MANUAL OF THE STEAM-ENGINE INDICATOR

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Trieste

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BY

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THE STEAM-ENGINE INDICATOR.

THE steam-engine indicator is an instrument invented by Watt to measure and record the pressure of the steam in the cylinder of an engine. The diagrams drawn by an indicator enable us to calculate the power of the engine, to examine and adjust the actions of the engine valves, and to make certain inferences concerning the transformation of heat into work and the influence of the metal of the cylinder on that operation. Too much emphasis cannot be given to the fact that the sole office of the indicator is to measure and record pressure; actions which are commonly said to be revealed by the indicator are really inferences based on the pressure or on changes of pressure.

The Watt Indicator.—While the exact form of the original indicator is not known, it is interesting to consider the form ascribed to it by tradition, more especially as that form presents the elements of the instrument clearly. In Fig. 1 *P* is a piston that moves freely in the cylinder *C*, which is open at the top, and

can be put in communication with the interior of the engine cylinder by the cock T and a short system of

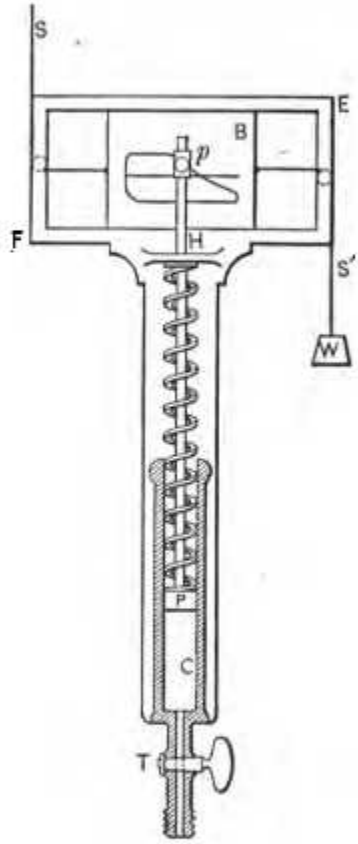

FIG. 1.

piping. The piston-rod HP passes up through a hole in the block H, and carries a pencil p at the upper end. A helical spring between the piston P and the guide-

block *H* measures the pressure at the under side of the piston *P*. At the top of the indicator there is a light board *B* which slides freely in the frame *EF*. This board has a motion like that of the piston of the engine, on a reduced scale, which is obtained from a proper reducing motion attached to the crosshead, and is communicated by the cord *S*. The weight *W* on the end of the string *S'* pulls the board *B* toward

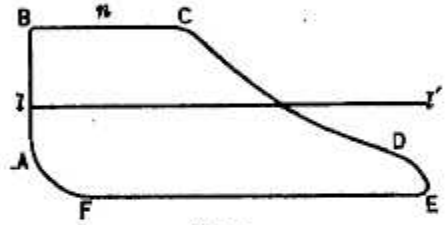

FIG. 2.

the right and keeps the strings taut. A piece of paper is attached to the board *B*, against which the pencil *p* can be pressed when a diagram is desired. Fig. 2 represents the diagram on a larger scale. To take a diagram, the string *S* is connected to the reducing motion so that the board *B* moves back and forth, keeping time with the piston of the engine. The cock *T* is now turned to open communication with the engine cylinder, and the pencil *p* rises when steam is admitted and falls when steam is exhausted. If the engine runs slowly the pencil can be pressed against the paper at any position of the piston of the engine; for example, at the beginning of the stroke. Admis-

sion of steam at the beginning of the stroke gives a sudden rise of pressure represented by the line *AB*; then the piston of the engine moves forward under nearly constant pressure of steam coming from the boiler, until the admission of steam is interrupted by the closing of the admission-valve; during the remainder of the stroke of the piston the steam in the cylinder expands in volume and loses pressure as indicated by the curve *CD*; at *D* the exhaust-valve opens and the pressure rapidly falls to the exhaust; during the greater part of the return-stroke of the piston, steam is exhausted to the condenser at constant pressure, as represented by the line *EF*; finally the steam caught in the cylinder by the closure of the exhaust-valve is compressed as shown by the curve *FA*. After the diagram is completed the cock *T* is turned so as to shut off communication with the engine cylinder and open communication from the lower end of the cylinder *C*, Fig. 1, and the atmosphere. The pencil then comes to its neutral position with atmospheric pressure both above and below the piston *P*, and with no tension (or compression) on the spring. A reference-line *ll'* is now drawn by pressing the pencil once again on the paper; this is called the atmospheric line. Every point of the diagram corresponds to a definite position of the engine piston; thus, *n* corresponds to one-fourth stroke of the piston, and further the distance of *n* from the line *ll'* measures the pressure of the steam in the cylinder at

quarter-stroke, reckoned above the pressure of the atmosphere. During exhaust, when the steam is flowing into the condenser, the vacuum in the cylinder is measured by the distance of the pencil below the atmospheric line; the spring is of course stretched in tension while this occurs.

Recent indicators differ from the original prototype in two principal ways: in the first place, the sliding-board *B* is replaced by a drum or cylinder turning on a vertical axis, and in the second place the pencil is carried by a parallel motion which multiplies the motion of the piston. The drum gives a smoother and truer motion to the paper, and the multiplication of the motion of the piston by the parallel motion permits of the use of a short and stiff spring. A few well-known indicators are chosen for description; it will be seen that they differ in detail only.

The Crosby Indicator.—Figs. 3 and 4 represent the Crosby indicator, made by the Crosby Steam-gage and Valve Company. Here 8 is the piston of the indicator, above which is the spring which measures the steam-pressure. The motion of the piston is multiplied by the pencil-motion 13, 14, 15, 16, and communicated to the pencil 23, which draws a diagram on a slip of paper that may be wound around the paper-drum 24.

The body or barrel of this indicator is made in three pieces, 1, 4, and 5. The part 1 carries the paper-drum at the end of an arm or bracket; the part 5 has at its

lower end a device for securing the indicator to the cock leading to the engine cylinder; the part 4 is bored out to receive the piston 8. The part 4 is more conveniently made separate, and may readily

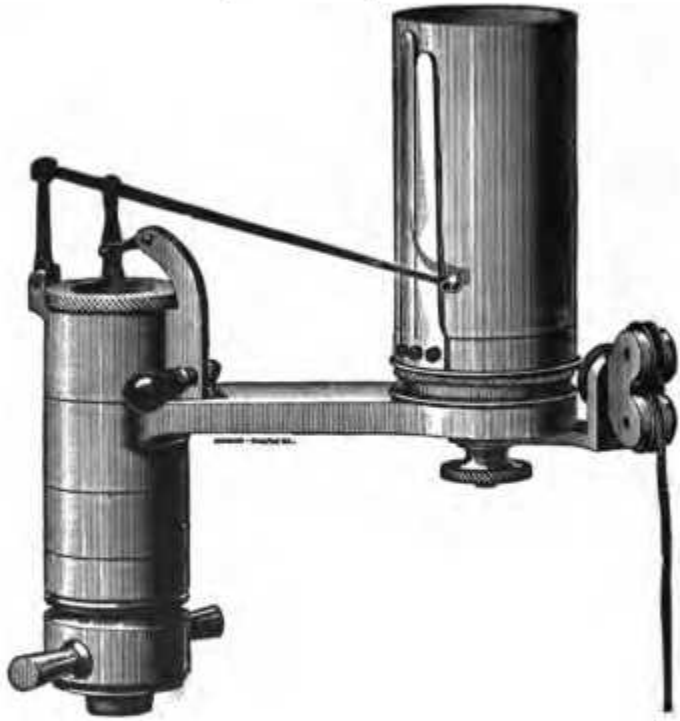

FIG. 3.

be replaced if its inner surface should become cut or scored; it is also surrounded by a steam-jacket, which insures a uniform temperature.

The spring, which is shown separately by Fig. 5, is a double helix wound from one piece of round wire,