HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC.

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LOCATING HOLES.

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INFLUENCE OF THE LIMIT OF VARIATION ON THE CHOICE OF METHOD TO BE USED—LOCATING HOLES BY OCULAR AND BY CONTACT MEASUREMENTS.

THERE are several methods by which holes may be located properly in reference to each other, and also to some fixed point in, or some surface of, any piece of machinery, the choice of method depending upon the limit of variation allowable. It is here assumed that the machinist is supplied with the tools mentioned further on, otherwise the methods must be modified to suit the conditions, and it should be distinctly understood that the methods given should be modified, when necessary, to suit the nature of the work.

Suppose on looking at a drawing of some piece of machinery we find that the center to center distance of two holes is given as 3 inches. To the ordinary mind this dimension conveys but one impression, viz.: that the holes must be located three inches apart. The first thought of the experienced toolmaker or machinist, however, is: How close to the given dimension must the holes be located? He knows that for some work the centers of the holes may be within $\frac{1}{16}$ of an inch of the given dimension and still be accurate enough, while for other work a variation of $\frac{1}{2500}$ of an inch in any direction may be sufficient to condemn the job. Now, since the greater the accuracy required, the greater the cost of the piece, it follows that the limit of variation allowable must be determined before commencing the work.

We will now consider the first and most general method employed, by which holes may be located within $\frac{1}{100}$ of an inch from their true location by a fairly skilled workman, and by expert toolmakers within even as small a limit as $\frac{1}{1000}$ of an inch. In Fig. 1 a part of a machine is shown, in which all surfaces are machine-finished square with each other, and within a fair limit of accuracy to the dimensions given. It is required to locate the holes *a* and *b* at the given distances from the surfaces *c* and *d*, the allowable limit of variation being $\frac{1}{200}$ of an inch in either direction. We shall proceed as follows: We place the part operated upon

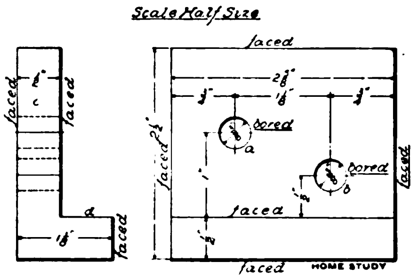

FIG. 1.

on a surface-plate (a cast-iron plate worked to a plane surface), and with a surface-gauge, as *e*, Fig. 2, scratch a faint line at a distance of $\frac{3}{4}$ inch from the surface *c*, Fig. 1; that is, at a distance of $\frac{3}{4}$ inch from the surface-plate. The marking-point of the scriber *f* is set to the right distance by shifting it until it coincides with the required graduation on a steel rule held vertically to the surface-plate; one end of the rule resting on the surface-plate. It will be found quite an advantage to place the rule against a try-square (see Fig. 2), unless it can be placed against some surface of the piece operated upon; this ensures a vertical position of the rule. In order that the scriber-lines may be plainly seen, it is considered good practice to copper the surface on which they are drawn, by applying some sulphate of copper (bluestone) dissolved in water. The surface must be free from grease, in order that a film of copper may be deposited upon it. The above applies to iron and steel surfaces only.

After locating one center line of each hole, Fig. 1, the piece is turned around until lines may be scribed at right angles to those drawn first. Scribe these lines at the distances called for by the drawing; their intersections will be the centers of the holes. Now, with a sharp center-punch, the point of which should be a right cone, a faint mark is made at each point of intersection. To find the true intersection point, the center-punch may be placed in one of the lines and slid along until the sense of touch tells that the required point has been reached. This requires some practice and a "light hand"; if the workman does not possess these, he must use his eyes to the best advantage. After center-punching the intersection points, the piece may be strapped to a true-running face-plate, which should be straight. It must now be shifted until the center-punch mark remains stationary when the lathe-spindle is revolved; i. e., until it coincides with the axis of the lathe-spindle. If great accuracy is required, a device called a center-indicator is used, this being an instrument which multiplies the motion of the center-punch mark. When the indicator remains stationary (the spindle being in motion), it shows that the center-punch mark is in the required position. If no indicator is at hand, we may draw a faint circle about each intersection point and true the piece up by these circles, placing a scriber into the tool-post and close to the surface of the piece operated upon. The eye can then readily detect a very small motion of the circle. After truing the piece, the clamps may be tightened, the correct alignment of the center-punch mark tested again, and, if found correct, the hole may be drilled and then bored to the required size.

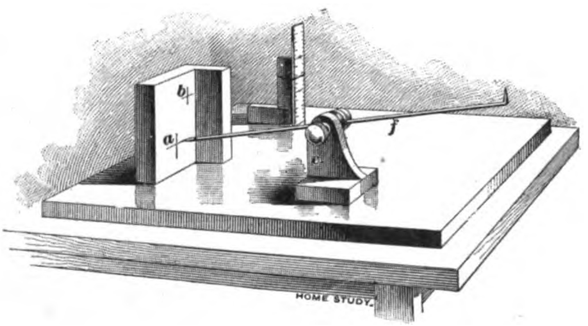

FIG. 2.

When holes are to be located within a limit of variation of $\frac{1}{2500}$ of an inch, a somewhat different method is employed, in which contact measurements take the place of ocular measurements, since by the sense of touch even an inexperienced person can usually detect as small a difference as $\frac{1}{10000}$ of an inch in size between two pieces, while highly-skilled toolmakers can detect one-third of that minute quantity. It should be understood that a micrometer is used for this, while in the ocular measurements mentioned before the naked eye alone is used.

First of all, the centers of the holes are located as in the first method; if located within $\frac{1}{64}$ of an inch, it is plenty close enough. The holes may now be drilled and tapped for fillister-head screws, having a diameter at least $\frac{1}{16}$ of an inch, and better still $\frac{1}{8}$ of an inch, smaller than the finished size of the hole. Usually a $\frac{1}{4}$-inch standard screw will answer, since holes smaller than $\frac{3}{8}$ of an inch are rarely bored. Next, some "buttons" are prepared. These are simply tool-steel disks, hardened, ground, and lapped to some standard size. A very convenient size is $\frac{1}{2}$ an inch in diameter and $\frac{1}{4}$ of an inch high, with a central hole $\frac{5}{16}$ of an inch in diameter. The sides of the buttons should be parallel and perpendicular to the axis of the button. It is not absolutely necessary that the buttons be standard size or all the same size, although it is a great convenience to have them so. The chief requirement is that they be perfectly cylindrical.

We will now proceed to locate the axis of the button *a′*, Fig. 3, at the given distances from the surfaces *c* and *d*. Using a button $\frac{500}{1000}$ of an inch in diameter, its axis is $\frac{500}{1000} \div 2 = \frac{250}{1000}$ of an inch from its cylindrical surface; hence, the latter is at a distance of $1 - \frac{250}{1000} = \frac{750}{1000}$ of an inch from the surface *d*, measuring perpendicular to the surface. We now file a piece of wire to a length of $\frac{750}{1000}$ of an inch, using a micrometer for measuring. The button is then screwed against the piece operated upon, the screw being adjusted just tight enough to allow the button to be shifted by a very light blow. For this reason, the hole in the button is made larger than the screw. Now, by shifting the button until the piece of wire mentioned before (*e*, Fig. 3) will just touch the button and the surface *d* when perpendicular to *d*, the axis may be properly located in reference to *d*. In order to secure accurate results, a micrometer should be set to the length of the wire, i. e., $\frac{750}{1000}$ of an inch. The wire should then be inserted between the two measuring surfaces and the fit of the wire noted. It should then fit equally tight between the button and the surface *d*. When a shop is provided with reference-disks (steel disks, hardened, ground, and lapped truly cylindrical and to standard size), it is better to use a disk $\frac{750}{1000}$ of an inch in diameter instead of a piece of wire. By rolling the disk along *d*, all uncertainty about the measurement being perpendicular to the surface measured from is removed. This follows from a well-known principle of geometry, viz., that two circles are tangent to each other on a line joining their respective centers.

To locate the axis of *a′* in reference to *c*, the piece may be placed on a surface-plate with the surface *c* resting on the plate. Then, in a manner similar to that employed to locate the button in reference to *d*, it may be located at the proper distance from *c*. The screw may now be tightened and the proper adjustment of the button tested again, since the tightening process is liable to shift it.

The location of *b′* in respect to *d* is simply a repetition of the method employed to locate *a′*. When we come to locate it in reference to the button *a′*, two ways may be employed. We may obtain the center to center distance between *a′* and *b′* by trigonometrical calculation, subtract the sum of the radius of the two buttons from it and file a wire, as *f*, Fig. 3, to it, and use this wire to align *b′*. If this is not feasible or desirable, the button *b′* may be located from the surface *c* in the same manner as *a′* was located in reference to that surface. After locating *b′*, it is clamped tightly to the piece and then tested again. If found correct, the piece may now be strapped to the face-plate of a lathe and trued up by shifting until one of the buttons runs true; that is, until its axis coincides with the axis of the lathe-spindle. An indicator is indispensable for this, since the motion of the button is greatly multiplied by it. It may be well to call attention to the fact that in order to do any accurate work of this nature, the lathe-spindle must be truly cylindrical and must fit the boxes very closely. The face-plate should also be counterbalanced. After truing up, the button may be removed and the hole bored to the required size. The other hole is similarly treated.

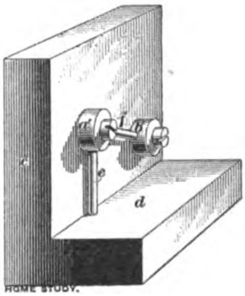

Fig. 3.

A POET'S EXPERIMENT IN MECHANICS.

It is related of the good poet Whittier, whose memory is sweet to us all, that, when a boy at home upon the farm, discovering that he could easily lift his brother Matt and that his brother could also lift him, and musing upon the fact while at work, he came to the conclusion that if they were to take hold of each other and lift together, they would rise simultaneously. The idea seemed plausible, but it is needless to state that when the experiment was tried the future poet was doomed to disappointment.

The problem involved factors which the youthful experimenter had not considered, and his disappointment was but a type of the disappointment common to all who attempt to deduce conclusions which are based upon a consideration of less than *all* the conditions involved. In a mechanical sense, Whittier's experiment was not a success. Ethically, however, his idea was correct, and it is beautifully typical of that greatness which ever characterized his life and so endeared him to the hearts of the American people. He lifted his fellow man, and by so doing was himself uplifted.