of the line. The interval *a* must not be confounded with the time required for each signal : it is a measure of the slowness of trans­mission ; but the number of signals which can be received in a given time, on any one line, depends on the method of working and on the sensibility of the instruments employed. The ratios of the number of signals which can be sent over different lines in a stated time are the same as the ratios of the values of *a* for these lines. The value of *a* for the different Atlantic cables varies between a fifth and a quarter of a second, and, as the time required for the current to reach 90 per cent. of its maximum value is ten times *a,* an instrument which requires as much as 90 per cent. of the full current to produce a signal and a fall to 50 per cent. between the signals could only receive about one signal every two seconds or between one and two words per minute. The instruments actually used attain to a speed of about twenty times this ; but they are capable of showing distinctly a current of a ten-thousandth, or even less, of the maximum current. The value of *a* for ordinary land lines is very small, probably not exceeding the five-thousandth part of a second for a circuit 500 miles in length. The current,

therefore, rises almost to its full value for each signal when the time of contact is as small as the five-hundredth part of a second, or, on the Wheatstone instrument, when the speed is about 500 words per minute. There is, however, a very sensible increase in the effective resistance of the circuit, especially when iron wire is used, when signals are sent as rapidly as 100 per second, so that higher battery power is required for fast than for slow rates of speed. The difficulty in working land lines at rates up to 300, or even more, words per minute is not to any serious extent electrical, but is in great measure due to material and magnetic inertia in the receiving instruments. Although land lines can be worked at a very high speed when the whole of the wire is insulated on poles, the rate is greatly diminished if a length of underground or of sub­marine cable is included in the circuit. In practice also the speed depends greatly on the position of the cable in the circuit ; for ex­ample, the actual speed from Dublin to London, according to Mr Preece, is about twice as great as that from London to Dublin. Mr Culley states that the greatest effect is produced when the cable is in the middle of the circuit. (T. GR.)

TELEMETER, or Rangefinder. This is an instru­ment used in modern warfare to determine the distance or range to an enemy’s position, in order that correct elevations may be given to guns or rifles directed against it. Telemeters have been made on three distinct princi­ples, and classified as acoustic, optical, and trigonometrical respectively.

*Acoustic telemeters* record the time which elapses between seeing the flash or smoke and hearing the report of a gun, rifle, or shell, the range being given in yards as “the time in seconds × 364∙6.” The Boulengé telemeter is the best known of this class. It consists of a graduated glass tube filled with liquid and containing a small metal tra­veller. At the flash the instrument is brought to a vertical position, and the traveller starts from zero ; at the detona­tion it is turned to a horizontal position and the traveller stops. The objections to the acoustic telemeter are that the rate of transmission of sound in air is affected by wind and other local conditions and that the instrument cannot be used until firing has commenced.

*Optical* or *perspective telemeters* determine the distance to any point by observing the size of some object of known dimensions, as seen in a graduated telescope. Porro’s telemeter, Elliott’s telescope, and Nordenfelt’s macro­meter illustrate the principle. The chief defect of the system is that the objects most conveniently observed— men and horses—vary considerably in size, so that the assumption of a constant dimension may be productive of error.

*Trigonometrical telemeters* shorten the ordinary methods of surveying by adapting them to military purposes. They are of two kinds,—field rangefinders and rangefinders for coast batteries.

(1) *Field rangefinders* exist in great variety, and differ from one another both in the trigonometrical methods pur­sued and in the mechanical peculiarities exhibited. The following are the common solutions of what is technically called “the range-finding triangle,”—*i*.*e*., a triangle in which O (fig. 1) is the object the distance to which is required, AOB an acute angle, and AB the base,—O being visible both from A and B. (i.) Where the base is a fixed length and the angles are variable.—A fixed base is rarely adopted except when the base forms part of the instrument, the angles being observed by powerful telescopes. The range is usually read in yards by the assistance of verniers, extreme perfection of mechanism being necessary. Many ingenious instru­ments of the kind have been devised, but none have as yet proved satisfactory. With a fixed base the accuracy diminishes as the range increases. (ii.) Where the base and the angles are variable.—The base angles are generally observed by instruments of the theodolite type, and the base is actually measured or found by means of a sub-base. The range is obtained by table or calculating scale. The Nolan rangefinder, which was the first telemeter used by the British artillery, was of this kind. (iii.) Where one base angle is a right angle, the other angles and base being variable.—The instrument used is generally double-reflect­ing of the sextant type,—the base being found as in (ii.). The most perfect example is the Watkin rangefinder, used

Fig. 2.—Watkin field rangefinder. by the British horse and field ar­tillery. It (fig. 2) consists of an horizon glass capable of assuming two positions, and an index glass set in a steel arm, which is worked by a movable collar on a graduated bar, and this again is moved by the turning of a graduated cylinder. O (fig. 3) being the object, the observer sets up a picket at A, and with the instrument at zero (the horizon glass being inclined 45o to the index glass) finds the right angle at the point C. A sub-base AB of 6 yards is then set off, and (with glasses set parallel and the sliding collar at 6) the ob­server reflects B upon A by turning the cy­linder, which is thus made to record the base AC in yards. This reading being set on the graduated bar by moving the sliding collar, the observer proceeds to A, and from there reflects C upon O, which causes the range to be given in yards on the cylinder. In this operation the position of the sliding collar regulates the movement of the steel bar so that the number of turns of the cylinder is always a true measure of the range OC, whatever the length of the base AC. (iv.) Where the angles are fixed and the base is a measure of the range.— The base points are determined by the use of prisms or of mirrors reflecting the particular angles adopted. The base is measured or found by a subsidiary triangle, and multi­plied by a constant to give the range. The Weldon range­finder, recently issued to the British infantry, is on this principle. It consists of three prisms, and is generally used as follows. O (fig. 4) being the object and D a con­venient distant point, the observer makes with the first prism the right angle OAD. He then retires in the direc­tion DA till the second prism records the angle OBD =