CONSTRUCTION OF AN ELECTRICAL PAIN STIMULATOR

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ABSTRACT
The construction of an electrical pain stimulator was described. The parameters of pulse width and frequency on the quality of pain stimulation was determined. The best design and construction of the electrode for the stimulator was produced.

Keywords: Pain, Pain stimulator, Aesthesiometer

INTRODUCTION
Pain is an everyday experience. It is very personal and is the most subjective of all human sensations. There are many facets of the complexity of pain. Pain has sensory qualities, but is also has emotional and motivational properties. It is usually caused by intense, noxious stimulation, yet it sometimes occurs spontaneously without apparent cause. It normally signals physical injury, but it sometimes fails to occur even when intensive areas of the body have been seriously injured. At other times, persists after all the injured tissues have healed. (1)

In an attempt to study pain, and oral perception, an electrical pain stimulator or aesthesiometer was constructed for the experimental production of pain in the clinic on healthy subjects and for the measurement of pain thresholds.

MATERIALS AND METHODS
For the experimental study of pain threshold in man, the following electrical specifications are generally accepted. (2, 3, 4)

1. A constant current circuit is required because the resistance of skin/mucosa may change within wide limits during stimulation.
2. A square wave stimulation is most suitable.
3. The type of electrode is important. Tursky advocated concentric ring electrodes.

A pulse generator circuit was utilized. This produces a positive impulse output. The basis of the stimulator was a wave form generator which is a precision oscillator and this drives a pulse wave which is a D.C. coupled constant current circuit. Current setting is achieved by varying the emitter resistance using the ten turn potentiometer. This transistor configuration used in the circuitry is known as a Darlington pair. There is also a variable pulse with potentiometer capable of producing a 25% to 75% variability. The frequency is adjustable from 200 to 20K cycles per second and was set at 400c/s (Fig 1, 2).

The current is determined relative to the position of the 10 turn potentiometer, bh measuring the voltage across the emitter resistor and applying the formulation,

current = voltage / resistance

I = V / R

The resistance of the circuit, excluding the ten turn potentiometer, is 300 ohms. The resistance of the ten turn potentiometer is 10,000 ohms. There, accordingly the resistance across the emitter resistance is 10,330 ohms at zero setting and 9,330 ohms at setting 1 and 330 ohms at setting 10 (Fig. 3). The lower 10,330 ohms at zero setting and 9,330 ohms at setting 1 and 330 ohms at setting 10 (Fig. 3). The lower the potentiometer setting, the lower the current, and lower the pain threshold stimulation obtained; the higher the setting the higher the current and therefore the higher the pain threshold value.

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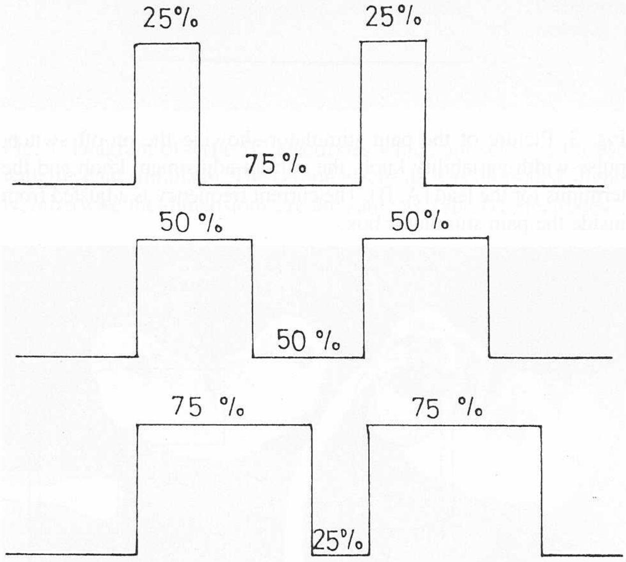

Fig. 1 Pulse-width Variability

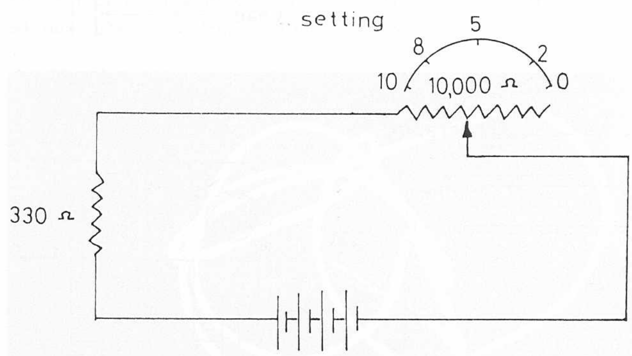

Fig. 2 Simplified Circuit Diagram of Variable Resistance of Ten Turn Potentiometer

Electrode Design and Construction
Electrodes of various designs and sizes were made.

Ring Electrodes
The contact surface of the electrode is that of a ring with a central depression. The electrodes are kept at a fixed distance

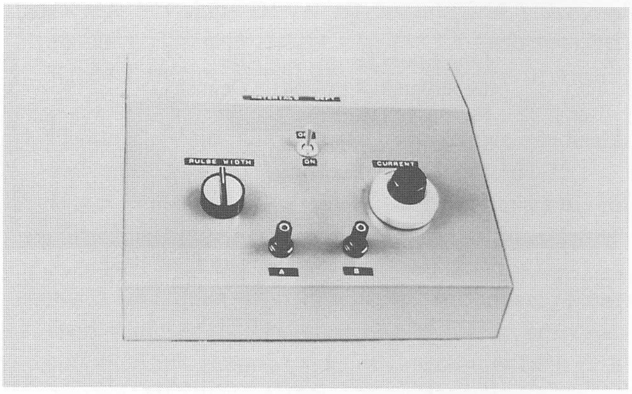

Fig. 3. Picture of the pain stimulator showing the on-off switch, pulse-width variability knob, the current adjustment knob and the terminus for the lead (A, B). The current frequency is adjusted from inside the pain stimulator box.

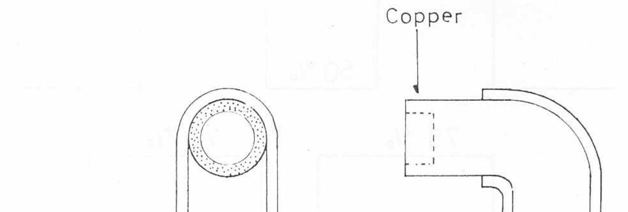

Fig. 4. Design of the experimental ring electrodes.

by means of a piece of perspex, with two holes to accommodate the electrodes (Fig. 4).

Distance parameter
Stimulation was tried with the electrodes placed at different distances from each other. There is little difference in the reading of the setting with variation of distance of the positive and negative electrodes (Table 1).

Pulse width variation
While variation of the pulse width has no discernible effect on the threshold value, it does alter the quality of the stimulation. Stimulation is nearer to 'pricking pain' with narrow than with broad wave form. This is in conformity with Procacci's finding that impulse duration must be 0.6 sec and below. Accordingly, the pulse width setting of the stimulation was to be kept at the minimum of 25% throughout.

Distance between Electrodes	Pulse Wideth	Reading of Setting
0.8 cm	25%	9.59
	25%	9.6
	50%	9.82
	50%	9.72
1.5 cm	25%	9.3
	35%	9.42
2.5 cm	25%	9.23
	50%	9.2

Table 1. The table shows the effect of distance of the positive and negative ring electrodes as well as pulse-width on the onset of pain stimulation.

Frequency
Frequency change, too, does not affect the threshold value. But decreasing the frequency produces slightly less parathesia in the stimulation. However, with further decrease, an increase in parathesia is noted. Frequency set at 300 c/s produce the best 'pricking pain' quality of stimulation.

Concentric Disc Electrodes
Two types of concentric disc electrodes were constructed and tried.

Type A series
The outer diameter of the outer electrode is 6 mm and length is 12 mm. The inner electrode is spring loaded. This is to ensure good contact, as the inner electrode is much smaller in contact area (Fig. 5).

Type B Series
This is similar to type A in the concentric configuration of the electrodes. It differs from the latter in the lack of spring loading and in its size. Type B electrodes has B1 and B2 subtypes.

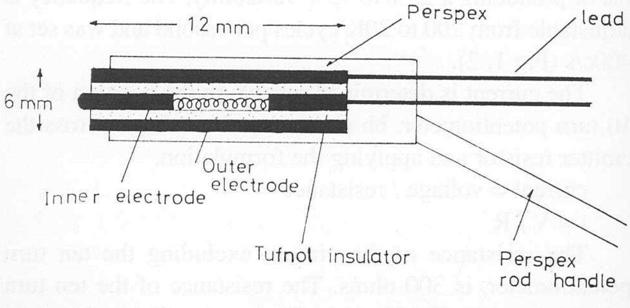

Fig. 5. Diagram of the experimental concentric disc electrodes with the central electrode spring loaded.

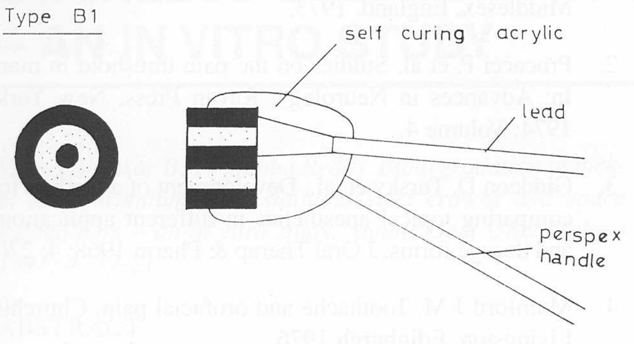

Fig. 6 Diagram of the experimental B1 type electrodes. The electrodes are smaller in size than the Type A variety and without spring loading.

B1 electrodes. The outer and inner electrodes are of the same level. This electrode is rather ineffective. Stimulation is weak and occasionally missed (Fig. 6).

B2 electrodes. This is an improvement on the B1. It was reasoned that since the inner electrode is exceedingly small, its contact with the ora mucosa is very critical. Accordingly the inner electrode is protruded slightly – 0.5mm, in order to improve contact and yet not cause pain from pressure by its slight protrusion (Fig. 7). The B2 electrodes show much better performance than the B1 type. The current required for stimulation is lower than that of Type A electrode. This has borne out Tursky's observations that less current is required for stimulation with smaller electrodes.

The B2 electrode design was chosen. The B2 electrode is also small enough to be incorporated into a dental veneer (Fig. 8) and yet versatile enough to be adopted into a 'probing electrode' by attaching a perspex rod to it (Fig. 9).

Electrode material

Copper is used for the electrodes. The insulator in the concentric electrodes is Tufnol, a resin impregnated paper. After a few stimulations, oxide formation takes place on the electrodes. To overcome this problem, the electrodes are nickel plated.

Electrode Jelly

'Cambridge Electrode Jelly' was tried on electrodes in order to assess its usefulness. While it is effective on the separate ring electrodes, its property of conductivity brings about short circuiting across the concentric electrodes and no pain stimulation is obtained.

RESULT

An effective electrical aesthesiometer was constructed for experimental pain production and measurement. For optimal production of pain threshold a 'pricking pain' stimulation is required. To achieve this the pulse width is tobe set at 25% and the frequency set at 300 c/s. Concentric disc electrodes of type B2 was the design of electrode chosen. The copper electrodes were nickel-plated and the 'probing electrode' type of delivery of pain stimulation is found most practical.

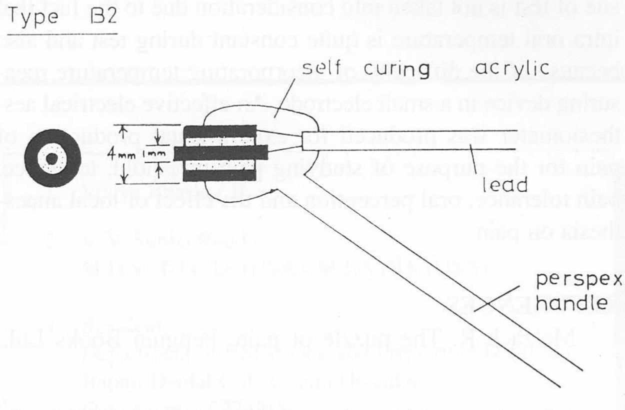

Fig. 7. Diagram of Type B2 electrodes which are selected for use with the pain stimulator. The central electrode was protruded slightly, otherwise the dimensions are the same as Type B1 electrodes.

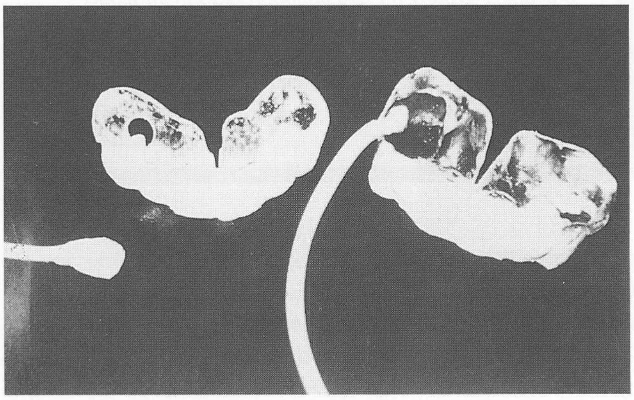

Fig. 8. Picture showing concentric disc/ring electrodes incorporated into carboxylate dental vernier.

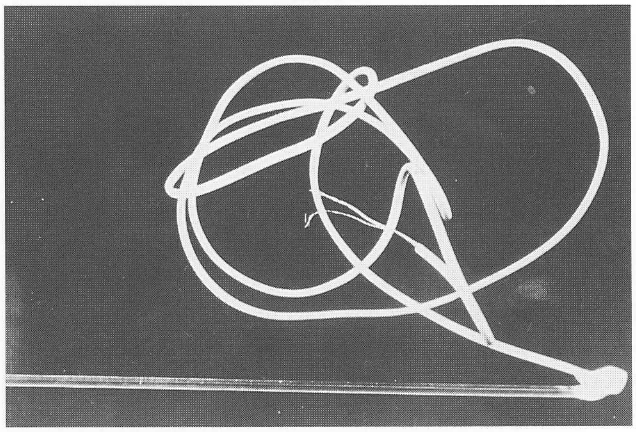

Fig. 9. Type B2 electrodes with a perspex rod attached to it for use as a probing electrode.

DISCUSSION AND CONCLUSION

Before the test, the spot on the oral mucosa is not only dried with cotton wool roll, it is also rubbed with the roll hoping to remove loose keratin over the mucosa surface. Drying the mucosa and removing loose keratin is an attempt to keep the impedance of the skin-electrode circuit to a low level, as it was found that resistance can best be maintained with least variability when it is kept at a low level. Temperature at the site of test is not taken into consideration due to the fact that intra oral temperature is quite constant during test and also because of the difficulty of incorporating temperature measuring device in a small electrode. An effective electrical aesthesiometer was produced for experimental production of pain for the purpose of studying pain threshold, tolerance, pain tolerance, oral perception and the effect of local anaesthesia on pain.

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