colza oil. With a clear atmsophere, and the light of the Plymouth Breakwater lighthouse (10 miles distant) distinctly visible, the lower burner only was worked at its minimum intensity of 450 candles, giving an intensity of the flashes of the optical apparatus of 37,800 candles; but whenever the atmosphere was so thick as to impair the visibility of the Breakwater-light, the full power of the two burners was put in action, with the aggregate intensity of 1,900 candles. This intensity was about 23.3 times greater than that of the fixed light latterly exhibited from Smeaton's tower, and about 3,282 times that of the light first exhibited in the tower from tallow candles. The new tower was built at a distance of 130 feet from Smeaton's lighthouse, a large portion of the foundation being laid below the level of low-water spring-tides. The estimate for the work was £78,000, and the cost £59,255. The first landing at the rock was made in July 1878, and the work was carried on until December. Around the foundation of the base of the tower a strong coffer-dam of brick and Roman cement was built for getting in the foundations. By June, 1879, the work was sufficiently advanced for the stones to be laid in the lower courses, and everything was arranged for H.R.H. the Duke of Edinburgh, Master of Trinity House, who was to be accompanied by H.R.H. the Prince of Wales, to lay the foundation-stone on the 12th of the month; but the weather being stormy the ceremony was postponed until the 19th of August, when the lowest stone was laid by the Duke of Edinburgh, assisted by the Prince of Wales. On the 17th of July, 1880, the cylindrical base was completed, and the 38th course by the early part of November. On the 1st of June, 1881, the Duke of Edinburgh, when passing up Channel in H.M.S. "Lively," landed at the rock, and laid the last stone of the tower. On the 18th May, 1882, the Duke of Edinburgh completed the work, by lighting the lamps and formally opening the lighthouse. The edifice was thus erected and fitted up within four years of its commencement, and one year under the time estimated. The whole of the stones, averaging more than 2 tons each, were landed and hoisted direct into the work, from the deck of the steam-tender "Hercules," by a chain-fall working between an iron crane fixed at the centre of the tower, and a steam-winch on the deck of the "Hercules," which was moored at a distance of 30 fathoms from the rock.

The Town Council and inhabitants of Plymouth having expressed a desire that Smeaton's lighthouse should be re-erected on Plymouth Hoe, in lieu of the Trinity House sea-mark thereat, the Trinity House made over to the authorities at Plymouth the lantern and four rooms of the tower. For taking down and shipping Smeaton's masonry, the "Hercules" was moored at 10 fathoms from the rock, and the stones were shipped, after the removal of the lantern, by her steam-machinery, by a process exactly the reverse of that by which the stones of the new tower were landed. After the removal of the structure to the floor of the lower room, the entrance doorway and well staircaise leading from it to the lower room were filled in with masonry, and an iron mast was fixed at the centre of the top of the frustum.

MOTION CURVES OF CUT-OFF VALVES.*

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(*For Illustrations See Pages* 8, 9 *and* 17.)

Among the many forms of diagram illustrating geometrically the movement of slide-valves by eccentrics, none have come under the writer's observation which will satisfactorily represent the distribution of steam effected by that class of valve gear in which a main slide-valve actuated by link motion constitutes a moving seat for double cut-off valves.

Looking at the slide-valve in its simplest form, operated directly by a single eccentric, the effects produced by certain proportions of lap, lead and travel are comparatively well known and easily understood; but when a link motion is introduced for effecting expansion within certain limits, as well as reversing the direction of motion, the action becomes extraordinarily complicated. Put, now, on the back of this motion double variable expansion valves, and it becomes a subject affording an unlimited field to engine designers and mathematicians for study and investigation.

The form of diagram about to be described is a modification of one already known to some engineers, and the idea of adapting the principle to link motions and variable cut-off valves, so as to show the extent and duration of the port opening, occurred to the writer while designing a small condensing marine engine recently, the dimensions of which are selected for the present illustration.

In the diagram No. 1, the large circle representing the path of the crank-pin is divided into a number of equal parts—12 in this case; these points of division are projected up to the line A B, which represents the stroke of piston, the points on which thus obtained are the piston positions corresponding to the numbered divisions of the crank-pin circle. The motion of the valves must now be considered to take place at right angles to the line A B, so that distance horizontally represents piston movement and distance vertically represents valve movement. Now, suppose the diagram to be moved horizontally a distance equal to and corresponding with A B, or the stroke of piston, in a similar manner to the movement of an indicator diagram, while the valve, receiving its relative motion from the link, moves vertically on it; then a point in the centre of the valve would trace a curved line of an elliptic form. This motion curve may be taken to represent the path of the centre of the main valve, and it may be drawn for various positions of the link, those shown in the diagram Fig. I being full gear forward, second notch forward and full gear back. They are laid down by ordinates derived from diagrams Fig. 4, which shows the journeyings of the link through its successive positions corresponding to the before-mentioned divisions of the crank-pin circle. A curve showing the exact movement of the main valve being drawn in this way, we can now draw parallel curves to represent the movement of its edges over the ports in the valve seat, as shown in diagram Fig. 2. The ports are projected across the diagram from C D, &c., and the extent to which they are opened during the stroke for steam or exhaust is shown by the curves of the outer and inner edges of the valve respectively. Referring to Fig. 2, it will be seen that the steam opening commences with 3-16 lead at C; then, widening rapidly, reaches its maximum at about 38-100th of the stroke, after which it gradually closes, cutting off at 9-10ths of the stroke.

Proceeding now to consider the movement of the cut-off valves, it will be seen that, if we draw parallel curves representing the moving parts in the main valve, we may lay down the movement of the cut-off valves over them in a similar manner, and thus trace the events between them. The position of the cut-off eccentric being diametrically opposite the crank-pin, the movement of the cut-off valves, if we suppose it to be traced in a similar manner to the main valve, will be represented on the diagram by straight lines K G and L D, Fig. 3, and the variable positions of their edges to effect any desired cut-off will be straight lines parallel to K G and L D. In the example the shaded areas of the part terminated by these lines represent the port opening up to their respective points of suppression by the cut-off valves. The various proportions of the cut-off valves for any desired range of expansion may now be determined by direct measurement from the diagram. For example, if the range of cut-off is to be from 1-5th to 3-4th, the distance, J M, between these two positions is 2 inches, which is the limit of adjustability for each valve. In like manner the necessary width in order to cover at extreme travel will be equal to N P, plus a small amount for cover; and if at the latest limit of cut-off the inner edges of the valves are shown to overlap each other, the ports in the back of the main valve must be separated by that amount in order to allow space for the adjustable movement.

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