numbers of these are being assembled, after they have been used in temporary erections or when nuts are brought from the stores to fit studs or bolts cut in the shop. This method may suffice in many classes of work, but it is utterly unsuited to an interchangeable system; and when there is a fair amount of the latter firms sometimes make thread gauges of their own, in general form like the plug and ring gauges, using, a hard quality of steel for small sizes or a tough quality of cast iron for the larger. These, though not hardened, will endure for a long time if treated carefully. But

though very useful and far better than none at all they lack two essentials. They are simply accommodation gauges, made to an existing tap or die, and do not therefore embody any precise abso­lute measurement, nor do they include any means for measuring variations from standard, nor are they hardened. To produce gauges to fulfil these requirements demands an original standard to work by, micrometric measurements, and the means of grinding after the hardening process. These requirements are fulfilled in the screw thread gauges and calipers of the Pratt & Whithey and the Brown & Sharpe companies. The essen­tial feature of a screw gauge is that it measures the sides of the threads with­out risk of a possible false reading due to contact on the bottom or top of the V. This is fulfilled by flatting the top and making the bottom of the gauge keen. The Pratt & Whithey gauges are made as a plug and ring (fig. 76), the plug being solid and the ring capable of precise adjustment round it. There is a plain round end, ground and lapped exactly to the standard size of the bottom of the thread, a dimension which is obliterated in the threaded end because of the bottoms of the angles being made keen for clearance. There are three kinds of this class of gauge made ; the first and most expensive is hardened and ground in the angle, while the second is hardened but not ground.. The first is intended for use when a very perfect gaugy is required, the second for ordinary shop usage. The third is made unhardened for purposes of reference simply, and it is not brought into contact with the work to be tested, at all, but measurements are taken by calipers; in every detail it repre- sents the standard threads. The Brown & Sharpe appliance, is of quite a different character. It is a micrometer caliper having a fixed V and a movable point between which the screw to be measured is embraced. By the reading of the micrometer, and the use of a constant the diameter of any thread in the middle of the thread can be estimated.

*Miscellaneous.—*The foregoing do not exhaust the gauges. There are gauges for the sectional shapes of screw threads of all pitches, gauges for drilled holes that have to be screwed, gauges for the depth and thickness of the teeth of gear-wheels, gauges for the tapers of machine spindles, gauges for key-grooves, &c. There are also the woodworker’s gauges—the marking and cutting, the panel, the mortise and the long-tooth.

*Indicators* are a small group of measuring instruments of a rather peculiar character. They magnify the most minute error by adapta­tions of long and short lever arms. The Bath, the Starrett and the Brown & Sharpe are familiar in high-class shops. Some simply magnify inaccuracy, but in one type an index reads to thousandths

of an inch (fig. 77). They are used in some kinds of lathe chuck work, but their principal value is in fitting and erecting the finer mechanisms.

*Surface Plates and Cognate Forms.*—Allied to the gauges are the instruments for testing the truth of plane surfaces: the surface plates, straight-edges and winding strips. The origination of plane surfaces by scraping, until the mutual coincidence of three plates is secured, was due to Whitworth. These surface plates (fig. 78, *A)* fill an important place in workshop practice, since in the best work plane surfaces are tested on them and corrected by scraping. To a large extent the precision grinding machines have lessened the value of scraping, but it is still retained for machine slides and other work of a similar class. In the shops there are two classes of surface plates: those employed daily about the shops, the accuracy of which becomes impaired in time, and the standard

plate or plates employed for test and correction. Straight-edges are derived from the surface plates, or may be originated like them. The largest are made of cast-iron, ribbed and curved on one edge, to prevent flexure, and provided with feet (fig. 78, B). But the smaller straight-edges are generally parallel, and a similar pair constitutes “ winding strips,” by which any twist or departure from a plane surface is detected.

Squares, of which there are numerous designs (fig. 78, *C* and *D),* are straight-edges set at right angles.

Bevels or bevel-squares (fig. 79),are straight-edges comprising a stock and a blade, which are ad­justable for angle in relation to each other. Shop protractors often include a blade adjustable for angle, forming a bevel with graduations. Spirit-levels test the horizontal truth of surfaces Many levels have two bubble tubes at right angles with each other, one of which tests the truth of vertical faces. Generally levels have flat feet, but some are made of V-section to fit over shafting. The common plumb-bob is in frequent use for locating the vertical position of centres not in the same horizontal plane. When a