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A SIMPLIFIED AUTOMATIC BLOOD PRESSURE RECORDER

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Over the past half century numerous methods for the recording of systolic and/or diastolic blood pressure have been put forth. In sphygmomanometry the technics of recording have been plethysmographic, mechanical, optical, audiometric and the direct intra-arterial method in man, which has become the accepted standard of accuracy. None of these elaborate devices have come into general clinical usage, because of size, complexities, and cost.

There is a clinical demand for automatic blood pressure recording in the study of hypertension, in physical fitness testing, and in anesthesia. The apparatus presented herein should meet this need since it is a compact, portable, mechanical arrangement which will record systolic and diastolic pressures intermittently over long periods without discomfort to the patient. The design and method of operation are described. Records of blood pressure at rest, and as affected by exercise and amyl nitrite inhalation illustrate the usefulness of the instrument. The clinical evaluation is based upon a consideration of accuracy and practicality.

Equipment, designed for continuous recording of both systolic and diastolic blood pressure, has been presented for clinical use by Erlanger[1] (1904), Fantus[2] (1917), Kolls[3] (1920), Blankenhorn[4] (1921), Slocum and his associates[5,6] (1941, 1942), as well as by Groedel and Miller[7] (1943). The modified Erlanger sphygmomanometer, designed by Fantus and the double cuff continuous method of Kolls have introduced concepts which have proved useful in the practical application of mechanical recording.

In planning this device, the literature and the experience of others were carefully studied. In fact, features from the contributions of Fantus, Slocum, and Kolls have been incorporated in the design of this blood pressure recorder. It is a mechanical sphygmomanometer which employs two cuffs. The upper cuff serves in the production of a calibration curve while the lower one creates a pressure wave, which starts at systole and shows a pulsatile rise to a pulseless maximum at diastole.

A diagram of the blood pressure recorder is shown in figure 1. A conventional pressure cuff, applied to the upper arm, is automatically inflated and deflated at desired intervals (1-3 min.). Air pressure is admitted and released through electromagnetic valves actuated by a synchronous motor. A Haydon clock operates a pair of micro-switches so as to allow the current to flow through the solenoids of the electromagnetic valves. When this occurs in valve 1, the iron core of the valve plunger is raised and the compressed air fills the cuff; exerts its pressure

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on the small heavy walled sylphon bellows, equipped with an ink writer; and registers on the Tycos aneroid gauge in mm. Hg. When valve 2 is actuated (1-3 minutes after valve 1) the same operation causes the air pressure to escape, thus allowing deflation. In the period between inflation and deflation, an adjustable slow-bleeding valve at the upper cuff allows a gradual decline from the peak pressure, well above systolic to a point below diastolic pressure at deflation. This gradual decrease in pressure is registered as a calibration both on the Tycos dial and recorded on kymograph paper, graduated in 5 mm. intervals from 0-300 mm. Hg. through the pen actuated by the sylphon bellows. A second cuff, placed on the forearm, and inflated to a fixed pressure (three-tenths of the diastolic pressure) is connected to another Tycos gauge and a more sensitive sylphon bellows, whose pen swings from the same axis as the other pen.

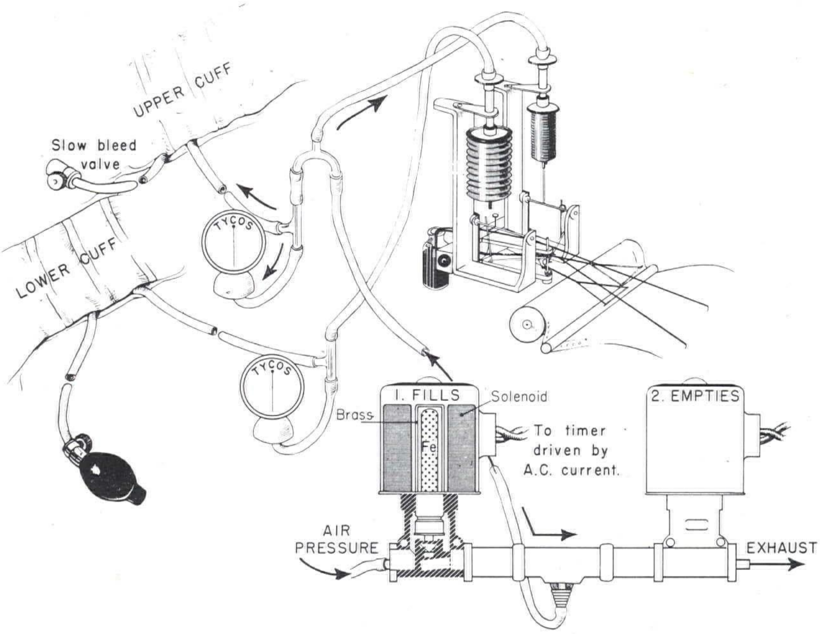

DIAGRAM OF BLOOD PRESSURE RECORDER.

Fig. 1

A pantograph of a typical blood pressure record is shown in figure 2. The tracing is read from right to left. The slow-bleed valve on the upper cuff allows a gradual decline from the peak pressure of 212 mm. Hg. to 43 mm. Hg. The ink writer from the heavy walled sylphon bellows records this pressure decrease as a calibration curve. Pressure fluctuations in the lower cuff create a characteristic curve during each interval, namely: a plateau, a sharp rise (systolic) to a peak level (diastolic) with subsequent decline, accentuated by deflation. This curve is transcribed on the paper through pressure variations within the thin walled sylphon bellows. Systolic and diastolic pressures are determined respectively by projecting (1) the break in the plateau and (2) the inception of the maximum level onto the descending calibration curve.

Blood pressure tracings on two normal individuals at rest are depicted in figures 3 and 4. One tracing shows an almost constant finding of 108/75 in six successive measurements (Fig. 3) whereas the other record indicates some degree of fluctuation (Fig. 4).

Examples of blood pressure recording in hypotensive and hypertensive states are illustrated in figures 5, 6, and 7. As the subject rests and becomes more relaxed with the device in operation, one observes a gradual decline in blood pressure in the hypotensive (Fig. 5) and in one of the hypertensive individuals (Fig. 6). The tracing of hypertension shown in figure 7 indicates a more variable systolic pressure and a more or less fixed diastolic pressure which does not respond to rest.

Continuous blood pressure recorded prior to and immediately following mild exercise is shown in figure 8. One may observe the steady blood pressure level maintained for several minutes before the bout of exercise. During the knee-bending at the rate of 30 times per minute for a two minute period, the tracing is vitiated due to movement. On cessation of exercise, elevation of blood pressure and an increased pulse pressure is immediately recorded. As subsequent determinations are made, a gradual return toward the pre-exercise level is visible.

The application of this recorder in the study of drugs which affect blood pressure is demonstrated in figure 9. Inhalation of the vasodilator, amyl nitrite creates an immediate 40 mm. Hg. decline in systolic pressure and a 24 mm. Hg. fall in diastolic pressure. It is interesting to note that the pressure in the lower cuff falls markedly as an immediate after effect of the inhalation. As the blood pressure is gradually restored, there is a concomitant increase in the height of the lower cuff curve. After eight minutes, both the blood pressure and the curve are comparable to the pre-administration findings.

The blood pressure records shown in figures 3-9 were checked at frequent intervals by the auscultatory method. In several hundred observations, agreement was within ± 3 mm. Hg., which should be adequate for clinical purposes.

The intra-arterial method (Sanborn) was recorded simultaneously with the mechanical sphygmomanometer in a few trial runs. Intra-arterial pressures from the left arm agreed with the mechanical tracing from the right arm within 5-10 mm. Hg. When the direct method was applied to the arm, used in the double cuff method, the intra-arterial recording was obliterated during the pre-systolic period as one would expect. It is difficult, then, to record the pressure from the same point in the arterial tree simultaneously with both methods. Perhaps, one should not expect to obtain the same values with the auscultatory or cuff method as with intra-arterial pressure measurement.

Intermittent recording of blood pressure over prolonged periods is the feature which should make this instrument clinically useful. Relative changes in arterial pressure, as affected by rest, narcosis, anesthesia, drugs, or exercise, may be made a part of the patient's permanent record.

SUMMARY

A simplified automatic blood pressure recorder is described. The mechanism

and operation of this double cuff sphygmomanometer is set forth. Typical recordings of blood pressure illustrate the method. Simplicity, portability, low cost and permanent recording should make clinical application feasible.

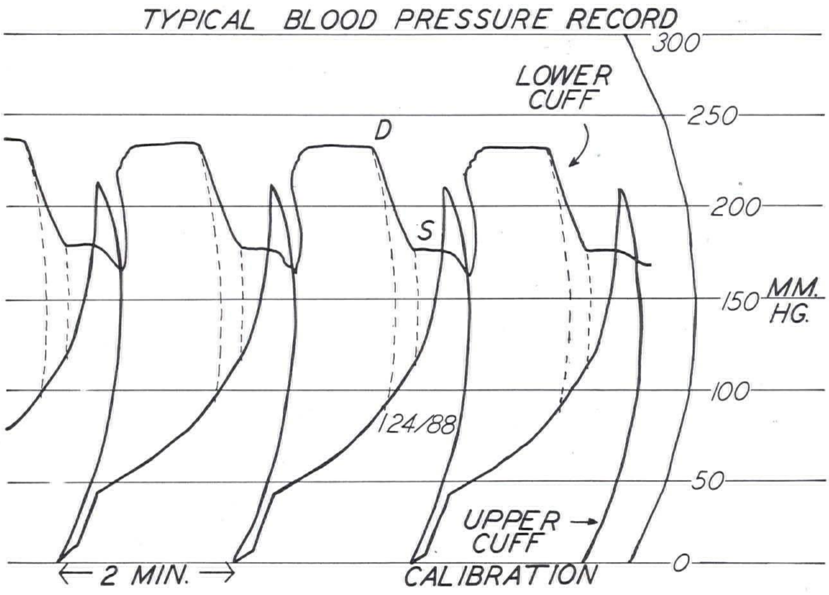

Fig. 2—In Figs. 2-9 the following terms are used: (Upper cuff) indicates the calibration tracing in mm. Hg; (Lower cuff) indicates the tracing made through pressure fluctuations in the lower cuff during each interval; (S) represents systole; (D) represents diastole; longitudinal divisions on the paper represent one minute; and (2 min.) indicates the duration of each blood pressure determination. Read from right to left.

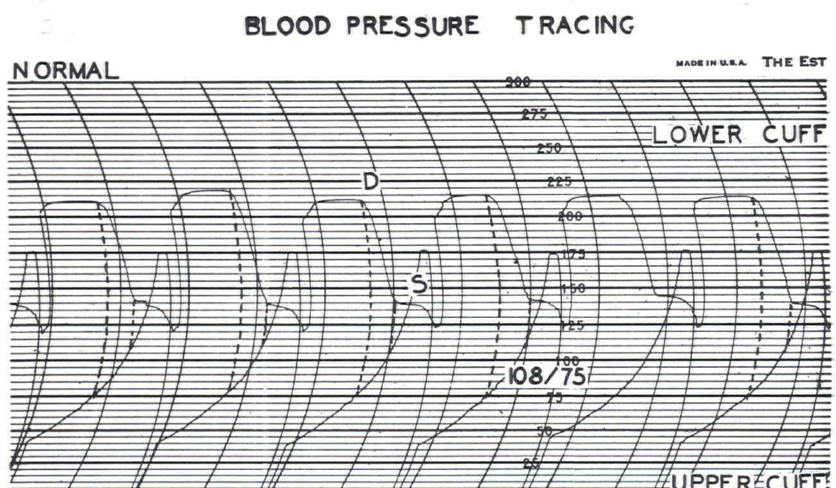

Fig. 3—(See Fig. 2 for legend)

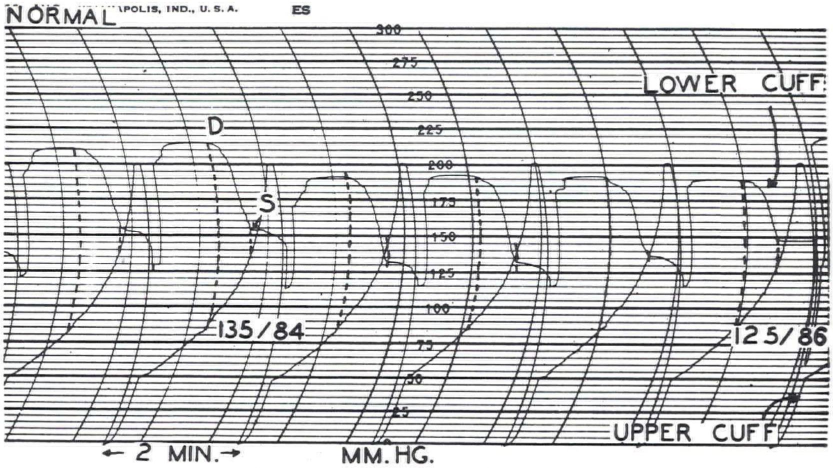

Fig. 4—(See Fig. 2 for legend)

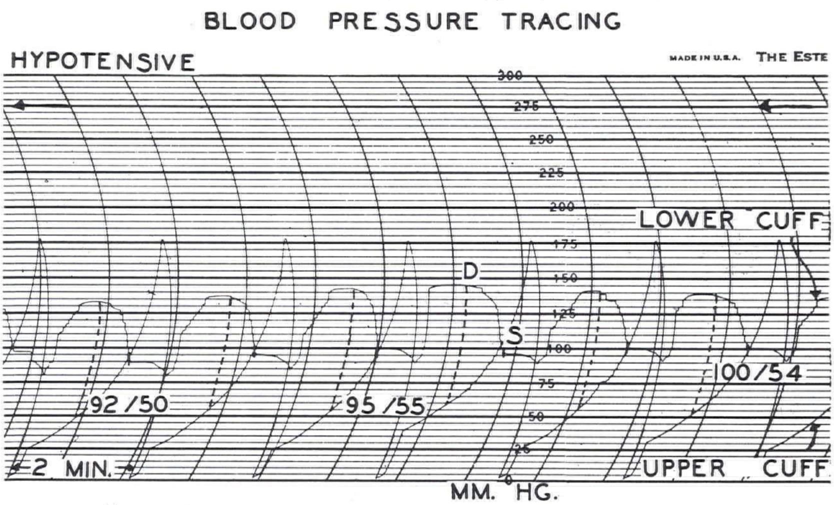

Fig. 5—(See Fig. 2 for legend)

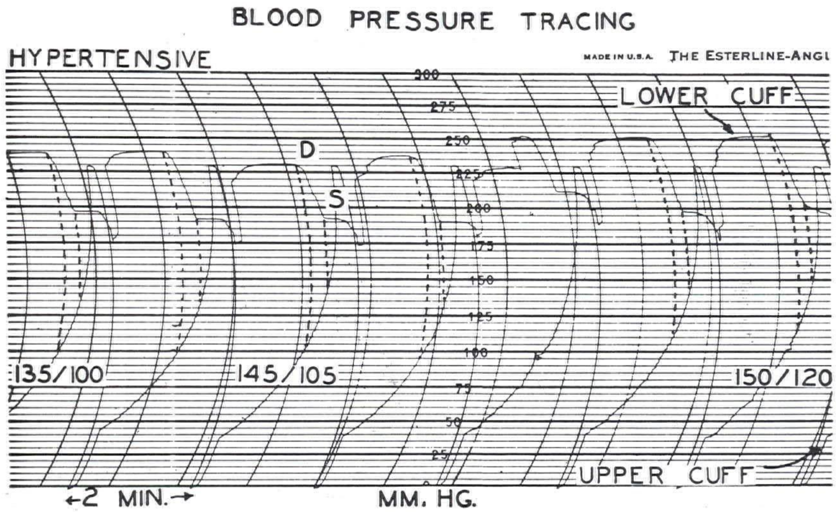

Fig. 6—(See Fig. 2 for legend)

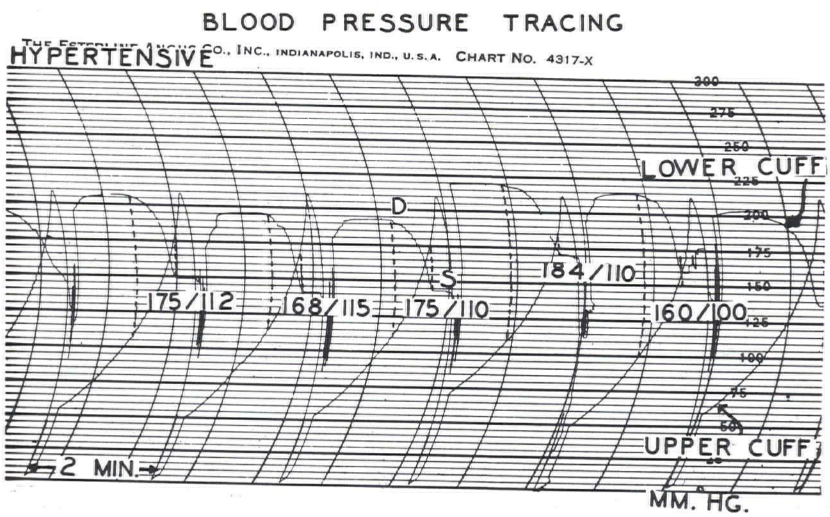

Fig. 7—(See Fig. 2 for legend)

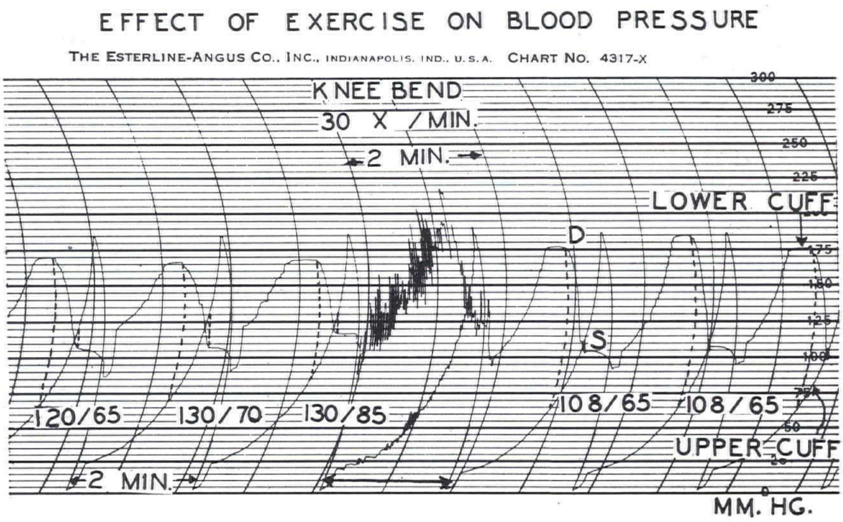

Fig. 8—(See Fig. 2 for legend)

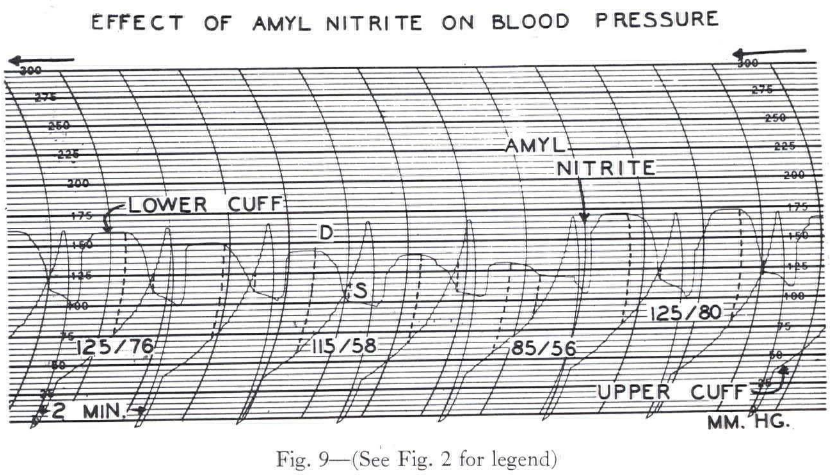

Fig. 9—(See Fig. 2 for legend)

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