*A* mechanical polyphase rectifier or rotary devised by Bragstad and La Cour is described in *Der Kaskadenumformer*, by E. Arnold and J. L. La Cour, Stuttgart, 1904. It consists of a three-phase induction motor coupled direct to a continuous current dynamo, the armatures of the two machines being electrically connected so that the three-phase current created in the rotor of the induction motor enters the continuous current armature and creates around it a rotary field. The connexions are such that the rotating field turns in a direction opposite to that in which the armature is turning, so that the field is stationary in space. From the con­tinuous current armature can therefore be drawn off a continuous current and the device acts as a transformer of three-phase alternat­ing current to a continuous current.

The ordinary induction coil (*q.v*.) may be regarded as the trans­former for converting continuous current at low voltage into high voltage intermittent continuous current, but the difficulties of interrupting the primary current render it impossible to transform in this way more than a small amount of power. Where, however, high voltages are required, high potential transformers are used which are now built for the purpose of wireless telegraphy and the transformation of power to give secondary voltages up to 20,000, 30,000 or 60,000 volts. Transformers have even been built. to give secondary voltages of half a million volts capable of giving a 14 in. spark in air. These machines, however, must be regarded as more physical laboratory instruments than appliances for tech­nical work. For description of one such extra high potential trans­former see Η. B. Smith, on " Experiments on Transformers for Very High Potentials,” *The Electrician* (1904), 54, p. 358. A trans­former of this kind must invariably be an oil insulated transformer, as under extremely high voltage the air itself becomes a conductor and no solid insulator that can be put upon the wires is strong enough to stand the electric strain.

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(J. A. F.)

**TRANSIT CIRCLE,** or Meridian Circle, an instrument for observing the time of a star’s passing the meridian, at the same time measuring its angular distance from the zenith. The idea of having an instrument (quadrant) fixed in the plane of the meridian occurred even to the ancient astronomers, and is mentioned by Ptolemy, but it was not carried into practice until Tycho Brahe constructed a large meridian quadrant. This instrument enabled the observer to determine simultaneously right ascension and declination, but it does not appear to have been much used for right ascension during the 17th century, the method of equal altitudes by portable quadrants or measures of the angular distance between stars with a sextant being preferred. These methods were, however, very inconvenient, which induced Römer to invent the transit instrument about 1690. It consists of a horizontal axis in the direction east and west resting on firmly fixed supports, and having a telescope fixed at right angles to it, revolving freely in the plane of the meridian. At the same time Römer invented the altitude and azimuth instrument for measuring vertical and horizontal angles, and in 1704 he combined a vertical circle with his transit instru­ment, so as to determine both co-ordinates at the same time. This latter idea was, however, not adopted elsewhere, although the transit instrument soon came into universal use (the first one at Greenwich was mounted in 1721), and the mural quadrant continued till the end of the century to be employed for deter­mining declinations. The advantage of using a whole circle, as less liable to change its figure, and not requiring reversal in order to observe stars north of the zenith, was then again recog­nized by Ramsden, who also improved the method of reading off angles by means of a micrometer microscope as described below. The making of circles was shortly afterwards taken up by Troughton, who in 1806 constructed the first modern transit circle for Groombridge’s observatory at Blackheath, but he afterwards abandoned the idea, and designed the mural circle to take the place of the mural quadrant. In the United King­dom the transit instrument and mural circle continued till the middle of the 19th century to be the principal instrument in observatories, the first transit circle constructed there being that at Greenwich (mounted in 1850) but on the continent the transit circle superseded them from the years 1818-1819, when two circles by Repsold and by Reichenbach were mounted at Göttingen, and one by Reichenbach at Königsberg.@@1 The firm of Repsold was for a number of years eclipsed by that of Pistor and Martins in Berlin, who furnished various observatories with first-class instruments, but since the death of. Martins the Repsolds have again taken the lead, and have of late years made many transit circles. The observatories of Harvard College (United States), Cambridge and Edinburgh have large circles by Troughton and Simms, who also made the Greenwich circle from the design of Airy.@@2

In the earliest transit instrument the telescope was not placed in the middle of the axis, but much nearer to one end, in order to prevent the axis from bending under the weight of the telescope. It is now always placed in the centre of the axis. The latter consists of one piece of brass or gun-metal with carefully turned cylindrical steel pivots at each end. Several recent instruments have been made entirely of steel, which is much more rigid than brass. The centre of the axis is shaped like a cube, the sides of which form the basis of two cones, which end in cylindrical parts. The pivots rest on V-shaped bearings, either let into the mas­sive stone or brick piers which support the instrument or attached to metal frameworks bolted on the tops of the piers. In order to relieve the pivots from the weight of the instrument, which would soon destroy their figure, the cylindrical part of each end of the axis is supported by a hook supplied with friction rollers, and suspended from a lever supported by the pier and counterbalanced so as to leave only about 10 lb pressure on each bearing. Near each end of the axis is attached a circle or wheel (generally of 3 or 3½ ft. diameter) finely divided to 2' or 5' on a slip of silver let into the face of the circle near the circumference. The graduation is read off by means of microscopes, generally four for each circle at 90°from each other, as by taking the mean of the four readings the eccentricity and the accidental errors of graduation are to a great extent eliminated.@@· In the earlier instruments by Pistor and Mar­tins the microscopes were fixed in holes drilled through the pier, but afterwards they let the piers be made narrower, so that the microscopes could be at the sides of them, attached to radial arms starting from near the bearings of the axis. This is preferable, as it allows of the temporary attachment of auxiliary microscopes for the purpose of investigating the errors of graduation of the circle, but the plan of the Repsolds and of Simms, to make the piers short and to let the microscopes and supports of the axis be carried by an iron framework, is better still, as no part of the circle is

@@@1 The most notable exception was the transit instrument and vertical circle of the Pulkovo observatory, specially designed by the elder Struve for fundamental determinations.

@@@2 This instrument differs in many particulars from others: the important principle of symmetry in all the parts (scrupulously followed in all others) is quite discarded; there is only one circle; and the instrument cannot be reversed. There is a similar instru­ment at the Cape observatory.

@@@3 On Reichenbach’s circles there were verniers instead of ink ro- scopes, and they were attached to an alidade circle, the immovability of which was tested by a level.