17204. Construction and Application of Shielded Silver Electrodes with Mercury Leads Designed for Prolonged Stimulation Experiments.*

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Prolonged electrical stimulation of the nervous system of conscious animals requires shielded electrodes which will not injure the nerves or cause undue local tissue reaction. The leads connecting the electrodes to the external electrical circuit must be capable of withstanding the almost continuous motion of a normal animal for periods of several months. The purpose of this report is to describe in detail the construction of electrodes and leads which have fulfilled the above requirements. The production of arterial hypertension by renal artery-nerve or splanchnic nerve stimulation with similar electrodes has been reported.[1-4]

The electrodes are constructed of No. 18 fine silver wire and are imbedded in a molded lucite block (Fig. 1). The silver electrode wire is exposed on the inner surface of the lucite block to provide direct contact with the nerve. The obturator occludes the slot in the block after the nerve is in place. The hollow stainless steel terminal is filled with mercury and connected to a mercury-filled, double lumen rubber tube which provides electrical contact to the external electrical circuits.

A double lumen latex tube joined in a Y at the stainless steel terminal provides a means of flushing and cleaning the mercury columns whenever necessary. 1N HCl, followed by water, alcohol and air, is injected into one tube, flowing through that tube, through the hole in the stainless steel terminal and out through the second tube. Then this system is refilled with clean mercury.

Construction of electrodes. The electrode blocks are molded from powdered lucite† at a temperature of 175°C and a pressure of approximately 1000 lbs./in.^{2} (Fig. 2).

Step 1: (Fig. 2, photo 1). The silver wire (b) is wrapped around the mandrel (c) and soldered to the stainless steel terminal (a). Soldering flux designed for stainless steel facilitates this step.‡

Step 2: The plate (h) (Fig. 2, photo 4) is placed in the bottom of the holder (j). The assembly in (1) is then placed in the holder (j) with the flat portion of the mandrel (c) inserted into the slot in the plate (h). The screw (k) is then tightened. The guide (g) (Fig. 2, photo 5) is now placed in the holder (j) and the cylinder (d) (photo 2) is attached to the holder (j). The entire assembly is filled with powdered lucite to about ⅛ inch from the top of the cylinder. Tapping the assembly will insure complete filling. The piston (e) (photo 2) is inserted into the cylinder and the complete unit is placed in the press. The springs are tightened until they are nearly closed.§ The press and molding assembly is placed in an oven at 175°C. After 20 minutes the springs are again tightened and the entire apparatus is returned to the oven for 15 minutes. After the final baking the mold is allowed to cool slowly to room temperature before releasing the spring tension. When the cylinder (d) (Fig. 2,

* Supported by a grant from the Life Insurance Medical Research Fund.

1 Kottke, F. J., Kubicek, W. G., and Visscher, M. B., *Am. J. Physiol.*, 1945, **145**, 38.

2 Kubicek, W. G., and Kottke, F. J., *Fed. Proc.*, 1946, **5**, No. 1.

3 Kottke, F. J., and Kubicek, W. G., *Fed. Proc.*, 1947, **6**, No. 1.

4 Kubicek, W. G., and Kottke, F. J., *Fed. Proc.*, 1947, **6**, No. 1.

† E. I. DuPont de Nemours Co., Plastic Dept., Arlington, N. J. Crystal, Color H7500, Comp. HG 22, Gran Fine No. H18876.

‡ The Lloyd S. Johnson Co., 2241 Indiana Ave., Chicago, Ill. Stainless steel soldering flux.

§ Eiler Spring Co., 637 Sexton Building, Minneapolis, Minn. .125″ wire coil compression springs, 10 turns 2 inches in length, ½″ inside diameter, approximately 90 lbs. to compress spring completely.

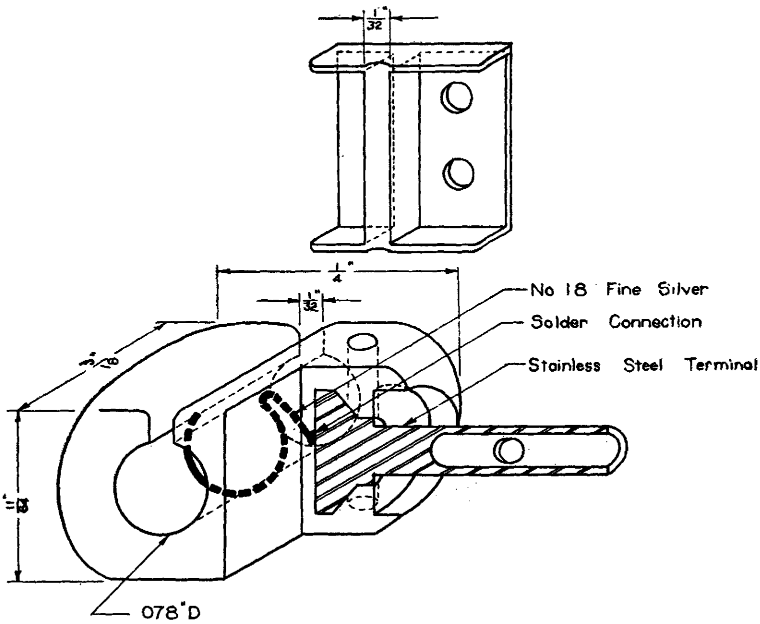

FIG. 1.
Pictorial diagram of lucite electrode block and obturator.

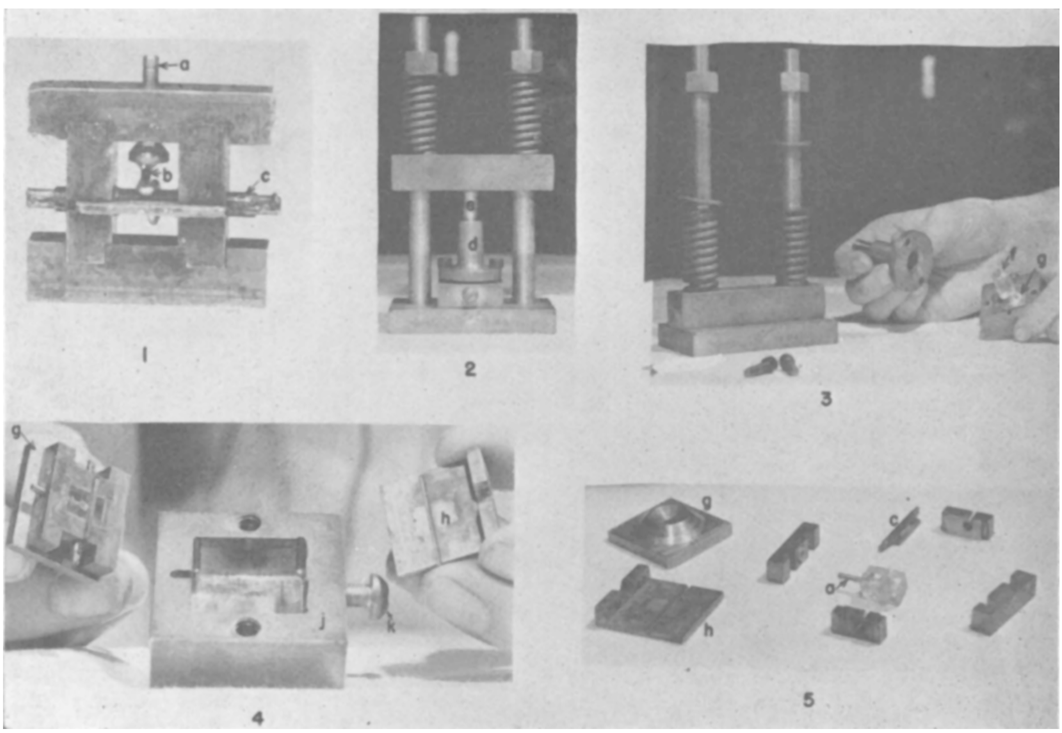

FIG. 2.
A composite photograph of the various steps in the molding process.

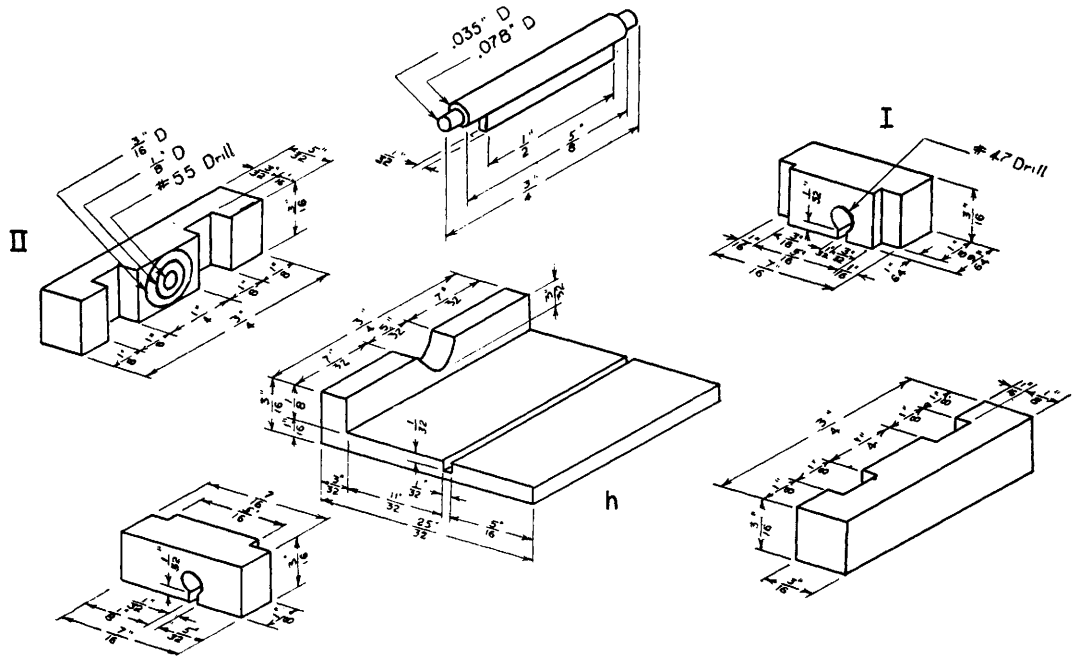

FIG. 3.
Assembly drawing of electrode mold.

photo 3) is removed, a lucite bar (f) is found attached to the bottom of the electrode block. This bar is twisted off and the guide (g) removed. The unit in photo 1 is placed astraddle a hole in a piece of wood in such a way as to allow the mandrel (c) to be driven out with a punch.

Step 3: Obturators (Fig. 1) are molded from powdered lucite by forcing molten lucite into a plaster cast of a wax impression of the slot in the electrode block. To form a wax impression, the electrode block is first painted with an aqueous soap solution. Inlay casting wax is softened over a flame and forced into the slot with pressure applied with the thumb. Molten wax is then added to strengthen the impression. The excess wax is trimmed off leaving small tabs at the corners to act as guides on the obturator (Fig. 1). After cooling under tap water a No. 48 drill is passed through the electrode block to remove the excess wax protruding into the lumen of the block and to shape the obturator in such a way as to fill completely the slot in the block and to leave the interior of the block smooth and cylindrical when the obturator is in place.

The plaster cast is made in a small metal box with mortised joints similar to the mold (Fig. 3). The box is .5" deep, .4" wide, and .75" long inside with ⅛" walls. A holder similar to (j) (Fig. 2) is used to support the cylinder (d) and the casting box. The guide (g) is not necessary in molding the obturators. When the box is filled with fine thoroughly mixed plaster the surface of the wax impression is painted with plaster to insure close adherence to the contour of the impression. The wax is then immersed, impression down, in the plaster. After setting, the excess plaster is chipped off and the wax removed after heating under hot tap water. Before filling the cast with lucite the surface of the plaster is painted with a sealing agent.|| The filling and baking procedure is the same as described for the electrodes. The obturator is formed on the end of a lucite bar (f, Fig. 2, photo 3) and is sawed off after the plaster has been chipped off. (A weak solution of HCl is useful in removing the last bits of plaster). The obturator is then slipped into place on the electrode block. After

|| L. D. Caulk Company, Milford, Dela. Al-Cote sealing agent.

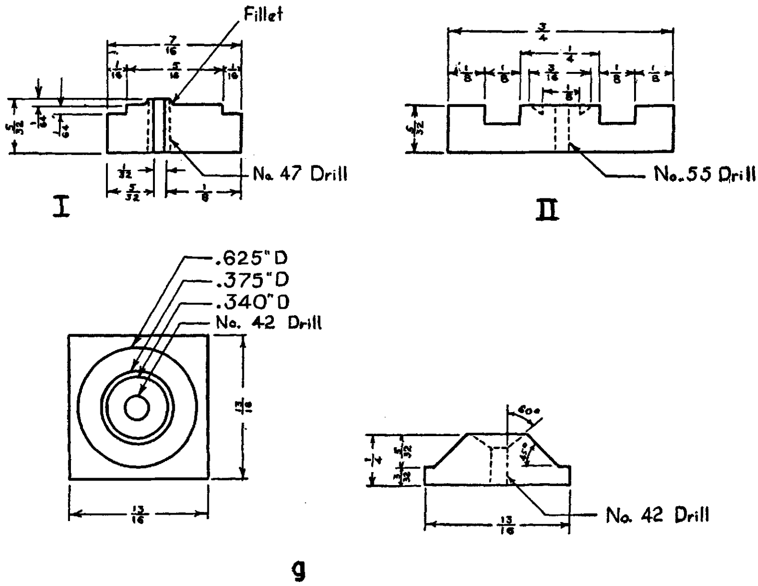

FIG. 4.
Detail drawing of mold parts I and II of Fig. 3 and guide (g) (Fig. 2) (photo 5).

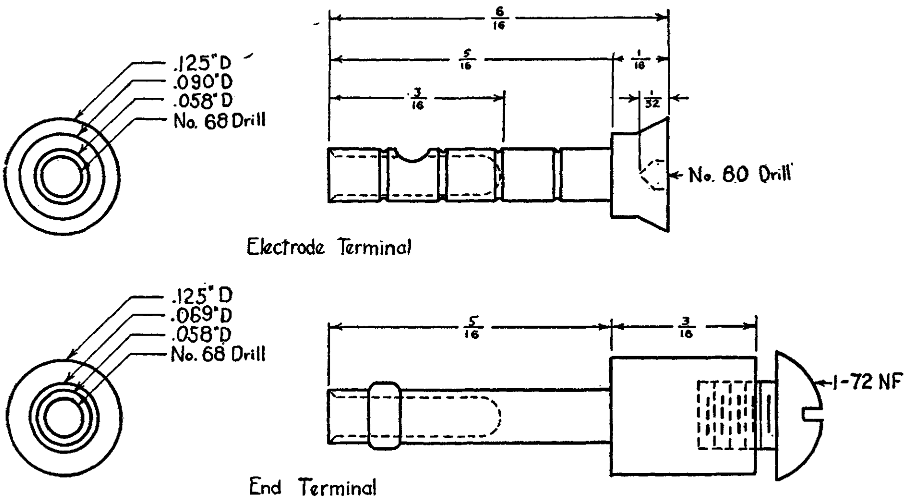

FIG. 5.
Detail drawing of electrode terminal and end terminal.

rounding off the corners and sharp edges the lucite is polished and the holes drilled for the ligatures (Fig. 1). Lubricating the drill with kerosene will facilitate drilling lucite. During the molding process a thin film of lucite forms over the silver electrode. The film is removed with a dental grinder.

Details of the molding apparatus are presented in Fig. 3-7.

Step 4: *Construction of small double lumen latex tubes.* Stainless steel wires are joined with Wood's metal (Fig. 8). The wires are then dipped into a clay or mica release medium,¶ then into a coagulant,¶ and finally into latex.¶ The wall thickness of the

¶ American Anode Company, Akron, Ohio. Clay or mica release medium, No. 545 coagulant 60% centrifuged latex (keep latex at pH 9).

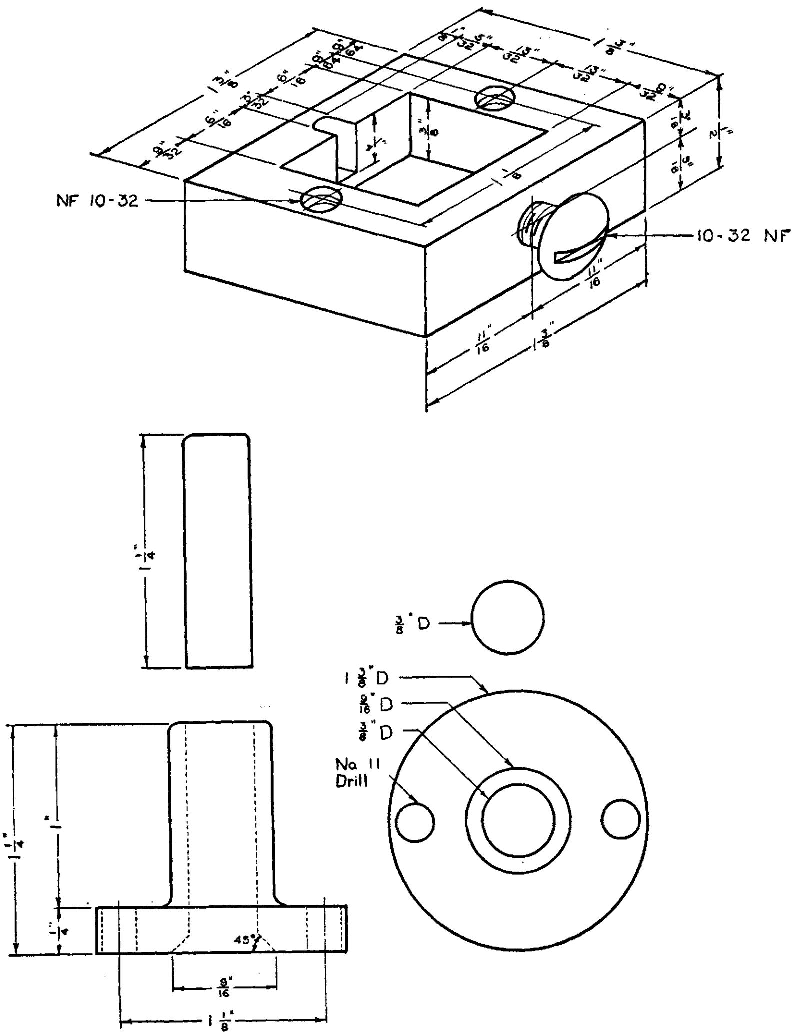

FIG. 6.
Pictorial drawing of holder (j) and detail of cylinder (d) and piston (e) (Fig. 2).

tubes is controlled by the length of time allowed for deposition of latex on the wires. Usually 5 to 10 minutes is sufficient. The wires are carefully removed from the latex and approximately one hour allowed for coagulation to proceed. The wires and tubes are then washed in tap water for one hour, rinsed in distilled water, and dried until all white color has disappeared. Twenty-four hours at room temperature or 12 hours at 50°C will usually complete the drying. The tubes are finally cured for 20 minutes at 105°C. The tubes are removed quickly from the curing oven and the wires separated at the Wood's metal junction. Later the wires are removed, the excess rubber is trimmed off, and the tubes cleaned with 1N HCl, water, alcohol, and dried with air. The tube extending past the junction of the lumina should be cut as short as possible to insure continuity of the junction of the tubes and the hole in the stainless steel terminal in the electrode block (Fig. 1).

Step 5: *Assembling the electrode and leads.* The hollow portion of the electrode terminal is filled with mercury with a syringe and needle. The terminal is inserted into the

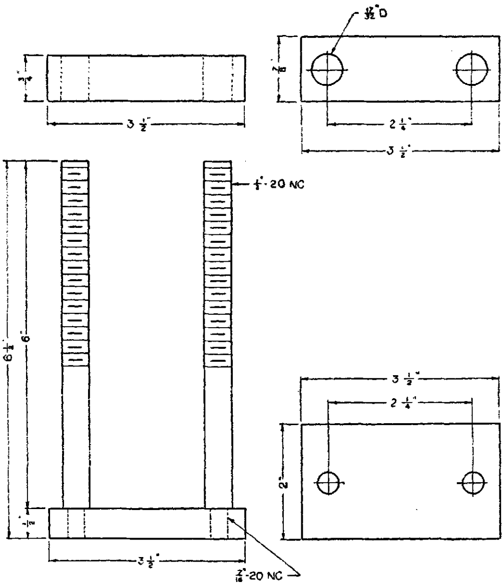

FIG. 7.
Detail drawing of press, (Fig. 2) (photo 2).

straight rubber tube until the hole in the side of the terminal coincides with the junction of the lumina. Pushing the terminal beyond this point and withdrawing to the proper position will produce a more reliable connection. Two or 3 turns of thread below the junction aids in securing the rubber to the terminal. Water-proof cement between the rubber tube and the lucite block insures good electrical insulation of the terminal. The hollow stainless steel terminal for the distal end of the tube is filled with mercury (Fig. 5). With a smooth 18-gauge needle and syringe 5 cc of mercury are flushed rapidly through the rubber tube and electrode terminal. Without allowing air to enter either tube and with the syringe in place the mercury in the distal terminal is joined by cohesion to the mercury in one lumen of the rubber tube and the terminal inserted. To insure complete filling the needle is re-

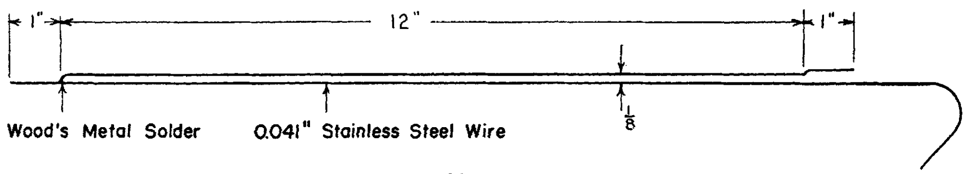

FIG. 8.
Diagram of stainless steel wires used for constructing double lumen latex leads.

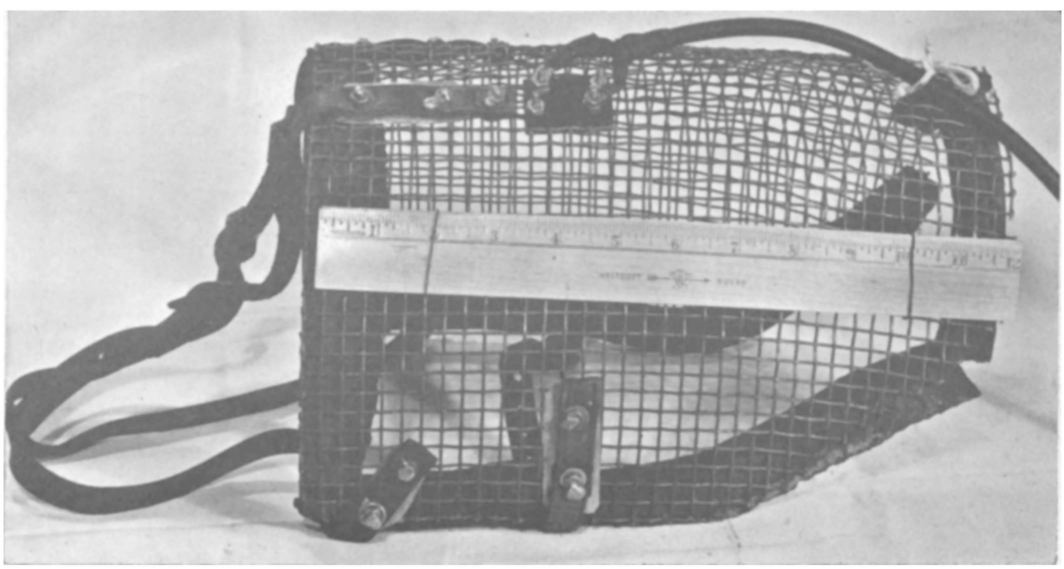

FIG. 9.
Photograph illustrating the gravel screen saddle, electrode terminal block, and lamp cord connecting the electrodes to the stimulator.

moved with the rubber tube in the vertical position since the rubber will distend slightly due to the pressure of the mercury column. When the remaining rubber tube is completely filled with mercury a metal obturator is inserted and several turns of thread applied tightly around both the obturator and the distal terminal.

Application of electrodes. The splanchnic nerves are exposed through bilateral dorsal incisions. The nerves are carefully dissected free of surrounding tissue. An electrode is placed around each nerve and the obturator tied in place. Two or three turns of linen ligature around the rubber tube and through adjacent fascia holds the electrode in position so that the course of the nerve is altered as little as possible. The mercury lead is then brought through the incision by a circuitous route and finally through the skin approximately two inches from the spine at about the level of the last rib. Anchoring the leads to bony structures and fascia at several points aids in securing the electrode in the proper position and prevents any pull directly on the nerve. Small flexible wire leads connect the mercury leads to a terminal block on the gravel screen saddle used to protect the leads (Fig. 9). The animal is tied to one end of a rectangular cage which allows him to lie down or stand at will but prevents turning completely around, thus preventing destruction of the leads to the stimulator.

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17205. Urinary Excretion of Digitoxin in the Rat.*

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Heretofore it has not been possible to measure the actual renal excretion of digitalis glycosides. However, by means of the embryonic duck heart method, we have been able to measure in a quantitative fashion minute amounts of digitoxin (Sandoz) in the 24-hour urine volumes of the rat.

Methods. The 24-hour urine sample of a rat is concentrated to 10 ml volume by boiling. Three grams of infusorial earth are added and the mixture dried at 80° *in vacuo.* The dried residue is broken up with a glass rod, 50 ml of U.S.P. grade chloroform is added, and the mixture is shaken for one hour in a mechanical shaker. The chloroform extract is separated by filtration through paper. The residue on the paper is washed 3 times with fresh 10 ml portions of chloroform, the solvent being pressed out of the residue after each washing. The washings are combined with the filtrate, the extract is concentrated to a small volume by boiling, and is then dried at 80°C *in vacuo.* The dried extract is taken up in 1 ml of ethanol by shaking for one hour. Ten ml of water is added to the alcohol and the solution is concentrated to 1 ml by boiling. Another 10 ml of water is added and the solution again concentrated to 1 ml. This concentrated solution is diluted to a final volume of 60 ml by the addition of 59 ml of Tyrode's solution (without glucose). Embryonic duck hearts are exposed to this latter solution and the time of "digitalis effect"[1] observed and the quantity of digitoxin estimated according to previously described methods.[2] It thus was found possible to detect as well as measure as little as one microgram of digitoxin added to the 24-hour urine sample of the rat. A quantitative differentia-

* Aided by grants from The Life Insurance Medical Research Fund, The U. S. Public Health Service, and The Sandoz Chemical Works.

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