscious' methods.

A study of the history, further reveals how the advent of a new agent can be met with enthusiasm and enlist many advocates, only to be followed by doubts, dispersion and even abandonment. Almost all agents - nitrous oxide, ether, chloroform, Evipal, thiopental, cyclopropane, Somnoform and more latterly methohexital have undergone this process. When an agent is first introduced, its role and its shortcomings are not readily defined. Commercial interests frequently play a part. There is a need for the placing of agents into their proper perspective and an understanding of the extent to which an agent may assist the treatment programme.

If there be risks attendant to the use of an agent
then these should be clearly defined. There is a need for more testing of methods and agents employed for dental purposes - this testing should not only be related to physiological effects and safety, but to psychological effects as well.

There has been little or no attempt to define situations and their demands. Technique selection has tended to be based on 'likes and dislikes', the experience of the operator, and the facilities available. Personalities have also been a major factor in influencing progress. It has been said that a variation in academic approach between Sydney and Melbourne Dental Schools, for example, towards dental general anaesthesia, resulted in a very different attitude arising in New South Wales from that in Victoria. Such a situation cannot be considered tenable today. Training and decisions should be made on logical factual evidence, influenced as little as possible by personality and geographical factors. Such discussion however has implications, and these have constantly featured in anaesthetic history. There is not only the question of agent, but of technique, and not only of technique, but of the training of the personnel, and not only of training, but also of judgement and experience. Thus any discussion must embody a consideration of all these factors.
It is often agreed that 'anaesthesia is anaesthesia' regardless of the operation (there is no 'minor' anaesthesia). It is contended however, that as anaesthesia is but the means which enables the operation to be performed, it should be closely tailored to the operation. History clearly shows that many operative procedures in dentistry have been, and can be, accomplished satisfactorily in the 'light' planes of anaesthesia. [Analgesia - (Taylor 1913); Analthesia - (Heimore 1948); Amnalgesia - (Klock 1955); Ultra-light anaesthesia (Drummond-Jackson 1967); Chemanesia - (Monheim 1968); Relative analgesia - (Langa 1968).] A deep level of surgical anaesthesia is not necessary to accomplish dental treatment (notably conservative treatment) in the vast majority of instances. The accomplishment of dental surgery in earlier days, was not hindered by lack of 'muscle relaxation'. Muscle relaxation and the concomitant 'assisted respiration' are not necessarily required for this type of surgery. In terms of safety therefore, omission of relaxant agents would seem to be of considerable importance, (Beecher & Todd 1954).

The use of 'light planes', supplemented at times with local anaesthesia represents advantages to the dentist and his patient, as opposed to general anaesthesia. In summary the advantages of relative analgesia, for example, are:-
(i) Patient conscious.
(ii) Patient can respond to questions.
(iii) Can be used routinely at every dental visit.
(iv) Premedication preparation rarely necessary.
(v) Rapid recovery.
(vi) No adjuncts needed, e.g. throat packs, restraining straps.

Above all however, is stressed that the use of relative analgesia, and this can be extended to include sedation, is designed to eliminate the 'fear of the dental procedure'. In other words it is the utilisation of a technique which embodies the control of perception - the psychological aspects of pain.

The dentist who seeks knowledge, training and the implementation of these methods is endeavouring to make dental treatment acceptable to a greater proportion of the community. He has inherited 125 years of development in the field of pain control, and he must not feel humiliated in his efforts. He must not be made to lack confidence in a field which holds prospects of making dental health a reality for more patients. If barriers exist which hazard his efforts then he must first clarify his need and the needs of his patients. From a better and more intimate understanding of the dentist/patient relationship will arise a better understanding of the need. This need will
be seen to be primarily to meet a behavioural problem - and basically to recognise that 'pain' can have both a physical and a psychological approach.

For too long we have regarded pain simply in physical or biological terms. It is necessary to now approach pain rather as a psychological phenomenon. Merskey & Spear (1967) give a well considered and operational definition of pain:-

'An unpleasant experience which we primarily associate with tissue damage or describe in terms of tissue damage or both'.

An understanding of the psychology of perception is in turn intimately related to the understanding of pain. It is perceptual experience which largely determines how a patient will react and relate to pain. (Ch, XI, B).

**SUMMARY:**

Dentists have made extensive use of general anaesthetic agents and techniques and have contributed not unworthily to the progress and development of general anaesthesia.

With the advent of efficient methods of local anaesthesia together with the firm establishment of general anaesthesia as a medical speciality, dentists have relied largely on the former for pain control in their routine procedures.
The medical specialists have proposed, and dental authorities have agreed, that the endotracheal method of anaesthesia, performed by a specialist anaesthetist in a hospital environment represented the ideal anaesthesia for dental work. The practising dentist however performs minor operative procedures as a constant part of his service throughout any working day. It would be quite impractical for every patient who requires such procedures to receive general anaesthesia. Many, probably a majority of patients readily accept their operative procedures with local anaesthesia, while some prefer no anaesthesia whatsoever. For many patients however, apprehension and fear militate against effective treatment. The dentist knows that he can perform a procedure free of pain sensation. For these patients however, the perceptual aspects of pain predominate. There has been little or no attempt to evolve a consideration of both these aspects in dental treatment programmes.

What is required therefore is a method or methods which account not only for physical pain, but for psychological pain as well. To be effective this method should be practised in the dental surgery environment. What the dentist is attempting is not only to perform a painless procedure, but also to alter the patients' conception of the procedure. By so doing he aims to condition this patient to receiving regular dental care - and to controlling the perceptual aspects to
such an extent that the control of physical pain by local anaesthesia may ultimately suffice.

Dental treatment is not 'one time' treatment. It is its serial nature and its accent on maintenance and regular preventive care that basically separates it from all other forms of surgery, together with the ability to perform much of the treatment at light anaesthetic levels.

The dental practitioner's destiny in the application of pain control lies more in field of controlled conscious techniques, than in the field of general anaesthesia (per se.)
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SECTION 2. PERCEPTION CONTROL - INTRAVENOUS SEDATION

XI1. CONSIDERATION OF:

A. NEUROPHYSIOLOGY

Distinction has already been drawn between the sensation and the perception involved in a dental procedure, and a definition of perception given (p. 6). In the consideration of perception we are dealing with the interpretation which a patient gives to the stimulus of the dental procedure. This interpretation is not confined to the duration of the operation, but may result from, or be conditioned by, previous association with dental procedures. The aim of control measures is two-fold:

(i) To produce a patient calm and amenable to the dental operation.

(ii) To produce a change of attitude towards future dental attention, and care.

Fig. 47 Schema of the spectrum of pain control in dentistry (after Trieger & Carr, 1969).
It is necessary to see measures for pain control in dentistry as something of a spectrum or schema, as shown above. (Fig. 47). Previous concepts have paid cursory attention to Zone B which is the area of particular interest in the control of perception.

Woolmer (1961) has said that 'the important thing about pain accompanying any surgical procedure is the distress it causes to the individual patient...'. Woolmer then drew a distinction between the mental reaction to pain (higher level) - the physician's problem, and the reflex (lower level) reaction - the surgeon's problem. The therapeutic management of the pain then, involves management of both pain sensation (physical or organic) and perception (psychological or mental).

As noted previously, the dental surgeon in his clinical management of a treatment procedure should seek an assessment from his patients of their attitude towards, and degree of stress normally experienced with respect to, dental procedures. Thus, his considerations will be concerned with:

(i) Pain sensation.
(ii) Perception of the procedure.
(iii) Conditioning the patient to future dental treatment and dental care (conceptual response).
These are first considered from the neurophysiological standpoint.

**Pain Sensation**

It is popularly believed that stimulation of dental tissues, notably dentine and the dental pulp is always elicited as pain; (Goetzl et al. 1951; Wyke 1958; Jenkins 1966). This has been questioned by Mumford (1968) who stimulated teeth electrically and found varied responses notably 'tingling', 'cold', 'warmth' and 'vibration'.

Within the tooth naked nerve endings travel between the odontoblasts, the peripheral layer of the pulp, and form a varicose arborization around the cell bodies. The nerves of the dental pulp are both myelinated and non-myelinated, the former being more numerous and of less than 2μ in diameter, while the non-myelinated fibres are less than 1μ (Provenza 1964). All pain afferents from the dental tissues enter the nucleus of the trigeminal nerve (5th cranial). The sensory innervation of the periodontal membrane subserves pain, pressure and touch, and there are plexuses of un-myelinated and small myelinated nerves in the structure of the membrane which pass into the trigeminal nerve. Thus pain, pressure and proprioceptive sensations are evocable from periodontal tissues (average diameter 10-12 μ) - larger more rapidly conducting fibres (Wyke 1960). This contrast of fibre diameter between pulp and periodontal membrane is
significant clinically in its application to the performance of conservative measures, as opposed to exodontic procedures. The smaller fibre size of the pulpal tissue means a limited type of response from this tissue, and a greater susceptibility to local anaesthetics. Wyke (1960) has stated a 'law' that: the dimensions of reaction of a nerve fibre are determined solely by its diameter.

The afferent fibres concerned with sensation (dental) have their cell bodies in the trigeminal ganglion. Central branches of the ganglion emerge through the concave postero-superior margin to form the sensory root of the trigeminal nerve (V). The sensory root sinks backwards for half an inch through the junction of pons and middle cerebellar peduncle, and its fibres divide into superior and inferior branches. The latter descending fibres constitute the spinal trigeminal tract, a distinct fibre bundle which is situated just underneath the lateral surface of the medulla oblongata. The fibres of the tract end in a longitudinal cell column medial to the tract, the nucleus of spinal trigeminal tract.* This extends from the ventrocaudal border of the chief sensory nucleus spinal-ward through the lower pons and medulla along the spinal tract of V, to overlap and become indistinguishable from substantia gelatinosa

* Tract: Fibre bundles connecting nuclei with the C.N.S.
at cervical levels. The transition between the two masses is gradual, the neurons with small cell bodies descend, with the mandibular being the most ventral (Crosby et al 1962). It is a separate nucleus - (the mesencephalic tract of the trigeminal nerve) which contains the proprioceptive fibres (Brodal 1969). This is a small bundle of fibres passing dorsally between motor and superior sensory nuclei to the lateral margin of the fourth ventricle (Romanes 1967).

Cranial nerve nuclei are also important links in numerous reflexes. When reflexes occur on stimulation of afferent fibres in the cranial nerves, these must be mediated by connexions between the incoming afferent sensory fibres and the nuclei giving rise to efferent fibres. According to Brodal (1965) this link has not been anatomically established, although it is clear that at least one neuron must be intercalated between the afferent and efferent fibres, and it is possible that these may be cells of the reticular formation, which receive collaterals from secondary sensory fibres.

The sensory cranial nerve nuclei are under the control of higher levels of the nervous system. Impulses from the cerebral cortex are able to inhibit the central propagation of sensory impulses entering via the trigeminal nerve. This then leads to the second consideration -
Perception of the procedure

The stimulus which is sufficient to cause pain (e.g., the cavity preparation or the exodontic procedure) is sufficient to activate other receptors capable of responding to the stimulus.

The nuclei of the trigeminal nerve are surrounded by the reticular formation of the brain stem, and such collaterals mediate impulses to the reticular activating system (Moruzzi and Magoun 1949). This multisynaptic system is essential for the maintenance of consciousness - in particular the alert state that makes perception possible (Ganong 1967). The system is non-specific being activated with equal facility by different sensory stimuli. (Fig. 48).

The nucleus of the spinal tract of the trigeminal nerve is continuous with the dorsolateral tract, a similar
bundle from the dorsal rootlets of the spinal nerves consisting principally of pain fibres. At this connection further transmission of sensory impulses occurs and long axons join the spinothalamic tract. The spinothalamic tract conveys impulses which have to do with the conscious appreciation of various sensations and run to the thalamus. Connections are also made with the superior colliculus (spino-tectal tract) said to be responsible for reflex movement to visual stimuli. From the chief sensory nucleus of V, an entirely separate projection system to higher centres has been described (dorsal secondary ascending tract of V) (Crosby et al. 1962). This tract appears to carry impulses relating to pressure (tactile perception), and deep pain from the facial area. Secondary fibres of the mesencephalic nucleus which synapse in the thalamus pass into this tract (Brand 1969).

The spinothalamic tract terminates in the cortical relay nuclei of the thalamus and there synapses with neurons whose axons form the thalamic radiation to the postcentral gyrus of the cortex. The thalamus is an important mediator in the relationship between sensory and perceptive modalities.

When we receive a stimulus, impulses are initiated which travel in sensory tracts and lemnisci to attain the sensory cortex by way of specific thalamocortical fibres.
bringing discreet information in regard to the character of the stimulus and its localisation (Himwich 1965).

The cerebral cortex functions as to the integration of those neural processes on which consciousness depends but this function in turn depends upon the integrity of diencephalic and brain stem activities (Brain 1962).7

There is considerable evidence that sensory stimuli are perceived in the absence of the cerebral cortex, and this is especially true of pain. The cortical receiving areas are apparently concerned with the discriminative, exact and meaningful interpretation of pain, but perception alone does not require the cortex (Ganong 1967). This has been a much debated question, but it is agreed by Brodal (1969)3 that the involvement of the cortex (more particularly the post-central gyrus) is not essential. There is however, says Brodal, considerable evidence that the thalamus is an important structure. There is physiological evidence that noxious stimuli give rise to potentials in the posterior group of nuclei of the thalamus (Poggio & Mountcastle 1963).

Other thalamic connections are important. One of these passes ventrally to the hypothalamus and through this system then are evoked visceral and hormonal changes which are inevitable concomitants of pain (Wyke 1958). The second passes in the thalamo-frontal radiation, from the medial
nucleus of the thalamus to the cortex of the frontal lobe, (Clark 1948), and the fibres reaching the orbito-frontal cortex are of special importance in the emotional reactions to painful stimulation - by virtue of which it is felt to be unpleasant, intolerable or agonising. Frontal lobotomy (leucotomy) operations have indicated that this area is concerned with tensions resulting from real or imagined failures of performance and tensions caused by delusions, compulsions and intense phobias. In some cases too, lobotomy can dissociate pain from its unpleasant subjective effect (Ganong 1967; Brodal 1969).

The further connection of importance which has been referred to, is that of the reticular activating system (R.A.S.)* The cells of this system receive afferent collaterals from all the sensory systems entering the brain stem including the spinothalamic tract. (Fig. 49).

* The activating system is a functional concept, the reticular formation a morphological one - and these do not necessarily correspond (Brodal 1969).
Fig. 49. Mid sagittal section view of right hemisphere. Sensory stimuli ascend the lemniscal classical sensory pathways and stimulate the specific sensory nuclei of the thalamus whence impulses are transmitted to the cortical specific somato-sensory areas via the specific thalamocortical projections.

The individual's awareness of his environment and the intensity of his sensory experiences are determined by the level of reticular activation. There are connections with trigeminal, auditory, visual and olfactory systems. The R.A.S. is intimately concerned with the electrical activity of the cortex (Ganong 1967). This activity has been monitored and a characteristic response is seen in animals under barbiturate anaesthesia. The sequence of potential changes is shown in Fig. 50.
Fig. 50. Response evoked in the contralateral sensory cortex by stimulation (at the arrow) of the sciatic nerve in a cat under barbiturate anesthesia.

The primary response is highly specific in its location and can be observed only where the pathways from a particular sense organ end (restricted to the appropriate specific sensory projection area) (Brain 1962). The secondary response is due to activity ascending from below the cortex. Afferent impulses responsible for the diffuse secondary response possibly ascend in the R.A.S. Now adaptation to an environment is by 'sampling'. That is, we take a sample of all the possible cues in a situation such that the higher the level of vigilance the more information we take in, and in perceiving we build up our ideas of the environment by responding in a selective manner only to certain of all the existing stimuli (Mowbray & Rodger 1967).

The reticular formation, having received sensory impulses through the collateral fibres from the sensory nerve
tracts sends on further impulses which enhance the sensitivity of certain parts of the receptor areas of the cortex and facilitate their nervous discharges, particularly in relation to percepts (Vernon 1962).43

The R.A.S. then is such as to

(a) Maintain a basic level of attention so that we can be aware of significant environmental cues,

(b) Determine which of those cues are to be responded to.

(c) Provide the conditions under which the input from the environment is organised in a meaningful fashion.

So long as a person is awake, he has the ability to direct his attention to specific aspects of his mental environment. Further, the degree of attention can change remarkably from -

(a) almost no attention at all,

to (b) broad overall attention,

to (c) intense attention to a minute facet of his momentary mental experience. These changes in attentiveness seem to be caused by changes in activity of the mesencephalic portion of the R.A.S. (Guyton 1968).

Activity in the reticular formation is important in regulating the level of consciousness. However, in this function it certainly collaborates with other parts of the brain (not least the thalamus and cerebral cortex) (Brodal 1969).46

Electrical stimuli applied to different portions

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of the R.A.S. have shown that the mesencephalic portion functions differently from the thalamic portion - the former being responsible for normal wakefulness. Stimulation of a single specific area in the thalamic portion of the R.A.S. generates only a specific area of the cerebral cortex. This is one of the mechanisms by which a person can direct his attention to specific aspects of his mental environment, whether these be immediate sensory experiences or stored memories.

Barbiturates have a specific depressant effect on the mesencephalic portion of the R.A.S. Barbiturate anaesthesia does not block transmission in most of the sensory systems and also does not block function of the thalamic portion of the R.A.S. (Guyton 1968). These actions help in the understanding of patient reaction to barbiturate 'ultralight' anaesthesia, in the loss of generalised perception, but the retention of specific perception to certain stimuli. Like R.A.S. activity the diffuse secondary response is inhibited by ether anaesthesia. However, it is present in animals anaesthetised with barbiturates.

The ability of general anaesthetics to produce unconsciousness appears to be due in part to their action in depressing conduction in the R.A.S. The action of the barbiturates may simply be a manifestation of general synaptic depression by these drugs. The degree of depression
obtained depends not only on the particular barbiturate, the dose and the route of administration, but also on the degree of excitability of the nervous system at the time, and the extent of the drug tolerance. (Sharpless 1965).

Whatever may be the effects of barbiturates elsewhere in the nervous system, it is the effect on the reticular system that seems to be responsible for the inability to maintain wakefulness under the influence of a barbiturate. The state of anaesthesia does not require that sensory impulses should be prevented from reaching the cortex (Brain 1962). In small doses, barbiturates increase the threshold of the reticular system to direct electrical stimulation and depress the potentials evoked in the system by a variety of sensory stimuli; this effect occurs with doses that only slightly affect transmission in primary sensory pathways.

Wise et al (1969) have observed a predominance of delta activity in E.E.G. recordings from patients under intermittent methohexital. Delta waves include all the waves below $3\frac{1}{2}$ cycles/sec., and occur in deep sleep. Delta activity can occur in the cortex independently of the lower structures of the brain. Separation of the cortex from the R.A.S. causes delta waves in the cortex. In clinical anaesthesia with barbiturates it is synaptic
transmission that is altered, and not the ability of neurons to conduct impulses through their length (Wyke 1965). The activities of the reticular formation are depressed or inhibited by concentration of these drugs too small to affect the direct sensory stimulation of the cortex (Vernon 1962). Clinical application of 'ultra-light' barbiturate anaesthesia must consider these factors. There are hundreds of synapses in the reticular pathways. At each synapse the excitatory postsynaptic potentials must build up until the firing level of the postsynaptic neurons is reached. An agent which has a moderately depressant effect on this process will block conduction in multisynaptic paths before blocking those with only a few synapses (Ganong 1967).

Now, amongst the afferent systems projecting to the reticular system, that subserving pain is the most potent in affecting its activity, and thereby the activity of the whole cerebral cortex (Delgado 1955).

According to Wyke (1965):

There is now considerable evidence that anaesthetic doses of all anaesthetic agents markedly depress transmission of impulses through the myriad synapses of the brain reticular system, thereby reducing reticulo-cortical activation. In contrast, projection of afferent impulses through the long-tract sensory systems and their primary thalamo-cortical relays - pathways that involve few synapses - remains relatively unimpaired - even in advanced surgical anaesthesia. It is important for the
anaesthetist to realise that even in surgically anaesthetised patients, volleys of impulses from peripheral sensory receptors especially pain receptor systems, continue to bombard the primary sensory sectors of the cerebral cortex through the thalamo-cortical relays thereto. Such afferent bombardment can in fact only be cut off if local anaesthetic block of the afferent nerve fibres is added to general anaesthesia, and this is of special practical importance when operations are conducted under very light general anaesthesia supplemented by relaxants.

In light anaesthesia all types of sensory stimulation lead to cortical activation (evidenced in intermittent methohexital techniques). With deeper anaesthesia only painful stimulation is thus effective - the patient's awareness of the arrival of painful stimuli is depressed to a greater extent. Roger et al (1956) have shown that trigeminal stimuli are predominant in their affect on the waking state. Suppression of trigeminal centripetal influences has demonstrated affects on the waking E.E.G. pattern. It is therefore suggested that light general anaesthesia and sedation be supplemented by local anaesthesia.

In the adult human who is at rest with eyes closed the electrical activity of the cortex as measured by the electroencephalogram (E.E.G.), is represented by a regular wave pattern (The alpha rhythm). Desynchronisation may be produced by trigeminal stimulation up to the level of the midbrain (Ganong 1967). It appears that the ascending
activity responsible for desynchronisation following sensory stimulation passes up the specific sensory systems to the midbrain, enters the R.A.S. via collaterals and continues through the thalamus and the non-specific thalamic projection system to the cortex.

It is sudden sensory stimulation which is most likely to produce the arousal effect. If the stimulus is not repeated or repeated in a monotonous fashion arousal may only be partial. However, a greater arousal effect occurs if the stimulus is 'meaningful'. (Vernon 1962).

The R.A.S. then appears to largely determine the intensity of the patient's pain and procedure experience, and his responses. These observations may help to explain why there are such wide differences in patient perception in terms of their clinical tolerance of pain, even though their thresholds of pain differ but little in experimental test situations. For in the tense, anxious subject there is a high level of reticular discharge - as evidenced in the electrical activity of his brain; and this reticular hyper-excitability sets his pain tolerance at a lower plane than exists in the relaxed, phlegmatic or sedated subject (Wyke 1958).

Further, there is evidence (Ganong 1967), that brain mechanisms regulate the generation of sensory
impulses, and these can turn 'up or down' the volume of afferent input by effects on the specific sensory pathways. The concentration is therefore on the individuals pain tolerance and this depends to a great degree on 'his attitude toward the procedure, the operator, and the surroundings' (Monheim 1969).

Perception can be further affected by the behavioural and emotional relationship to an environment. This responsibility seems to lie with the limbic system (previously called the rhinencephalon). The limbic system consists of a rim of cortical tissue around the hilum of the cerebral hemisphere, and a group of deep structures notably the amygdala and the hippocampus. (Figs. 51, 52).

Fig. 51 Medial aspect of the right cerebral hemisphere with the limbic system coloured. The olfactory bulb, tract, and lateral stria, the uncus, and the dentate gyrus are shown in red. The hippocampus, supracallosal hippocampal vestige (indusium griseum), paraterminal gyrus, septum pellucidum and medial olfactory stria are shown in blue.
Fig. 52 Principle connections of the limbic system.

Str. Med. Stria medullaris.
Tub. Olfactory tubercle.
D.B. Diagonal band of Broca.
Sep. Septum.
A.T. Anterior nucleus of thalamus.
M Mammillary body.
P Interpeduncular nucleus.
MFB Medial forebrain bundle.

Brodal (1969) notes that there is no unanimously accepted definition of the limbic system - which is more correctly called the limbic lobe. Recent anatomical and physiological research tends to fractionate the 'limbic system' into several units with quite different projection and functional significance. The afferent and efferent connections of this 'system' are complex. There is little connection with the neocortex, although neocortical activity does modify emotional behaviour.
In the temporal and limbic lobes we find the anatomical basis of what appears to be a still higher level of integration at which perception becomes linked with memory and emotion and the impulse to action. We then reach a distinctly human level with conceptual thought (Brain 1962). Fear reaction can be produced by stimulation of the hypothalamus and amygdaloid nuclei and conversely the fear reaction together with its autonomic and endocrine manifestations are absent in situations in which they would normally be evoked, when the amygdalae are destroyed. Evidence seems to indicate that the common response to bilateral amygdaloid lesions is placidity (Ganong 1967). The amygdala is functionally related to emotional experiences and reactions. However, it is not alone concerned in these functions - the hypothalamus is also involved.

The amygdalae are said to be the site of action of diazepam (Parkes 1968). Diazepam appears to have depressant influences on limbic structures (Septum, amygdala and hippocampus). This may indirectly render hypothalamic mechanisms less susceptible to stimuli and therefore diminish reactions to stressful stimuli. Unfortunately the action of diazepam in the hippocampus would seem to be an affect on 'recent memory' (when a patient is unable
to establish lasting new memories - while that stored in the past is retained (Brodal 1969). This would seem to militate against the complete effectiveness of diazepam, and reliance on this agent to produce new patterns of dental attitude in the patient. This leads to the question of -

**Conditioning**

One further neurophysiological phenomenon is related to the present considerations - that of conditioned reflexes. A conditioned reflex is a reflex response to a stimulus which did not previously elicit the response, acquired by repeatedly pairing the stimulus with another stimulus which does produce the response. This was classically demonstrated by Pavlov in 1928, with his experiments on dogs - when the ringing of a bell (conditioned stimulus) produced, after sufficient pairing, excessive salivation previously only associated with the placing of meat in the mouth (unconditioned stimulus). (Pavlov & Anrep 1960).”

The apprehension experienced by many patients prior to a dental appointment may be likened to a conditioned stimulus, and whatever is associated with a stimulus that produces pain, can come to elicit a set of responses (Sternbach 1968). This takes the form of a premonition of the prospective procedures based on the conception of
the dental environment. It is important therefore, to understand that if this conditioned stimulus is to be reduced, and in fact eliminated, it must be paired with an unconditioned stimulus which does not correspond in any way to this premonition. The performance of the dental procedure should in no ways be akin to the patient's premonition of the procedure. Alterations in sensory input can modify pain behaviour. The source for the conditioned stimulus must also be explored, with a view to obviating it.

Now, B.E.G. recordings have demonstrated that when a new sensory stimulus is first presented to an animal it produces diffuse B.E.G. arousal. Behaviourally the human or animal becomes alert and attentive (orienting reflex - the 'what is it?' response). If the stimulus is neither pleasurable nor abnoxious it evokes less electrical response when repeated, and the animal becomes accustomed to the stimulus and ignores it. Further, there is behavioural arousal if the stimulus be paired with an unpleasant experience. Electrical activity is observed in the hippocampus - although not in the direct sensory pathways - by sensory stimuli presumably via the R.A.S. (Ganong 1967). Simple conditioning is not in itself sufficient to explain ways in which a patient's attitude may deliberately be changed. The question of reinforcement
also applies (see part C.).

The major factor related to pain behaviour is anxiety, which itself is a set of responses to an anticipated painful event. The individual's response to pain seems largely determined by his capacity for, and style of dealing with his anxiety. Pain responses may be modified by:

(a) Altering of patterning of stimuli to the primary sensory modalities.

(b) Modification of anxiety or the anxious responses.

The major elements in pain behaviour are:

(i) Perceptual coping style of behaviour.

(ii) Association of pain stimuli and pain responses, with social stimuli and anxiety responses.

(iii) Modification of these by inputs which elicit responses which interfere with anxiety (Sternbach 1968).

The implication is that research directed towards ways of alleviating pain may profitably investigate ways of interfering with anxious responses (Sternbach 1968).

It is important to stress that perceptual awareness is not vigorously stimulus-bound, nor is it dependent solely upon the transducer properties of peripheral receptors and the manner in which the impulses they generate are conducted and transferred to reach specific receiving stations in the thalamus and cerebral cortex (Jasper 1966).

Summary

In the consideration of perception there is not
simply the question of stimulus, but also of the following factors:

(i) Tolerance of noxious stimuli.
(ii) Degree of alertness or awareness.
(iii) Tensions and delusions.
(iv) Emotional behaviour.
(v) Conditioning and reinforcement.
(vi) Memory and amnesia.

Local anaesthesia alone does not necessarily form a complete protection for the patient. The transmission of the message is suppressed, but this form of analgesia only modifies secondarily the behaviour in response to pain. Inversely the drugs which modify behaviour (rendering the patient indifferent to pain, but allowing suffering to subsist) may not be analgesic.

The association of "narcosis" with analgesia, ideally, leads to the total suppression of perceptions and sensations, and consequently the responses to these perceptions as well, at all integrative levels. This is the definition of general anaesthesia. (Huguenard 1968). A powerful anaesthetic may thus provide the result of sensation/perception control, but in a non-selective fashion, and often ill adapted to the needs of the particular case or patient, and to the patient undergoing routine dental
treatment in the dental surgery.

What is required is the ability to control and modify in a selective fashion, as necessary, patient response to the dental procedure. Use of methods of control is coupled with evaluation by the dentist, in order to determine the effectiveness and progress towards the desired goals.
B. PSYCHOLOGY

Anxiety

Control studies in the field of preventive mental health, particularly as discussed by Caplan (1964) indicate that disturbances are most likely to be found in people who have had insufficient help in weathering crises and major changes in their lives. Behavioural patterns in the form of perception and expectation are influenced by:

(i) Actual emotional maturity.
(ii) Socio-economic and cultural position.
(iii) Psychological and physical condition. (Gayral 1965).

Any classification of behavioural disorders will include 'anxiety', and this will often be concealed. Every clinician should be able to recognize this problem in his patient. Dental patient anxiety problems and personality types have been summarised by Evans (1967). He has discussed the association of anxiety with pain, body damage, narcissism, and authoritarian upbringing. Personality 'types' are described as oral, hysterical, compulsive, and paranoid-schizoid, and every clinician should recognise these traits, says Evans.

Physical symptoms often accompany anxiety:

(i) Unpleasant sensation in epigastrium (butterflies).
(ii) Dryness of the mouth.
(iii) Hyperventilation.
(iv) Increase in muscle tone.
(v) Increased tension in frontalis muscles.

There are many foundations for anxiety, but the main concern here is for that engendered by the prospect of dental treatment, (notably apprehension). The physiological responses to anxiety are important, as dental patients may exhibit these responses (increased heart rate, blood pressure, pupillary effect) - the 'fight or flight' reactions. In particular, 'overalertness' should be noted, with its accompanying increased response to stimulus. Relevant signs of anxiety are:

(i) Apprehension (anxiety in a 'pure form' - objectless fear).
(ii) Nervous tension.
(iii) Irritability.
(iv) Insomnia.
(v) Fatigue.
(vi) Depression.
(vii) Lack of concentration.
(viii) Difficulties in personal relationships.
(ix) Restlessness.
(x) Obsessions.
(xi) Stuttering. (Meares 1968).

Each patient should be regarded as unique; his problem is unique to him (it is quite likely that his dental
visit represents a crisis situation), and consideration
of treatment planning should account for this. The dentist
must recognise the importance of counselling his patient.
If the dental appointment or procedure represents a crisis
situation for the patient, a great deal can be accomplished
in the pre-operative preparation simply by informed listening.
The dentist must be prepared to listen sympathetically to
fears, wishes, fantasies, memories, and anxieties. We must
remember to think of pain as an emotional experience (based
on memories and patterns of behaviour) and not merely as
sensation. (Quimby 1968). Anxiety is an extraneous variable
and a factor which can confound pain responses and which
must therefore be controlled. (Sternbach 1968).

Abram and Gill (1961) found that the patient's
pre-operative level of anxiety, his expectation of surgery
and his use of denial*, correlated well with his psychological
post-operative course. In searching for anxiety one must
determine if the patient has come to grips with his situation
maturely, or if bravado masks terror. Egbert et al (1963)
have demonstrated that premedication alone cannot allay
pre-operative apprehension. Those who face an anxiety
generating situation look for emotional support. An authority,

* Denial: means a defence mechanism by which fear,
real or imagined, can be reduced by one's minimizing
or denying the existence of the threatening situation.
supposedly able to modify the danger, becomes invested with a strong emotional significance.

Opton (1969) has observed the importance of anticipation in the production of the stress response in a patient. Experiments are cited which have shown that the expectation of harm, produced as much stress reaction as the harm itself. It was the expectation, not the experience, which caused the stress. Changing the experience should change future expectations, although methods of coping must also be important:

(i) Deployment of attention away from the threat.
(ii) Communication.
(iii) Control.
(iv) Affiliation.
(v) Rehearsal.

The importance of the application of behavioural studies in dentistry has been stressed by Cawson (1969). He has listed certain factors:

(i) Morbid fantasies held by patients about dentistry which effect their attitude to treatment.
(ii) Dentist-patient communication.
(iii) Emotional interaction between dentist and patient.
(iv) Dentist must make his awareness of patient feelings apparent.

Thus, where there is anxiety, the threat is not actually present or concrete, but is anticipated at some
future time (Evans 1967). It must be borne in mind that anxiety can be a 'normal' function such as anxiety before an examination or before a dental appointment. The dentist must be aware of this dimension of his patient's problem.

Psychological studies show that the extent to which a stimulus will be effective in producing such responses in a patient depends on his state of readiness - the extent to which he has previously been aroused; (Mowbray and Rodger 1967). In considering treatment, attention should be directed to an uncovering of the unrecognised sources of anxiety, to the action of psychodynamic factors, to their adjustment and to re-education. Less attention should be paid to the anxiety attacks, than to a study of the patient's personality, and to attitudes and situations that cause frustration and tension (Noyes and Kolb 1963).

In summary:

(i) The extent and degree of patient anxiety should be elicited.

(ii) Treatment planning should allow for modification of the experience which is responsible for the anxiety, with the aim of changing future expectations.

Phobias

Although the term 'fear' has popular colloquial usage, it has little psychological application in this context. Fear relates to an 'actual danger or threat'. Fear facilitates
only defence or escape behaviour not perception, learning or performance and not creativity, or positive interpersonal relating (Izard and Tomkins 1966). Few people then would categorise dental treatment as a fearful situation. Where this appears to exist, it is better understood as a 'phobia'.

The dentist must be careful not to mistake an anxiety for a phobia and vice-versa. The latter will be found rarely, but will be encountered. Anxiety, when appropriate, is a normal mode of response, where the phobia is inappropriate and excessive in degree - the disturbance of feeling and attitude impairs the individual's adjustment. Patients can have a general dental phobia, or it may relate to something more specific, for example, needles, or a choking sensation from material placed in the mouth. As such, one is then dealing with a psycho-neurotic illness. The patient's anxiety becomes detached from a specific idea, object or situation in his daily life and is displaced to some situation in the form of a specific neurotic fear. The fear that he feels in the presence of a certain object or experience is really the displaced fear of some anxiety producing component within his own personality (Noyes and Kolb 1963)."?

Gale and Ayer (1969) have discussed the treatment
of dental phobias - by means of reciprocal inhibition or desensitisation therapy. The patient is taught to relax and while relaxed to visualise non-anxiety evoking situations. Desensitisation involves the establishment of a heirarchy of anxiety - provoking stimuli and the gradual visualisation of these heirarchy from the least to the most, whilst relaxed. Treatment of a case of dental phobia using intravenous medication and supportive suggestion therapy was described by Silver and Wolpert (1968).

If a phobia is detected, behavioural therapy must become an integral part of the treatment plan.

Pain

Much difficulty has been met in seeking the meaning of, and defining pain. Dentists have tended traditionally to regard pain as a biological phenomenon, but it is not possible to regard pain as something which occurs independently of the emotional state of the individual. The main defence against pain has been embodied in medicine, surgery and anaesthesia. Thus the dentist has sought to relieve pain by these methods. There is a tendency to regard pain as a problem of pathological physiology, and only a psychiatric problem when somatic abnormalities are absent.

It is better to consider pain not in terms of components, but rather in terms of contributory causes or
approach. Here we are concerned with the psychological approach - instead of dwelling on the body as a physical machine, we focus on man and his relationships with himself and others. Then, the psychological method of observation and description is essential.

It is not uncommon for reference to be made for example, to 'pain pathways' or 'pain travelling up the spinothalamic tract'. Walters (1963) prefers reference to noxious stimuli, and their pathways and patterns - the distinction being drawn in that a given sensation does not necessarily elicit a painful response. This leads to the question of pain 'thresholds' - of which there can be thought to be two, - the pain perception threshold (P.P.T.) and the pain reaction threshold, or better - severe pain threshold (S.P.T.) (Merskey 1965). P.P.T. means the point at which pain is first perceived; S.P.T. is the point at which pain is severe or intolerable, What we experience must not be confused with our response. The P.P.T. is only rarely the same as the point at which peripheral sense receptors start to discharge. Our awareness of almost any group of stimuli within the range of our sensory field varies enormously with attention, interest and stress (Merskey and Spear 1967). Wolff et al (1966) studied pain thresholds and analgesics and distinguished between P.P.T. and S.P.T. They found
evidence that analgesics principally affect S.P.T. Now P.P.T. involves the word 'perception' which would be better not applied to this situation. The word 'threshold' alone suffices. A simpler form would be

\[
\text{Sensation or Impulse} \rightarrow \text{Becomes pain (Threshold)} \rightarrow \text{Pain interval} \rightarrow \text{Tolerance}
\]

By exercising perception control the dentist can affect this pattern, where it is such as to hinder effective treatment programming. There is evidence, (Gelfand et al 1963, Wolff et al 1966), that pain threshold is related more to physiological factors, while tolerance is related to psychological ones. Those who can tolerate pain most are 'perceptual reducers' and are relatively free of anxiety (Sternbach 1968). Care is needed in the use of the word 'perception' as it relates to pain - if we alter pain experience then we alter perception. Thus when one patient claims to feel pain but it does not bother him, while for another, a similar stimulus is claimed to 'hurt', it is not the pain which has changed but the perception. They both 'feel' the pain, and may have the same threshold, but perceive it differently. Persons exposed to the same painful stimulus will seem to feel it differently, and react to it differently.
One reason is the individual differences in the perception of the situation in which the pain is experienced. (Sternbach 1968). Following the operation of frontal lobotomy, referred to earlier (p. 362) patients claim to still feel pain but it 'doesn't bother them' (Ganong 1967). Petrie (1960) says of this surgery, 'the source of pain has not been dealt with, nor the threshold for pain been altered; instead the person experiencing the pain has been altered'. Not only has the person 'altered', but so has his perception - although he is still able to discriminate stimuli.

We must thus understand that it is not 'pain' which is transmitted, for example, during cavity preparation - pain only arises when impulses reach the brain, and are interpreted as such. A classical illustration of the relationship between pain and perception is in the comparison of war wounded soldiers and civilian surgical wounds (Beecher 1956). Beecher showed that the soldiers required less sedation than his civilian patients, and held that the difference was in the significance of the wounds to the patients.

The dentist must be able to make an objective assessment of the patient's complaints of pain and assess the reality of this complaint. He knows, or should know, what is likely to be painful experience and what is not, and so the extent of the 'neurotic' or psychological influence
will be clarified.

Two other factors should be mentioned which bear on pain tolerance. Firstly, a person's level of performance under conditions of stress will relate to his level of social consciousness. There is a definite relationship between social competence, coping potential and psychological development (Phillips 1968). Secondly, exaggerated expression of pain may be associated with certain ethnic groups (e.g. Italians). Pain 'expression' is not necessarily related to pain tolerance (Sternbach 1968).

Pain then can be seen as a consequence of the perception of a threat to bodily integrity (Szasz 1957). A sensation becomes a pain when and if there is activation of the conflict between a primary process of withdrawal from a noxious stimulus by the mechanisms of wish, anticipation or fantasy, and a secondary process - a motor attempt to preserve the physical integrity of the organism. The intensity of pain is directly proportional to the degree of activation of this conflict (Kast 1968).

Szasz (1957) defines three levels of symbolization of pain:

(i) Biological meaning - signal of threat.

(ii) Expression of pain - the communication of the experience to another person.

(iii) Where pain is seen as a 'request for help' or a
complaint about being unfairly treated, or an attack and retribution against a needed but unconsciously hated object.

**Perception**

Perception has been defined (p. 6) as interpretation of a stimulus and recognition of the object that produces a sensation.

Perceiving means being aware of meaningful sensory input, and is dependent upon sensory data from the environment. But, perceiving is not only 'input', it also involves the organism operating on the environment. This two-way traffic in perceiving has been referred to as the organism-environment transaction (Mowbray and Rodger 1967).

Needs and emotions of the perceiver also determine what is perceived. The person who is anxious, is likely to perceive events and situations as being fearful and threatening - such factors are referred to as perceptual sets, and indicate the perceiver's readiness to respond to certain organisations of stimuli. Perceptual sets are the basis of attending - the processes whereby we focus on certain aspects of a situation. The principles of perceiving are involved in creative problem-solving. Some patients have sufficient insight into a situation such that a solution is achieved immediately, with no trial or behavioural problem. The speed with which the problem is solved depends upon the amount of
previous relevant experience which might help in the solution. People vary in their capacity to perceive, or at least to cognize, their surroundings, just as they vary in their other psychological capacities. This variation may be merely one of efficiency; some people perceive more quickly and accurately than do others.

The more intelligent individual can learn to modify his manner of perception according to circumstances. Thus, although in general his perception may be quick and rather superficial in certain particular situations he learns to search carefully and attentively and to study closely (Vernon 1962). The most popular classification is into the 'synthetic' and 'analytic' methods of perceiving. The observer who adopts the first method tends to see the perceptual field as an integrated whole. The second observer breaks up the field into constituent parts (Vernon 1962).

Thus it may be put forward that in supposing the input were reduced simultaneously in a number of sensory modalities - nothing would be perceived - although the patient could still be remembering and imaging (reacting to past stimulation) - and would still experience something.

Perception involves knowledge of the object. There are three classes of learning in perception:

(1) Discrimination learning - for example:
differentiating one taste from another.

(ii) Learning new relationships between information from different systems.

If the stimulus input into one system is modified, the individual learns a new relationship between that system and another. A new co-ordination can be established after a period of practice (Day 1969).

An essential condition of our application of the concept of perception to a being of any kind, is that such a being should have sense experiences or sensations. Yet those sensations need play no part in the mechanism which makes it possible to behave in ways which, but for the absence of experiences we should describe as behaviour in the light of perception. The having of sensation is necessary to perceiving, but is not sufficient (Hamlyn 1961). Concepts of sensation and perception must not be studied by way of an investigation of one's own experiences. The important thing is how the activity appears to the person concerned.

Unpleasant states are liable to disrupt the process of perception, making it slower or more uncontrolled and inaccurate. Some people, however, appear to be stimulated by these experiences and try harder. A severely painful experience is likely to have a prolonged disruptive effect. Violent needs and emotions tend to monopolize attention completely, making the observer incapable of perceiving
anything in his surroundings unless it, or some distorted perception of it can be related to his need. A mild degree of pain or unpleasant emotion may make the observer more cautious, or may stimulate him to attend with greater concentration, hence producing in some cases, more rapid and accurate perception (Vernon 1962).

Perceptual consciousness then, is an active process of the patient in the dental environment, and will vary in form from individual to individual and will also be dependent on the particular stage, and the nature of the dental procedure which the patient is undergoing.

Perceptual consciousness is the activity, which when caused by a corresponding external object amounts to perception. The characteristics of perceptual consciousness have been summarised by Wyburn et al (1964) as:

(i) It is awareness of external objects or properties.
(ii) It is intuitive (immediate and undoubting at the time).
(iii) May be erroneous or inadequate.
(iv) Involves issues in judgement - attention and selection, learning and experience.

Distinction is drawn between 'perception' and 'perceptual consciousness'. In normal perceiving the subject's perceptual consciousness is caused by the corresponding external object, in illusions it may be caused by a different object, in hallucinations there may be no
external cause at all. (By 'corresponding object' is meant the object which corresponds in its characteristics to the content experienced in the perceptual consciousness). It will thus be seen that perceiving differs significantly from the other mental activities in that it does involve an observable transitive relation, a causal process between subject and object. Perceptual consciousness, however, resembles them closely in that it is theoretically adverbial, a mode of activity, but possesses an experienced content which seems to the subject to be distinct and external (Wyburn et al 1964).

It is a mistake to assume that the content of experience is simply an external object, and that perception or perceptual consciousness is direct confrontation with an external object or environment. Perceptual consciousness has a conceptual aspect - the 'thought' of the object and a characterisation and identification of what is perceived. In the perceptual consciousness of an object or environment the parts do not have equal force; some stand out, and within the whole there is an organisation or pattern in which some elements are subordinate to others. This organisation may change when it is not clear-cut, or does not accord with other information, or past experience. Thus we may see perceptual consciousness as being a mental process having a dual character - the transitive awareness of the
object as it appears to the person concerned, and the adverbial or qualifying activity based on previous experience and interpretation.

Thus under conditions of restriction of sensory inputs, which appear to be relatively innocuous conditions, unexpectedly severe changes in physiological function can occur. These changes are changes in perception.

With the dental patient perceptual factors remain, even though sensations can be obliterated (local anaesthesia). The use of general anaesthesia does not fully overcome this problem either, as the patient's conceptions of dental treatment may still remain. What is needed is a form of therapy designed to alter perception in order to overcome the implanted memory of past experience, and restore confidence to the patient in their ability to accept treatment in the dental chair in the normal way. The aim is to produce changes in conception and response by affecting perceptual consciousness.

Reinforcement

The phenomenon of 'conditioned reflexes' has been discussed in the section on neurophysiology. These may be recognised in ourselves and our patients under such names as 'education', 'habits' or 'training' (Pavlov and Anrep 1960)\(^3\). When conditioned reflexes are being established
for the first time, the whole environment acquires conditioned properties. Later, if there is a special reflex to a single definite stimulus, all other elements of the environment gradually lose their conditioned significance. Associations once established and acquired between definite stimuli and responses are persistently reproduced, even though we fight against them (Pavlov and Anrep 1960). The same influences may produce a profound disturbance in some individuals and no trace of effect in others. One must know why these conditions and difficulties produce such a result in one patient when they are without influence on other people (Pavlov and Gantt 1941).

Habits may be built up by reinforcement as well as by conditioning.

The Hull formula (Mowbray and Rodger 1968) is:

\[ \text{SER} = \text{SHR} \times \text{D} \]

where \( \text{SER} \) = performance

\( \text{SHR} \) = habit

\( \text{D} \) = drive

Performance is different to learning, the former term implying the ways in which newly learnt patterns are translated into behaviour. Habit develops from a number of re-inforcements, but before habit reveals itself in performance it must be transformed into reaction - potential
(the speed with which a learned response follows the stimulus). Reinforcement will operate if given almost immediately after the response.

Emotions may be regarded as responses to specific stimuli. It is possible to use conditioning principles in explaining emotional reactions, and further to regard emotions as capable of being learned. Hunt (1960) reporting on 'conditioned fear' says that through learning, a neutral signal acquires the power to evoke an intense emotional disturbance greater than that which re-inforcing shocks could evolve initially. It has been found that if extinction be inadequate, at a later time the conditioned response could suddenly reappear at its full intensity. It is thus necessary to devise an active method of removing conditioned behaviour. It is postulated that general anaesthesia away from the dental surgery environment, does not have the requisite effect in altering the pattern of conditioned patient behaviour towards dental treatment.

This leads to the consideration of Behaviour Therapy - by active methods of desensitising patients in a progressive fashion. The concept of 'reciprocal inhibition of neurotic responses' has been put forward by Wolpe (1958), and Gale and Ayer (1969). The technique involves seeing the patient with a view to bringing out information about all the
situations or objects which serve as threats and produce anxiety. A 'hierarchy of responses' is constructed and the patient is progressively desensitised to the least disturbing threats first of all, and then step by step until the patient no longer feels at all threatened. The rationale is that if psychoneurotic symptoms are learned emotional responses, they can also be reduced by being 'unlearned'.

The principle in reinforcement is to reinforce necessary behaviour, and an understanding of reinforcement can help the dentist in his patient relationship. The dentist must focus on the behaviour wished for, such that the patient learns that behaviour (Winslow and Ferris 1970).

(h) Summary

On the information obtained from his counselling the dental surgeon may elect to undertake his treatment programme (bearing in mind that the counselling itself should have eased the crisis situation). The following factors may require consideration in treatment planning:

(i) Explanation of particular problems elicited.

(ii) Elimination of the pain sensation associated with the procedure.

(iii) The dulling of the awareness of the procedure; affecting perceptual consciousness.

(iv) The overcoming of a dental/dentist phobia and its associated tensions.
(v) Conditioning the patient to future dental care and treatment which is anxiety-free; encouragement (reinforcement).
C. **PHARMACOLOGY**

The use of drugs is a realistic but a limited approach to the treatment of anxiety. The prime consideration is that of the patient and his characteristics, but if drugs are to be used then the characteristics of those drugs must also be considered.

Brief notes are given on the following, relative to succeeding case reports:

(a) Barbiturates: Pentobarbital Sodium and Methohexital Sodium.

(b) Atropine and Scopolamine.

(c) Pethidine and Pentazocine.

(d) Propanadid.

(e) Diazepam.

(f) The Placebo effect.

(a) **Barbiturates** (Pentobarbital, methohexital)

Pentobarbital sodium (Nembutal) is an intermediate acting barbiturate, while methohexital sodium is ultra-short acting, and is an oxybarbiturate, having an additional oxygen atom in the place of the sulphur atom of thiopental (Pentothal). (Dundee, 1961, regards this type of subdivision of barbiturates as misleading, since the duration of narcosis is related to the dosage, and if sufficient be given, recovery may be prolonged).

It is generally believed that the synapse is the
site of the action of hypnotic compounds, and it suggests that activity transmitted over poly-synaptic pathways should be especially susceptible to barbiturate depression. The degree of depression obtained depends on the particular barbiturate, the dose, route of administration and excitability of the nervous system at the time. The reticular activating system (R.A.S.) is exquisitely sensitive to the depressant effects of barbiturates, this has already been discussed. (p.366)

It is generally agreed that barbiturates are poor analgesics although Brophy (1968) states that barbiturates have no analgesic properties at all - and are actually antianalgesic. These statements are based on observations made by Dundee (1964), and Finch and de Kornfield (1967) (Dundee showed that subanaesthetic doses of methohexital produced increased sensibility to somatic pain).

The desirability of the concomitant use of local anaesthesia with barbiturates has been noted (p.369). Wilson and Schild (1968) state that hypnotic doses of barbiturates help to relieve moderate pain, by diminishing the anxiety and fear associated with pain. With small doses of methohexital there is an increase in the energy of the high frequency part of the Electroencephalogram (E.E.G.) spectrum - 15 - 35 CPs. It is accompanied by clouding of
consciousness and occasionally euphoria. As the dosage is increased slow waves (2-8 CPS) appear and consciousness is lost, although the patient may respond to strong painful stimuli. Increasing the dose still further causes a decrease in the amplitude of wave forms with brief periods of electrical silence. Barbiturates are respiratory depressants but only slight depressors of protective reflexes - in animals the cough reflex is depressed only by doses that seriously embarrass respiration. Coughing, sneezing, hiccoughing and laryngospasm are complications of intravenous methohexital (Sharpless, 1965).

The administration of methohexital is associated with minimal effects on blood pressure (Dundee and Moore 1961) a rise being not unusual. This has been attributed to an increase in cardiac output (Wise et al 1969). Skovsted et al (1970) have indicated that barbiturate action is such that barostatic reflexes are unaffected and circulatory stability remains during barbiturate anaesthesia.

Rises in pulse rate have been reported in patients receiving methohexital (Christenson et al 1961; Wise et al 1969). There has been some controversy over the incidence of apnoea following methohexital. Differing results appear to be related to the dosage, concentration and speed of injection (Thornton 1970). Respiratory depression may last
15 to 20 seconds after a rapid injection, but the degree of depression is less than that after equipotent doses of thiopental (Kay 1969). Caution is essential when either drug is administered in the presence of any respiratory difficulty.

The ultra short action of methohexital contrasts with the slower pentobarbital. This difference appears to be in the rapidity of penetration of the blood-brain barrier (Goldstein and Aronow 1960). Methohexital has a lower oil to water partition co-efficient than the thiobarbiturates, and its rate of detoxification is more rapid. Patients are more alert and with less hangover than with thiopental (Redish et al 1958). Methohexital shows some evidence of cumulation but this property is considerably less evident than with thiobarbiturates. Methohexital and pentobarbital are degraded in the liver to inactive metabolites. Slow injection of both drugs is essential if deleterious effects are to be minimized. A significant difference between the tranquillisers and the barbiturates is that the latter exert more profound effects on the neocortical areas associated with the higher functions of the mind. In contrast to the anti-anxiety drugs, pentobarbital does not 'tame' (Jenner 1965).

**Preparations**
Methohexitol (Eli Lilley)

Is a white hygroscopic powder, soluble in water and stable in solution 4 - 6 weeks (25°C). The usual form of supply is a 500 mg. multiple dose ampoule to which 25 ml. of water for injection B.P. is added to produce a 2 per cent solution.

Pentobarbital

Martindale - Samoore (British Pack) - as a white powder in ampoules containing 250 mg. 5 ml. of water for injection B.P. is added and 125 mg. are added to a further 7.5 ml. water such that the injected solution contains 12.5 mg. per ml.

Abbott Laboratories (American Pack) - Premixed in ampoules 2 ml. each containing 100 mg. in Alcohol 10%; Propylene Glycol 40%; water for injection q.s. 8 ml. water for injection B.P. added to 2 ml. ampoule gives solution containing 10 mg. per ml.

(b) Parasympathetic Blocking Agents

Atropine, and Scopolamine (Hyoscine)

These drugs belong to a group known as the belladonna alkaloids and inhibit the action of acetyl choline by competitive action on structures innervated by post-ganglionic cholinergic nerves (Innes and Nickerson 1965).
The two drugs differ in certain respects:
Atropine is more effective in blocking the muscarinic effect on the heart. Thus, a mild tachycardia may follow its administration. It has no sedative or analgesic effect, and does not depress the central nervous system (C.N.S.) in clinical doses.
Scopolamine differs in producing a depression of the C.N.S. causing drowsiness, sleep and amnesia. The action on the heart and bronchial musculature is weaker than that of atropine (Norris and Campbell 1968). Infants and young children are particularly susceptible to the alkaloids.

Toxic effects include a dry burning mouth, swallowing and talking become difficult, and there is a marked thirst, dilated pupils, tachycardia, cutaneous flush and fever.

Scopolamine alone, or with a barbiturate, tends to produce excitement and delirium which is absent when the drug is administered with a narcotic (Hinds and Keats).

Supply
(i) Atropine sulphate inj. 600 micro gm. (1/100 gr.) in ml. ampoules (Knoll).
(ii) Scopolamine, as Hyoscine hydrobromide B.P. 400 micro gm. in 1 ml. ampoules. (Knoll).
(c) Analgesics (Pethidine; Pentazocine)
Pethidine
Pethidine exerts its chief pharmacological effect on the C.N.S. Therapeutic doses produce analgesia, sedation, euphoria, respiratory depression and other diverse C.N.S. effects. 80-100 mg. is said to represent the clinical optimum when satisfactory analgesia is balanced against side effects and toxicity. Smaller doses have been shown to produce euphoria (in the present series 25 mg. pethidine hydrochloride was never exceeded). The untoward effects include dizziness, palpitation, syncope and sedation. Severe reaction may occur when pethidine is administered to patients being treated with mono-amine oxidase inhibitors. These are characterised by excitation, delirium and convulsions, or severe respiratory depression and cyanosis. Overdosage can result in profound respiratory depression, tremors or convulsions and even death.

When given with a barbiturate, pethidine appears to have a synergistic effect, and has a sedative effect of its own. Also, it raises the pain threshold and gives the patient a sense of well being. It does not depress the cough reflex (Wise 1966).

Its disadvantages, apart from the reaction mentioned above, are:

(i) It is narcotic, and as such may be abused.

(ii) Possibility of respiratory or cardiac depression.
(iii) May stimulate vomiting centre.

(Jorgensen 1967).

According to Jorgensen however, no serious side effects have been noted in twenty years experience. Nalorphine hydrobromide (Lethidrone) is recommended as an antagonist. A further disadvantage to its use in Australia is that suitable packaging (25 mg. mixed with 0.4 mg. Scopolamine) is not available; local ampoules contain 100 mg. with 0.43 mg. scopolamine.

**Pentazocine (Fortral, Talwin)**

Pentazocine is a member of the benzomorphan group of compounds which possess narcotic-antagonist properties in addition to being strong analgesics.

Pentazocine is a white crystalline substance soluble in acidic aqueous solution. It is supplied as a sterile isotonic solution in 1 ml. ampoules containing 30 mg. pentazocine base (as lactate). It is claimed that 30 mg. of Pentazocine is equivalent in analgesic effect to 75 mg. Pethidine administered pre-operatively (Keats and Telford 1964). Paddock *et al.* (1969) found the sedative effect of 20 mg. pentazocine to be similar to 10 mg. morphine and 30 mg. equivalent to 10 mg. morphine as an analgesic. Claim is also made that analgesia lasts three hours or longer. Studies have indicated that pentazocine is relatively
free of abuse liability, (Fraser and Rosenberg, 1964) and is not classified consequently as a drug of addiction. Jasinski et al (1970) indicated however, that pentazocine has abuse potential although less than with morphine, and has no capacity to substitute for morphine. Respiratory depression can occur with pentazocine and is apparently dose related (Sadove et al 1964). Methylphenidate hydrochloride (Ritalin) is recommended as a respiratory stimulant in such event (Telford and Keats 1965; Kallos and Smith 1968). Doran and Burt (1970) also found satisfactory reversal with 4 ml. 25 per cent solution of nikethamide. In equipotent doses pentazocine produces less nausea and less respiratory depression than morphine (Poswillo 1968). Other side effects are nausea, vertigo, dizziness, vomiting and euphoria. Some degree of sedation has been noted in 31 per cent of patients undergoing double and single-blind studies (Winthrop Labs, 1968).

The American Medical Association registry on adverse drug reactions records 20 reports relating to pentazocine in two years since July, 1967. Seven (35%) cited a hallucinatory effect, whereas others reported drowsiness, dizziness, inability to think, vertigo, vomiting, euphoria, inco-ordination. Details of the seven cases where patients had experienced hallucinatory effect are given
(De Nosaquo 1969). Jasinski et al (1970) in their study claim that at least 60 mg. was required to produce hallucinations and derealisation.

The utilization of pentazocine intravenously for dental work has been reported by Kurland (1968), who used it in combination with methohexital and propanadid together with the anti-emetic cyclizine. He found that 'only one third of the usual dose of each anaesthetic was required when combined with pentazocine and this regime enabled patients to remain conscious throughout the operation'.

Supply

(i) Pethidine (Martindale and Samoore) premixed with 0.4 mg. 25 mg. Scopolamine (2 ml.)

(ii) Pentazocine - Ampoules 1 ml. cont. 30 mg. as lactate (Winthrop).

(d) Propanadid

An ultra-short acting anaesthetic agent, propanadid is a derivative of phenoxy1 oxyacetic acid. It is supplied in ampoules (500 mg. in 10 ml.) in a solubilising agent, poly-oxyethylated castor oil, which is non-toxic and non-anaesthetic. The resultant clear solution is oily to touch, bitter to taste, with a faint smell of castor oil. It has a storage life at room temperature of at least two years. It is used in doses of up to 10 mg./kg., and narcosis ensues in one arm-brain circulation time. There is seldom
any definite sensation during induction, save an occasional report of a 'taste', often described as bitter. Pupils often dilate widely. Electroencephalographic patterns are individual and distinct from barbiturate patterns. There is a freedom from drug inter-action, except with suxemethonium the effect of which is potentiated (Howells 1966). Caution should be exercised in cases of haemolytic anaemia and renal disease. Following induction there is a phase of hyper-ventilation lasting 30 seconds followed by a phase of respiratory depression. Laryngospasm did not occur in a series of 100 patients observed by Howells (1966), even though deliberate stimulation of the cords had attempted to initiate a spasm. Bronchospasm likewise was not seen.

Howells et al (1964) noted a brief period of hypotension during induction, the fall mainly being systolic, a 30 per cent drop within the first minute and a return to 10 per cent of the initial value being regarded as normal. A return to normal in 2 minutes was noted (Howells 1966). The analgesic effect was found to be variable. Side effects reported have been variable, but are commonly, involuntary muscle movements 6 per cent, hiccups 8 per cent (Howells 1966).

A dramatic feature of propanadid is its breakdown; 50 per cent of the induction dose being metabolised within
twenty minutes, while 90 per cent of the breakdown products are excreted in the urine within two hours. Recovery is speedy and complete without euphoria or hangover. Nausea and vomiting are rare if this agent is used as a sole-anaesthetic (Clarke and Dundee 1966).

**Supply**

Propanadid 0.5 g. in 10 ml. ampoules (Bayer).

(e) **Diazepam**

Is a tranquilliser of the benzodiazepine class, supplied for intravenous injection in 2 ml. ampoules containing 10 mg.

The tranquillizing action appears to be due to its interfering with neuronal transmission at supra-spinal levels, and it is suggested that the amygdala may be the site of the action of diazepam in breaking the patterns of neuronal activity responsible for anxiety (Parkes 1968). The powerful effect of diazepam on the 'emotional component of pain' was reported by Hoffmeister (1968). Given alone even large doses appear to have little effect on respiratory or cardiovascular stability in normal healthy subjects (Brown and Dundee 1968; Brown 1968). O'Neil et al (1970) found that the average heart rate did not change to any noteworthy extent after diazepam, but was lowered in patients with a high initial rate. They also found slight
fall of systolic blood pressure and no detectable respiratory depression.

Diazepam appears to produce marked potentiation of barbiturates (Foreman et al. 1968). Amnesia has been noted by some workers although this is not a consistent observation. Retrograde amnesia (lack of recall of the pre-injection object) was not found to be produced to any extent, by Dundee and Keilty (1969). Memory for subsequent events was markedly reduced when diazepam was given in combination with pethidine or hyoscine, but was little affected by 10 mg. diazepam alone. In two studies with dental patients, (Keilty and Blackwood 1969; O'Neil et al. 1970) virtually all patients remembered the diazepam administration, while few recalled the subsequent intra-oral injections.

The principal actions are manifested by detachment, slowing of speech, tendency to ptosis, reduced muscle tone, fixation of eyeballs with lids closing, masseters relaxing, sometimes a little stertor. Onset takes thirty to ninety seconds (Foreman 1969). The individual reaction and the duration of the action are variable. The most common side effects reported are pain during injection, and in larger doses prolonged disorientation, hypotension and respiratory depression.
One of the most reliable signs that the patient has received sufficient dosage is that noted by Verrill (1968). He observed that with the patient supine before administration of diazepam the upper eyelid is approximately level with the upper edge of the iris. As injection of diazepam proceeds, and its relaxant properties begin to take effect on the orbicularis oculi musculature, the eyelid slowly droops until it reaches the level halfway across the pupil, indicating sufficient dosage has been given, and the patient is adequately relaxed and sedated.

Clinical experience and laboratory tests have confirmed that diazepam has no harmful effects on the liver, kidneys or haemopoietic system (Zbinden and Randall 1967). Diazepam has been widely used for sedation in labor, and has been shown to produce no untoward effects upon mothers or infants (Dundee and Keilty 1969). Patients should avoid taking alcohol while under the influence of the treatment.

Diazepam should be injected alone, as in routine mixed injections it is incompatible with aqueous solutions of other medicaments, and precipitation of the active substance will ensue. Dundee and Haslett (1970) report that the soporific action of diazepam may be potentiated by its combination with pethidine, and also with hyoscine.

Supply

10 mg. diazepam in 2 ml. ampoules (Roche).
(f) The Placebo effect

The importance of the placebo effect must not be over-looked. Beecher (1955a) has indicated an astonishing effectiveness of placebos in relieving or significantly improving subjective responses. No evidence has been found to suggest that patients who responded to the placebo belonged to the neurotic fringe. The main factor was the patient's expectation of relief from taking drugs. The personal characteristics of the dentist, and interaction in dentist-patient relationship can also determine response. This writer has, for example, observed a sense of confidence in patients who have been referred by another dentist - thus the importance of the counselling and conditioning by the dentist is again apparent.

Beecher (1955a, 1955b, and 1959) points out that 35 ± 2.2 per cent of subjects were relieved by placebos. Beecher also reviews ample evidence which he has collected to show that morphine is effective in relieving pain because of its action in allaying anxiety. This has been supported by Wolff et al (1966).

There is evidence then that, when analgesics and sedatives are employed patients enjoy relief of pain, and some part of this relief is attributable to a placebo response,
and some to abatement of anxiety by sedation. It should be noted that as a rule the effect is reduction of pain and not abolition. The placebo effect may be reinforced in the presence of a state of central excitation induced through conditioning. The desired response may be conditioned - and one of the most important conditional stimuli is the dentist himself. Chambiras (1970) notes 'the degree to which he is able to induce in his patients a state of arousal or readiness for a favourable response, the more potent the sedation he gives will be'.

The placebo effect of active drugs is masked by their active pharmacological effect. Total effect = placebo effect + active effect.

The clinical trial of a drug should show how far the effectiveness of the drug is greater than the placebo effect.

In general this means:

(i) Large enough number of observations

(ii) 'Blind' or 'double blind' trials.

Clinical experience of this writer in the application of the principles of perception control as reported in the next section has been of a large number of cases in private dental practice. Kingston (1962) has said that 'a double-blind trial in private practice is impracticable, if not
unethical. However, a clinical evaluation by means of observation of the effects of the drug in the circumstances under which it will be used, provides a complement to the institution-based controlled trials'.

On this basis then, are the cases presented.
XIII. MATERIAL AND METHODS

The study of the application of methods to control patient perception was undertaken by the present writer in his private dental practice. Two hundred and sixty patients of the practice were involved in this study, which extended over a two year period (September 1968 to October 1970). Assistance was provided by a trained nurse assistant and a chairside assistant. Treatment was provided in the dental surgery, with the exception of 8 patients who were hospitalised, and underwent treatment under general anaesthesia administered by a specialist anaesthetist.

Sedation techniques were only employed where it was considered that patient attitude and the necessary treatment justified it.

A. Patient assessment and technique selection

A thorough dental examination is of course the first prerequisite in patient assessment and technique selection. The results of this examination are paired with an appropriate technique, following the counselling of the patient. This counselling seeks to obtain an introspective report of the patient's emotional state as it relates to the prospective treatment. With a majority of patients simple measures involving local anaesthesia will suffice. Other patients will however, relate in such terms as: 'I'm terrified', or
'I'm scared stiff', or 'I hate the needle' or 'I'd rather have a baby than sit here', or 'I don't mind what the doctor does to me, but I can't stand the dentist'. The list is limitless, but the basis is the same — apprehension and anxiety — a conceptual relationship to the dental environment which arises from the process of perception. Some patients will not readily admit their feelings and sham confidence, but skilful questioning by the dentist will elicit the true attitude.

Thus the dentist may elect to adopt some measure of perception control, with the aim of restoring this lack of confidence, overcoming the anxiety, and conditioning the patient to future dental care. Sedation techniques can be most effective in meeting the problems. There are other situations commonly encountered in dental practice, which, whilst they are mundane, deserve consideration by the dentist if they represent barriers to effective treatment programming.

(i) Patients who live at a distance from the practice and find travelling a problem (this is of interest in country areas).

(ii) Young mothers who find baby-sitting arrangements a problem.

(iii) The casual-minded patient who is likely to fail appointments or tire of treatment, before completion.
(iv) The patient who is heavily committed with his work, and finds his time at a premium.

Before selecting a technique, a medical history is recorded (Seldin 1965; Jolly 1967). The following may be listed as contra-indications to intravenous sedation:

(i) Lack of palpable veins.

(ii) Very short procedures.

(iii) Medical history reveals a metabolic disorder (in particular, cardio-vascular disease, respiratory and liver dysfunction, porphyria).

(iv) Pregnancy (in view of the possibility of teratological effects — unlikely, but if such occurred, could be thought to be connected).

(v) Patient's current drug therapy is incompatible with drugs used — in particular cortico steroids, tranquillisers, anti-depressants. (The use of pethidine is absolutely contra-indicated in patients on mono-amine oxidase inhibitors).

(vi) If the patient is suffering from a cold, cough or sinusitis, treatment should be postponed.

(vii) Known poor alcohol tolerance.

(viii) It is not possible to arrange an escort, post-operatively.

(ix) Scepticism on the part of the patient, or patients' parents, as to the effect or desirability of utilising sedation.

(x) Inadequate staffing (two assistants should be present, one of whom having had general nursing experience).

(xi) Lack of resuscitative equipment or emergency drugs, and knowledge of their application.

(xii) Marked apprehension relating to injections in the arm (rare).
INDICATIONS

(1) **Jorgensen technique**

The Jorgensen technique or slight modifications thereof, provides an excellent method of perception control. More specifically the indications have been found to be:

(a) Extensive conservative work with long operating time (between 2 - 3 hours).

(b) The need for a maintained reliable sedation level throughout the operation.

(c) The patient who suffers from extreme fear or dental phobia.

(d) Procedures which require extensive manipulative work, e.g. prolonged oral surgery or crown and bridge work.

(e) Where rapid recovery is unimportant.

(2) **Intravenous diazepam**

Indications:

(a) Sedation for shorter procedures (up to 90 minutes).

(b) Mild to moderate anxiety.

(3) **Methohexital, propanadid**

As applied to the present series, the indications are:

(a) To supplement intravenous diazepam.

(b) Acute alveolar abscess incision.

(c) Exodontia (where no complication is foreseen - X-rays are desirable).

(i) Acute alveolar abscess.
(ii) Extreme fear of local anaesthesia.

(iii) Immediate dentures where no bone shaping is required (not absolute).

(d) As a supplement to local anaesthesia in subanaesthetic doses (provides short-acting sedation).

Food or drink must not have been taken within four, preferably six hours. Recovery facilities are required together with adequate supervision of patient recovery. This method should not be attempted in the presence of factors liable to interfere with the airway, e.g. retropharyngeal abscess, sore throat, sinusitis, the 'bull-necked' patient.

Other contra-indications as for sedation.

(4) **Endotracheal anaesthesia (Hospital)**

General anaesthesia is preferred, where there is a contra-indication to sedation. The following indications have been found to apply (present series):

(i) Extremely anxious patients undergoing extensive conservative dentistry, for whom intravenous sedation is contra-indicated.

(ii) Mentally handicapped patients. (In this respect it should be noted however, that the use of intravenous diazepam/local anaesthesia has been suggested as an alternative method by Healy et al 1970).

(iii) Multiple extractions.

(iv) Recalcitrant child requiring multiple conservation and/or exodontia.
(v) Where there exists a contra-indication to the use of local anaesthesia.

This method may also be preferred for the patient undergoing a 'one-time' dental operation — for example, third molar surgery. Ready availability of facilities can also be an influence in the selection of this technique.

(5) Other techniques

Whilst not forming part of this series other techniques are acknowledged, notably inhalation analgesia and nasal mask inhalation nitrous oxide/oxygen plus supplement. That these are not included is not intended as a reflection on their efficacy or otherwise. It is contended however that the methods here put forward allow for a more natural transition to perception control for the Australian dental practitioner. Nitrous oxide/oxygen has always enjoyed a close association with dental work, and its use as an analgesic agent is most certainly worthy of further study. Indeed, observations by the present writer on the growth of interest in nitrous oxide/oxygen analgesia, and the advent of purpose-designed machines would indicate that hypalgesia has a definite place in perception control — particularly for the shorter procedure, and where rapid recovery is required.

Intravenous sedation techniques enable the surgeon to broaden the spectrum of operating conditions which he is able
to utilise, and thus enable him to exercise better selection relative to patient need. In this way he can serve, not only his patients, but the cause of general improvement in communal dental health, and appreciation of dental services.
B. Clinical procedures

(a) Examination (pre-appointment)

(1) The dental and oral examination, together with any necessary radiographs.

(2) Consultation and discussion with the patient as to:
   (i) Their treatment requirements.
   (ii) Their attitude to treatment.
   (iii) Any specific fears or anxieties.
   (iv) An explanation of the suggested procedure, designed to account for their emotional relationship to treatment.

(3) History taking (information was obtained from each patient, in particular relative medical history was recorded, and details of any current or recent drug therapy noted).

(4) Patients were checked for location of suitable veins, and a note made accordingly.

(5) Pre-operative instructions were issued (Appendix 11) and appointment arrangements made.

(b) Appointment (general)

(1) Patient reception and attendance to toilet arrangements if necessary.

(2) Pre-operative recording of blood pressure, pulse rate and respiration rate (preferably in an office apart from the surgery).

(3) Confirmation of patient transport arrangements for the conclusion of appointment.

(4) Venepuncture.

The patient is seated in the dental chair which is adjusted to a reclined supine position. The patient's arm
is extended along an armboard attached to the chair arm rest.

![Patient position prior to venepuncture — Intravenous sedation.](image)

A Prameta tourniquet is applied to the upper arm above the injection site, and in some cases additional support is given with a velcro strap across the wrist. A suitable vein is palpated. In the majority of instances the most favourable site is the cubital fossa — the median cephalic vein, or in some cases, the median basilic vein.
Fig. 54 Venous anatomy cubital fossa.

Lack of palpable veins in this region may mean the choosing of other sites, such as the forearm, dorsum of the hand or preference of one arm to the other. Wrist veins were used in one instance.
The selected area is scrubbed with a surface disinfectant such as chlorhexidine (Hibitane), and 4 - 5 drops of ethyl chloride are dripped on to the injection site. Three types of needle have been used:

- 25 G x 15/16"
- 23 G x 13/16"
- 23 G x 1" (with attached plastic tubing)

Syringes used were 10 ml disposable type with an eccentric nozzle (Johnson & Johnson). Glass syringes with eccentric metal nozzles sterilised in sealed containers by dry heat have also been used.

![Diagram](image)

**Fig. 55** Armamentarium - Intravenous sedation.
Venepuncture is checked by aspiration of blood into the syringe prior to injection. A small amount of drug is injected followed by a pause to assess any initial reaction.

![Venepuncture Diagram](image)

**Fig. 56** Venepuncture:

A. Large needle, small vein, possible haematoma if bevel up.

B. Bevel down, small veins.

C. Large vein, bevel up or down.

If a second syringe is to be utilised the needle may be strapped in position with sticking plaster while the syringes are changed. Alternatively an adapter such as the Gordh adapter may be used.
Fig. 57 Gordh adapter.

At the completion of the injection the area is again swabbed and a small piece of sticking plaster placed over the injection site. The arm-band is removed and the patient elevates the forearm for a brief period.

Local injections are then given as appropriate.

Throughout the operative procedure, which is carried out with the patient semi-supine and the operator seated, high velocity low-vacuum evacuating equipment is used.
**Fig. 58** Operating on the sedated patient.

Note suction tube and the chain of mouth-prop.
Fig. 59 High velocity low vacuum evacuating unit.

This evacuates water from the high speed handpiece (in this respect a handpiece having a mist spray is recommended), and also debris, in particular amalgam scrapings. A rubber mouth-prop is placed when work is carried out on posterior teeth. (Fig. 58). Although the cough reflex is present in sedated patients, further protection and absorbing can be obtained from the use of a cellulose mouth-pack. (Fig. 55).
An alternative is the 'Vac-ejector' which combines mouth-prop, suction and rubber shield or mouthpiece attached, for the retaining of debris.

Fig. 60 Vac-ejector in position on models.

Fig. 61 Sedated patient, vac-ejector in place.
At intervals of 15, 30, 60 and 90 minutes recordings were made as per patient rating scale (Carpenter et al 1961). (See B page 464)

Further, 30 minutes after induction, blood pressure, pulse rate and respiration rate were recorded, and again on completion.

Fig. 62 Blood pressure is recorded on completion of treatment. Note relaxed state of patient.

The sedated patient will ideally maintain a steady level throughout (see B page 464) but is able to respond to requests, e.g. to rinse the mouth, if so desired.
(c) **Post-operative**

Patients were able, very often unsupported, to leave the chair on completion.

![Image of patient in chair](image)

**Fig. 63** Photograph taken immediately after previous Figure. Patient is easily roused and able to leave the chair.

They were issued with post-operative instructions (Appendix III) and transport arrangements finalised. In most instances they were seen again for polishing and post-operative sequelae checked. One hundred and thirty patients completed a post-operative questionnaire (Appendix IV).

**TECHNIQUE**

(1) **Jorgensen technique**

Pentobarbital sodium is injected slowly at a rate of 1 ml containing 10 mg. (American Pack) or 12.5 mg. (Brit.
Pack per 30 seconds. 'The patient is carefully watched and listened to, for signs of drowsiness, dizziness or slight blurring of vision. This stage is referred to as the 'baseline'. The amount of drug necessary to produce this baseline may vary from 30 - 100 mg. and is individual. After the baseline is reached a variable amount is injected further, usually from 5 - 15 mg.' (Jorgensen and Hayden 1967).

The needle is flushed with blood then left in situ, and a fresh syringe attached containing 25 mg. pethidine hydrochloride, 0.4 mg., hyoscine hydrobromide mixture. In the majority of cases this is injected as a standard dosage, although where the amount of pentobarbital is significantly less than 100 mg., so the pethidine is adjusted in accordance with a 100/25 ratio.

**Modified Jorgensen technique**

The Jorgensen method was modified by the substitution of pentazocine 30 mg., for the pethidine. This substitution was made for three reasons:

(i) Better availability of pentazocine in Australia.

(ii) Pentazocine has been shown to have low abuse liability as opposed to a narcotic analgesic such as pethidine (Fraser and Rosenberg 1964).

(iii) 30 mg. pentazocine is said to be equal in analgesic activity to 75 mg. pethidine (Winthrop Lab. 1968).
(2) **Intravenous diazepam (Valium)**

Undiluted diazepam is injected slowly (2.5 mg. per 30 seconds). The patient is observed constantly for signs of the onset of sedation, in particular a drooping effect of the upper eyelid (ptosis). A ceiling dosage of 20 mg. was observed throughout the series, although certain patients did not appear satisfactorily sedated at this level.

**Modifications:**

(a) Atropine 0.6 mg. was frequently combined with the diazepam in the syringe, to control salivary secretion.

(b) Methohexital in very small amounts 20 — 30 mg. may be given to 'cover' the local injections (reaction to the latter is often marked).

(3) **Intravenous methohexital**

**Single dosage**

A single sleep dosage of 2 per cent methohexital was given assessed on the relation to body weight (approx. 11 mg. per kg.; 8 mg. per stone). Mouth packing was then placed and the operation commenced immediately. Two assistants were always present, one of whom handled the suction nozzle, whilst the other steadied and observed the patient. Pressure was maintained over an extraction site until recovery was apparent. Recovery is rapid, and the patient is usually able to walk from the chair assisted to the recovery room, within a few minutes.
In some cases the induction dose was used to mask a local anaesthetic injection, which then allowed completion of operation during the recovery period.

(4) **Intravenous propanadid**

More rapid recovery time is noted than with methohexital with a dosage variation from 5 — 7 mg/kg being recommended. This given as for single-dosage methohexital.

(5) **Endotracheal intubation**

These cases were carried out in theatre at Canberra Hospital, a specialist anaesthetist, in each case, being in attendance. It is not, therefore, proposed to elaborate further on technique.

**EMERGENCY MEASURES**

It has not been necessary to institute any emergency measures throughout this series. The following are, however, kept at hand:

(1) Full oxygen cylinder coupled to an "Air-Viva".
(2) Guedel airways — set of three.
(3) Goldman nasopharyngeal tubes (set of three) and lubricant.
(4) Macintosh laryngoscope.
(5) Smelling salts.
(6) **Drugs:**
    (a) Hydrocortisone Sodium Succinate Injection B.P. 100 mg, plus water solvent.
(b) Nalorphine hydrobromide 10 mg./ml. (Lethidrone).
(c) Methylphenidate hydrochloride (Ritalin) Amps. 20 mg. plus solvent.
(d) Procaine hydrochloride 1% 10 ml.
(e) Cyclizine lactate 50 mg./ml. 1 ml. amps.
(f) Diphenhydramine hydrochloride (Benadryl). 10 mg. per 1 ml. 10 ml. vial.
(g) Chlorpromazine Inj. (Largactil) 2 ml. 2.5%.
(h) Aminophylline (Cardophyllin) 0.5 gm. 2 ml. amps.
(i) Levophed (Noradrenaline) 2 ml. 0.1%. Vasylox (Methoxamine Hydrochlor.) 20 mg. 1 ml. Cardiazol 1 ml. 10%.
(j) 8.4 per cent sodium bicarbonate sterile (500 ml).

Fig. 64 Part of emergency armamentarium.

A discussion of the application of emergency measures and drugs is given by Robinson (1970), Drummond-Jackson (1970), and Emergencies in dental practice (1970).
XIV. RESULTS

A. General results

Results of two hundred and sixty cases are presented, tabulated according to the techniques with specific reference to particular cases of interest.

The Jorgensen technique and intravenous diazepam are compared in part B of this chapter.

Methods were:

(1) Jorgensen technique (including modifications).
(2) Intravenous diazepam (including modifications).
(3) Single dose methohexital/propanadid.
(4) Endotracheal intubation (hospital general anaesthetic).

(1) Jorgensen technique

Sixty six cases were treated utilizing this technique during the period 25th September, 1968 to 1st July, 1970. There were 39 females and 27 males. One male and one female were treated twice. The age range of this group was 13 to 41 with an average age of 23.4.

Racial type

All were 'white' with origins: Australasia : 41
                          Britain    : 12
                          Northern Europe  : 8
                          Central Europe : 2
                          Southern Europe : 3

Intelligence appraisal

A purely objective appraisal of intelligence levels, showed the majority of patients to be in an average
intelligence grouping, with perhaps 4 to 6 who could be placed in either a high and low intelligence group.

Physical condition

All patients were physically fit (i.e. no disablement), although four could be considered overweight, and one was of particularly light frame.

<table>
<thead>
<tr>
<th>Smoking</th>
<th>Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy</td>
<td>20%</td>
</tr>
<tr>
<td>Moderate</td>
<td>21%</td>
</tr>
<tr>
<td>Non-smokers</td>
<td>59%</td>
</tr>
<tr>
<td>Heavy</td>
<td>1.5%</td>
</tr>
<tr>
<td>Moderate</td>
<td>47.0%</td>
</tr>
<tr>
<td>No</td>
<td>51.5%</td>
</tr>
</tbody>
</table>

Dental History

Patients were classified as follows:

(a) Regular - (visited a dentist at least annually).
(b) Spasmodic - (visited the dentist, but very irregularly).
(c) As a child only (had not been to the dentist since childhood).
(d) Pain relief - (only ever visited the dentist for pain relief).
(e) No previous dental experience.

| Spasmodic | 50 (45.4%) | Regular | 9 (13.6%) |
| Never     | 1 (1.55%)  | Pain relief | 20 (30.4%) |
| As a child| 6 (9.0%)   |

The largest percentage will be seen to be the spasmodic type of patient, and the non-dentally orientated.

Medical history

Very little of relevance was observed, although two cases are of interest:

(a) Mr. D. - who had had a 'nervous breakdown' in mid 1968.
(b) Mrs. L. - had been five years under psychotherapy having attempted suicide (1964).

Drugs taken

Antibiotics - 7
Nembudeine - 1
Iron - 2  Panadol - 1
Valium - 2  Amytal - 1
Contraceptives - 2  Tryptanol - 1
Tavegyl - 1  Tegretol - 1
Furadantin - 1  Gantrisin - 1

**Palpability of veins**

Where veins were obvious and easily palpated they were classed as 'good'. If deeper and less obvious - 'fair'; while, where there were no obvious subcutaneous veins, they were classed as 'poor'. In one case it was necessary to use the dorsum of the hand, and with another wrist veins were the only ones visible.

<table>
<thead>
<tr>
<th>Palpability</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>41</td>
<td>63.6%</td>
</tr>
<tr>
<td>Fair</td>
<td>15</td>
<td>22.7%</td>
</tr>
<tr>
<td>Poor</td>
<td>10</td>
<td>13.7%</td>
</tr>
</tbody>
</table>

**Anxiety level**

The assessment of anxiety can only be objective, resulting from the information gleaned by noting patients' comments. Anxiety is not readily classified, but the following was an attempt:

**Placid**

The patient who confronted the proposed dental treatment without obvious emotional disturbance. Sedation techniques may be utilized in this situation where the patient has a casual approach to dental treatment, or was not conscious of the need, and is likely not to complete a course of treatment, or where a block appointment simply provides greater convenience than multiple appointments.

**Mild**

Some anxiety expressed by the patient - although a reasonable tolerance level evident. This type
of patient will admit a dislike for needles or drilling, for example, but will have usually tolerated dental procedures reasonably well.

**Obvious**

The patient would express fears and doubts spontaneously - such comments as 'I'm terrified', or 'I'm petrified', or 'scared stiff' are common in this group.

**Extreme**

This patient would be restless or emotional on the occasion of the oral examination, sensitive to probing, with an acute state of alertness particularly focussed on the dental situation.

On this basis the percentages were:

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placid</td>
<td>9</td>
<td>(13.6%)</td>
</tr>
<tr>
<td>Mild</td>
<td>17</td>
<td>(25.7%)</td>
</tr>
<tr>
<td>Obvious</td>
<td>32</td>
<td>(48.5%)</td>
</tr>
<tr>
<td>Extreme</td>
<td>8</td>
<td>(12.2%)</td>
</tr>
</tbody>
</table>

Questioned with respect to more specific problems (questionnaire) these were:

- Injections (oral) - 47%
- Drilling - 74%
- 'Things' in mouth - 28%
- Having to come several times - 53%
- Arranging baby sitting - 8%
- Interference with work/travelling - 24%

**Dosage**

Pentobarbital Sodium -

- Range: 56 - 250 mg.
- Mean: 115.6 mg.

25 mg. pethidine, 0.4 mg. hyoscine was never exceeded. When the dosage of pentobarbital did not exceed 100 mg., the pethidine was reduced in a 100/25 proportion.

Pentazocine 30 mg. was not exceeded in those cases where this was substituted for pethidine.
Duration of Treatment Procedure

Range : 1 hour 15 minutes to 3 hours 10 minutes.
Mean : 2 hours 28 minutes.

Work Accomplished

All cases were for the performance of conservative procedures, and the extent of the work completed was dependent on the circumstances surrounding each item of treatment, in particular the extent of the caries. However, in the majority of cases between 10 and 18 restorations were completed. Other work performed included root canal therapy, pulp capping and dressing and extraction including one surgical extraction.

Blood Pressure

At 30 minutes, 55 per cent showed a rise in systolic pressure from the pre-operative reading, 29 per cent a fall and 11 per cent a constant reading. Fluctuations either way were not great (mean 8 mm.).

On completion of treatment 46.6 per cent showed a fall, 35 per cent a rise, and 18.4 per cent constant when compared to pre-operative reading. Again fluctuation was not great. Blood pressure readings always remained within normal adult limits (90/60 - 150/100).

Respiration

Sedated patients all exhibited quiet and rhythmic normal breathing, and there was no clinical evidence of
respiratory depression. After 30 minutes 45.5 per cent showed a decreased respiration rate, 36.2 retained a constant rate and the remainder a rise (18.3). Fluctuations were very slight and not significant.

**Pulse rate**

Readings taken after 30 minutes showed an equal number with increased rate to those with a fall or constant reading. Patients might be expected because of apprehension to exhibit a pulse rate above normal pre-operatively, and there was a noticeably higher number showing a fall post-operatively (88.3 per cent). (Tested for significance the Standard Error was found to be 4.16% - and this result significant (99% confidence) within the range 75.8 to 100%).

If the normal adult range be considered as 60 - 80 per minute, 27 patients showed pre-operative rates higher than this normal range - the maximum being 108 in 3 cases (mean: 92.3). Post-operatively 13 remained outside this range (Mean: 89.4).

**Technique Variations and cases of particular interest**

(i) **Mrs. L.**

This patient had been treated with pentobarbital as part of psychotherapy, and some tolerance was apparent. She became restless after two hours (initial dose 125 mg. pentobarbital) and a further dose, approximately half the initial dose, was administered to allow completion of work.
(ii) Mrs. C.

This patient was extremely anxious. She had attended her physician prior to treatment for pre-operative sedation, and had subsequently suffered from overdosage of the drug prescribed (Nembutaline). The first treatment session was consequently postponed. Although a dosage of 212 mg. pentobarbital was given, the patient strongly resisted sedation effects. She had a persistent cough during induction, and this continued during treatment. In spite of sedation she was emphatic that local injections were 'going to hurt'. Propanidid (325 mg.) was given to 'cover' the local injections, and a further 325 mg. was given prior to extraction of a lower molar. The persistent cough made for poor operating conditions.

(iii) Mrs. H.

Extremely anxious patient. Atropine 0.6 mg. was substituted for hyoscine (as supply was delayed). Severe reaction to painful stimuli (local injection) after 30 minutes, 60 mg. methohexitol was used as supplement.

(iv) Miss R.

This patient was terrified of operative procedures, (? phobia), and also of the intravenous injection. She
pulled her arm away rapidly following venepuncture, and
vein was lost. However, with restraint, and more rapid
injection satisfactory conditions were achieved, although
there was considerable body movement throughout the entire
procedure, and constant restraint and assurance were necessary.
Dosage 120 mg. could well have been exceeded.

(v) Mr. McG.

80 mg. methohexital supplement for the extraction
of a single lower molar on one side, avoided the necessity
of a double mandibular block.

(vi) Miss W.

60 mg. methohexital was given prior to local inject-
ions. Extremely anxious patient.

(vii) Mr. B.

Received ceiling dose of 250 mg. pentobarbital but
still appeared alert throughout. He stated however that he had
'never felt so relaxed at the dentist', and operating was
uneventful.

**Minor complications**

(a) Local injection reaction (patient shows a
facial expression of pain on local injection) - 6

(b) Patient felt cold/shivering - 2

(c) Mouth breathing making operating difficult - 1
**Objective assessment**

(Sedation and operating conditions)

<table>
<thead>
<tr>
<th>Quality</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good to excellent</td>
<td>58</td>
<td>87.8%</td>
</tr>
<tr>
<td>Fair</td>
<td>6</td>
<td>9.1%</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
<td>3.1%</td>
</tr>
</tbody>
</table>

In those cases assessed as poor and fair, the impression was that insufficient dosage was probably the main influencing factor.

**Post Operative Complications**

The majority of patients (81.5 per cent) reported as having had a sleep on arrival home, after which they felt refreshed and without after-effects. Ten patients said that they had a 'hangover' or persistence of sedation effects, for a few days following their appointment.

Nausea and vomiting were reported by one patient during the evening following her appointment. Five patients complained of a 'sore-arm', at the injection site. One patient claimed to have suffered a cold afterwards, but further questioning established no link with the sedation procedure.

**Amnesia**

Answers to the question "Did you remember much about the dental procedures afterwards?" were:

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everything</td>
<td>9%</td>
</tr>
<tr>
<td>A little</td>
<td>78%</td>
</tr>
<tr>
<td>Nothing</td>
<td>13%</td>
</tr>
</tbody>
</table>
Personal questioning usually revealed only a vague and unspecific recollection in each case. The patients who claimed to remember everything seemed, simply, to be under the impression that they had remembered.

**Attitude**

72 per cent of patients claimed to feel less nervous and more confident in their relation to dental treatment. The remaining 28 per cent felt 'the same'. None claimed to be less confident.

(2) **Intravenous Diazepam**

128 cases were treated utilising this method and agent in the period 27th November, 1968, to 31st July, 1970. There were:

- 95 females and
- 33 males

One female patient was treated three times, 9 females twice, and one male twice. (Figures are related to cases, rather than patients - e.g, one patient treated twice is taken as two cases).

The age range was: 14 to 44, with an average age of 24.5.
Racial type

All 'white' with origins:

<table>
<thead>
<tr>
<th>Region</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>90</td>
</tr>
<tr>
<td>Britain</td>
<td>11</td>
</tr>
<tr>
<td>Northern Europe</td>
<td>17</td>
</tr>
<tr>
<td>Central Europe</td>
<td>5</td>
</tr>
<tr>
<td>Southern Europe</td>
<td>5</td>
</tr>
</tbody>
</table>

Intelligence

As for Jorgensen technique.

Physical Condition

All patients physically fit.

<table>
<thead>
<tr>
<th>Smoking</th>
<th>Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy</td>
<td>10.9%</td>
</tr>
<tr>
<td>Moderate</td>
<td>56.5%</td>
</tr>
<tr>
<td>Non-smokers</td>
<td>32.6%</td>
</tr>
</tbody>
</table>

Dental History

<table>
<thead>
<tr>
<th>Type</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regularly</td>
<td>11.8%</td>
</tr>
<tr>
<td>Spasmodic</td>
<td>45.7%</td>
</tr>
<tr>
<td>Pain relief</td>
<td>41.7%</td>
</tr>
<tr>
<td>Child only</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

Medical History

One patient had been as a child in a Japanese P.O.W. camp, and stuttered when nervous - was of generally nervous disposition.

A number of patients had at times, consulted their physician for 'bad nerves', three suffering migraine headaches supposedly from this cause.

Drugs taken

<table>
<thead>
<tr>
<th>Drug</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraceptives</td>
<td>18</td>
</tr>
<tr>
<td>Amytal</td>
<td>6</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>5</td>
</tr>
<tr>
<td>Valium (tablets)</td>
<td>3</td>
</tr>
<tr>
<td>Migral</td>
<td>1</td>
</tr>
<tr>
<td>Librium</td>
<td>1</td>
</tr>
<tr>
<td>'Contact 500'</td>
<td>1</td>
</tr>
<tr>
<td>Tryptanol</td>
<td>1</td>
</tr>
<tr>
<td>Iron</td>
<td>1</td>
</tr>
<tr>
<td>Chlotride</td>
<td>1</td>
</tr>
<tr>
<td>Aventyl</td>
<td>1</td>
</tr>
<tr>
<td>Triominic</td>
<td>1</td>
</tr>
<tr>
<td>Tofranil</td>
<td>1</td>
</tr>
<tr>
<td>Dilantin</td>
<td>1</td>
</tr>
<tr>
<td>Estigyn</td>
<td>1</td>
</tr>
<tr>
<td>Ponderax</td>
<td>1</td>
</tr>
</tbody>
</table>
Palpability of Veins

Good - 60%
Fair - 30%
Poor - 10%

Anxiety Level

Placid - 0.7%
Mild - 22.4%
Obvious - 53.5%
Extreme - 23.4%

Specific problems (questionnaire answers):

Injections: 60%
Drilling: 81%
'Things' in mouth: 21%
Having to come several times: 43%
Arranging baby sitting: 13%
Interference with work: 17%

Dosage - (of diazepam)

Range - 10 mg. to 20 + 10 mg. (supplemental dose)
Mean - 16.1 mg.

Duration of treatment procedure

Range: 10 minutes to 3 hours
Mean: 1 hour 30 minutes

Work accomplished

Most commonly conservation was performed within a range of 1 to 18 restorations (Avg: 7) according to the particular requirements. In 25 cases extractions were combined with conservation with a range of 17 restorations plus one extraction to 8 restorations and 7 extractions. Other work performed included the following:
(i) **Oral Surgery**

- Apicectomy - 1
- Surgical removal third molars - 3
- Single extractions - 3
- 4 extractions, immediate denture insertion - 1

(ii) **Operative**

- 3 to 5 restorations plus crown preparation - 2
- 7 to 9 restorations plus root canal therapy - 4
- 5 to 7 restorations plus impression taking - 2
- 5 restorations plus inlay preparation - 1
- Inlay preparation - 1
- Crown preparations - (4) - 1
- - (5) - 1

**Blood Pressure**

<table>
<thead>
<tr>
<th></th>
<th>At 30 minutes</th>
<th>End of treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>49.3%</td>
<td>52.8%</td>
</tr>
<tr>
<td>Rise</td>
<td>28.1%</td>
<td>26.9%</td>
</tr>
<tr>
<td>Constant</td>
<td>16.0%</td>
<td>20.3%</td>
</tr>
</tbody>
</table>

Fluctuations were very slight and always remained within normal adult limits.

- Range of fluctuation: 2 - 22 mm.
- Mean fluctuation: 8 mm.
- Respiration rate
  - 30 minutes: Increase - 32.2%, Decrease - 25.4%, Constant - 42.4%
  - End of treatment: Increase - 22.4%, Decrease - 32.6%, Constant - 45.0%
- Range of variation: 1 - 10/min.
- Mean variation: 2.5/min.

**Pulse rate**
- 30 minutes Rise - 38% Range: 2-20 Mean: 9.0
- Fall - 35% Range: 2-14 Mean: 7.0
- Constant - 27%
End of treatment

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Range:</th>
<th>Mean</th>
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</thead>
<tbody>
<tr>
<td>Rise</td>
<td>34.9%</td>
<td>2-20</td>
<td>8.4</td>
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<tr>
<td>Fall</td>
<td>40.9%</td>
<td>2-20</td>
<td>8.5</td>
</tr>
<tr>
<td>Constant</td>
<td>24.2%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There was no significant effect on blood pressure, respiration or pulse rates evident from these records.

**Technique variations, and cases of interest**

The use of diazepam as an adjunct to local anaesthesia provides in many cases an excellent solution to the problem of pain/perception control. However ideal conditions are not always attainable with this drug.

(i) **Miss Ca**

Emergency (in pain), patient aged 17, with considerable neglect of dentition. Another practitioner had tried to arrange a general anaesthetic appointment at hospital, but had found four weeks delay, and said he "wouldn't touch her with local". Mother claimed that patient would not 'take' a local injection. 15 mg. diazepam, 10 mg. methohexital intravenously and local anaesthesia, allowed the extraction to be completed without problems.

(ii) **Mrs. P.**

Attended as an emergency case - was actually 'shaking' in the chair. 10 mg. diazepam and local injection allowed extraction free of complication.

(iii) **Miss Cl.**

(It is considered that this patient actually suffers from phobia with respect to dental treatment). 20 mg.
diazepam, 0.6 mg, atropine intravenously. Patient reacted severely to local injections and was extremely restless, claiming strongly that "it hurt". Operating conditions were quite unsatisfactory, and abandoned after 35 minutes. Veins were almost invisible and there was no opportunity or likelihood of a successful second venepuncture.

(iv) Mr. K.

20 mg. diazepam, 0.6 mg, atropine intravenously. Patient reacted strongly to local injections and operating, which situation was not greatly improved by supplemental 20-30 mg. dosage of methohexital. 30 mg. pentazocine was then given, and satisfactory operating conditions ensued.

(v) Mrs. L.

Wore contact lenses and was annoyed by these during procedure. It is advisable that patients who wear contact lenses remove these before procedure.

(vi) Mrs. G.

Tremor, 50 minutes after induction. 40 mg. pentobarbital sodium given intravenously, and tremor ceased. Operating conditions also improved.

(vii) Mrs. B.

10 mg. diazepam (early case). Patient expressed alarm, and said she felt no different; was very restless throughout.
(viii) Mrs. J. and Miss H.

These two patients presented a very deep level of sedation for 40 minutes - dozing and sleeping, then suddenly 'snapped out' and were then apparently quite alert.

(ix) Mr. L.

Two silicate and one amalgam restorations following 17 mg. diazepam, 60 mg. methohexital then given, and two extractions were performed (no local).

(x) Mr. K.

20 mg. diazepam - six amalgam and 2 silicate restorations completed. 40 mg. methohexital at 45 minutes to cover local injections. Seven extractions completed following operative work, 110 mg. methohexital intermittently + local anaesthesia.

(xi) Mr. M.

Extremely nervous patient. 20 mg. diazepam; 40 mg. methohexital as a 'cover' for local injections; Five amalgam restorations, 70 mg. methohexital subsequently as a 'cover' for two extractions.

(xii) Miss R.

At 60 minutes she claimed to be finding respiration difficult, and hyperventilated. Was corrected by reassurance.
(xiii) Mrs. McG.

20 mg. diazepam, 10 mg. methohexital. Emerged rapidly, and could not even tolerate drilling of a plastic crown on a non-vital tooth. Placed hands on her ears during subsequent drilling to deaden sound. 'Sound' gave her more concern than any other feature. 'Audio-analgesia' would probably have assisted.

(xiv) Mrs. S.

10 mg. diazepam, 13 small restorations under tranquil conditions. Subsequently returned for prophylaxis, and was extremely restless during this procedure.

(xv) Mrs. M. and Mrs. W.

Supplemental dose of 10 mg. diazepam given after 90 minutes (initial dose 20 mg.).

(xiv) Mrs. D.

Very apprehensive about intravenous injection; subsequently cried a great deal and rejected treatment altogether in the beginning (20 mg. diazepam), claiming to be depressed. She apparently reacts similarly to quite small amounts of alcohol. (A known poor alcohol tolerance would seem to be a contra-indication). Operating proceeded (8 amalgams) under poor conditions.

(xvii) Miss W.

Extremely nervous patient. Had had Jorgensen technique 6 months previously. On recall she required one silicate restoration only. 10 mg. diazepam plus local, satisfactory.
Minor complications

Apart from those indicated above, the most common complication was a severe reaction (facial contortion and withdrawal) to local injections. This appeared to be potentiated when atropine was employed, particularly so in 6 cases. Patients commonly have great desire to scratch the nose and upper lip, which sometimes is annoying to the operator.

Other complications:

- Persistent coughing: 3
- Shivering (cold) and tremor: 3
- Crying: 2
- Inflammatory reaction at injection site: 1
- Talkative: 3
- Mouth breathing: 1

Objective assessment
(Sedation and operating conditions)

- Good to excellent: 113 (88.2%)
- Fair: 9 (7.0%)
- Poor: 6 (4.8%)

(3) Miscellaneous Group

(a) Diazepam/Jorgensen

Between 31st July and 10th October, 1970, 15 patients have been treated by a technique whereby diazepam is substituted for the pentobarbital sodium in the Jorgensen technique. While the number of cases is small, the general impression is that this method provides an excellent means of prolonging and intensifying the effects of diazepam, while not providing quite as reliable or prolonged an effect as the Jorgensen technique.
All cases were for extensive conservative work. Operating time was 1 hour 30 minutes to 2 hours 45 minutes with 12 rated as 'good to excellent' operating conditions and 3 as 'fair'.

The three cases rated as 'fair' were:

(i) Mr. D.
This patient kept referring to his watch to check on the time. 10 mg. diazepam supplement after 45 minutes (initial dose 20 mg.) helped to provide better conditions.

(ii) Mr. B.
Patient was very talkative, but operative conditions were otherwise satisfactory.

(iii) Miss S. (aged 17)
Pulse rate was rapid (120) after 30 minutes and there was heavy breathing, and severe withdrawal reaction to local injections. 30 mg. methohexital was given as 'cover' for subsequent injections. Operating conditions poor, some restraint being necessary.

(b) Diazepam/Pentazocine
14 patients who received diazepam sedation in the same period (August - October 1970) have been supplemented with 15 to 30 mg. pentazocine. This combination serves well where it is felt desirable to raise the pain tolerance as well as providing sedation. In all cases good conditions were provided. Average operating time: 1 hour. This combination has been used particularly where extractions and
oral surgical work were involved. While the number of cases is again small, the general impression is one of a desirable potentiation of diazepam effects. It has subsequently been noted that Dixon et al (1970), comparing the effects of diazepam and pentazocine alone and combined, found that the greatest percentage of calm and relaxed patients occurred with a diazepam/pentazocine combination, and included about 75 per cent of patients in this group.

**Post-operative - Diazepam cases**

**Complications**

The majority of patients (87½%) had a short sleep on returning home and felt no after effects. The remainder returned to normal activity soon after their appointments, whilst two patients reported a 'hangover' effect for a few days. One patient claimed to suffer 'acute depression' for three days post-operatively. No patients suffered nausea and vomiting.

Thirteen patients complained of a sore arm at the injection site.

Two patients said they suffered from cold/cough/chest symptoms. These cases were investigated and questioned further, and were nasal congestion, which appeared unrelated to the sedation procedure.

**Amnesia**

The majority (67 per cent) said they remembered a 'little', 17 per cent - 'everything' and 16 per cent 'nothing'.
Attitude

More confident and less nervous - 84 per cent
Same - 15 per cent
1 patient (Miss Cl. referred to earlier) claimed to feel less confident than before.

(3) (A) Methohexital (Alone)

While the use of a general anaesthetic agent by dentists remains controversial, I have found that methohexital or propanadid administered in single dose injections has a useful, although limited place. 20 cases (one patient twice) were involved where methohexital was used as a sole agent (10.12.68 to 1.7.70). The age range was 19 - 48 (average age 29).

Notes of cases

(i) Mr. E.
90 mg. methohexital; extractions and drainage (45).
Rapid recovery.

(ii) Mr. H.
Convinced that injections 'don't take'.
110 mg. methohexital, extraction 5/5.
Rapid recovery.

(iii) Mrs. C.
Acute alveolar abscess (45). Extremely nervous patient, 100 mg. methohexital; extraction (45).
Rapid recovery.

(iv) Mr. B.
Acute alveolar abscess 21. 80 mg. methohexital; extraction 21. Rapid recovery.

(v) Mr. E.
Acute alveolar abscess 4. 100 mg. methohexital and extraction 4. Rapid recovery.
(vi) Mr. S.

Broken down lower teeth opposing full upper denture. Extremely nervous patient. Methohexital used as sedation with local anaesthesia. 10 extractions and immediate denture fitting. 40 mg. methohexital with increments 20 mg. + 20 mg.

(vii) Mrs. H.

Patient terrified of needles in mouth. 60 mg. methohexital; extraction 1/4. Rapid recovery.

(viii) Mr. M.

Extremely nervous patient. 100 mg. methohexital; extraction 1/4. Copious saliva, constant suction necessary. Rapid recovery.

(ix) Mr. W.

Nervous patient. 70 mg. methohexital; extraction 7/7. Rapid recovery.

(x) Mr. T.

Nervous patient. 110 mg. methohexital, 3 extractions and immediate denture fitting.

(xi) Mrs. S.

90 mg. methohexital, 4 extractions and fitting of immediate denture.

(xii) Mr. R.

Nervous patient. 90 mg. methohexital. 1 extraction.

(xiii) Mr. M.

Nervous patient. Methohexital administered intermittently - total 190 mg. 10 extractions and fitting of immediate full denture.

(xiv) Mrs. H. (twice)

Very neglected mouth, extremely nervous patient
(i) 100 mg. methohexital, 7 extractions.
(ii) 80 mg. methohexital, 6 extractions/immediate denture.

On the second occasion patient cried and was noisy during extractions.
(xv) Mrs. G.

90 mg. methohexitol, 5 extractions, immediate denture fitting. One crown fractured, and local injection immediately deposited. Removal of retained root during recovery period.

(xvi) Mrs. G.

90 mg. methohexitol, 2 extractions. Some body movement.

(xvii) Mrs. B.

80 mg. methohexitol, 1 extraction.

(xviii) Mr. G.

100 mg. methohexitol, abscess incision and drainage. Mild spasm and slightly delayed recovery.

(xix) Mrs. M.

Extremely nervous, 100 mg. methohexitol, 5 extractions and immediate denture fitting. Crying on recovery.

General observations

A single dose of methohexitol (usually in a range of 50 - 120 mg.) can provide reasonable conditions for exodontia, as a sole agent. It is suggested, however, that the most suitable role for this agent is as a short term sedation supplement to local anaesthesia. Complications experienced in this series have been minimal. In the use of this technique however there are of course, certain implications.

(a) Medical history satisfactory.
(b) Complete pre-operative assessment of proposed surgery.
(c) Blood pressure recording pre-operatively.
(d) No food within four (preferably six) hours of operation.
(e) Trained team of surgeon plus two assistants.
(f) Adequate, strong, and constant suction.
(g) Mouthpacking.
(h) Chair readily tips horizontally.
(i) Ready availability of oxygen under pressure.
(j) Recovery facilities and post-operative supervision.
Recovery is usually very rapid with complete amnesia, and the patient is able to leave the surgery within a few minutes and the premises (accompanied) within 15 minutes. No adverse effect on blood pressure, pulse, or respiration rate has been observed.

(B) **Propanadid**

5 cases (3 males, 2 females) were treated utilising propanadid from 15,9,68 to 1.7,70. All cases involved acute alveolar abscess - in 3 cases extractions, and in 2 cases incision and drainage. Dosage ranged from 300 to 500 mg. Excellent short duration anaesthesia was provided, with very rapid recovery. Local anaesthesia was not used. Smooth induction (in one case mild hyperventilation) and tranquil operating conditions were observed in each case.

(4) **Endotracheal intubation (hospital)**

Hospitalisation and general anaesthesia was the method of choice in eight cases.

(a) Two members of the same family whose medical history showed a lack of serum cholinesterase, a sensitivity to muscle relaxants, and a contra-indication to local anaesthesia.

(b) Four cases which involved multiple extractions and immediate denture insertion.

(i) Female, age 17; full clearance
(ii) Male, age 24; full upper clearance
(iii) Female, age 21; full upper clearance
ex Extractions and conservation lower.
(iv) Female age 30; full upper clearance.

Multiple extraction cases are now uncommon, and indeed should become rarer; hospitalisation and anaesthesia was considered the best method for these cases, although they may be satisfactorily managed with sedation or in some cases with local anaesthesia alone.

(C) Two cases of extremely apprehensive patients both requiring extensive conservation work, with poor tolerance of dental procedures, and who lacked palpable veins. While venepuncture may have been accomplished, where there is some doubt, and the patient is apprehensive, it is preferable not to attempt sedation. Failure to locate a vein prior to a long treatment session could result in embarrassment and loss of valuable time. Follow-up treatment for these patients would ideally employ an inhalation analgesia technique, with the use of oral sedation a possible alternative.
B. Sedation Effects of Jorgensen Technique and Intravenous Diazepam Compared

The two principle methods of perception control employed viz, the Jorgensen Technique and Intravenous Diazepam, are compared. This comparison is based on objective observations during the procedures, and on replies to questionnaires sent to patients post-operatively.

Observations

A patient rating scale according to Carpenter et al (1961), was used to record the effect of sedative agents, recordings being made at 15, 30, 60 and 90 minute intervals where applicable. The same person (J.K.G.), recorded every time.

<table>
<thead>
<tr>
<th>EYELID MOVEMENT</th>
<th>AWAKENESS</th>
<th>BODILY MOVEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Extreme</td>
<td>7. Deeply asleep</td>
<td>1. None</td>
</tr>
<tr>
<td>5. Much</td>
<td>5. Moderately asleep</td>
<td>3. Little</td>
</tr>
<tr>
<td>1. None</td>
<td>1. Very alert</td>
<td>7. Extreme</td>
</tr>
</tbody>
</table>

TALKING

1. Extremely talkative - spontaneously
2. Moderately talkative - spontaneously
TALKING (Contd)

3. Slightly talkative - spontaneously
4. Normal response to questions
5. Moderately reduced response to questions
6. Little response to questions
7. No response to questions.

EYELID POSITION

1. Eyelid opening very wide
2. Eyelid opening wide
3. Eyelid opening medium
4. Tendency to close eyelids
5. Marked tendency to close eyelids
6. Closed eyelids, opening on stimulation
7. Closed eyelids, not opening on stimulation.

RESULTS:

A. Eyelid Movement

<table>
<thead>
<tr>
<th></th>
<th>Pre-op.</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.8</td>
<td>2.3</td>
<td>2.3</td>
<td>2.2</td>
<td>2.3</td>
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<tr>
<td>Mean Dev.</td>
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<td>1.1</td>
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<tr>
<td>Stand.Dev.</td>
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<td>2.9</td>
<td>2.3</td>
<td>2.9</td>
</tr>
<tr>
<td>99%</td>
<td>3.5</td>
<td>1.7</td>
<td>1.7</td>
<td>2.1</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Table 1. - Eyelid movement - Jorgensen Technique.

<table>
<thead>
<tr>
<th></th>
<th>Pre-op.</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
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<td>2.7</td>
<td>3.0</td>
<td>3.3</td>
<td>3.3</td>
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<tr>
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<td>0.9</td>
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<tr>
<td>Stand.Dev.</td>
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<td>1.3</td>
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<td>1.3</td>
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<tr>
<td>Stand.Error</td>
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<td>0.14</td>
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<tr>
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<td>3.1</td>
<td>3.4</td>
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<td>4.0</td>
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<tr>
<td>99%</td>
<td>3.4</td>
<td>2.3</td>
<td>2.6</td>
<td>2.9</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Table 2. - Eyelid Movement - Diazepam.
Fig. 65 - Graphic representation objective assessment eyelid movement.

- Jorgensen Technique.
- Diazepam - (shaded portion represents 99% Confidence level).

With both techniques there was a statistically significant depression of eyelid movement compared to pre-operative values, at 15 and 30 minute intervals. This was maintained at 60 and 90 minutes in the Jorgensen cases, but with the diazepam cases at 60 minutes there was probably not a significant difference, while at 90 minutes the difference was not significant. Comparing the two techniques showed a comparable level at 15 minutes. At 30 and 60 minutes there was a significant difference between the two, indicating a more consistent sedation level with the Jorgensen technique. This was probably also true at 90 minutes.
### B. Awareness

<table>
<thead>
<tr>
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<th>Pre-op</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>2.8</td>
<td>4.3</td>
<td>4.4</td>
<td>4.4</td>
<td>4.3</td>
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<tr>
<td><strong>Mean Dev.</strong></td>
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<tr>
<td><strong>Stand.Dev.</strong></td>
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<td>1.2</td>
<td>1.4</td>
<td>1.4</td>
<td>1.3</td>
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<tr>
<td><strong>Stand.Error</strong></td>
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<td>4.9</td>
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<td>3.7</td>
<td>3.8</td>
<td>3.8</td>
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</tbody>
</table>

**Table 3 - Awareness - Jorgensen Technique.**

<table>
<thead>
<tr>
<th></th>
<th>Pre-op</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
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</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>3.0</td>
<td>3.9</td>
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<td><strong>Mean Dev.</strong></td>
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<td>0.2</td>
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<td>2.7</td>
<td>3.7</td>
<td>3.4</td>
<td>3.6</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Table 4 - Awareness - Diazepam.**
Fig. 66 - Graphic representation objective assessment of awareness.

- Jorgensen Technique
- Diazepam,

(shaded portion represents 99% Conf. Level).

With both techniques at 15, 30 and 60 minutes there was a significant difference to the level of awareness compared to normal. This was more marked and clearly significant with the Jorgensen technique. At 30 and 60 minutes the figures could only be said to be 'probably significant' with diazepam, and not significant at 90 minutes.

Comparing the two techniques shows a possibly significant difference at 15, 30 and 90 minutes. Figures at 60 minutes indicate that a significantly deeper level was maintained with the Jorgensen technique.
C. Talking

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
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<td>5.3</td>
<td>5.3</td>
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<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
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<td>1.2</td>
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<tr>
<td>99%</td>
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<td>4.7</td>
<td>4.7</td>
<td>4.5</td>
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</table>

Table 5 - Talking - Jorgensen Technique.

<table>
<thead>
<tr>
<th></th>
<th>Pre-op.</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
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<tbody>
<tr>
<td>Mean</td>
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<td>5.0</td>
<td>4.9</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>Mean Dev.</td>
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<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Stand.Dev.</td>
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<td>1.2</td>
<td>1.1</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Stand.Error</td>
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<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
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</tr>
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<td>3.6</td>
<td>4.7</td>
<td>4.7</td>
<td>4.4</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Table 6 - Talking - Diazepam.
Fig. 67 - Graphic representation objective assessment - Talking.

- Jorgensen Technique
- Diazepam

(shaded portion represents 99% Conf. Level).

A significant change in response to questions was noted for both techniques up to 60 minutes, compared to the pre-operative assessment. When the two techniques are compared there appears to be a difference in that the Jorgensen cases averaged a higher reading (less response), but this was only statistically significant at 60 minutes.
D. Body Movement

<table>
<thead>
<tr>
<th></th>
<th>Pre-op</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
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<td>1.4</td>
<td>1.4</td>
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<td>1.5</td>
</tr>
<tr>
<td>Mean Dev.</td>
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</tr>
<tr>
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<td>0.9</td>
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<td>0.8</td>
</tr>
<tr>
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<td>0.1</td>
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</tr>
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<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
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<td>1.0</td>
<td>1.1</td>
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<td>1.2</td>
</tr>
</tbody>
</table>

Table 7 - Body movement - Jorgensen Technique.

<table>
<thead>
<tr>
<th></th>
<th>Pre-op</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.6</td>
<td>1.5</td>
<td>1.5</td>
<td>1.7</td>
<td>1.7</td>
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<td>1.8</td>
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<td>1.2</td>
<td>1.2</td>
<td>1.4</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 8 - Body movement - Diazepam.
Fig. 68 - Graphic representation objective assessment - Body Movement.

- Jorgensen Technique.
- Diazepam.

(Shaded portion represents 99% Conf. Level).

Throughout the procedure no significant change was evident in body movement, with very little change from the pre-operative rating. With both techniques, at all time intervals the rating was from 'none' to 'very little'. The mean figures for the diazepam cases were slightly above those of the Jorgensen cases. Favourable operating conditions were maintained throughout, from this viewpoint.
E. Eyelid Position

<table>
<thead>
<tr>
<th></th>
<th>Pre-op</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
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<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
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<td>5.8</td>
<td>5.8</td>
<td>5.8</td>
</tr>
<tr>
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<td>2.9</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Table 9 - Eyelid position - Jorgensen Technique.

<table>
<thead>
<tr>
<th></th>
<th>Pre-op</th>
<th>15'</th>
<th>30'</th>
<th>60'</th>
<th>90'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.0</td>
<td>3.9</td>
<td>3.8</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Mean Dev.</td>
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<td>0.9</td>
<td>0.9</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Stand.Dev.</td>
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<td>1.2</td>
<td>1.2</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
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</tr>
<tr>
<td>Conf.Level</td>
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<td>5.8</td>
<td>5.8</td>
<td>5.8</td>
<td>5.8</td>
</tr>
<tr>
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<td>2.9</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Table 10 - Eyelid position - Diazepam.
Fig. 69 - Graphic representation objective assessment - Eyelid Position.

- Jorgensen Technique
- Diazepam.

(shaded portion represents 99% Conf. Level.)

There was a highly significant change in the reading of eyelid position for the Jorgensen cases over the entire 90 minute period, with a marked tendency evident to close the eyelids. With diazepam, the change was significant at 15 and 30 minutes, probably significant at 60 minutes, but not at 90 minutes. Comparing the two techniques, a deeper sedation level as indicated by eyelid position was present in the Jorgensen cases at all time intervals.
Conclusions:

An objective assessment of the sedated patient reveals certain clinically evident changes when compared to a pre-operative assessment. The sedation level of patients treated with the Jorgensen technique is more likely to be sustained over a 90 minute period than is the case with those treated with intravenous diazepam. Where it is thought desirable to maintain the patient in a more reliable and constant level of sedation over a prolonged operating period, the Jorgensen technique is more suitable. Over short periods - up to 45 to 60 minutes, and more particularly in the early stages, there is not a marked difference, although the figures do tend to indicate that diazepam will provide a generally lighter level throughout, than when the Jorgensen technique is used.

Post-Operative Assessment

Results from a post-operative questionnaire (Appendix IV) obtained from 130 patients who had undergone dental treatment with sedation indicate that with each technique there has been a resultant increase in patient confidence. This was particularly so with the diazepam cases, where 84 per cent admitted to being less nervous and more confident with respect to dental treatment. (Significant 99% confidence level - 62 to 99%).
Overall 80 per cent of patients made this claim (Sig. 99% Conf. level - 70 to 90%).

Patient emotional attitudes to dental treatment would, then, seem to be affected favourably in at least 70 per cent of patients, and possibly as many as 90 per cent.

**Patient Preference**

Patients were questioned post-operatively as to their preference:

<table>
<thead>
<tr>
<th>(a) where several fillings are required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jorgensen cases - 95 per cent preferred sedation, (Sig. 99% Conf. level - 85 to 100%).</td>
</tr>
<tr>
<td>Diazepam cases - 98 per cent (Sig. 99% Conf. Level - 93 to 100%).</td>
</tr>
<tr>
<td>Overall - 97 per cent preferred sedation, (Sig. 99% Conf. Level - 92.5 to 100%).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(b) one filling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jørgensen cases - Local anaesthesia only 55%</td>
</tr>
<tr>
<td>Local plus sedation 42%</td>
</tr>
<tr>
<td>Diazepam cases - Local anaesthesia only 57%</td>
</tr>
<tr>
<td>Local plus sedation 43%</td>
</tr>
<tr>
<td>Overall - Local anaesthesia only 56% (Sig. 99% Conf. level - 43 to 69%).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(c) extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jørgensen cases - Local only 43%</td>
</tr>
<tr>
<td>Local and sedation 53%</td>
</tr>
<tr>
<td>General anaesthesia 4%</td>
</tr>
</tbody>
</table>
Diazepam cases - Local only 48%
Local and sedation 52%
General anaesthesia nil

Overall - 52.5 per cent preferred local injection plus sedation for an extraction.
(Sig. 99% Conf. level - 39 to 66%)

In summary, the response to the questionnaire indicates an appreciation of the application of sedation to multiple conservation. For single procedures a greater level of patient confidence is evident, and patients seem fairly evenly divided in their preference or otherwise for sedation. As the majority of patients were apprehensive pre-operatively this could be interpreted as a reflection of increased confidence by half the patients in their ability to accept treatment by conventional means. It could also mean, however, that they could not reconcile the sedation effects for single procedures. (Inhalation analgesia would seem to have application in this respect).

Summary:

It has been found that of patients who are apprehensive with respect to dental treatment, at least 93 per cent prefer sedation for multiple conservation, only as many as 69 per cent and possibly as few as 43 per cent prefer unsupplemented local anaesthesia for a single conservative procedure. For extractions at least 39 per cent and possibly as many as 66 per cent of these patients would prefer supplemented local anaesthesia.
XV. DISCUSSION

Evaluation of Sedation and Anaesthesia in Dental Education

In the early part of the twentieth century Dentistry developed as a department within the Faculty of Medicine, but before 1910 independence was recognised. Dentistry was largely based on craftsmanship, and with this exceptionally strong bias, Medicine and Dentistry were so far apart that the latter had no alternative to working out and establishing its own discipline. Of necessity, in producing graduates proficient in basic dental procedures, dental education has had a biological foundation, followed by technical and clinical instruction. Walker (1969) has said: 'Dental education from its beginning has been built around techniques, and the teaching to a considerable degree repeats one manual performance after another; as a result, the entire concept of dentistry is to a large degree a mechanical process for rectifying the consequences of disease'.

The basic pattern of the dental course has changed little. Howe (1969) has said that most dental curricula are 'the products of expediency and compromise', with the problem of meeting the 'demands of vocational training and the need to provide a university education'. There is, however, says Howe, reason to question the whole pattern of
dental education; he stresses the necessity to adapt to change, and to constantly seek to improve our service to our patients.

Changes in the practice of dentistry are inevitable, and undergraduate education should provide the key to continuing education which enables the practitioner to adapt his practice to meet new challenges and altered requirements. Emphasis in undergraduate education should be on the acquisition of basic knowledge, skills, and principles in relation to all facets of the dental condition of the patient. In a consideration of sedation and anaesthesia in meeting the problems of pain control, it is important that some distinction between the two be drawn. The application of sedation methods to control patient perception and resultant response, has a psychological foundation. This cannot strictly be said of general anaesthesia, which simply seeks to provide the surgeon with a patient, with all cortical and sub-cortical centres depressed, on whom he can perform a given operation at a given time under convenient conditions.

Thus, in the former there is implication of a behavioural problem which does not necessarily apply in the latter. The nature of this problem and methods of overcoming it have been discussed previously. It would be
quite unreal to deny methods, which provide sedation, to dental practice as it is the dental procedures which arouse in the patient the very problems which require consideration. General anaesthesia needs only to be used in particular and limited situations, when the services of a specialist anaesthetist may then be sought.

It is suggested that reasonable and liberal criteria for general anaesthesia for dental procedures, as practised by the specialist anaesthetist, might be:

(i) Major oral surgery including multiple extractions.

(ii) Mentally retarded patient.

(iii) Known medical contra-indication to local anaesthesia.

(iv) Dental phobia including the recalcitrant small child who requires multiple conservation for initial treatment.

(v) Where the patient's medical history reveals a metabolic disorder which, in the opinion of dentist and physician, is of a nature to justify hospitalisation and specialist care, for the undertaking of dental procedures.

Undergraduate curricula then, should include a staged programme which considers the perceptual and conceptual aspects of dental treatment. Howe (1969) has said:
An understanding of psychology is desirable, for it is fundamental to the handling and management of patients on which the successful treatment of them ultimately rests. Allied to this is the widespread and constantly increasing use of drugs with which the practising dentist must be familiar because of their effects on behaviour or possible interaction with other agents which he himself may require to use. The public's enhanced awareness of their dental state and their knowledge that pain and apprehension can now be controlled, lead them to expect the application of sedatives and anaesthetic techniques of increasing complexity. Teaching in physiology and pharmacology to a further degree than was formerly considered appropriate, is now required.

Sara (1969) has indicated some of the requirements for the introduction of intravenous sedation into a dental curriculum. These are, summarised:

(i) Fuller course in pharmacology.
(ii) Tuition in venepuncture.
(iii) Extension of training in cardio-respiratory resuscitation.

In a paper which draws attention to shortcomings in dental education, Cawson (1969) has stressed the importance of improving dentist-patient relationship as a major step towards better community dental health. Speaking of intravenous sedation, he said 'public demand will increase.... The schools should be in a position to have done sufficient research to know precisely what the dangers of these methods
are, and precisely what are the safe techniques the dental student should be taught'. Sedation of the highly anxious patient must be used whenever required, and not regarded as a luxury demanded as a whim. Adequate training of students and research into the uses and limitations of sedative agents is an essential duty of the dental schools'. Jaffe and Kutner (1967) have suggested the inclusion of appropriate courses in behavioural science for dental students, and the seeking of scientific knowledge about dentistry and practitioner-patient relationship from existing research and writings.

A suggested staged programme should thus begin pre-clinically with basic behavioural concepts (psychology, sociology and related disciplines) being re-inforced with appropriate physiology, anatomy and pharmacology leading subsequently to clinical applications. Clinical training should include:

1. An opportunity for patient counselling by the student, and his being practised in equating the dental and psychological needs of the patient.

2. Tuition in venepuncture and associated procedures.

3. Lectures on the use and abuse of sedation, with correlated clinical cases, which should include the completion of case reports, pre- and post-operative assessments.
(4) Tutorials in the management of emergencies. Emphasis must be placed on criteria for the use of sedation, such that the student understands to discipline his application of these techniques.

When considering training for the dentist in general anaesthesia, the question must be asked as to whether this service can always be provided by the specialist, whenever required. To what extent training should be provided in general anaesthesia for dentists will tend to be in accordance with the answer to this question. In some parts of Britain and the U.S.A. dentists are receiving extensive training in general anaesthesia for dental purposes. Notable is the course conducted by Monheim at the University of Pittsburgh, U.S.A. Monheim (1970) in a personal communication notes:

The role in dental practice of a dentist who has special training in general anaesthesia in no way conflicts with the specialist. The general practitioner usually works with some other dentist or they practice in pairs and utilize general anesthesia when indicated for operative dentistry. At present there are a shortage of specialists in anesthesia and they could never give this service without impinging upon their primary duties.

The teaching of anaesthesia in British dental schools has been investigated by Hopper (1969) who presented criteria for future undergraduate training in general anaesthesia. In summary, these criteria were:
(1) Pre-operative patient assessment.
(2) Knowledge of pharmacology.
(3) Knowledge of hazards.
(4) Critical attitude to new methods.
(5) The criteria of techniques.
(6) That students on graduation be able to give an anaesthetic.
(7) Methods of resuscitation.
(8) The anaesthetic should not be given by the operator.

Hopper noted 'that opinion concerning anaesthesia is changing and if there was to be a greater use of intravenous anaesthesia in dental practice the dental schools should recognise this fact, and be prepared to teach the student something about this aspect of his work, and not leave him entirely in the dark'.

One Dental School which has effected changes in its under-graduate curriculum to incorporate intravenous techniques is Dundee. This is described by Main (1970):

In April 1965 a pilot test scheme started. Now, four years later, we consider that our decision to teach students intravenous injection and induction has been an unqualified success. Our students practice venepuncture on each other and on patients with suitable veins, under skilled supervision. We set a high example of responsibility and patient care. A calm patient is an excellent subject
on which to teach airway control, demonstrate partial obstruction by depressing the mandible etc., and showing virtually what NOT to do, and to show positive pressure ventilation. Every Dundee student also now dissected the upper limb. Intravenous techniques are taught to students in the final year, and they attend an average of 16 sessions each of about 10 patients. In addition students attend operating sessions for major and minor oral surgery.

Thus in certain quarters at least, the instruction of dentists in general anaesthesia is considered desirable. However, there has been a dearth of practical training for dentists in general anaesthesia in Australia since 1930, and the majority of dental operations are accomplished using local anaesthesia. This does not however adequately cater for the problems of apprehension or comprehensive pain control, as has been indicated. The prime need, then, is not to seek to make dentists proficient general anaesthetists but rather for their under-graduate training to broaden in the field of pain control founded on local anaesthesia. This is a natural and more logical step forward from the situation as it exists today.

If, subsequently, it can be reasonably demonstrated that there exists also a need for dental general anaesthetists — and this need would be slight, when considered against the need for sedation, then measures designed to train and fit graduates to this task could be instituted. There is little
or no reason to alter the present undergraduate structure in this field, although such training should not have an entirely negative approach.

**Postgraduate**

Postgraduate education must be considered at two levels.

(i) Short post-graduate refresher or training courses.

(ii) Postgraduate training leading to a diploma.

(i) **Short courses**

Here there is an urgent need for the academic community to provide thought and stimulus. Much of the teaching has to date 'sprung up in a wasteland of organisational anarchy' (Jaffe 1970), resulting from impatience, commercial interests, or well meaning individuals endeavouring to do their best with inadequate facilities. Intensive short postgraduate courses could be of two types:

(a) Those designed for graduates new to these concepts. Content of these courses should include refresher lectures and tutorials in relevant anatomy, physiology and pharmacology, together with associated psychology. Tutorials and lectures on technique and application with clinical cases should follow.

(b) Follow-up courses of shorter duration.
Possible content of short postgraduate courses is well demonstrated by the 'Manchester Courses' held at Greygarth University Hall Manchester, in November 1969. This course consisted of ten lectures, covering medico-legal aspects, pharmacology, management of the poor risk patient, anaesthetic emergencies and surgery design. Practical sessions included the use of the laryngoscope, and methods used for positive inflation. Nine clinical cases were demonstrated.

A postgraduate course at the University of Washington, School of Dentistry in October 1969 and April 1970, as another example, was of the following content:

Concepts of analgesia, its objectives, equipment, pharmacology of nitrous oxide, patient evaluation and selection, monitoring. Intravenous analgesia agents, techniques and emergency drugs. Comparison of intravenous and inhalational agents.

The use of sedation and of analgesia should be within the province of the general dental surgeon practitioner. The relief of patient anxiety and the use of sedation with respect to this, should be an unchallenged part of dental practice. The majority of dentists now practising will lack formal training in these concepts and will appreciate
their own limitations. Thus a measure of control will exist. Postgraduate courses should be introduced as soon as possible, and held at not infrequent intervals.

At a later point, the use of agents to produce short anaesthesia could be introduced — general anaesthesia in dentistry could, by stages, become a specialised field of study in its own right — open to both medically and dentally trained postgraduate students. This field of study should not be confined solely to technique, but be concerned particularly with research into new methods and drugs, with assessment, and the placing into proper perspective those which are at present employed. In particular, technique such as the use of ultra-light planes and analgesia applicable to dental work should be stressed.

Lowell (1963) has described some of the peculiarly dental aspects of anaesthesia. He discussed the problems of hospitalising patients, and some of the differing circumstances surrounding 'medical' anaesthesia to those applicable to dentistry. 'The administration of a sound, effective general anaesthetic to an ambulant dental patient is the result of extensive study, thought, expense and training on the part of the dentist', said Lowell. He called for more attention to be paid to the subject in
dental schools, and more training programmes for graduate dentists.

Ultimately then, a course in general dental anaesthesia leading to a diploma could be augmented, but a gradual introduction is necessary. The purpose of such a diploma, and the role which recipients might be expected to fill should be carefully studied and defined. The requirements of general anaesthesia for dental purposes should be determined, together with an approach to anaesthetists as to their ability, interest and preparedness to meet these demands. The trained dental anaesthetist would be expected to exercise his knowledge within group type practice and in situations where the attendance of a specialist medical anaesthetist was impractical.

It must be again stressed however, that the need today in dentistry is not so much for general anaesthesia, as for analgesic and sedation techniques — controlled conscious techniques.

In discussing the logistics of dental anaesthesia Coplans (1968) sought to enquire whether the 'ideal' — that of a specialist anaesthetist administering all dental anaesthetics (United Kingdom) — was realistic. He states that this ideal appreciates that 'the present-day medical training furnishes the best available basis on which to
superimpose postgraduate expertise'. In his discussion on postgraduate training he equates doctors and dentists as being competent to undertake this — although a longer course would be required in the case of the dentist.

The specialist will always be the finest of anaesthetists, but it is not merely a question of qualification. There is also implication of an active interest and co-operation with dentistry and the requirements of dental anaesthesia. The patient is the dentist's; the dentist must not be antagonised, his work scorned, nor his enthusiasm for pain control obstructed. The whole aim is the gradual building of a framework wherein the correlation of patient behavioural pattern, attitude to treatment, and medical history with the dental programme, will allow for treatment to be carried out in such a manner that complete patient confidence in themselves and in dental treatment, will be a reality. The age-old association of dentistry with the unpleasant, and all its implications must be removed completely; that the modern dentist should continue to bear this stigma is intolerable.

There is therefore now a need for the establishment of guidelines for the teaching of comprehensive pain control at all levels of dental education.
CONCLUSIONS

This thesis has sought to establish the need for the dental surgeon to expand his spectrum of pain control, and the purpose of this expansion. Further, it has sought to illustrate means whereby this need can be met in the clinical situation.

A patient's response to, and conception of, dental treatment, will largely depend on his previous experience, and his interpretation of that experience. It is therefore necessary for the dentist to be able to modify patient interpretation of the dental environment. The dentist must revise his thoughts on "pain" - and understand that the response to pain is dependent not only on the intensity of the stimuli, but also on the manner in which these stimuli are interpreted - in other words, on perception.

Perception then, does not simply mean the being aware of stimuli. If we take the example of the patient who has conservative dental work routinely performed without any form of anaesthesia or analgesia, we may say, "he feels pain, but it doesn't bother him". A better and more accurate description would be "he is aware of noxious stimuli, but his perception is such as to elicit little or no response". By modifying or controlling perception, the aim is thus to modify or control response and conception, and to this end the use of conscious
techniques short of full general anaesthesia, may be utilised. Drug therapy must not, however, be considered as a substitute for the establishment of good dentist/patient relationships. Stress must be placed on the importance of the dentist being an informed listener, and behavioural sciences must receive greater recognition in the dental curriculum, with a more complete understanding of the relevant established principles of psychology, neurophysiology and pharmacology.

There is also a need for more logical scientific thinking and research in the field of pain control - there having been too much emotional thinking in the past. The dentist will find extensive clinical application in this field of his undergraduate training in basic sciences. It is unrealistic to expect the dental practitioner without postgraduate training to obtain status in anaesthesia equal with the specialist anaesthetist, nor generally is it necessary that he should. He must, nevertheless be able to offer his patients comprehensive pain control. Dentists must seek their own solutions to their own problems.

It is, and has been thought, that if local anaesthesia alone proved inadequate to accomplish the necessary dental treatment a general anaesthetic had to be used. This concept does not cater in a comprehensive, or selective manner for
the needs of the dental patient.

While there are many side issues, the essential requirements are:

(i) The accomplishment of necessary treatment under conditions which satisfactorily eliminate pain sensation, and control the perceptual aspects of the procedure.

(ii) The encouragement in the patient of confidence in dental treatment, and a renewed interest in dental welfare.

It is suggested that conscious techniques short of general anaesthesia are of great value in meeting these needs, and an illustration of the application of these techniques has been presented. The Jørgensen technique and the use of diazepam intravenously have been shown to be most effective in this respect. Pentazocine has been found to be a most useful supplemental agent. In addition, the use of methohexital and propanadid in meeting some of the treatment problems created in particular by acute infection or "needle phobia", has been illustrated.

If patient concepts and responses to the dental environment are to be changed, then the change must be effected in this environment. By the control of the perceptual aspects of dental procedures, much can be accomplished in the extension of dental services to those patients emotionally intolerant of this environment.
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APPENDIX 1

MEMORANDUM REGARDING TEACHING & ADMINISTRATION OF
DENTAL ANAESTHETICS AS ISSUED BY
ROYAL AUSTRALASIAN COLLEGE OF SURGEONS
COMMENTS BY AUSTRALIAN DENTAL ASSOCIATION

Preamble

In the second paragraph of the preamble it is stated that "the Faculty of Anaesthetists (R.A.C.S.) is now authorized to deal with matters of this nature". We would seek information as to whether or not this authority was delegated by a statutory body and why the dental profession or the University teaching schools were not officially consulted before the document was issued.

Clause 1. It is recommended that the administration of dental anaesthetics to humans be restricted to legally qualified medical practitioners.

We fully realise the advances that have been made in general anaesthesia over the past twenty years and today the number of dentists who would administer an anaesthetic is few. However the administration of dental anaesthetics has been within the province of dentistry since general anaesthetics were first used in dental practice. It has not been shown statistically that the use of such agents by dentists is occasioned by any more risk than when such agents are used under similar conditions by medical practitioners.

In several Australian States and in New Zealand the Dentists Act specifically allows for the administration by a registered dentist of any anaesthetic for the performance of a dental operation and this Association objects to the restriction on the rights of this profession.

Any pharmacological advances which would allow the introduction of new agents and permit greater safety for dental anaesthesia could not be applied by dentists if the right to administer anaesthetics was restricted to medical practitioners.
Clause 2. It is stressed that on all possible occasions regional analgesic methods be employed, and that the express wish of a patient for general anaesthesia ought not to be considered an indication for it, since patients are unable to assess the respective risks of local and general anaesthesia. It will always be the dentist's right to decide if local analgesia is unsuitable, being mindful of:

1. his own capabilities
2. the nature of the operation
3. the temperament of the patient.

However, the anaesthetist reserves the right to reject the administration of a general anaesthetic on medical grounds.

This clause as it reads is somewhat ungenerous - particularly the inclusion of Sub-Clause 1 and giving to it priority. Dentists are well qualified in conducting anaesthesia of their own particular sphere. Further, we would point out that dentistry is a much older profession than that of the "specialist anaesthetist" and its members are sufficiently responsible to make decisions in the best interests of the patient.

Clause 3. Teaching of Anaesthetics

(a) To Dental students
It is recommended that dental students be taught local analgesia - and the principles only of general anaesthesia, i.e. airway protection, post-operative care.

(b) To medical students
It is recommended that medical students be taught principles only, and that training in general anaesthesia for dentistry be regarded as post-graduate.

This clause is again restrictive in outlook and is obviously intended to prevent dentists from obtaining post graduate or any form of instruction in the field of general anaesthesia. Today no University Dental School in Australia attempts to train its students as dental anaesthetists. However, the students are given basic instruction in anaesthetics and if they so desire they may then proceed overseas to undertake the special courses that are available for dental graduates in the U.S.A., in Canada and in Great Britain. Two Tasmanian
Dentists were recently admitted by examination to a Fellowship in the American College of Anaesthetists.

Clause 6. It is recommended that ideally all general anaesthetics for dental procedures be given in a hospital - medical or dental - where proper facilities for administration and post-operative recovery are obtainable, but realising the economic and practical difficulties which this implies, the necessity at present for the administration of dental anaesthetics for minor procedures in a dental surgery is conceded. Certain minimum requirements must obtain whenever and wherever a general anaesthetic is given - be it hospital or dental surgery.

1. Oxygen
2. Means of inflating lungs under positive pressure
3. Suction
4. Presence of a third person as assistant to the anaesthetist.
5. Facilities for care of patient during recovery period.

It would be an ideal recommendation that no patient requiring endotracheal intubation be given a general anaesthetic in a dental surgery. Patients who have had endotracheal anaesthesia must be observed for a more prolonged post-operative period, and this may require an overnight stay in hospital.

We fully support the initial paragraphs of this section except for Sub Clause 4 to which we would suggest the addition of the words "and later to the dentist". Nevertheless we would point out that the present situation is largely due to the fact that many specialist anaesthetists are completely disinterested in the administration of anaesthetics in a dental surgery. Further the services of a member of the Society of Anaesthetists are seldom available - when and where required.

We cannot subscribe to the views expressed in the final paragraph of this section. There are in Melbourne a number of medical graduates who have limited their practices to general anaesthesia for dentists. These gentlemen have no special academic training - they are not members of the Society of Anaesthetists and they constantly employ the broad tube endotracheal induction when working in the dental surgery. They contend that if the intubation is carried out gently and rapidly there is no problem and in more than thirty thousand
cases there has been no instance of post operative laryngeal oedema.

However these medical practitioners do supply a standard of dental anaesthesia which is infinitely superior to that otherwise available. The dental profession will stoutly defend the anaesthetic service that is provided by these individuals.

Clause 10. Nature of Anaesthetic Technique

It is pointless to particularise on the nature of the general anaesthetic - this will depend on the individual choice of a trained anaesthetist, but the practice of using (unsupplemented) nitrous-oxide is to be condemned, as is the use of unsupported intravenous agents.

The implication that the dental anaesthetists still use unsupplemented nitrous oxide is hardly proper. The "laughing gas bag" was abandoned by the dental profession at least forty years ago.

Clause 11. Pre-operative assessment

It is recommended that the dentist give adequate warning to the anaesthetist of any patients likely to present anaesthetic problems. To assist in assessment, a suggested questionnaire is attached - to be filled in by the dentist and sent to the anaesthetist when the booking is made.

The suggested questionnaire consists of some thirty questions. We wonder how a Fellow of the Royal Australasian College of Surgeons would react if he was instructed to obtain such data for every contemplated operation? It is our belief that an anaesthetist should examine his patient and take his own history in advance.

Clause 12. It is the dentist's responsibility to give written instructions to the patient when last food and drink is permitted - a suggested suitable form is attached.

In general, no food or drink for five hours before operation.
Early morning patients - starve from midnight.
Early afternoon patients - starve from breakfast.
We maintain that this is not our responsibility. The dentist is quite prepared to do so, but in our opinion it is the responsibility of the anaesthetist to see that his patient is properly prepared.

(Signed)

John M. Wark
PRE-APPOINTMENT INSTRUCTIONS

HISTORY: Any personal illness, weakness or known susceptibility must be reported; also details of any drugs recently prescribed or being taken - especially sleeping drugs, tranquillizers or cortisone preparations.

No tight clothing should be worn, sleeves should be easily drawn up past the elbow. Contact lenses to be removed.

FOLLOWING SEDATION: It may be found preferable to attend alone, but arrangements should be made for a responsible friend to accompany the patient home afterwards. The friend can telephone half-an-hour after the appointment time to make the final arrangements for calling.

Any patient accepting a sedation appointment must specifically agree:

- Not to drive a vehicle or operate any machinery the same day;
- Not to undertake any responsible business matters;
- Not to drink any alcohol.
APPENDIX III

POST-OPERATIVE INSTRUCTIONS

Instructions to Patient

You must NOT drive a vehicle or operate any machinery the same day.
You must NOT undertake any responsible business matters.
You must NOT take any alcohol.

Instructions to person accompanying patient

This patient has had dental treatment carried out painlessly with the use of short-acting intravenous drugs.

However, as well as being sedative in action, such drugs may on occasion produce post-operative amnesia for a short time, and possibly drowsiness.

You are therefore requested to:-

1. See the patient safely home, and arrange for responsible care for several hours until fully recovered,

2. See that the above instructions are strictly adhered to.

Following surgical procedures

Do NOT rinse or take hot drinks for 4 hours.

After 4 hours, use warm saline mouthwash. (½ teaspoon salt per glass of hot water. After 24 hours rinse often for several days).

Bite firmly on mouth packs provided to control any minor bleeding.

If pain present: take 1 to 2 A.P. Codeine tablets every 4 hours.

REPORT TO DENTAL SURGEON IMMEDIATELY SHOULD ANY COMPLICATION DEVELOP

e.g. excessive pain, abnormal bleeding or swelling etc.
APPENDIX IV

Telephone: 81 5145

J.K. Grainger, B.D.S.,
Dental Surgeon,
9 Devonport Street,
LYONS, A.C.T. 2606

I require follow-up information relating to your dental treatment with sedation, with respect to post-graduate study within the University of Sydney.

In consequence I would be grateful for you filling out this questionnaire and returning it to me in the envelope provided.

1. Immediately following your sedation appointment did you experience one of the following?
   (a) Short sleep, then felt all right
   (b) Long sleep, then felt all right
   (c) Hangover for a few days
   (d) Nausea or vomiting
   (e) Sore arm
   (f) Other

2. Did you suffer from a cough or cold or chest trouble shortly afterwards?
   Yes  
   No

3. Did you remember much about the dental procedures afterwards?
   Everything  
   A little  
   Nothing
4. What aspect worried you most about having dental treatment - (You can tick more than one).

- Injections
- Drilling
- Things in mouth
- Having to come several times
- Arranging baby sitting
- Interference with work
- Other

5. Do you now feel more confident and less nervous than before about dental treatment?

- Yes
- Same
- Less confident

6. Which do you prefer? (Supposing at least several fillings were required.)

- Injection only
- Treatment with Sedation
- General anaesthetic at hospital

7. For one filling only.

- Injection only
- Sedation
- General anaesthetic at hospital

8. For an extraction.

- Injection
- Sedation and injection
- General anaesthetic at hospital

NAME: