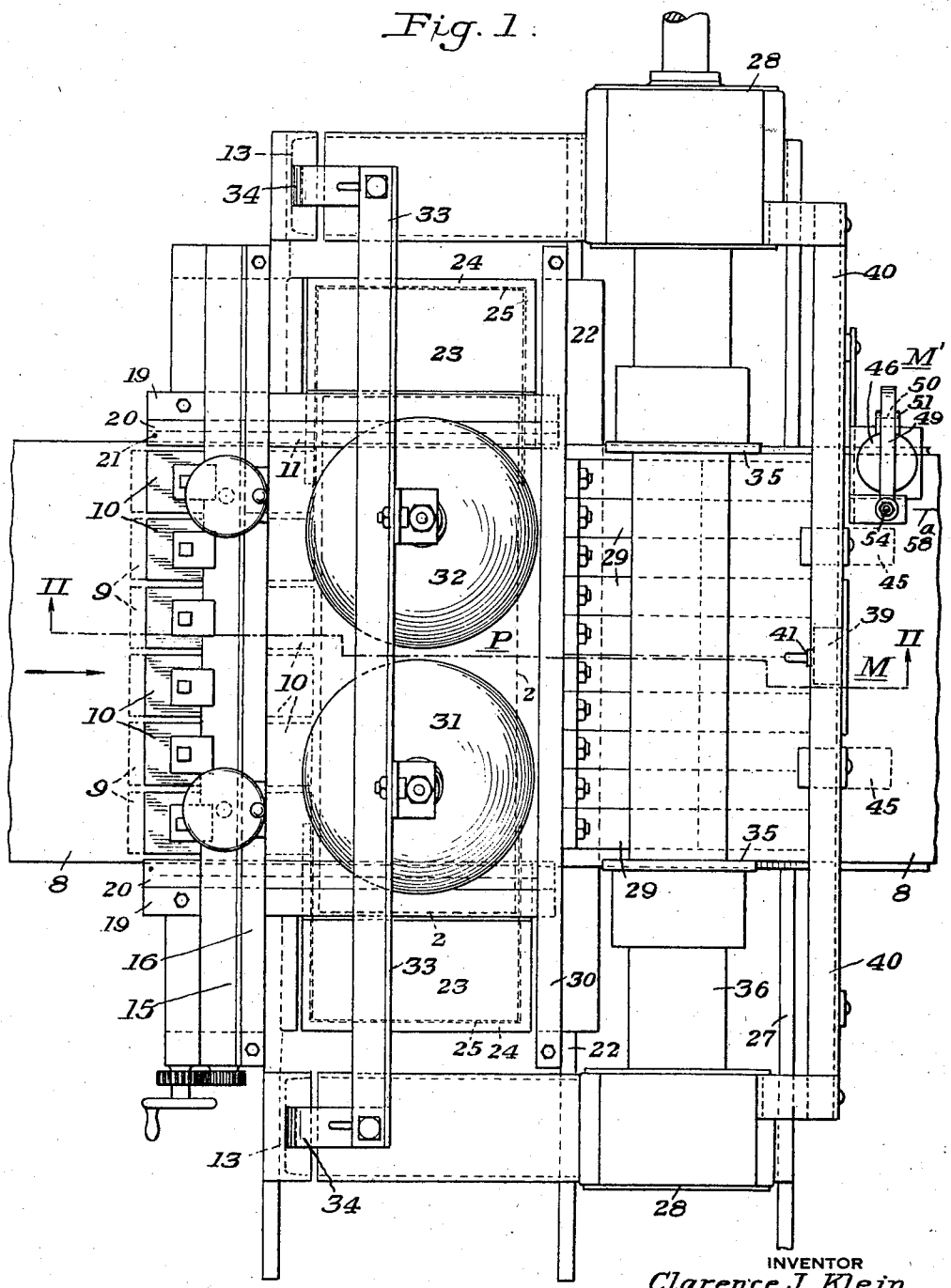
Feb. 22, 1944. C. J. KLEIN ET AL 2,342,474

METHOD OF AND APPARATUS FOR INSPECTING STRIP MATERIAL

Filed Aug. 24, 1938 4 Sheets-Sheet 1

Fig. 1.



INVENTOR
Clarence J. Klein
Ernest W. Rieger
Allan W. Duncan
by their attorney
Stebbins, Blenko & Pennelee

Feb. 22, 1944. C. J. KLEIN ET AL 2,342,474

METHOD OF AND APPARATUS FOR INSPECTING STRIP MATERIAL

Filed Aug. 24, 1938 4 Sheets-Sheet 2

Fig. 2.

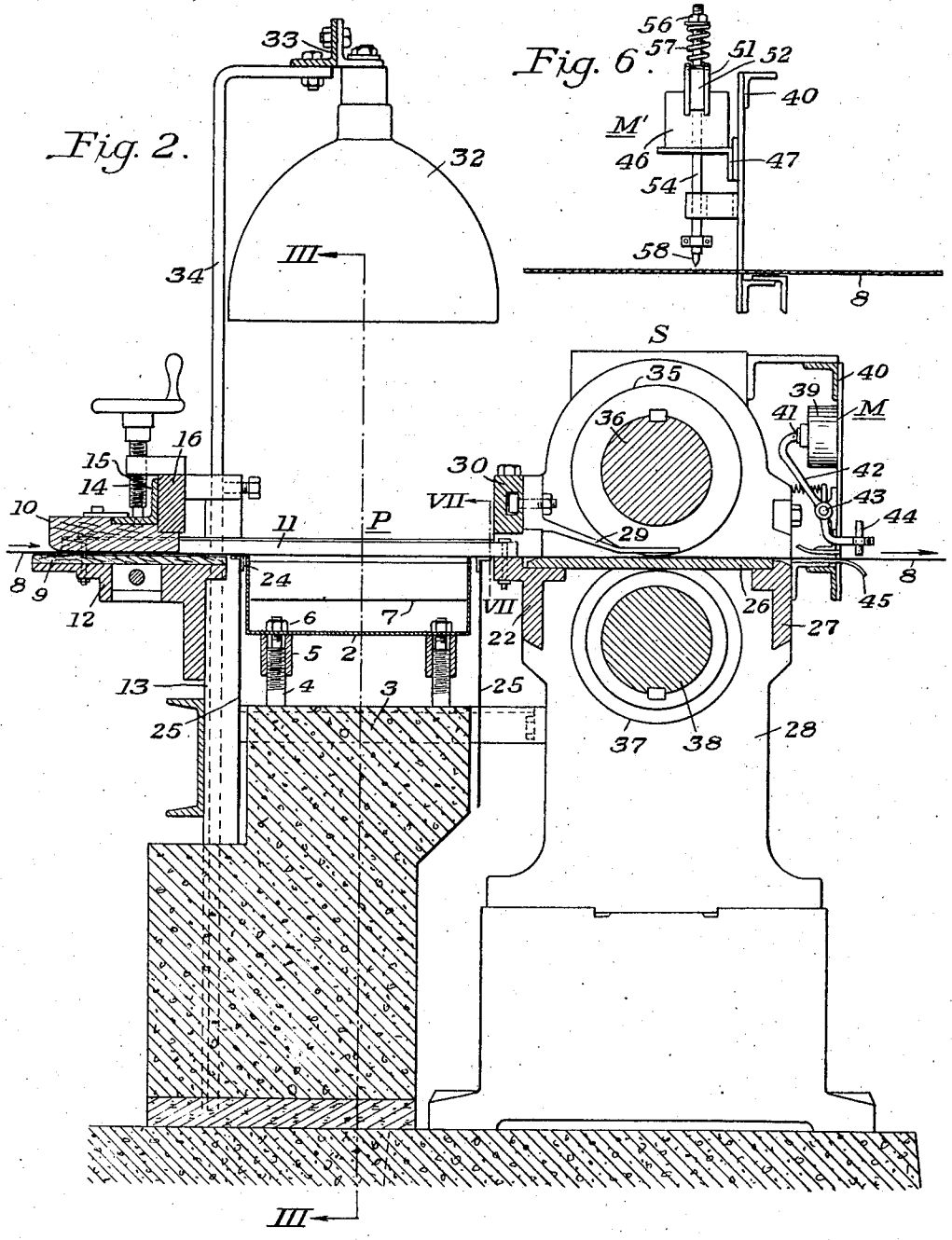


Fig. 6.

INVENTORS
Clarence J. Klein
Ernest W. Rieger
Allan W. Duncan
by their attorneys
Stebbins, Blenko & Parmelee

Feb. 22, 1944. C. J. KLEIN ET AL 2,342,474

METHOD OF AND APPARATUS FOR INSPECTING STRIP MATERIAL

Filed Aug. 24, 1938 4 Sheets-Sheet 3

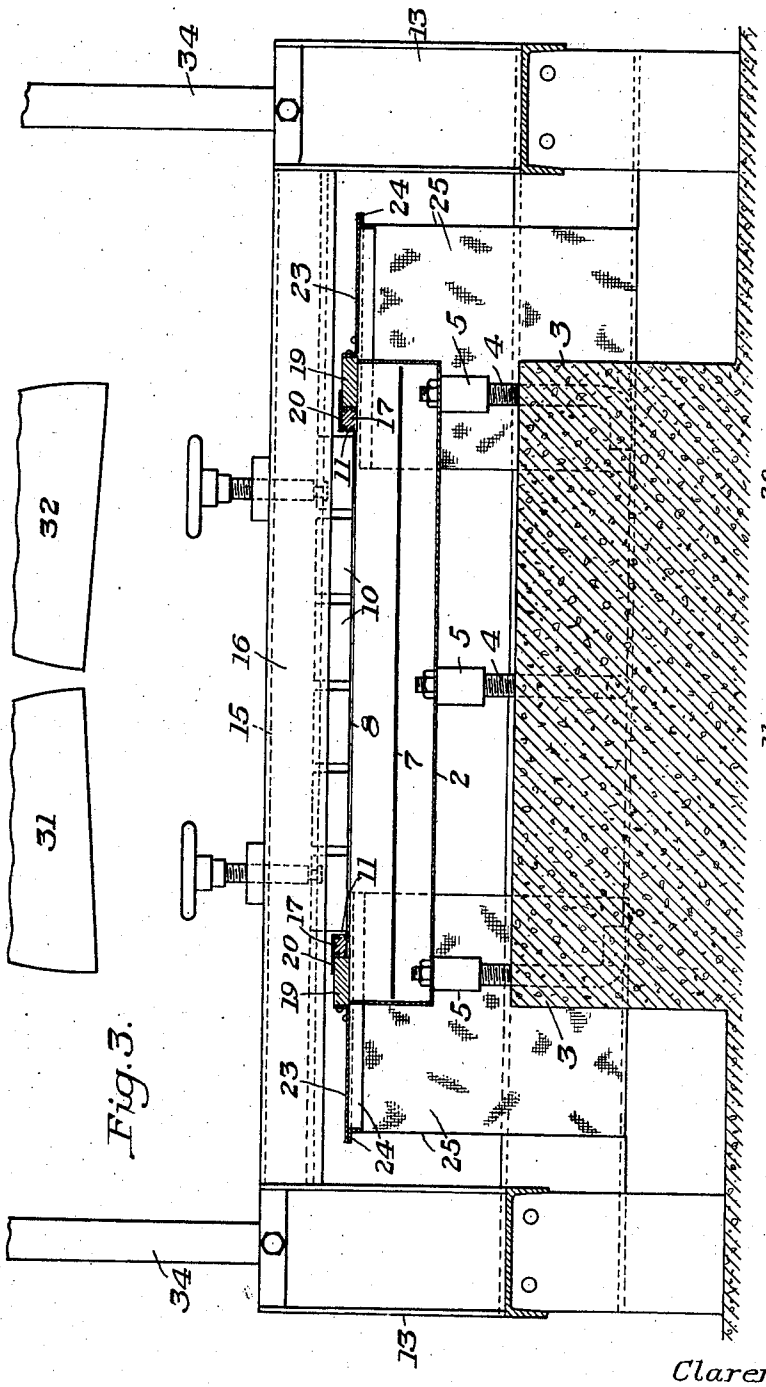


Fig. 3.

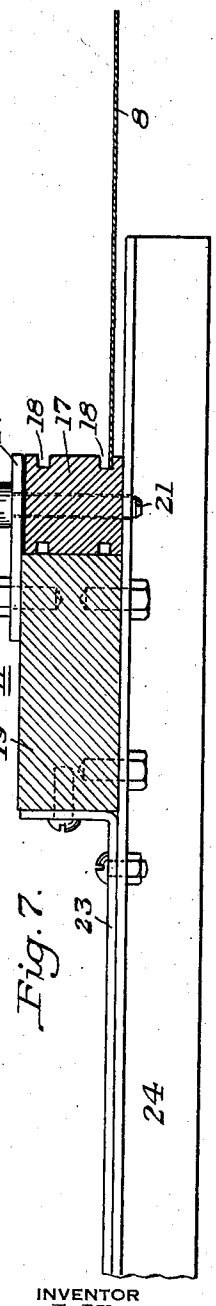


Fig. 7.

INVENTOR
Clarence J. Klein
Ernest W. Rieger
Allan W. Duncan
by their attorneys
Stebbins, Blenko & Parmelee

Feb. 22, 1944. C. J. KLEIN ET AL 2,342,474

METHOD OF AND APPARATUS FOR INSPECTING STRIP MATERIAL

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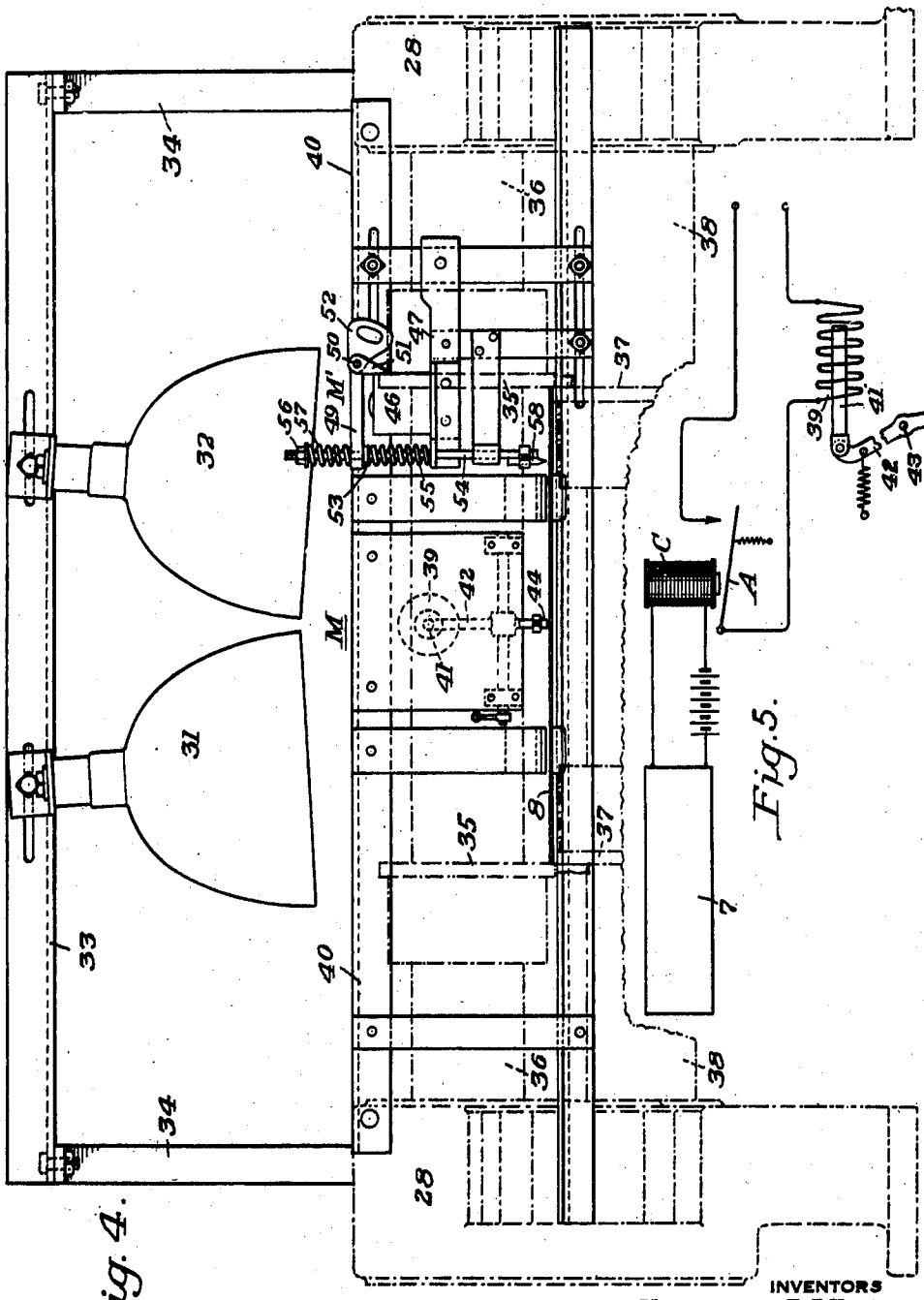


Fig. 4.

Fig. 5.

INVENTORS
Clarence J. Klein
Ernest W. Rieger
Allan W. Duncan
by their attorneys
Stebbins, Blenko & Bumela

Patented Feb. 22, 1944 2,342,474

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2,342,474

METHOD OF AND APPARATUS FOR INSPECTING STRIP MATERIAL

Clarence J. Klein, Hollidays Cove, W. Va., and Ernest W. Rieger, Bloomingdale, and Allan W. Duncan, Steubenville, Ohio, assignors to Bethlehem Steel Company, a corporation of Pennsylvania

Application August 24, 1938, Serial No. 226,502

7 Claims. (Cl. 164—61)

Our invention relates in general to a method of and apparatus for inspecting strip material, and it is particularly applicable for inspecting metal in strip form for holes which may appear therein, but it may also be used for inspecting other material in strip form. Inasmuch as it is of great value in inspecting strip metal, it will be described with reference thereto, it being understood, however, that this is not the only application of our invention.

In forming material, for example strip metal to be used for tin plate, it is the common practice to roll the metal in long strips on a hot mill of the four-high type to a thickness usually above .05". The hot rolled strip is then pickled, washed and cleaned, and is then cold rolled on a four-high mill to the desired thickness and wound into coils or reels as it leaves the mill. This cold rolled material is passed from the reels through a cleaning and cutting line where the side edges are trimmed to the desired width and the sheets cut to length and stacked. Subsequently the stacked sheets are annealed and after cleaning, the annealed sheets may be sold as black sheets or the sheets may be coated with another metal such as lead to form terne plate or with tin to form tin plate. Other operations than those described may be performed on the sheets before they are tin plated or otherwise coated.

During the processes of rolling, despite the elaborate precautions that are taken in the processes, holes sometimes appear in the strip at irregular intervals. These holes are frequently small in size and are not readily discernible with the naked eye unless the sheet is held up to the light. If the sheets containing holes are not detected, and are later used in the fabrication of fluid tight containers, the container will have to be discarded, if the holes are then found, because a very minute hole will cause deterioration and spoilage of the contents. If the hole is not found the contents of the container will more or less be affected by air and content leakage, and loss will result. It is apparent that a first class merchantable sheet to be used for fluid containers should be free from holes.

To insure that all holes in the sheet are detected, we have developed a photo-electric eye apparatus and method for using the same. This apparatus and method can be employed at any desired place in the sheet manufacturing process and preferably in the cleaning and cutting line while the material remains in strip form. Any hole in the strip will be detected instantly and a mark made on the strip so as to indicate the length of the strip wherein the hole appears. This is done while the strip is passing through the apparatus at a high rate of speed usually in excess of 600 feet per minute or more. The mark placed on the material is readily discernible to the inspector and the sheet on which it appears is discarded or used for purposes where holes therein are not disadvantageous.

In the drawings there is shown apparatus suitable for carrying out our invention interposed in a cleaning and cutting up strip line. The apparatus consists in general of a photo-electric scanning device and marking apparatus, the operation of which is controlled by the scanning device. The strip to be inspected is passed between a light source and a photo-electric cell and if a hole is present the cell is energized by the light passing therethrough to initiate and control the operation of a marking device, so situated as to place a visible mark on the sheet in approximately the same transverse plane as that in which the hole appears. The edges of rolled strip are irregular and must be trimmed. It is also essential that no light be allowed to leak past the irregular edges to the cell. We therefore pass the edges of the strip through opaque screening guides which take care of irregular edged strip and prevent leakage of light to the cell. After passing through the guides the portions protected by the guides are cut off by regular edge trimmers associated with the apparatus. The marker may be positioned between the cell and the edge shears or beyond the edge shears, depending on the operating characteristics of the cell and the marker.

By means of our invention the detection of holes in the strip material of sufficient size to permit a beam of light to pass therethrough is positive and accurate. The apparatus is quite inexpensive, has low operating and low maintenance costs and can be readily positioned at practically any desired place in the processing of the strip material.

In the drawings in which we have shown for illustration only the present preferred embodiment of our invention;

Figure 1 represents a top plan view of suitable apparatus,

Figure 2 is a view in elevation, partly in section, along the line II—II of Figure 1,

Figure 3 is a view in section along the line III—III of Figure 2,

Figure 4 is a view in elevation from the right of and looking toward Figure 1,

Figure 5 is a diagram of the electric control circuit,

Figure 6 is a detail in elevation of a suitable marking device, and

Figure 7 is a detail in section along the line VII—VII of Figure 2.

In the drawings there is shown a photo-electric scanning device P, edge shears S, and a marking device M.

The scanning device P consists of a photo-electric cell holder 2 which is supported on a concrete base 3 by bolts 4. The studs 4 have thereon an interiorly threaded sleeve 5 and a nut 6. The cell holder 2 may be adjusted vertically by manipulating the sleeve 5 and the nut 6. Inside the cell holder 2 a photo-electric cell 7 is mounted.

The strip 8 is guided to and through the scanning apparatus by lower entry guides 9, upper entry guides 10 and edge guides 11. The lower guide 9 is made up of blocks which are assembled in spaced apart parallel relationship and each is fastened to a transverse support 12 which in turn is secured to the framework 13. The top of the lower guide 9 is at the pass line of the strip 8. The top of the cell holder 2 and the top of the photo-electric cell 7 are just below the pass line. The upper guide 10 is made up of blocks which are assembled in spaced apart parallel relationship fastened to an angle 15. The angle 15 is adjustably supported on screw shafts threaded through nuts secured to a transverse supporting member 16 which is connected to the framework 13. By means of hand wheels on the screw shafts 14, the guide 10 may be adjusted to a desired position immediately above the guide 9 moved away from the lower guide 9 when it is desired to thread the strip through the apparatus. The blocks comprising guides 9 and 10 are made of soft metal or of wood so as not to mark the strip, and the blocks are separately removable so that various widths of strip may be accommodated.

Strip material as rolled has irregular edge portions which are trimmed off at some point in the processing of the strip, and we have taken advantage of this fact to prevent light from passing between the edge guides 11 and the edges of the strip 8. Such light would affect the photo-electric cell 7 even though the strip were free from holes. The edge guide 11, see particularly Figure 7, is made up of an edge portion 17 which has grooves 18 therein. These grooves are deep enough to take care of the irregularity of the edge of the sheet. The edge piece 17 is secured to a cross bar 19 by means of a plate 20. A pin 21 passes through the plate 20 and through the edge piece 17 and holds the edge piece in position. The grooves 18 are so arranged that either of the four grooves shown can readily be presented to the edge of the strip by proper reversal of the portion 17. This arrangement prolongs the life of the edge portions. The cross bar 19 is secured to supporting member 12 and to supporting member 22 by bolts which are received in slots in the supporting member 12 and a similar member 22. This allows the edge guides 11 to be adjusted so as to take care of various widths of sheets. The edge portions 17 of the guides 11 may be conveniently made of brass or metal, which will not injure the strip or wear too rapidly, and they are spaced apart so that the minimum distance between them is the same as the width of the finished sheet after the edges have been trimmed. A cover plate 23 with a turned up edge is fastened to the cross bar 19 and closely fitted against the top of the photo-electric cell holder 2. The plate 23 has angle members 24 fastened along its sides and ends. A light proof canvas curtain 25 is attached to the angles 24 and extends toward the center line of the photo-electric cell holder 2 and interiorly of both the guides 11 as shown in Figure 3. The top of the canvas curtain 25 extends up to the pass line.

At the right hand side of the cell holder 2 as viewed in Figure 2, there is arranged an exit supporting bed 26 which is made up of individual blocks of metal or wood, arranged parallel to one another and to the center line of the strip 8. The ends of the bed or guide 26 are supported on the cross bar 22 and on a cross bar 27. The bars 22 and 27 are in turn secured to the housing 28 of the edge shear S. A number of upper guide pieces 29 are secured to a cross bar 30 which bar is in turn secured to the supporting member 22. These pieces are formed of a material which will not mark the strip and they extend downwardly toward the strip 8 and then parallel to it to a position a little beyond the center line of the edge shear S. The bed 26 and the upper guide pieces 29 are made in separate removable sections so that by removing or inserting sections various widths of sheets may be accommodated.

Two light reflectors 31 and 32 are secured to a cross bar 33 which in turn is secured to adjustable uprights 34. The light reflectors are positioned so that the rays of light from the lamps contained therein will be projected directly on the top of the photo-electric cell 7, or on the top of the strip 8 directly thereabove.

The edge shears S include a pair of cutting discs 35 secured on a shaft 36. The cutting discs 35 are arranged in shearing relationship to similar cutting discs 37 which are keyed to a shaft 38 which is positioned directly below the shaft 36. These cutters are of a well-known type and are adjustable to accommodate various widths of sheets. The ends of the shafts 36 and 38 are journalled in the housings 28, which housings are in turn secured to the framework of the scanning device P.

The marking device M shown in Figures 2, 4 and 5, consists of a solenoid 39 mounted in a desired position on a support 40 which in turn is secured to the housings 28 of the shear S. The core 41 of the solenoid is pivotally secured at one end to a lever 42 which is pivoted at 43. The other end of the lever has attached to it a marker 44 which is here shown as a piece of crayon. If desired, instead of a crayon a cutting or scratching tool could be used. In fact, we prefer to use a cutting tool since a crayon may injuriously mark the sheet immediately thereabove during the annealing process, if the sheets are subsequently annealed. Upon energization of the solenoid 39 the crayon 44 (or marking tool) will be forced down on the strip 8 and will mark it. A support 45 is provided for the strip in the vicinity of the marking tool. When the solenoid 39 is energized by an electric current controlled by the photo-electric cell 7, the lever 42 is operated to cause the marker 44 to contact and mark the strip 8.

Instead of using a solenoid to actuate the marking device M, an arrangement using an electro-magnet can be employed. It is, of course, understood that the marking device whether of the solenoid or of the electro-magnetic type or of any other type, can be located at any part

of the width of the strip. We have shown the solenoid 39 as being located at the center of the strip, whereas the marking device of the electro-magnetic type is placed near one edge of the sheet. A suitable marker device M' of the electro-magnetic type is illustrated in Figures 4 (right hand) and 6. The device consists of an electro magnet 46 secured to supports 47 which in turn are adjustably connected by means of the framework 40 to the housings 28 of the edge shear S. An armature 49 is pivoted at 50 to the supporting framework 40. The armature has depending lugs 51 which contact the side of the magnet housing to limit the upstroke of the armature and a handle 52 whereby the armature can be moved manually. One end of the armature 49 rests on a nut 53 which is attached to a pusher bar 54. Around the pusher bar 54 and between the nut 53 and the support 47, a coil spring 55 is placed, and between the armature 49 and a nut 56 at the top of the pusher bar 54, a coil spring 57 is placed. To the lower end of the pusher bar 54, a marking tool such as a cutting tool 58 is secured. When the magnet 46 is energized the cutting tool 58 marks the strip 8 which is passing thereunder. Such a mark is indicated as 58a.

It is apparent that the marking device, whether of the solenoid type first described or of the electro magnet type last described, can be placed before or behind the edge shears S or at any other convenient place in the line. Both the marking devices are here shown as behind the edge shears S. The positioning of the markers depends on the operating characteristics of the marking device and the speed of travel of the strip. The spacing of the marker from the photo-electric cell 7 must be sufficient so that with a given speed of operation of the marking device and travel of the strip, a mark will be placed on the strip at a position in the transverse plane of the hole which has caused the scanning device to operate.

The electrical hook-up of the photo-electric cell P and the marking device M is shown in Figure 5. The photo-electric cell 7 is connected to the magnetic coil C. A change in the electric output of the photo-electric cell 7, caused by an impingement thereon of a ray of light from the source of illumination (lights 31 and 32), is sufficient to energize the coil C and attract the armature A which closes an electric circuit through the coil of the marking device M. This will cause the crayon (or marking tool) to be forced against the sheet. When the light ray to the cell 7 is shut off, the coil C is deenergized sufficiently to release the armature A and thus cut off the current to the marking device M whereon the crayon (or marking tool) is lifted from the sheet.

The apparatus has been described as applied to a cleaning and cutting up line. In such an arrangement, a strip of material is fed through the apparatus from left to right (see Figures 1 and 2) by the action of rolls not here shown, and which form no part of our invention. It is apparent that the apparatus could be placed in some other location through which the strip is passed.

While the strip is passing through the scanning device P is free from holes, no ray of light can pass from the light reflectors 31 and 32 to the photo-electric cell 7. If the strip 8 has a hole or holes therein between the edges of the guides 11, light will pass therethrough and affect the photo-electric cell 7. The marking device which is electrically connected to the cell 7, will then be operated to mark the strip. As all electro magnets with which we are familiar have a time lag, it is necessary that the marking device M be placed at a distance from the cell along the line of passage of the strip, so that the mark when made on the strip will be in the same transverse plane as the hole. The unscanned edges of the sheet protected by the opaque guides are trimmed off. The marked sheet when cut and annealed can be readily detected by an inspector and discarded.

While we have illustrated and described certain preferred embodiments of our invention, it will be understood that the invention is not limited thereto, and that various changes in the shape, size, number and arrangement of parts may be resorted to without departing from the spirit of our invention or the scope of the following claims.

We claim:

1. The method of continuously handling strip material which comprises moving the material between a light source and a photo-electric cell coextensive with the width of the material which it is desired to inspect with the edge portions of the strip in overlapping relation to opaque guides whereby the cell may be energized only by light projecting through a perforation in the portion of the strip located between the guides, and thereafter trimming the edges which overlapped the opaque guides while the strip is still in alignment with the guides.

2. Apparatus of the class described comprising in combination, means for projecting light against one face of the strip material to be trimmed across the full width of the strip, opaque guides at the point of illumination of the material overlapping the edges of the material, means adjacent the opposite face of the strip responsive to any light which may pass through the material, means located beyond the light-projecting means and in alignment with the guides for shearing the screened edges of the strip while the strip is moving and signalling means operated by the light responsive means for indicating the presence of a defect in the strip between the guides.

3. Apparatus of the class described in which strip material is inspected as it moves through the apparatus comprising in combination means for shearing the edges of the strip, means in advance of the edge shear for projecting light against one face of the strip material to be trimmed across its full width, means adjacent the opposite face of the strip responsive to any light which may pass through a perforation in the material, light screens at the point of illumination of the material interposed between the light source and the light responsive means for overlapping and screening the edges to be sheared, said edge shearing means being disposed beyond the projecting means and arranged so as to cut off the screened edge portions of the strip, and means succeeding the shear operated by the light responsive means and so positioned as to mark the unscreened material in the vicinity of the perforation after it has passed through the edge shear.

4. Apparatus of the class described in which strip material is inspected as it is being moved from one point to another, comprising photo-electric scanning means for detecting holes in the material in only that portion which extends from the center toward the edges a distance less than the full width of the strip as it moves between said points, means the operation of which is initiated by the operation of the scanning means for marking the strip in the vicinity in which holes

occur and means succeeding the scanning means and in alignment with the scanned portions of the strip for edge trimming the unscanned edge portions of the strip.

5. Apparatus of the class described in which strip material is inspected while being moved from one point to another, comprising a source of illumination located between said points, a photoelectric cell located at the same point but on the opposite side of the strip to the source of the illumination, and means in which the edges of the strip are received for screening the edges of the strip interposed between the source of illumination and the photo-electric cell, said means comprising edge guides extending parallel to the center line of the strip and having grooves extending into the guides in which the edges of the strip are received.

6. Apparatus of the class described in which strip material of irregular width is inspected while being moved from one point to another, scanning means including a source of illumination located between said points and a photoelectric cell located at the same point but on the side of the strip opposite to the source of the illumination, means for overlapping and screening the edges of the strip interposed between the source of illumination and the photoelectric cell, said means comprising edge guides extending parallel to the center line of the strip and having grooves extending into the guides in which the edges of the strip are received, an adjustable shear positioned closely adjacent and beyond the scanning means for cutting off the unscanned edges of the strip, an adjustable bed composed of strips of material softer than the strip material to be inspected over which the strip is moved as it passes from the scanning means, and adjustable guide means spaced above the bed and above the path of the strip and extending from a position adjacent the photoelectric cell to the point of engagement of the strip and shear.

7. Apparatus of the class described in which strip material having portions of irregular width is inspected while the material is being moved from one point to another, comprising photo-electric scanning means for detecting holes in a desired cross section of the material extending from the center line of the strip outwardly to a point short of the edges of the strip as it moves between said points, means overlapping and screening the edges of the strip as they pass the scanning means, means controlled by the scanning means for marking the cross section of the strip in which holes occur and means adjacent and beyond the screening means and in alignment therewith for shearing the screened edges of the strip.

CLARENCE J. KLEIN.
ERNEST W. RIEGER.
ALLAN W. DUNCAN.