to the piston P. The newly coated wire is passed through a long trough T, containing cold water, until it is sufficiently cold to allow it to be safely wound on a bobbin B' This operation completed, the wire is wound from the bobbin B' on to another, and at the same time carefu∏y examined for air-holes or other flaws, all of which arc eliminated. The coated wire is treated in the same way as the copper strand—the die D, or another of the same size, being placed at the back of the cylinder and a larger one substituted at the front. A second coating is then laid on, and after it passes through a similar process of examination a third coating is applied, and so on until the requisite number is completed. The finished core changes rapidly in its electric qualities at first, and is generally kept for a stated interval of time before being subjected to the specified tests. It is then placed in a tank of water and kept at a certain fixed temperature, usually 75° F., until it assumes approxi­mately a constant electrical state. Its conductor and dielectric resistance and its electrostatic capacity are then measured. These tests are in some cases repeated at another temperature, say 50° F., for the purpose of obtaining at the same time greater certainty of the soundness of the core and the rate of variation of the conductor and dielectric resistances with temperature. The subjection of the core to a hydraulic pressure of four tons to the square inch and an electric pressure of 5000 volts from an alternating-current trans­former has been adopted, by one manufacturer at least, to secure the detection of masked faults which might develop themselves after submergence. Should these tests prove satisfactory the core is served with jute yarn, coiled in water-tight tanks, and surrounded with salt water. The insulation is again tested, and if no fault is discovered the served core is passed through the sheathing machine, and the iron sheath and the outer covering are laid on. As the cable is sheathed it is stored in large water-tight tanks and kept at a nearly uniform temperature by means of water.

When the cable is to be laid it is transferred to a cable ship, provided with water-tight tanks similar to those used in the factory for storing it. The tanks are nearly cylindrical in form and have a truncated cone fixed in the centre, as shown at C, fig. 9. The cable is carefully coiled into the tanks in horizontal flakes, each of which is begun at the outside of the tank and coiled towards the centre. The different coils are prevented from adhering by a coating of whitewash, and the end of each nautical mile is carefully marked for future reference. After the cable has been again subjected to the proper electrical tests and found to be in perfect condition, the ship is taken to the place where the shore end is to be landed. A sufficient length of cable to reach the shore or the cable-house is paid overboard and coiled on a raft or rafts, or on the deck of a steam-launch, in order to be connected with the shore. The end is taken into the testing room in the cable-house and the conductor connected with the testing instruments, and, should the electrical tests continue satis­factory, the ship is put on the proper course and steams slowly ahead, paying out the cable over her stern. The cable must not be overstrained in the process of submersion, and must be paid out at the proper rate to give the requisite slack. This involves the introduction of machinery for measuring and controlling the speed at which it leaves the ship and for measuring the pull on the cable. The essential parts of this apparatus are shown in fig. 9. The lower end *e* of the cable in the tank T is taken to the testing room, so that continuous tests for electrical condition can be made. The upper end is passed over a guiding quadrant Q to a set of wheels or fixed quadrants 1, 2, 3, . . . then to the paying-out drum P, from it to the dynamometer D, and finally to the stern pulley, over which it passes into the sea. The wheels 1, 2, 3, . . . are so arranged that 2, 4, 6, . . . can be raised or lowered so as to give the cable less or more bend as it passes between them, while I, 3, 5, . . . are furnished with brakes. The whole system provides the means of giving sufficient back-pull to the cable to make it grip the drum P, round which it passes several times to prevent slipping. On the same shaft with P is fixed a brake-wheel furnished with a powerful brake B, by the proper manipulation of which the speed of paying out is regulated, the pull on the cable being at the same time observed by means of D. The shaft of P can be readily put in gear with a powerful engine for the purpose of hauling back the cable should it be found necessary to do so. The length paid out and the rate of paying out are obtained approximately from the number of turns made by the drum P and its rate of turning. This is checked by the mile marks, the known position of the joints, &c., as they pass. The speed of the ship can be roughly estimated from the speed of the engines; it is more accurately obtained by one or other of the various forms of log, or it may be. measured by paying out continuously a steel wire over a measuring wheel. The average speed is obtained very accurately from solar and stellar observations for the position of the ship. The difference between the speed of the ship and the rate of paying out gives the amount of slack. The amount of slack varies in different cases between 3 and 10 per cent., but some is always allowed, so that the cable may easily adapt itself to inequalities of the bottom and may be more readily lifted for repairs. But the mere paying out of sufficient slack is not a guarantee that the cable will always lie closely along the bottom or be free from spans. Whilst it is being paid out the portion between the surface of the water and the bottom of the sea lies along a straight line, the component of the weight at right angles to its length being supported by the frictional resistance to sinking in the water. If, then, the speed of the ship be *v,* the rate of paying out *u*, the angle of immersion *i,* the depth of the water *h,* the weight per unit length of the cable *w,* the pull on the cable at the surface P, and A, B constants, we have—

P=⅛j∞-(A∕sin i)∕(w-v cos t)I (a)

and *∙w* cos *i* = B∕(r sin *i) (β),*

where *f* stand for “ function.” The factors A∕ *{u-v* cos í) and B∕ (v sin í) give the frictional resistance to sinking, per unit length of the cable, in the direction of the length and transverse to the length respectively.@@1 It is evident from equation (β) that the angle of immersion depends solely on the speed of the ship; hence in laying a cable on an irregular bottom it is of great importance that the speed should be sufficiently low. This may be illustrated very simply as follows: suppose *a a* (fig. 10) to be the surface of the sea, *b* *c* the bottom, and *c c* the straight line made by the cable; then, if a hill H, which is at any part steeper than the inclination of the cable, is passed over, the cable touches it at some point *t* before it touches the part immediately below *t,* and if the. friction between the cable and the ground is sufficient the cable will either break or be left in a long span ready to break at some future time. It is important to observe that the risk is in no way obviated by the increasing slack paid out, except in so far as the amount of sliding which the strength of the cable is able to produce at the points of contact with the ground may be thereby increased. The speed of the ship must therefore be so regulated that the angle of. immersion is as great as the inclination of the steepest slope passed over. In ordinary circumstances the angle of immersion *i* varies between six and nine degrees.

The “ slack indicator ”. of Messrs Siemens Brothers & Co. yields a con­tinuous indication and record of the actual slack paid out. It consists of a long screw spindle, coupled by suitable gearing with the cable drum, and thus rotating at the speed of the outgoing cable; on this screw works a nut which forms the centre of a thin circular disk, the edge of which is pressed against the surface of a right circular cone, the line of contact, as the nut moves along the screw, being parallel to the axis of the latter. This cone is driven by gearing from the wire drum, so that it rotates at the speed of the outgoing wire, the direction of rotation being such as to cause the nut to travel towards the smaller end of the cone. If both nut and screw are rotating at the same speed, the position of the former will remain fixed ; and as the nut is driven by friction from the surface of the cone, this equality of speed will obtain only when the product of the diameter (d) of the cone at that position multi­plied into its speed of rotation (n) equals the product of the diameter (a) of the disk multiplied into the. speed of rotation (*N*) of the screw, or *N∣n≈d∣a,* and thus the ratio of cable paid out to that of wire paid out is continuously given by a pointer controlled

@@@1 See Sir W. Thomson (Lord Kelvin) *Mathematical and Physical Papers,* vol. ii. p. 165.