tion and injected into healthy elm seedlings, typical symptoms of the Dutch elm disease appeared. Young leaves wilted and died, older leaves curled upward or developed necrotic spots; cell walls were discolored for long distances from the injection hole and dark gums appeared to plug the vessels. Tomato, elm, snapdragon and maple cuttings placed in tubes containing the filtrate from fungus cultures wilted severely, usually in from one to four hours. Uninoculated nutrient solution did not affect elm trees or plant cuttings, nor did control solutions adjusted to the pH of the fungus filtrate.

Five potted elms in the greenhouse and 10 elms three to four feet tall growing in nursery rows were injected with filtrate from a 25-day-old culture. Within three days the above-mentioned symptoms appeared on all trees. An average of 20 per cent. of the leaves were killed, and the average height to which the wood discoloration extended above the injection hole was 24 inches on five trees injected with 75 cc of filtrate; comparable figures for five trees injected with 200 cc of filtrate were: 29 per cent. leaf kill and 29 inches for the average height of discoloration. Tests on the time factor in relation to toxin production showed slight toxin formation after three days growth of the fungus and optimum production after a 12-day incubation period. As expected, toxin production is closely related to vigor of growth of the fungus culture.

Thermostability of the toxin after boiling for five minutes indicates that it is not enzymatic. The toxin is adsorbed by activated charcoal, is removed from aqueous solution by an excess of toluene and is antidoted by several organic chemicals.[5] Further work on the identity of the toxic substance is in progress.

Thus it has been demonstrated that symptoms similar to those of the Dutch elm disease can be reproduced by injecting a sterile filtrate from cultures of the fungus. This indicates that the same type of reaction takes place in the tree and that wilting and necrosis of leaves and discoloration of the wood are a response to the fungus toxin produced in the tree in the same way as they are to the fungus toxin produced in culture. As infection develops and more toxin is formed, gum and tylosis formation undoubtedly increases until the plugging of vessels becomes the important secondary disease factor. As a result of this plugging, water conduction may be shut off entirely and the tree dies unless new wood can be formed.

If, as these results indicate, *C. ulmi* is effective in killing elm trees primarily because of toxin production, several different approaches to attempted control of the disease by chemotherapy are indicated. As stated recently,[5] it may not be necessary to attempt to *kill* the pathogen by chemotherapy. This has been the prevailing endeavor in the past, but if the fungus toxin can be antidoted for a sufficient time by injection of a suitable chemical, the tree may outgrow and wall off the infection, particularly in a vascular disease of this type. Thus the chemical nature of the toxin becomes important in selecting chemicals which may affect it in the diseased plant. Chemotherapy, of course, can also attempt to affect the processes causing toxin production, by injecting chemicals with the aim of directly interfering with some phase of metabolism of the pathogen.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A PHOTOELECTRIC MEMBRANE MANOMETER*

THE device to be described was designed for the purpose of making an accurate record of the pressure changes in the cardiovascular systems of various animals, especially the dog and turtle. Probably the most successful method has been used by Wiggers[1] and others, who have had good results with it in the dog. This method uses a membrane manometer similar to that shown, except that a complicated adjusting mechanism is necessary. The light source is a powerful carbon arc focused on the mirror, and the light reflected must be projected fifteen feet to a moving strip of photographic paper. This great distance is needed to provide sufficient optical magnification. Auricular pressures in the turtle would be almost impossible to record with this instrument. Because of the inconvenience of the method, its lack of sensitivity and the difficulty of making simultaneous cathode ray oscillograph records of the electrical changes on the surface of the heart it was decided to try to find some electronic means of pressure recording.

Several methods seemed promising, among them the variable resistance devices, on which Edison took out dozens of interesting patents in his search for a practical microphone. These devices were not sufficiently stable to return to the base line when the pressure was removed or had some other disadvantage. The piezoelectric pressure recorders will not record accurately a sustained pressure increase. Using the diaphragm as a condenser microphone has the same objection.

[5] J. G. Horsfall and G. A. Zentmyer, 17th Proc. Nat. Shade Tree Conf., pp. 7–15, 1941.

* Supported in part by a grant from the Wisconsin Alumni Research Foundation.

[1] C. J. Wiggers, "The Pressure Pulses in the Cardiovascular System." New York: Longmans, Green and Company. 1928.

If, however, the changing capacitance be used to frequency modulate an oscillator tuned to the sharply sloping portion of the selectivity curve of an intermediate frequency amplifier, and the amplifier output rectified by a diode, the rectified voltage will be in effect a directly coupled function of the voltage. This method was tried and worked quite well, but was abandoned because of mechanical difficulties in making a condenser microphone small enough to go into the heart. The principle has been used in a myograph, which will be described in a later article.

The method finally used is shown in the diagram (Fig. 1). The various parts are mounted on a tri-

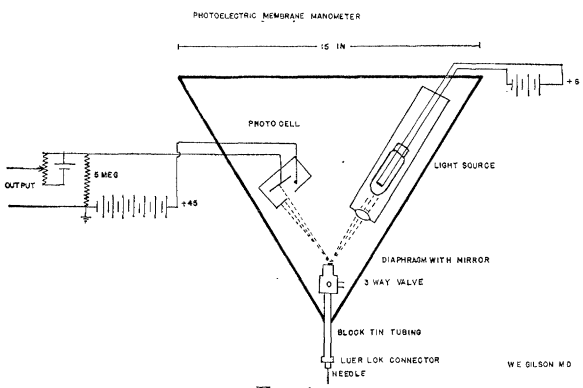

FIG. 1.

angular piece of one-half inch steel. The light source is a 75-watt exciter lamp of the type used in sound-on-film motion picture projectors. A single lens is used to focus the light on the mirror, which reflects a cone of light toward the photocell, an RCA 921 or 922. The apparatus is so adjusted that with zero pressure a small part of the light falls on the photocell. As the pressure applied to the diaphragm increases, the mirror is deflected and more light falls on the photocell. This produces an electrical change which is amplified by a push-pull direct coupled amplifier[2] and causes a deflection of the cathode ray spot, the amplitude of which is controlled by varying the gain of the amplifier.

The entire pressure system is filled with citrate solution. The three-way valve provides for connection between the diaphragm chamber and the side arm, for calibration against a mercury column, between the diaphragm chamber and the needle for record taking, and between the side arm and the needle for washing out the pressure system.

The output is linear over a wide range, as determined by accurate calibration. The device is easily adjusted and very flexible. It may be used to record the 160 mm Hg pressure change in the dog ventricle or the 1 mm Hg change in the turtle auricle. To my knowledge the latter has not been accurately recorded previously.

The frequency response is good, and entirely dependent on the mechanical design of the membrane manometer. This design is discussed by Wiggers.[1] The first part of his book would be of value to any one interested in using an instrument of this type.

The results and records obtained may be seen in papers by Eyster, Meek and Goldberg.[3, 4]

The photoelectric membrane manometer is not restricted in its application to cardiovascular research, but should be of value in a wide variety of physical and engineering problems.

In summary, its advantages over optical projection are:

1. Greater sensitivity.
2. Variable sensitivity. Pressure changes of any magnitude may be represented by any desired deflection of the cathode ray spot, simply by changing the amplifier gain.
3. Electrical changes may easily be recorded simultaneously.
4. Insertion of the needle is easy, because the entire device may be moved as a unit to any position desired.
5. It is not necessary to work in a room twenty feet in length.

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[2] H. Goldberg, "Electrical Engineering," January, 1940, Trans. p. 60.

[3] H. Goldberg and J. A. E. Eyster, *Am. Jour. Physiol.*, 131: 416, 1940.

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