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VASCULAR AND RESPIRATORY PRESSURIZATION OF THE THORAX

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This discussion describes the techniques used at HSRI for pressurization of the thorax as well as handling and positioning of human subjects before and after pressurization. These techniques are applicable to both direct impact testing using a pendulum impactor and to whole body impact sled testing.

The techniques used for pressurization of the vascular system are based on modifications of the method developed by Tarriere et al. of the Peugeot-Renault Association, Paris, France. They involve catheter construction, surgical installation, and pressurization methods. The techniques for pressurization of the respiratory system were developed at HSRI. They involve trachea tube construction, surgical installation, and pressurization methods. The techniques for handling of human subjects are a modification of ambulance emergency procedures used for extraction of patients from automobiles after an accident.

Catheter construction starts with removal of the center tube section of a Foley balloon catheter. The section is replaced with suitable lengths of polyethylene tubing. Two diameters of tubing are necessary, one for the pressurizing fluid and one for the balloon inflation. Lead targets are inserted in the end of the exit port of the tip for later radiographic location within the test subject, and the port is sealed with epoxy. Holes are then made in the polyethylene fluid pressurization tube before the occluding balloon to allow the fluid to flow out into the occluded blood vessel (See Figure 1).

Surgical installation of the catheter consists of locating the carotid artery in the neck and making a short longitudinal incision just long enough to allow the catheter to pass through the artery and into the descending aorta. When it is desired to measure pressure in the ascending aorta, a balloon catheter is inserted through the carotid artery into the descending aorta, just below the level

of the heart. A length of additional polyethylene tubing, to act as a pathway for a miniature pressure transducer, is then inserted next to the catheter and into the ascending aorta (Figure 2).

Once all the tubes have been placed in the appropriate arteries, the carotid incision is sealed with quick-setting plastic to prevent fluid leakage. Various pressurization fluids have been used such as water, water and black india ink, and thickening agent with black india ink. The purpose of the ink is to mark ruptures due to impact, while the purpose of the thickening agent is to prevent the fluid from entering the very small blood vessels that communicate with the venous system. By varying the amount of thickening agent in the fluid, the degree of perfusion can be somewhat controlled. For direct pendulum impact testing, an air hose is connected to a 5-liter, fluid-filled container which in turn is connected to the catheter inlet tube (Figure 3). When air pressure is applied to the air container, the fluid is forced into the cadaver. Prior to pressurization, the catheter balloon is inflated to block off the descending aorta. During pressurization, the air pressure increases until the pressure in the cadaver vascular system stabilizes at approximately 75 mm Hg. Once stability is achieved, testing commences. For pressurizing a cadaver mounted on an impact sled, an air hose is connected to a 10-liter, air-filled container, which in turn is connected to a 5-liter, fluid-filled container, which in turn is connected to the catheter inlet tube (Figure 5). When air pressure is applied to the air container, the fluid is forced into the cadaver. Prior to pressurization, the catheter balloon is inflated to block off the descending aorta. During pressurization, the air pressure in the air container is increased until the pressure in the cadaver vascular system reaches approximately 75 mm Hg and has become stable as indicated by the pressure transducer. After the desired pressure level is attained, the air tank inlet is shut off, leaving the air tank to maintain the fluid pressure.

The respiratory pressurization equipment consists of a flexible plastic tube that has been wrapped with adhesive tape (Figure 6). The amount of tape is determined by the size of each individual trachea. To ensure that the tube fits snugly in the trachea, the last layers of tape are not applied until after the trachea is exposed and measured.

The surgical procedure consists of making a longitudinal incision in the neck above the trachea. The incision is cut so that the trachea can be assessed easily. To allow for intubation, a small x-like incision is made in the trachea just big enough for the trachea tube to pass through. Once the tubes has been inserted into the trachea, a length of stainless steel wire is wrapped around the outside of the trachea, covering that part of the tube wrapped with tape. Then it is twisted until the plastic tube cannot be removed.

For direct impact and sled testing, the plastic tube is connected to a 10-liter, air-filled tank that has been pre-pressurized. Immediately before impact, the tank is opened (Figures 3, 4), pressurizing the respiratory system.

Once the subject has been instrumented with both the pressurization equipment and accelerometers, it is necessary to place the subject in an appropriate position prior to the test. For pendulum impact tests, a head stabilizing restraint strap assembly is attached to the head of the subject from an overhead boom. The subject is raised into sitting position by use of the boom and is placed in a specially constructed chair (Figure 4). This chair has the capability of moving in three directions. Up-and-down motion is accomplished by use of a large-threaded rod attached to the platform that the subject is seated on. The rod screws into a base that is allowed to move freely in the plane tangent to the earth by riding on two sets of linear bearings. Once the subject is in position, all three directions are locked.

Positioning for a sled test is accomplished with the use of a Build-A-Board (Figure 6) and a scoop stretch (Figure 7) which can be molded around a subject in almost any position and locked to ensure that that position of the subject does not change. The subject is placed in the Build-A-Board in approximately the same seated position as will be used on the sled. All target placement and cabling of accelerometer wires are done at this time. The subject is then placed on the sled in a seated position (Figure 5), connected to the pressurization, and placed in final position (Figure 9).

After impact, there is a strong possibility that the subject is injured. We have chosen to splint the thorax by the use of various back boards, scoop stretchers (Figure 10) and Build-A-Boards. Once placed on a board or in a Build-A-Board, the subject is lowered either by hand or with the help of an overhead crane (Figure 11) to a Gurney stretcher. After unloading the subject onto a Gurney, the subject can then be moved with the use of a scoop stretcher to an autopsy table or x-ray table, or stored.

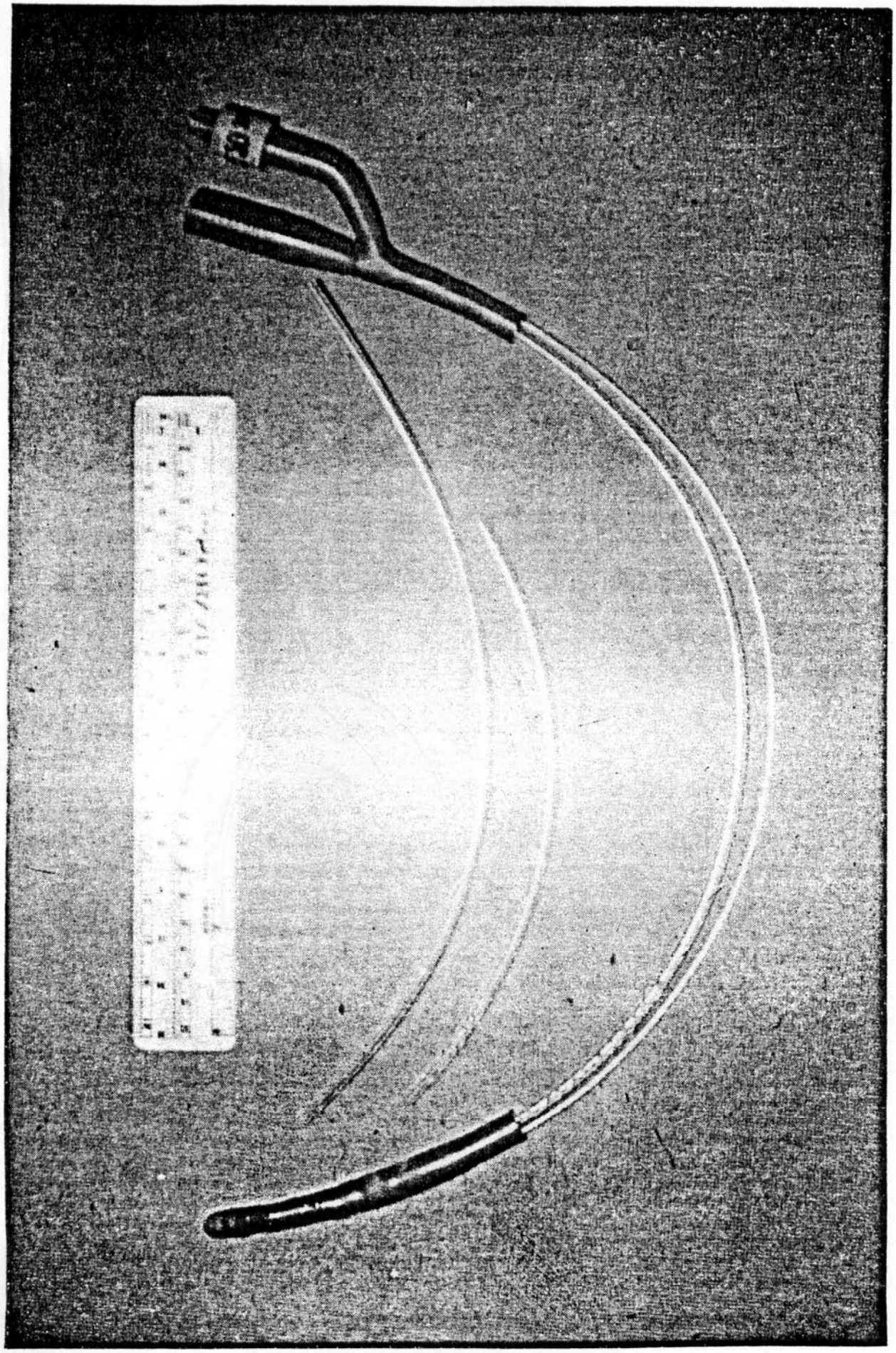


FIGURE 1.

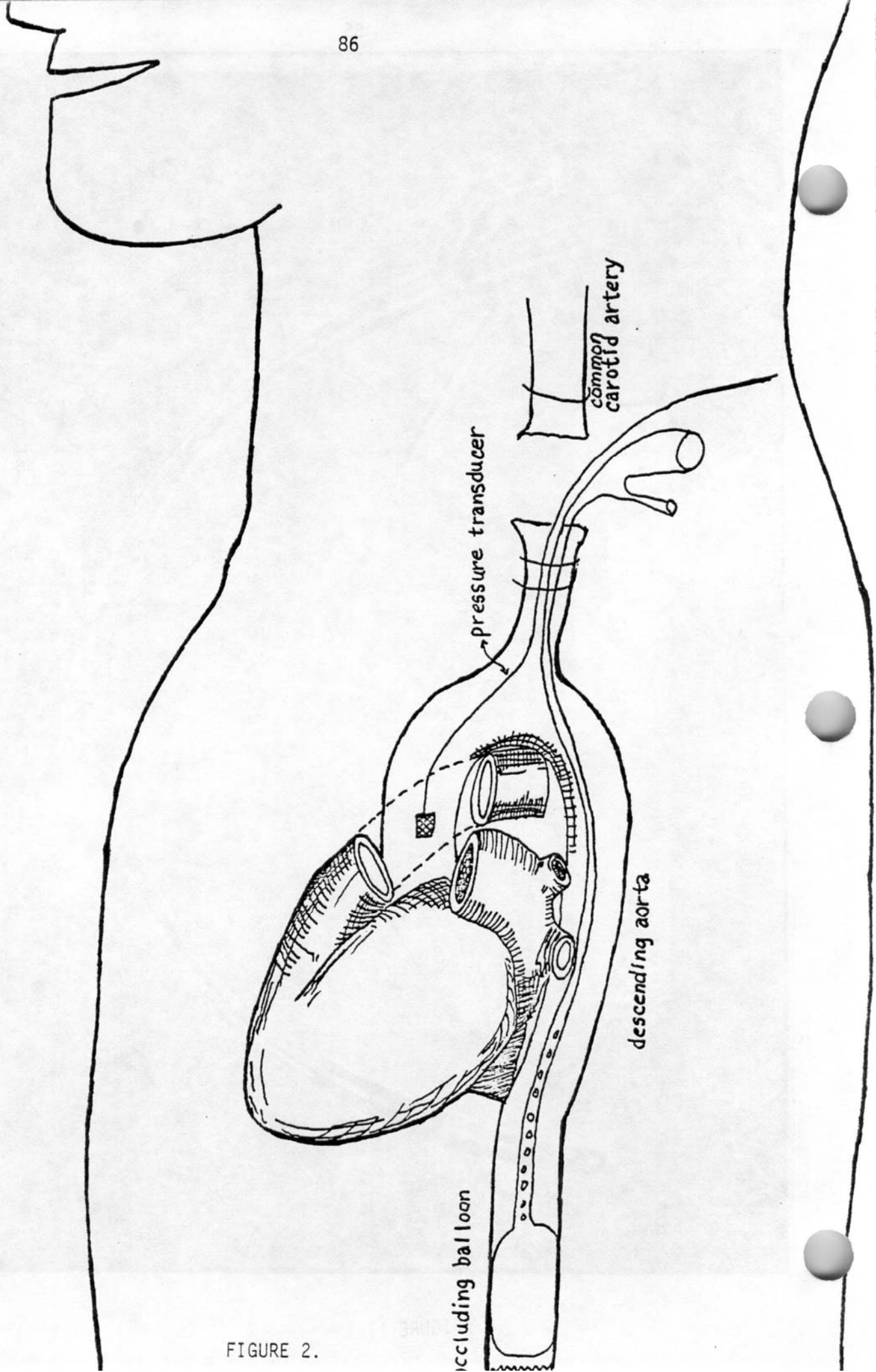
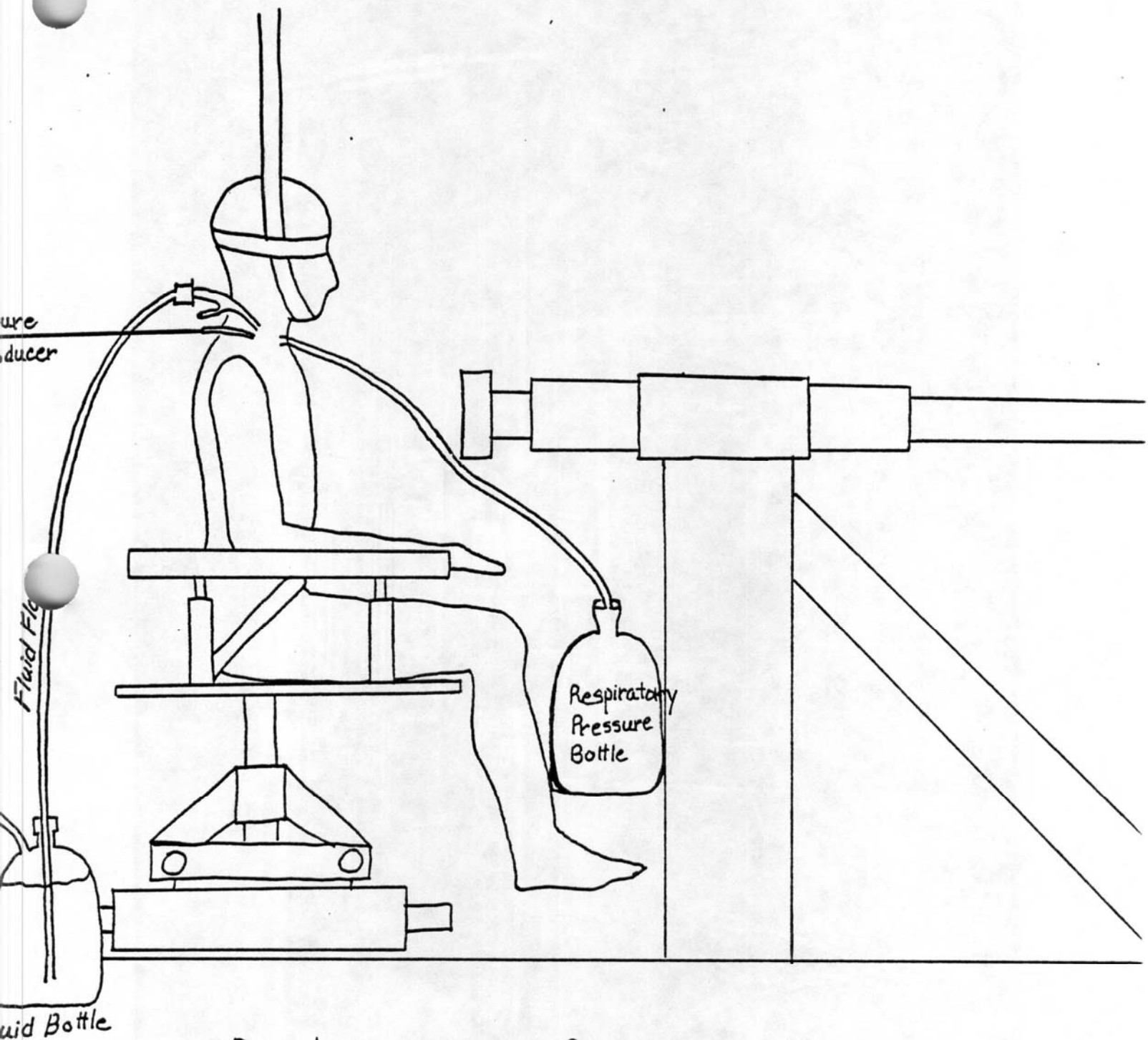

common carotid artery
pressure transducer
descending aorta
occluding balloon

FIGURE 2.



Pendulum Set up

FIGURE 3.

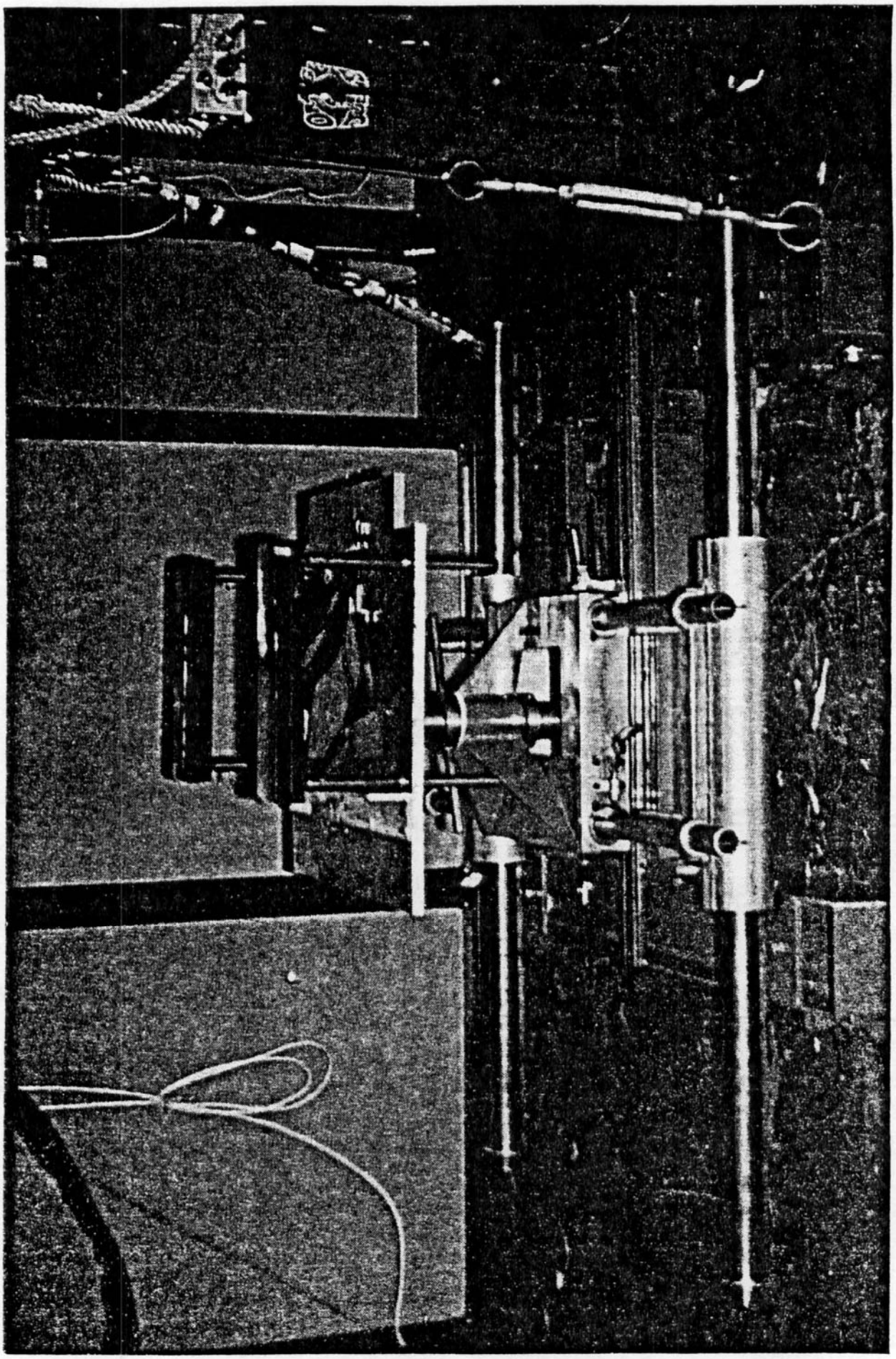
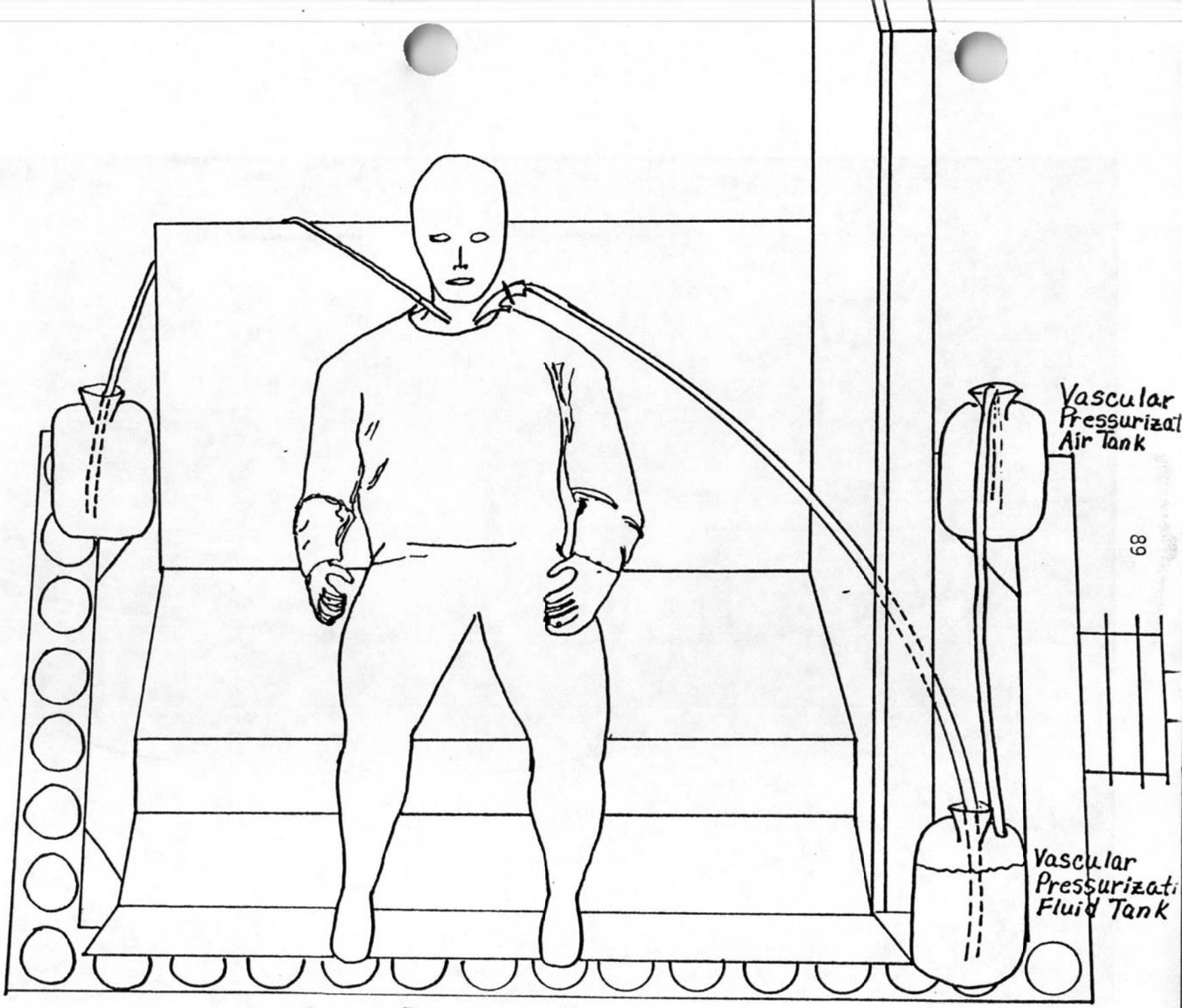


FIGURE 4.



SLED SET UP

FIGURE 5.

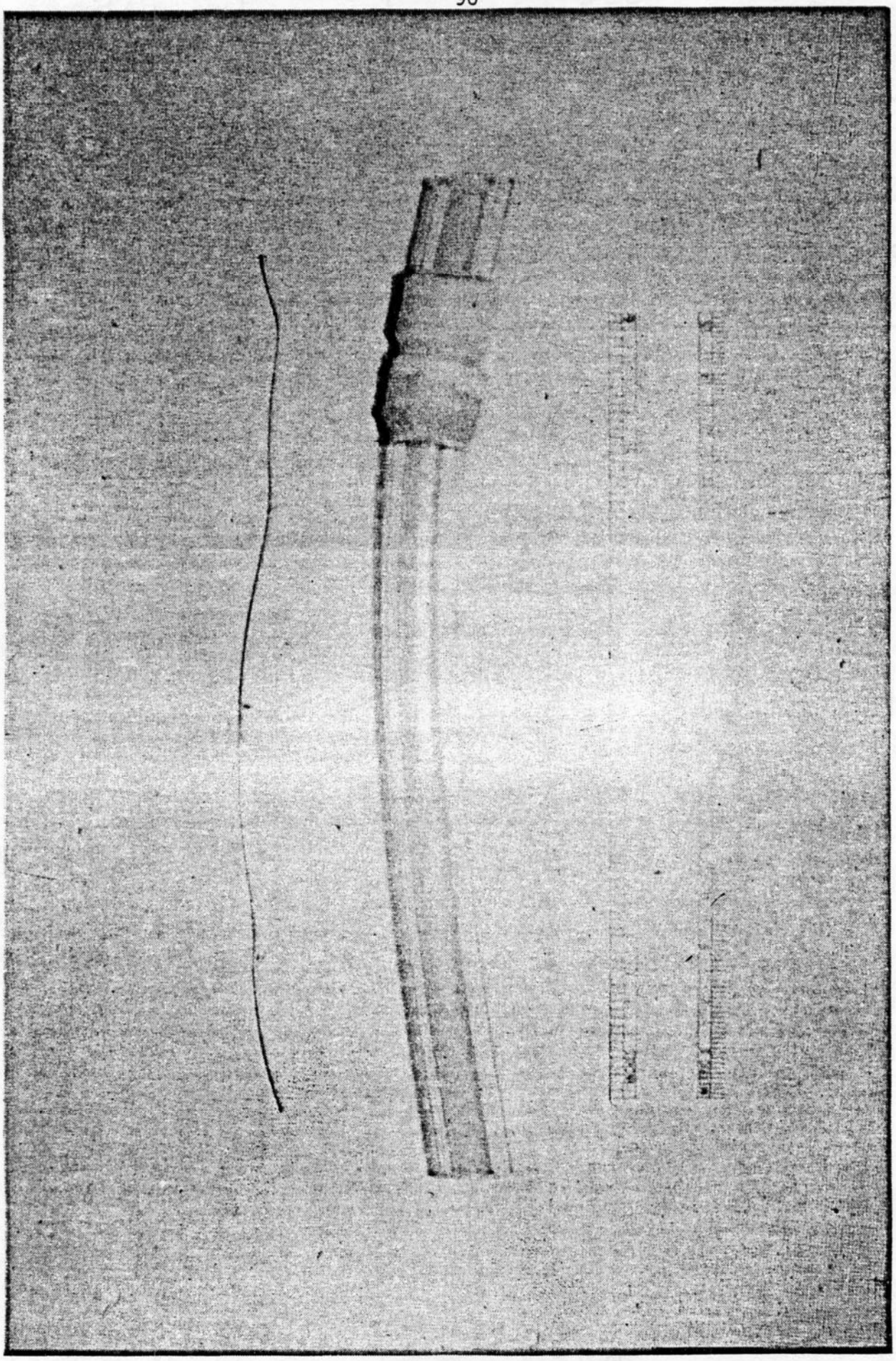


FIGURE 6.

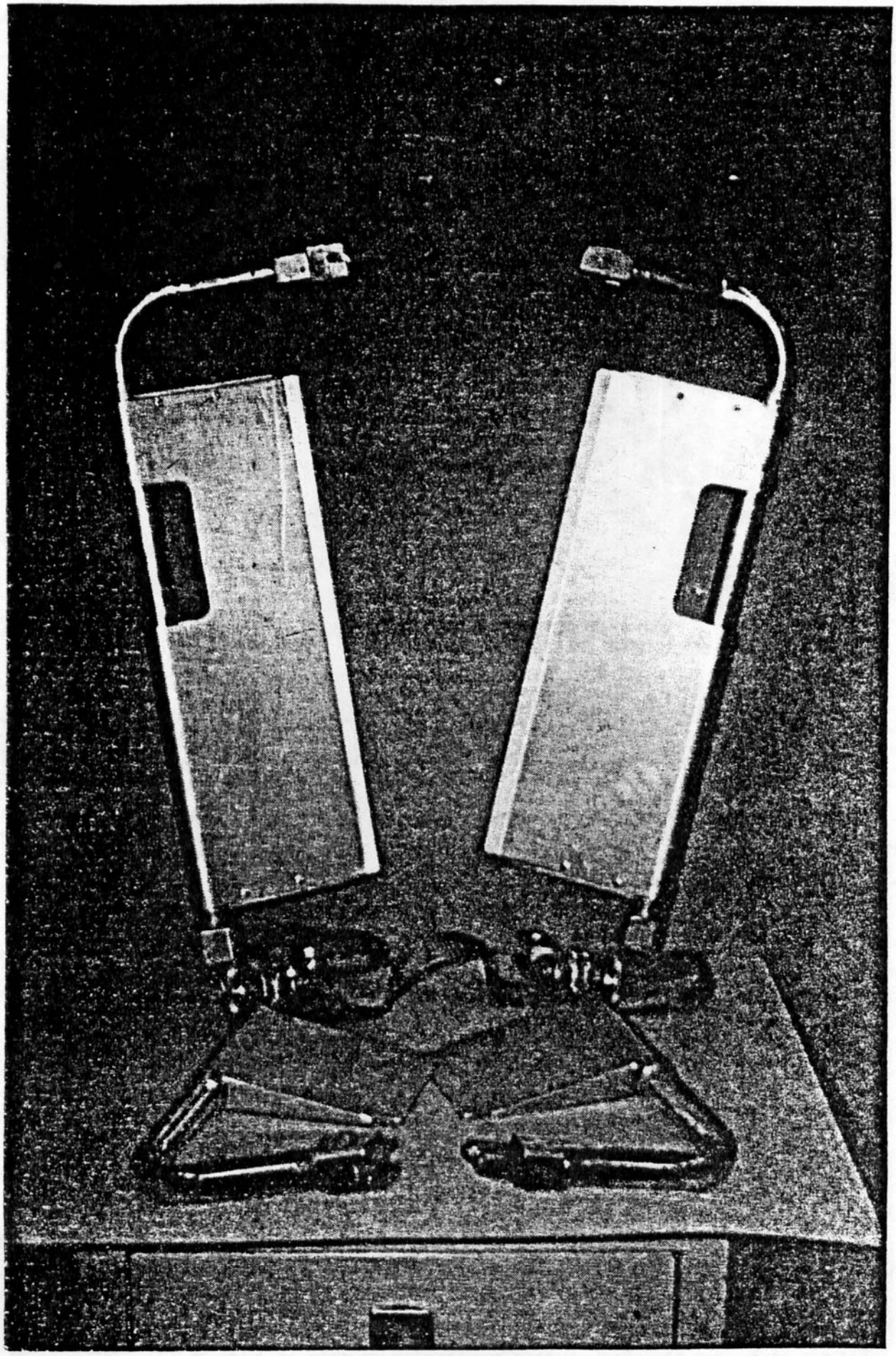


FIGURE 7.

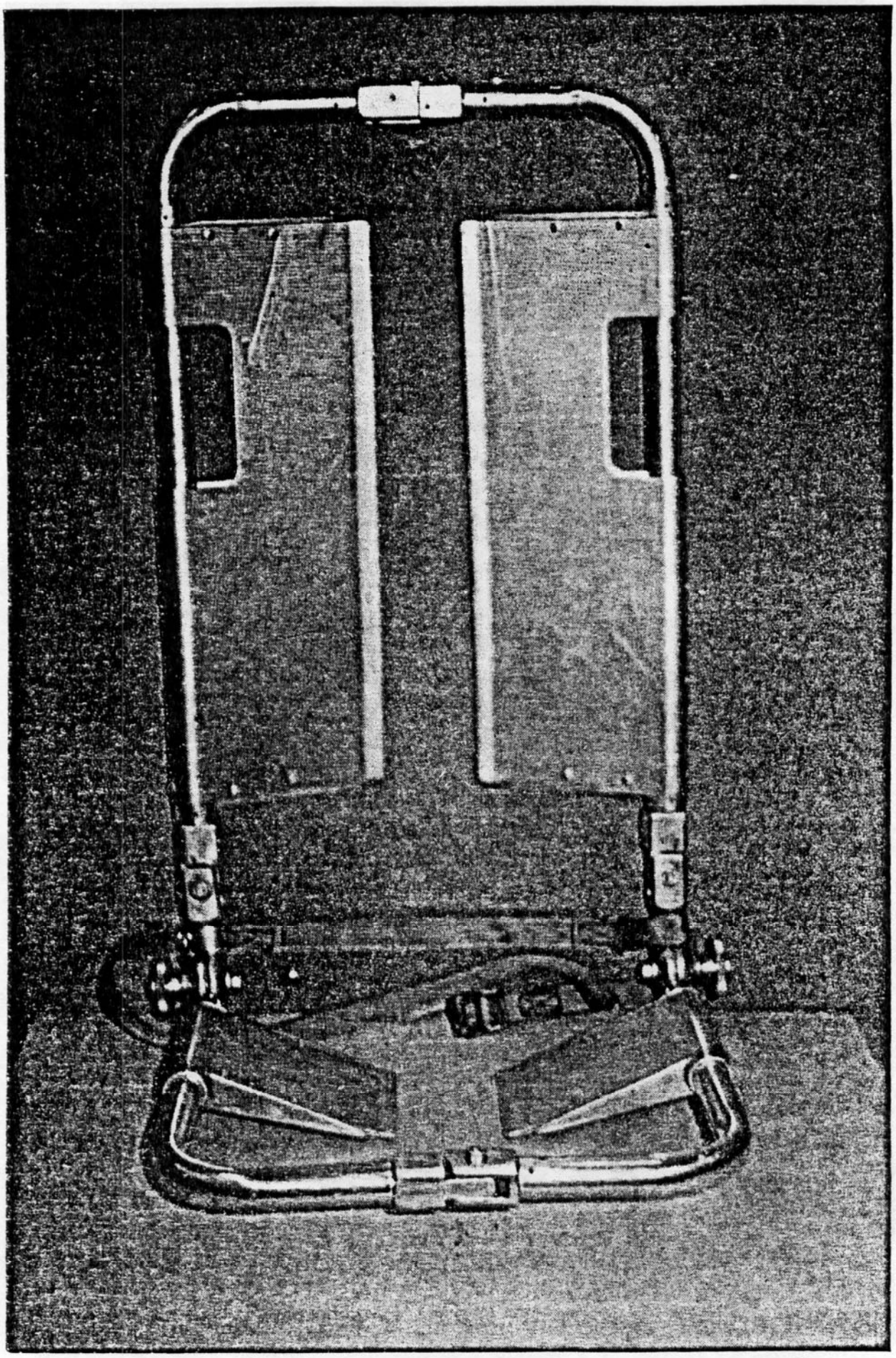


FIGURE 8.

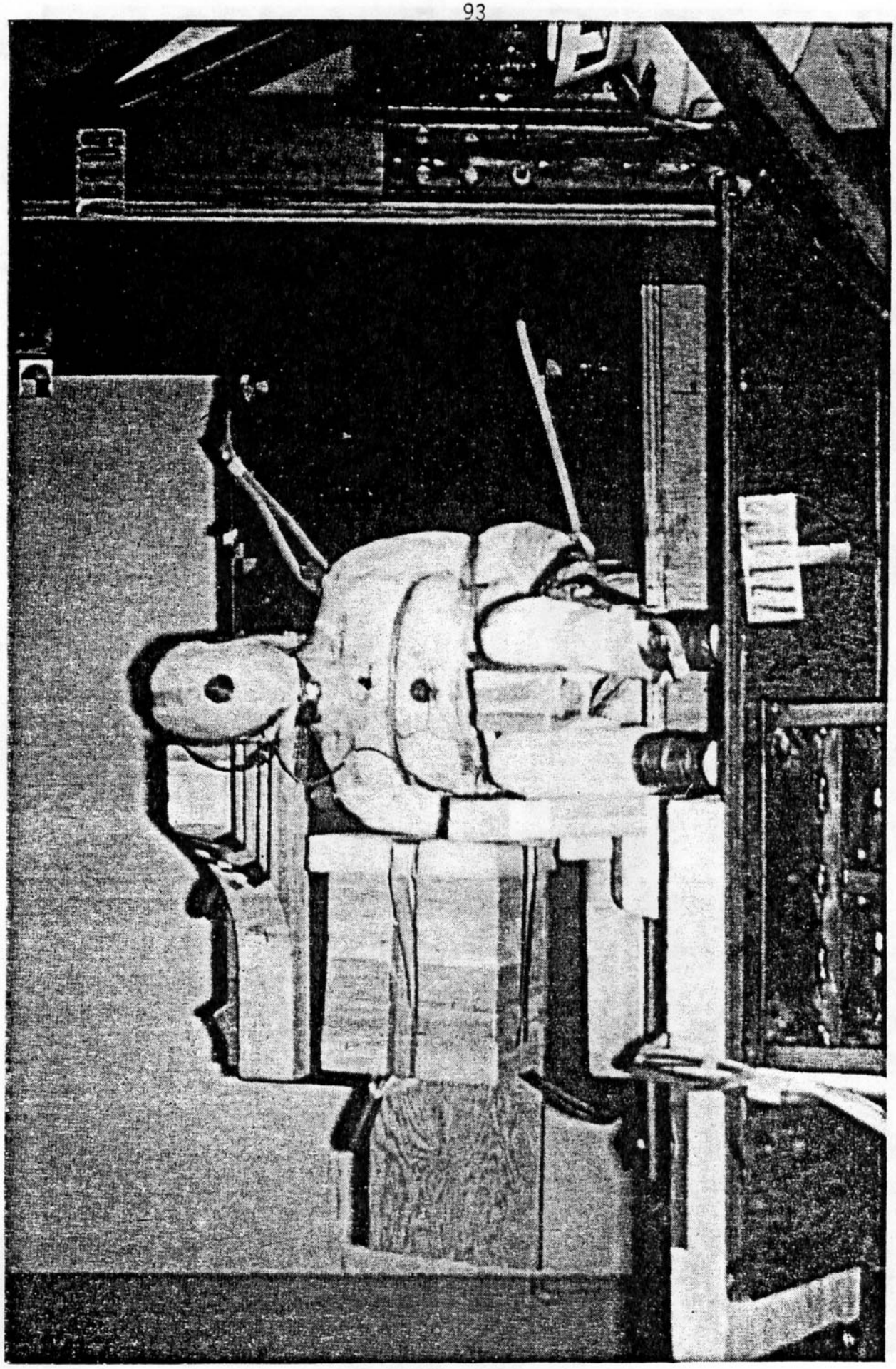


FIGURE 9.

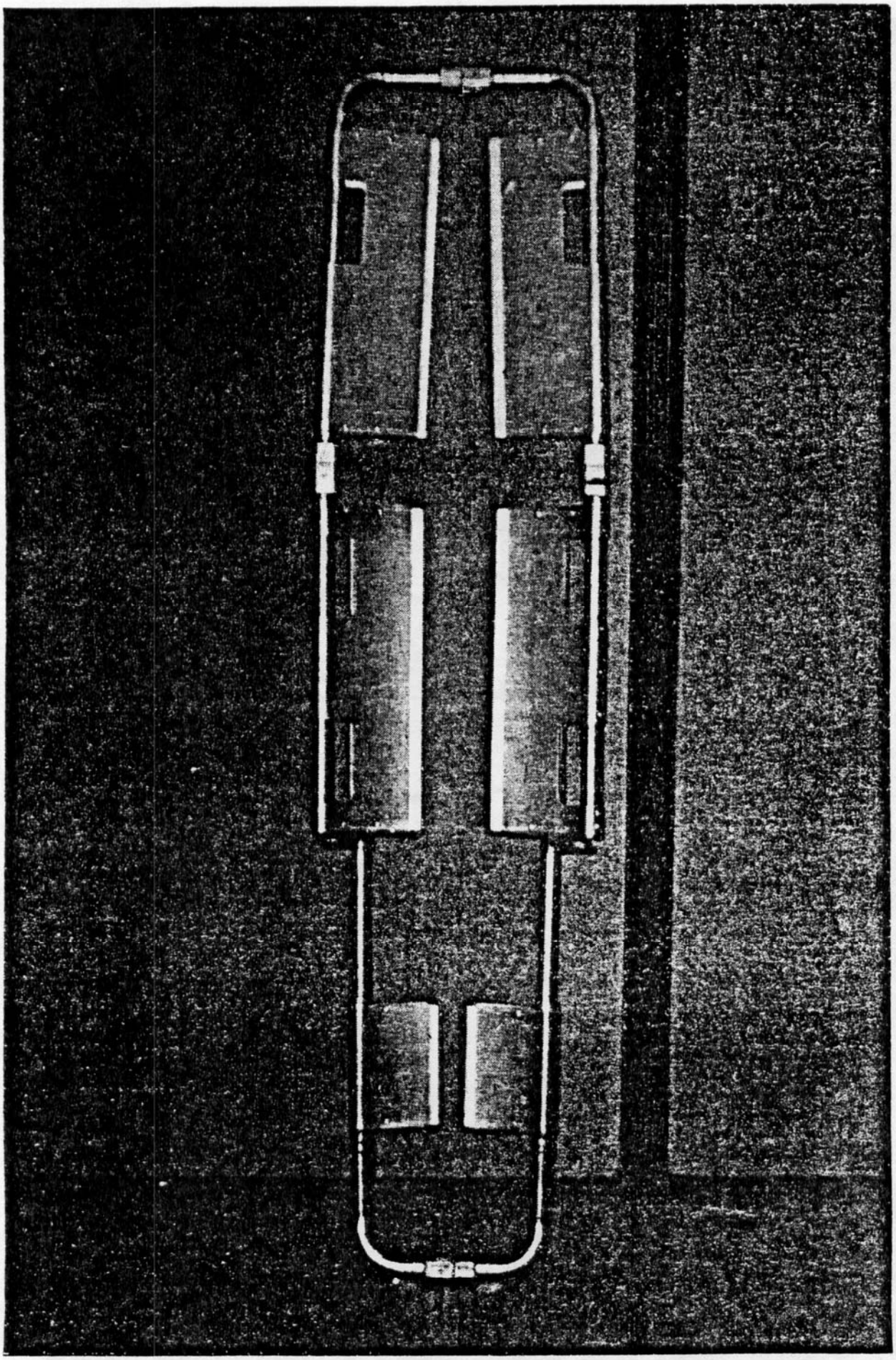


FIGURE 10.

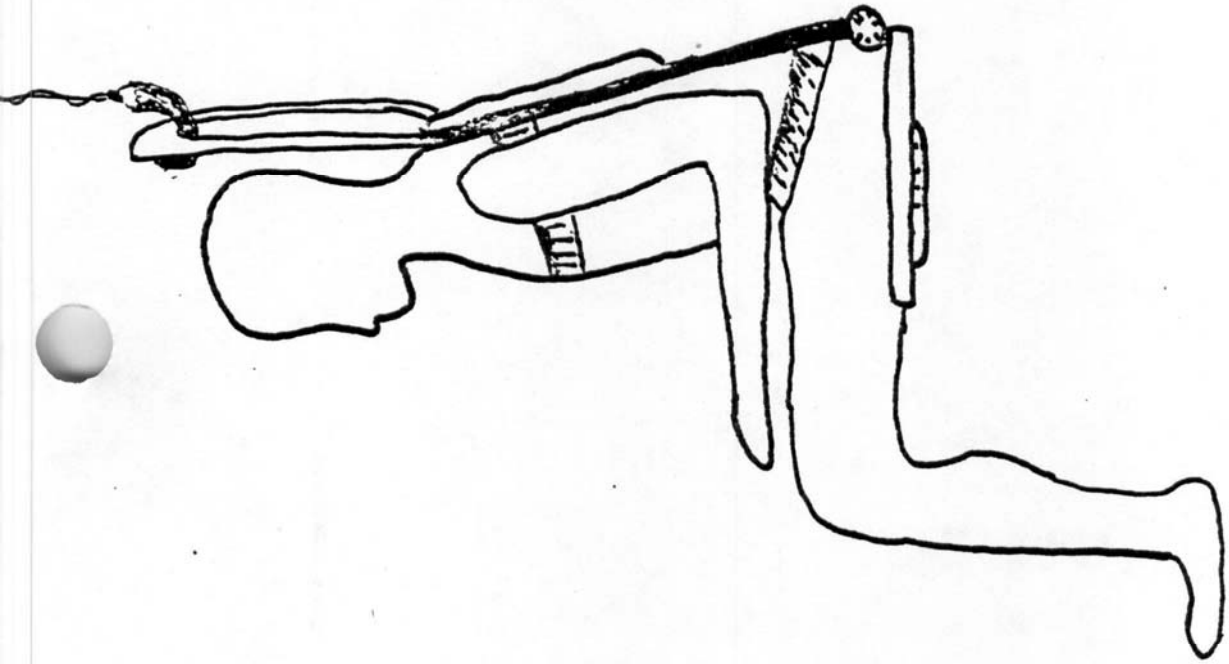


FIGURE 11.