gratings for optical purposes. Suppose it is our purpose to produce a screw which is finally to be 9 inches long, not including bearings, and 11/8 inches in diameter. Select a bar of soft Bessemer steel, which has not the hard spots usually found in cast steel, about 13/8 inches in diameter and 30 long. Put it between lathe centres and turn it down to 1 inch diameter everywhere, except about 12 inches in the centre, where it is left a little over 11/8 inches in diameter for cutting the screw. Now cut the screw with a triangular thread a little sharper than 60°. Above all, avoid a fine screw, using about 20 threads to the inch.

The grinding nut, about 11 inches long, has now to be made. Fig. 1 represents a section of the nut, which is made of brass, or better

of Bessemer steel. It consists of four segments,—*a*, *a,* which can be drawn about the screw by two collars, *b, b,* and the screw c. Wedges between the segments prevent too great pressure on the screw. The final clamping is effected by the rings and screws, *d, d,* which enclose the flanges, *e,* of the segments. The screw is now placed in a lathe and surrounded by water whose temperature can be kept constant to 1° C., and the nut placed on it. In order that the weight of the nut may not make the ends too small, it must either be counterbalanced by weights hung from a rope passing over pulleys in the ceiling, or the screw must be vertical during the whole process. Emery and oil seem to be the only available grinding materials, though a softer silica powder might be used towards the end of the operation to clean off the emery and prevent future wear. Now grind the screw in the nut, making the nut pass backwards and forwards over the screw, its whole range being nearly 20 inches at first. Turn the nut end for end every ten minutes and continue for two weeks, finally making the range of the nut only about 10 inches, using finer washed emery and moving the lathe slower to avoid heating. Finish with a fine silica powder or rouge. During the process, if the thread becomes too blunt, recut the nut by a *short* tap so as not to change the pitch at any point. This must of course not be done less than five days before the finish. Now cut to the proper length ; centre again in the lathe under a microscope ; and turn the bearings. A screw so ground has less errors than from any other system of mounting. The periodic error especially will be too small to be discovered, though the mountings and graduation and centering of the head will introduce it ; it must therefore finally be corrected.

*Mounting of Screws.—*The mounting must be devised most care­fully, and is indeed more difficult to make without error than the screw itself. The principle which should be adopted is that no workmanship is perfect ; the design must make up for its imper­fections. Thus the screw can never be made to run true on its bearings, and hence the device of resting one end of the carriage on the nut must be rejected. Also all rigid connexion between the nut and the carriage must be avoided, as the screw can never be adjusted parallel to the ways on which the carriage rests. For many purposes, such as ruling optical gratings, the carriage must move accurately forward in a straight line as far as the horizontal ’ plane is concerned, while a little curvature in the vertical plane produces very little effect. These conditions can be satisfied by making the ways V-shaped and grinding with a grinder somewhat shorter than the ways. By constant reversals and by lengthening or shortening the stroke, they will finally become nearly perfect. The vertical curvature can be sufficiently tested by a short carriage carrying a delicate spirit level. Another and very efficient form of ways is V-shaped with a flat top and nearly vertical sides. The carriage rests on the flat top and is held by springs against one of the nearly vertical sides. To determine with accuracy whether the ways are straight, fix a flat piece of glass on the carriage and rule a line on it by moving it under a diamond ; reverse and rule another line near the first, and measure the distance apart at the centre and at the two ends by a micrometer. If the centre measure­ment is equal to the mean of the two end ones, the line is straight. This is better than the method with a mirror mounted on the carriage and a telescope. The screw itself must rest in bearings, and the end motion be prevented by a point bearing against its flat end, which is protected by hardened steel or a flat diamond. Collar bearings introduce periodic errors. The secret of success is so to

design the nut and its connexions as to eliminate all adjustments of the screw and indeed all imperfect workmanship. The connexion must also be such as to give means of correcting any residual periodic errors or errors of run which may be introduced in the mountings or by the wear of the machine.

The nut is shown in fig. 2. It is made in two halves, of wrought iron filled with boxwood or lignum vitæ plugs, on which the screw is cut. To each half a long piece of sheet steel is fixed which bears against a guiding

edge, to be described presently. The two halves are held to the screw by springs, so that each moves for­ward almost indepen­dently of the other.

To join the nut to the

carriage, a ring is attached to the latter, whose plane is

vertical and which can turn round a vertical axis.

The bars fixed midway on the two halves of the nut bear

against this ring at points 90° distant from its axis.

Hence each half does its share independently of the

other in moving the carriage forward. Any want of

parallelism between the screw and the ways or eccen­tricity in the screw mountings thus scarcely affects

the forward motion of the carriage. The guide against

which the steel pieces of the nut rest can be made of such

form as to correct any small error of run due to wear of

the screw. Also, by causing it to move backwards and

forwards periodically, the periodic error of the head and

mountings can be corrected.

In making gratings for optical purposes the periodic

error must be very perfectly eliminated, since the peri­odic displacement of the lines only one- millionth of an

inch from their mean position will produce “ ghosts ”

in the spectrum. @@1 Indeed this is the most sensitive method of detecting the existence of this error, and it is practically impos­sible to mount the most perfect of screws without introducing it. A very practical method of determining this error is to rule a short grating with very long lines on a piece of common thin plate glass ; cut it in two with a diamond and superimpose the two halves with the rulings together and displaced sideways over each other one-half the pitch of the screw. On now looking at the plates in a proper light so as to have the spectral colours show through it, dark lines will appear, which are wavy if there is a periodic error and straight if there is none. By measuring the comparative amplitude of the waves and the distance apart of two lines, the amount of the periodic error can be determined. The phase of the periodic error is best found by a series of trials after setting the corrector at the proper amplitude as determined above.

A machine properly made as above and kept at a constant temperature should be able to make a scale of 6 inches in length, with errors at no point exceeding 1/100000th of an inch. When, however, a grating of that length is attempted at the rate of 14,000 lines to the inch, four days and nights are required and the result is seldom perfect, possibly on account of the wear of the machine or changes of temperature. Gratings, however, less than 3 inches long are easy to make. (H. A. R.)

SCRIBE, Augustin Eugène (1791-1861), the most popular playwright of France, was born at Paris on 24th December 1791, and died there on 20th February 1861. His father was a silk merchant and he was well educated, being destined for the bar. But, having a real gift for the theatre (a gift which unfortunately was not allied with sufficient literary power to make his works last), he very soon broke away from professional study and at the age of twenty produced, in collaboration, as is common in France, the first of a series of dramas which continued for fifty years. *Les Demis* (1811). is usually cited as the first play in which he took a hand, though, as for some time he did not sign his work, identification is somewhat difficult. He achieved no distinct success till 1816, when *Une Nuit de Garde Nationale* made him in a way famous. Thence­forward his fertility was unceasing and its results pro­digious. There may be in existence a complete list of Scribe’s works, but we have never seen any that pretended to be such. He wrote every kind of drama—vaudevilles,

@@@1 In a machine made by the present writer for ruling gratings the periodic error is entirely due to the graduation and centering of the head. The uncorrected periodic error from this cause displaces the lines 1/300000th of an inch, which is sufficient to entirely ruin all gratings made without correcting it.