THE INDICATOR.

"What the stethoscope is to the physician the indicator is to the skilful engineer, revealing the secret workings of the inner system and detecting minute derangements in parts obscurely situate."

The importance and usefulness of the indicator to all concerned in the proper working of the steam engine, and especially to the working engineer, can scarcely be overrated. It is used to ascertain the internal condition of the engine, the state of the vacuum, the amount and variations in the pressure of steam at every part of the stroke, the condition of the valves, whether too much or too little lap or lead—in fact, it tells us the power and all the faults by which that power is impaired. It may also be attached to the air-pump, the hot well, the condenser, &c., when it will tell us the nature of the pressures there existing.

Without the indicator (says Mr. Ingham) nine-tenths of the operations and adjustments of the most experienced engineer are the interest groping and guess-work, and not infrequently they are attended with the most serious blunders and mishaps. Take, for instance the process of valve-setting. Such is the difference of capacity in thoroughfares and clearance, between one end of the cylinder and the other, and between one engine and another, that, however careful and experienced a person may be by the mere "rack of the eye" or with the two-foot rule, in nineteen cases out of twenty the valves, will be more or less inaccurately set. There will either be too much or too little "lead" in the steam or in the exhaust of both valves, or inequality betwixt the one and the other, and a corresponding irregularity and imperfection in the working of the engine, the true nature of which can only be discovered by means of the indicator and diagrams taken from the engine whilst working. Again, should an engine gradually or suddenly refuse to perform its accustomed duty, instead of begining to take its several parts to pieces, and perhaps expend hours or even nights of laborious toil to find out the defect, by placing the indicator upon the engine and taking a diagram the defect or derangement is at once discovered and the remedy prepared by the next time the engine stops, and thus much useless labour and expense are thereby prevented.

By an aequaintance with the indicator an intelligent engineer may acquire more real practical and theoretical knowledge and experience of a steam engine in twelve months than used to be acquired under the "old school" during a seven years' apprenticeship. I would therefore urge upon every person who has the charge of one or more steam engines the absolute necessity of an immediate and complete acquaintance with it in all its bearings, or otherwise he may rest assured that this, the most intellectual portion of an engineer's duties, will gradually pass out of his hands into those of the manager. To avoid this, and in order that working engineers may keep pace with the improvements and progress of the age, the following description of the mechanism and the principle on which it works is extracted from the work, "The Engine Room, and who should be in it and what they should do," by an Old Hand. Published by Mr. T. L. Ainsley, South Shields, who has kindly supplied the block for the frontispiece :—

MECHANISM OF THE INDICATOR.—The brass barrel A, having the split graduated scale B attached, is called the paper cylinder. On it the diagram paper is fixed. This paper cylinder can be detached from the instrument by pulling it upwards. On being detached another barrel is seen, having the horizontal pulley L on its bottom end, and a small coiled spring contained in a drum at the top. It will be observed that on pulling the cord the pulley barrel will revolve until it comes against a stop; on slackening the cord the coiled spring will bring it back. At the bottom of this pulley barrel will be seen a small projection C. Now, when the paper cylinder is replaced, and the notch in it fitting this projection, the revolving and return motions of the paper cylinder will be clearly understood. On the upper end of tho barrel D the lever arm M is carried. These levers E E are connected by the link F; this link is the pencil carrier. This metallic pencil is hald by a screw, which regulates its distance from the paper cylinder. The lever E is attached by a swivel at J to the piston-rod G. On unscrewing the top milled cap H the level arm can be detached from the barrel D, bringing with it the piston-rod and also the spring used. Within the barrel D is contained the small cylinder in which the piston I works. To shift the spring, unscrew the round miled nut J on the end of the piston-rod, then unscrew the milled cap H from the nut on the end of the spring; the piston-rod is then free, and the spring can then be unscrewed from the piston I. It will be observed that the springs have a brass nut on each end; on one nut is marked the limit pressures, thus, $\frac{47}{15}$ — 47lb. steam, 15lb. vacuum; on the other the scale strength of the spring, thus, $\frac{1}{20}$. On putting the small piston into the cylinder it will be seen that it is an accurate fit. Great care must therefore be taken to keep the cylinder perfectly clean. On the bottom end of the barrel D is the conical stem having the tightening nut K attached. This nut has two small arms on it. The conical stem is a ground fit into the top end of the cock supplied with each indicator. This cock has its conical seat protected by a brass cap; unscrew this cap and insert the conical stem, screw down the tightening nut, and as this nut has its threads of different pitches it firmly secures the indicator to the cock. The communication between the top and bottom of the engine cylinder is obtained by means of a pipe attached to each end and coupled in the centre to a cock; this cock has a projection on it which is tapped to suit the indicator cock.

PRINCIPLE ON WHICH THE INDICATOR WORKS. — From the foregoing description of the mechanism of the indicator it is at once apparent that if a pressure is brought to bear on the under side of the small piston the spring will be compressed, and if on the upper, or spring side, it will be extented; therefore, as the pressure of the steam varies in the cylinders of the engines so will the position of the indicator piston vary in its cylinder—the slightest increase of pressure occasions a rising, the slightest diminution a falling. The position the piston (or pencil) is in when unacted upon by any pressure, *i.e.*, having the pressure of the atmosphere on both sides of the piston, is called the zero position. From this position the atmospheric line is marked.

Now suppose communication to be opened to either the top or bottom of the cylinder of the engine, we find that when the port is opening for steam the indicator piston will shoot upwards and remain so until the port is closing; when closed, and by reason of the steam expanding and losing its pressure, the spring will force the small piston downwards, and on the port being opened to the condenser the pressure of the atmosphere acts on the upper side of the small piston and extends the spring, and if a pencil was attached to the end of the indicator piston-rod it would mark a straight line—the top end of this line would indicate the greatest pressure, the bottom the least. From the zero position upwards would be the steam pressure, below it atmospheric pressure. But the straight line would not tell us of the varying pressures going on in the cylinder of the engine, therefore, to obtain this, we must have recourse to the paper cylinder, which receives its reduced motion from some part of the engine, and as it revolves from right to left, or *vice versa* (the indicator cock being open to either end of the cylinder of the engine), a figure or diagram is marked upon the paper by the metallic pencil, faithfully representing and recording the "varying pressures within the cylinder at any part of the stroke." From this diagram the total pressure upon the piston, or the mean pressure throughout the stroke, can be obtained; for as the various springs used are made to suit the pressure carried in the boiler, the strength or amount of compression of the spring under a given weight being known, it is a very easy matter to calculate the pressure by the diagram. The strength of each spring is marked on it, and if a $\frac{1}{15}$ spring is used a $\frac{1}{15}$ of an inch up or down on the diagram represents 1lb. pressure; if a $\frac{1}{20}$, a $\frac{1}{20}$ of an each is 1lb., and so on. One great advantage of Richard's indicator is in its having a short travel of piston in comparison to its pencil; a stiffer spring is used, thereby a more correct diagram is obtained, and also greater sensitiveness under varying pressures.

METHOD OF TAKING DIAGRAMS.—To fix the paper: Detach the paper cylinder from the indicator, and enter one corner of the paper under the split scale, leaving about half-an-inch projecting; turn the paper round on the cylinder and enter the other corner; take hold of the two corners and pull the paper gently down for about one inch with the finger and thumb; make the two ends of the paper assume, as near as possible, the form of the part entered on the cylinder—this will tend to prevent the ends of the scale cutting the paper. Now draw the paper down to the bottom of the scale, and have it lying even and tight on the cylinder; the paper being on, replace the cylinder, taking care that the projection C on the pulley barrel is in the notch on the paper cylinder. Before screwing the indicator cock on to the pipe cock open the pipe cock to each end of the cylinder so as to blow out any grease or dirt that may be in the pipe; having done so, screw on the indicator cock; then fix the indicator by means of the tightening nut K; make a loop on one end of the cord (this cord should be hard and having no stretch), reeve the other end through a strip of brass, say 1½in. long, ½in. broad, by ⅛in. thick, having three small holes in it, thus :—

By this means a ready adjustment of the cord is obtained. Ascertain if the hook on the lower end has a travel of about five inches (this should be about the length of the diagram); now