surface or scale set at a distance of about 3 ft., forming a bright spot on the surface; the slightest angular deflexion of the mirror, owing to its distance from the scale, moves the spot of light a very appreciable distance to the right or left according to the direction of the angular movement. These indications form the telegraph alphabet and are read in the same manner as in the case of the "single needle" instrument used on land.

The spark recorder in some respects foreshadowed the more perfect instrument—the siphon recorder—which was introduced some years later. Its action was as follows. . To an indicator, suitably supported, a to-and-fro motion was given by the electromagnetic actions due to the electric currents constituting the signals. The indicator was connected with a Ruhmkorff coil or other equivalent apparatus, designed to cause a continual succession of sparks to pass between the indicator and a metal plate situated beneath it and having a plane surface parallel to its line of motion. Over the sur­face of the plate and between it and the indicator there was passed, at a regularly uniform speed, in a direc­tion perpendicular to the line of motion of the indicator, a material capable of being acted on physically by the sparks, through either their chemical action, their heat, or their perforating force. The record of the signals given by this instrument was an undulating line of fine perforations or spots, and the character and succes­sion of the undulations were used to interpret the signals desired to be sent.

In the original form of the siphon recorder (fig. 31), for which Lord

Kelvin obtained his first patent in 1867, the indi­cator consisted of a light rectangular signal-coil of fine wire, suspended between the poles of two powerful electromagnets Μ, M so as to be free to move about its longer axis, which is vertical, and so joined that the electric signal currents through the cable pass through it. A fine glass siphon tube is sus­pended with freedom to move in only one degree, and is connected with the signal-coil and moves with it. The short leg of the siphon tube dips into an insulated ink-bottle, so that the ink it contains becomes electrified, while the long leg has its open end at a very small distance from a brass table, placed with its surface parallel to the plane in which the mouth of the leg moves, and over which a slip of paper may be passed at a uniform rate, as in the spark recorder. The ink is electrified by a small induction electrical machine E placed on the top of the instrument ; this causes it to fall in very minute drops from the open end of the siphon tube upon the brass table or the paper slip passing over it. When therefore the signal­coil moves in obedience to the electric signal-currents passed through it, the motion communicated to the siphon is recorded on the moving slip of paper by a wavy line of ink-marks very close together. The interpretation of the signals is according to the Morse code,—the dot and dash being represented by deflexions of the line of dots to one side or other of the centre line of the paper. A very much simpler form of siphon recorder, constructed by Dr Muirhead, is now in general use. The magnet between the poles of which the rectangular signal coil moves is built up of a number of thin flat horseshoe-shaped permanent magnets of a special quality of steel, and is provided with adjustable pole pieces. The signal coil is suspended by fibres and is mounted together with a fixed soft iron core on a brass plate affixed to a rack, with which a pinion operated by a milled head screw engages. To the brass plate is attached an arm carrying the bridge piece. A wire or fibre carrying the aluminium siphon cradle is stretched across this bridge piece, and on it is also mounted the small electromagnet, forming part of the “vibrator” arrangement with its hinged armature, to which one end of the stretched wire carrying the siphon is fastened. The ink-box is made adjustable, being carried by an arm attached to a pillar provided with a rack with which a pinion operated by a milled head screw engages. The motor is usually supported on a platform at the back of the instrument, its driving- wheel being connected to the shaft of the paper roller by means of a spirally wound steel band. In what is known as the “ hybrid" form of recorder the permanent magnets are provided with windings of insulated copper wire; the object of these windings is to pro­vide a means of . refreshing " the magnets by means of a strong current temporarily sent through the coils when required, as it has been found that, owing to magnetic leakage and other causes, the magnets tend to lose their power, especially in hot climates. Instruments of the siphon recorder type have been made to work both with and without electrification of the ink. In the latter case, which is the standard practice, mechanical vibration of the siphon is substituted in the place of electrification of the ink, so as to eliminate the effect of atmospheric conditions which frequently caused discontinuity in the flow of ink.

Fig. 33 shows a facsimile of part of a message received and re­corded by a siphon recorder, such as that of fig. 31, from one of the Eastern Telegraph Company's cables about 830 miles long. As the earth is used for completing the electric circuit, the signals received on such sensitive instruments as these are liable to be disturbed by the return currents of other systems in their immediate neighbourhood, which also use the earth as return, when such are of the magnitude generated by the working of electric tramways or similar undertakings, and to obviate this it is necessary to form the “earth” for the cable a few miles out at sea and make connexion thereto by an insulated return wire, which is enclosed in the same sheathing as the core of the main cable.

The heavier cores, with the consequent advance in speed of work­ing attainable, have necessitated the introduction of automatic sending, the instruments adopted being in general a modification of the Wheatstone transmitter adapted to the form of cable signals, while the regularity of transmission thus secured has caused its introduction even on circuits where the speed cannot exceed that of the ordinary operator's hand signalling.