Instrumentation

A STRAIN GAUGE PAIN STIMULATOR

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ABSTRACT

Focal pressure, applied to the skin over bone, is a method of evoking experimental pain of an "aching" nature in which actual receptor stimulation is closely related to the applied stimulus. Methodological faults in previous applications of this method are eliminated by a pain stimulator which utilizes a bonded strain gauge.

DESCRIPTORS: Pain, Pain stimulator (mechanical), Gross pressure, Strain gauge. (A. G. Forgione)

Research on pain must strive to ensure a constant relationship between the physical parameters of the applied stimulus and the actual stimulation of the receptor sites. If the applied stimulus can be modified by extraneous physiological events before it reaches the receptors, a source of error is introduced. For instance, the applied stimulus in cold pressor pain is water at a temperature much lower than that of the immersed limb. However, the actual stimulation—the rate and degree of thermal reduction in tissues surrounding the receptor sites—is a function of the amount of warm blood flowing through the limb. Since subjects differ with respect to initial values and subsequent variation of blood pressure, heart rate, and vasomotor activity, each subject is exposed to varying degrees of actual stimulation.

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Focal pressure, applied to skin over bone in areas sparse in muscle and fatty tissue, is an applied stimulus which is relatively unmodified by extraneous physiological events. The actual stimulation—the rate and amount of tissue deformation at a given pressure—is a function of the mechanical properties of the skin of each subject, a variable that does not exhibit rapid fluctuations during the experiment.

Prior methods of applying pressure to skin over bone have a number of disadvantages which render them unacceptable for rigorous experimentation. Spring devices (Clutton-Brock, 1957; Haslam, 1967; Keele, 1954; Merskey & Spear, 1964; Pelner, 1941) have been designed to be hand held, resulting in variations in the applied stimulus during each trial. When the body part and pressure source are mechanically fixed, pres-

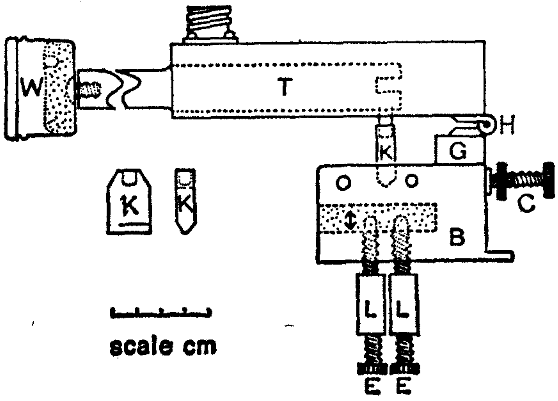

FIG. 1. Side view representation of the Pain Stimulator showing detail of the lucite knife. W = weight, T = transducer in aluminum handle, H = hinge, G = large aluminum end block, K = lucite knife, C = finger locking bolt for finger tip, B = large aluminum channel, E = elevating bolt, and L = locking nut with soldered tube extension. The vertically sliding lucite block is represented by the stippled rectangle in "B." Side finger locking bolts are not shown.

sure must be pumped by hand (Gluzek, 1944) or hand cranked (Eddy, 1932). When using any one of these methods, the pressure readings must be made visually from the movement of a pointer on a scale and they must be hand recorded. Furthermore, these methods do not provide an exact record of the time course of stimulation and variation in pressure.

The use of a bonded strain gauge eliminates the problems mentioned above. Since the readout is directly recorded on the same chart as electrophysiological responses, a record is provided of the exact temporal parameters of stimulation and of very small variations in stimulation.

The apparatus described below was designed to deliver constant pressure athwart and perpendicularly to the second phalanx of a restrained digit, by means of a lucite knife edge attached to a bonded strain gauge.

DESCRIPTION

Fig. 1 presents the important details of the pain stimulator[1]. The transducer[2], supplied by the manufacturer, was already mounted in a solid aluminum handle (T). The handle was housed in two short lengths of appropriately drilled extruded aluminum channels. The exposed, round end of the handle was tapped to accommodate a bolt for the attachment of weights. Weights (W) were prepared by pouring lead into metal ointment cans each of which had been punched through the bottom for insertion of a bolt. Half of a steel hinge (H) was attached to one end of the housing.

The base was assembled in a large extruded aluminum channel (B, Figs. 1 and 2). An aluminum block (G) was cut to fit inside one end of the channel and drilled to accommodate a finger locking bolt (C, Fig. 1), screwed in from the outside, and a retracted "no-rotate" washer[3] (soldered to the tip

[1] A more detailed plan of construction is available from the authors.

[2] FT-10C, Grass Instrument Company, Quincy, Massachusetts.

[3] The "no-rotate" faucet washer is constructed of a solid rubber disc, housed in a brass base. Extending from this brass base is a clip that rotates freely. With the clip soldered to the end of the finger locking bolt, the rubber disc can be brought into contact with the digit by turning the bolt. Further tightening of the bolt will result in increasing pressure on the digit without rotation of the disc.

Hardware stores usually carry a wide selection of these washers which are dis-

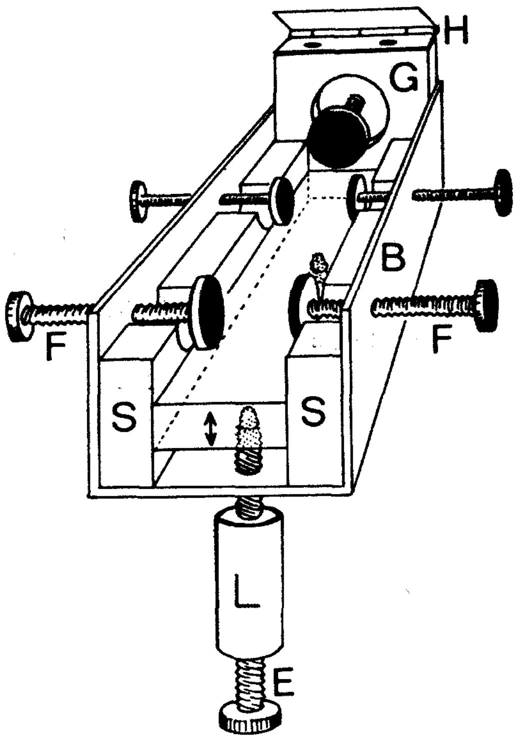

FIG. 2. Frontal view of the base of the Pain Stimulator with transducer housing removed. Rendering is distorted for clarity. F = side finger locking bolts, S = small aluminum block forming recess for vertically sliding lucite block (double arrow); other designations as in Fig. 1.

of bolt "C") on the inner side (Fig. 2). With block "G" fixed in one end of the channel, the other half of the hinge, "H," was attached to the top of the block. Two smaller aluminum blocks (S, Fig. 2), gouged to allow retraction of the "no-rotate" washers of the side finger locking bolts (F, Fig. 2), were fixed to the inner sides of the large channel to form a recess bordered on two sides by blocks "S," on one side by block "G," and open on the front end. A lucite block, 1 cm thick (double arrow), was cut to slide vertically in this recess, and the bottom surface drilled to loosely accommodate the rounded ends of two elevating bolts (E, Figs. 1 and 2). The height of the lucite table could then be varied by bolts "E" and fixed in position by locking nuts soldered in short copper tubes (L). The tubes would enable tightening when the base is secured to an appropriately drilled table. "No-rotate" washers were then soldered to the two finger locking bolts (F), which had been screwed in through each side of the channel (B, Fig. 2).

A lucite knife (K) 6 mm thick was cut out and a knife edge formed by sanding each surface at an angle of 45 degrees along the lower edge. The sharp edge that was formed was sanded flat so that it measured 0.25 mm wide. The top of the knife was then carefully drilled to fit tightly around one arm of the transducer.

To prevent slippage, the lead from the polygraph, at a point approximately 7 inches below the Cannon connector, was attached by means of a clip to block "G." The assembled pain stimulator, in use, is shown in Fig. 3.

CALIBRATION

Calibration was performed by removing the hinge pin, turning the housing over with the knife pointing upward, and rigidly supporting the

tributed by Kirkhill, Inc., Downey, California, or Des Plaines, Illinois.

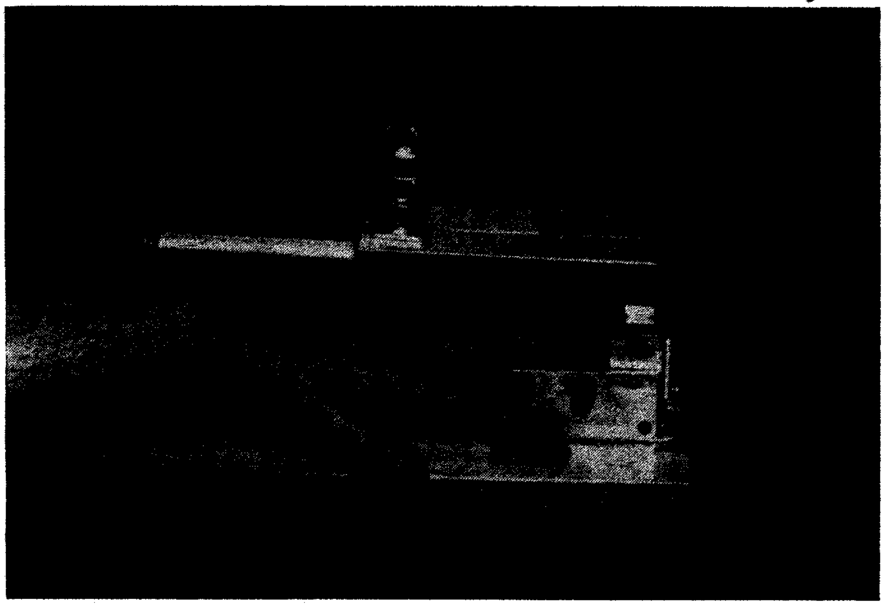

FIG. 3. Side view of the assembled stimulator in use from an angle of 45°

housing in a horizontal position. After recording the weight of the lucite knife, weights of known value were suspended from the hole already provided in the uncovered arm of the transducer. For our purposes, the preamplifier was balanced to read on a scale of 1800–2200 g (10 g/mm excursion) with 2000 g at centerline. The pain stimulator was then reassembled (polygraph lead attached) and a solid lucite cylinder (false finger) was placed on the adjustable lucite block. Since the knife was perpendicular to the housing, the horizontality of the housing with respect to the base was used to adjust the verticality of the knife. Various prepared weights (W) were screwed into the end of the handle until a value slightly greater than 2000 g was obtained. The lead was then drilled until an exact 2000 g reading was obtained.

APPLICATION

The strain gauge pain stimulator, which was designed for the method of constant pressure with time varying (Beecher, 1959), produces a continuously building "aching" pain that tends to resemble the type of pain commonly observed in clinical settings. Although there are other procedures for producing similar experimental pain, e.g., immersion of limb in ice water, or vascular occlusion with exercise, they differ from focal pressure in that they are affected by extraneous physiological events before actual stimulation occurs at the receptor sites.

The pain stimulator described above meets most of the requirements for a useful algometer that have been specified by Beecher (1959). For instance, it provides "(a) a stimulus which can be applied to a body part where neurohistological variations are at a minimum in different individuals, where it can be measured and closely associated with the changes which produce pain; (b) quantitative data in response to a given stimulus under given conditions, with little tissue damage at the pain threshold level and the hazard to the subject small at the highest intensities . . . [and] easy application of the stimulus and clear identification of the pain end point [p. 14]." In our laboratories, we have found the strain gauge pain stimulator to be useful: a) in measuring pain threshold and pain tolerance with concurrent monitoring of autonomic variables, and b) in determining the effects on pain tolerance of placebos, suggestions, distraction, and hypnosis.

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