June 24, 1941. F. BENFORD 2,247,113

OPTICAL ALIGNMENT DEVICE

Filed Dec. 19, 1939

Fig. 1.

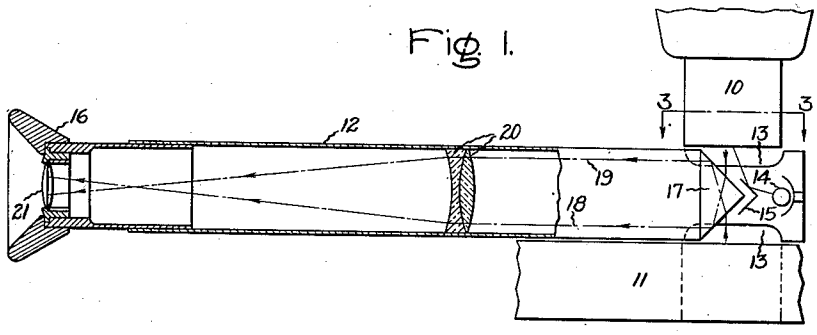

Fig. 2.

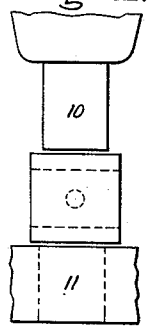

Fig. 3.

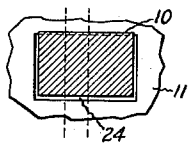

Fig. 4.

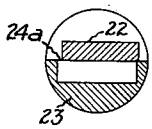

Fig. 5.

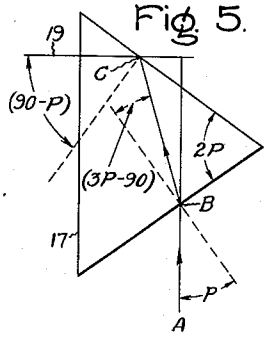

Fig. 6.

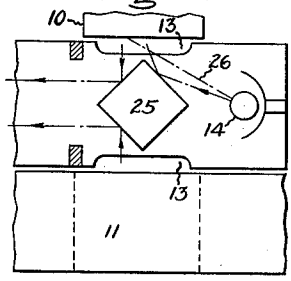

Fig. 7.

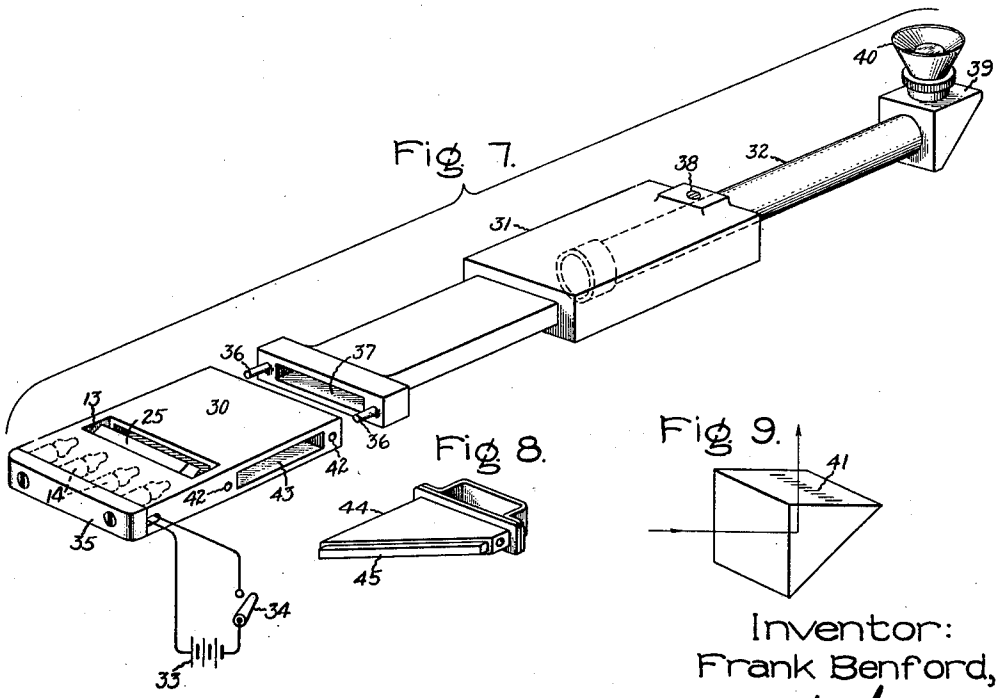

Fig. 8.

Fig. 9.

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OPTICAL ALIGNMENT DEVICE

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Application December 19, 1939, Serial No. 310,023

2 Claims. (Cl. 88—14)

My invention relates to an optical device and in particular to a device for observing the alignment of spaced parts such as the cooperating cutting surfaces of a punch and die when they are assembled in a punch press and are separated preparatory to a punching operation. My instrument will show by direct inspection if the punch and die parts are properly aligned or if not the extent and direction of misalignment.

Punch and die parts often cost thousands of dollars. If they are not properly aligned they are damaged by the punching operations and are broken or worn out prematurely. Also the work done by improperly aligned punch and dies is very apt to be of poor quality. It is therefore important that punch and die parts be properly aligned. This is sometimes quite difficult and my invention provides an inspection tool whereby punch and die parts may be quickly and easily aligned when they are initially installed and before there has been any damaging trial punching operations.

In carrying my invention into effect I provide means for illuminating the cutting surfaces of the punch and die and an optical system including a part that may be inserted between the spaced punch and die parts for conveying a combined magnified image of the cutting surfaces of both punch and die parts in their true alignment relation to a convenient observation eye piece.

The features of my invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. For a better understanding of my invention, reference is made in the following description to the accompanying drawing in which Fig. 1 represents a schematic side view of my optical system as set up between a punch and die as assembled in a punch press. Fig. 2 represents a right hand end view of the apparatus of Fig. 1. Fig. 3 is an explanatory outline of the punch and die parts of Fig. 1 assumed to be out of alignment. Fig. 5 indicates geometrical relations of a prism that may be used in my optical device. Fig. 4 is a view of the improperly aligned parts as seen through my optical device. Fig. 6 represents a modified form of device in which mirrors instead of a prism are employed for turning the light ray images 90 degrees. Fig. 7 is a perspective view of one of my devices showing its external appearance as completed. Fig. 8 is an angle-changing mirror attachment for use with the device of Fig. 7, and Fig. 9 is an angle-changing graduated prism that may be used with the optical device for greater convenience.

Referring to Fig. 1, 10 represents a punch and 11 a die of a punch press with the punch and die in assembled relation and with these parts separated as they would be preparatory to a punching operation. The die has an opening, the lateral dimensions of which are indicated in dotted lines in Fig. 1. The other dimensions of the punch and die are indicated in Fig. 2 which represents a view of Fig. 1 looking at it from the right. Let it be assumed that the punch is slightly smaller than the die opening and that these parts are slightly out of proper alignment by the amount indicated in their outline views as shown in Fig. 3. Fig. 3 may be considered as an outline view of the punch and the die opening, assuming that these outlines could be viewed from above in Fig. 1. It is seen that the punch 10 is slightly too far to the rear in Fig. 1 to align properly with the die opening and should be moved forward slightly. To an observer looking in the eye piece 16 the misalignment appears to the right or left as the case may be. This misalignment is also indicated in Fig. 2 by the failure of the sides of punch 10 to the line up with the dotted lines indicating the opening in die part 11.

Now, an alignment outline view such as represented in Fig. 3 cannot be made by attempting to align these parts with the unaided eye because it is impossible to get the eye in position to sight along the sides of the punch when these parts are assembled in a punch press, as indicated. My invention comprises an optical device by means of which the equivalent of such outline view, Fig. 3, may be had on a magnified scale. A schematic view of such device is represented in Fig. 1 in position to view the alignment of the punch and die parts.

The device consists of a suitable holder or casing 12, one end of which is dimensioned to be inserted between the punch and die as indicated. The end of the device which is to be thus inserted between the punch and die is provided with aligned windows 13 facing upward and downward or in opposite directions at right angles to the axis of the holder. One or more tiny electric lamps 14 are provided to cooperate with a V-shaped mirror 15 to direct light through the windows 13 onto the surfaces of the punch and die in order that such surfaces shall be well illuminated. Optical means are also provided to receive light from the surfaces of the punch and die back through the windows and direct it through a suitable image magnifying lens system to the eye piece at 16. In Fig. 1 I have provided a triangular shaped prism 17 for

this purpose with its axis parallel with the window openings and located between them. Light rays from the surface of the punch such as the light ray indicated by line 18 are refracted on passing through the upper inclined surface of the prism and reflected at the lower inclined surface of the prism and directed towards the eye piece at a total angle of 90 degrees. Likewise light rays from the surface of the die such as the light ray indicated by line 19 are refracted at the lower surface of the prism and reflected at the upper surface of the prism for a total angle of 90 degrees and directed towards the eye piece parallel with ray 18. The exact triangular shape of the prism for this purpose will depend upon the index of refraction of the glass used. If the index of refraction be designated by n, the rays will be turned through 90 degrees when $n \cos 3P + \sin P = 0$, where P is one-half of the angle at the apex of the prism. The geometry of such a prism is indicated in Fig. 5. The light ray 19 entering the prism from A is refracted at B and reflected at C for a total angle of 90 degrees. In this way a light ray image of a section of the face of the punch and a light ray image of a section of the face of the die which are directly opposite each other are projected parallel and side by side towards the eye piece, the image of the punch coming through the lower half of the back side of the prism and the image of the die coming through the upper half of the back side of the prism. The image sections thus directed towards the eye piece are those sections appearing in the windows opposite the effective observation areas of the prism, and for the position of the prism shown in Fig. 1, approximately the sections represented as contained within the two vertical dotted lines in Fig. 3 will be seen. The lenses shown at 20 constitute the ordinary objective lens and the lens 21 at the eye piece together with the objective lens reverses the images and produces a telescopic magnification thereof. Thus both images appear simultaneously in side by side magnified relation.

Fig. 4 represents what will be seen in the eye piece for the set-up represented in Fig. 1 where 22 represents an image of a section of the face of punch 10 and 23 a section of the face of die 11. The portions shown shaded are bright and the other portions dark. The improper alignment of punch and die in a direction at right angles to the axis of the telescope device is clearly apparent as the out-of-line condition of the surfaces at point 24, Fig. 3, shows up at the point 24*a*, Fig. 4. In moving the punch to the front in Fig. 1 into alignment, the image 22, Fig. 4, will move to the left because the image is in reverse relation to the object. The line between the two images corresponds to the line where the two surfaces of the prism meet at the center apex.

To check the alignment of punch and die in their other axis, i. e., parallel to the surface of the drawing instead of normal thereto, looking at Fig. 1, the optical device is inserted at right angles to the position shown and adjusted to the desired observation position or positions. It is not essential that the optical device be exactly the same distance from punch and die but it should be positioned with its axis parallel with the surfaces to be aligned and for this purpose its upper and lower surfaces will be furnished to rest flat on the upper surface of the die face, where used as described above. The optical device may be used either side up.

Instead of the prism 17 of Fig. 1 I may, and generally prefer to, build the optical device from a square bar faced with mirror surfaces as shown at 25 in Fig. 6. In this case the four surfaces of the bar are polished or otherwise provided with mirror surfaces. The reflecting surfaces opposite the lamp 14 serve to assist in brightly illuminating the surfaces of punch and die to be compared and the reflecting surfaces towards the eye piece are inclined at an angle of 45 degrees to the windows and serve to turn the light rays from the surfaces to be compared through 90 degree angles and project them in parallel and in the same direction towards the eye piece. The bar-shaped mirror member 25 also serves to screen the eye from direct rays of the lamp. In Fig. 6 it will be noted that the lamp is sufficiently removed from the mirror that direct illumination as well as reflected illumination can be had of the surfaces to be illuminated. Thus light ray 26 strikes the face of punch 10 in the objective area directly without reflection. The device of Fig. 6 may be similar to that of Fig. 1 in other respects. It will be evident that using the mirror system of Fig. 6 instead of a prism as in Fig. 1, the image as it appears in the eye piece will have the image of the punch section below and the image of the die section above the central horizontal dividing line. This is because there is a reversal of the images by the lens system as in Fig. 1 but the transposition of the images from top to bottom as produced by the prism 17, Fig. 1, is absent.

In Fig. 7 I have illustrated a perspective view of a practicable form of my optical alignment device. The device is built up of three main parts which might be termed the head piece 30, the main hollow casing 31 and the telescope part 32. The head piece 30 is the part which is inserted between the parts to be aligned and is provided with finished upper and lower surfaces so that it may lie flat on any suitable supporting structure such as the surface of a die when inserted with either flat side down. The head section may have dimensions of the order of ½ inch in thickness, three inches in width and four inches in length. It is provided with upper and lower aligned windows 13, one of which may be seen in the upper flat surface of the head. These windows are elongated across the head to provide a wide viewing area without movement of the head. It is also provided with a square bar mirror device 25, as explained in connection with Fig. 6. The length of the window and exposed part of the bar mirror may vary. I have found that a length of from two to three inches for this dimension is suitable for most requirements. For such length of observation windows it is desirable to provide several lamps along its length. In the illustration, I have indicated four lamps 14. These are tiny low-voltage lamps suitable for being energized from one or two dry cells indicated at 33, through a switch 34. The lamps and their terminal connections are supported by an insulating bar 35 which closes the forward end of this head piece. The head 30 is separable from the casing 31 for purposes which will be explained and is shown separated in the illustration, but in position to be assembled. For this purpose the casing is provided with projecting dowel pins 36 which are adapted to fit snugly into correspondingly spaced openings in the rear side of the head piece adjacent the side walls thereof. These attachment facilities may be varied. When thus assembled, the opening seen

at 37 in the casing aligns with a similar opening in the rear side of the head.

In order that the telescope part 32 may be directed to various positions along the bar mirror 25, the telescope section 32 is pivoted at 38 in the rear end of the casing 31 and extends into the casing which is made sufficiently deep at this end to accommodate the telescope when it is swinging about pivot 38 in a small, horizontal arc. For greater convenience the telescope is provided with a prism or mirror in the part 39 for turning the light rays 90 degrees to the eye piece 40 and the part 39 may be swiveled in the telescope tube so that the eye piece 40 may be turned in a plane at right angles to the axis of the telescope tube to any position which happens to be most convenient to the user. A 90 degree prism for this purpose is shown in Fig. 9 and I prefer also to include on the prism a graduated scale 41 calibrated with the optical system in mills in order that out of alignment dimensions may be accurately measured. This will enable a person who is doing the aligning to select the proper shim or otherwise guide him in making the correct adjustment. A telescope of about 30 magnifying power is satisfactory.

Oftentimes it will be difficult, if not impossible, to insert the optical device between a punch and die as assembled in a punch press and have the casing 31 and telescope part 32 extend in any other direction than to the front of the punch press. To overcome this difficulty and still permit orientation of the head part 30 through 90 degrees, the head piece 30 is removed from the casing 31 and turned 90 degrees and again attached to the casing by inserting pins 36 into the holes shown at 42 in the near side of head 30. The opening 37 now lines up with the opening shown at 43. A snugly fitting plug piece 44 shown in Fig. 8 is shoved into the opening left exposed at the rear side of head 30. This plug piece has a diagonal forward edge to which is secured a mirror 45 at an angle of 45 degrees to the new line of sight. This then turns the light rays reflected from mirror 25 90 degrees in line with the telescope as thus oriented and the operator may proceed to check the alignments in a direction parallel to the axis of casing 31. The opening at 43 will preferably be closed when it is not being used.

While the apparatus has been described as adapted for the alignment of a punch and die, it may be used for the alignment of other parts or for the inspection of surfaces that cannot be observed directly because of the close proximity of interfering objects.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An optical alignment device comprising a casing having elongated aligned windows in opposite walls thereof, a pair of elongated mirrors located between said windows, one mirror serving to reflect light rays entering normal to one window through a 90 degree angle and the other mirror serving to reflect light rays entering normal to the other window through a 90 degree angle such that the reflected light rays from both windows are parallel and are projected in the same direction, the adjacent reflecting surfaces of said mirrors meeting in a line which thus divides the light ray images reflected by the two mirrors, and a telescope device supported with said casing through which both light ray images may be simultaneously viewed, said telescope being pivoted to swing in an arc in order that it may be directed to observe the two images along any portion of the length of said elongated mirrors.

2. An optical alignment device comprising a hollow elongated casing structure having a main section, a telescope inserted at one end thereof and a removable head section at the other end, the head section being rectangular in shape and having dimensions of the order of one-half inch in depth, three inches in width and four inches in length, said head section having elongated aligned windows across its top and bottom walls, a pair of elongated mirrors located between said windows inclined at an angle of 45 degrees to the top and end walls of the head section with the edges meeting in a line parallel with the windows, such that light ray images appearing in said windows will be reflected towards one end wall of said head section in side by side relation, said one end wall having an opening communicating with and in line with the main section of the casing so that such light ray images may be viewed through the telescope when the head section is attached to the main section, said head section also having an elongated opening in a side wall thereof, and facilities whereby the head section may be attached to the main casing section to align with the last mentioned opening, and a closure plug for the elongated opening in the end wall of said head section having an internal mirror surface which, when said plug is inserted, reflects light ray images from the first mentioned mirrors to the elongated opening in the side wall of said casing.

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