June 30, 1959 G. B. LINDERMAN 2,892,951

DETECTING APPARATUS

Filed July 11, 1956

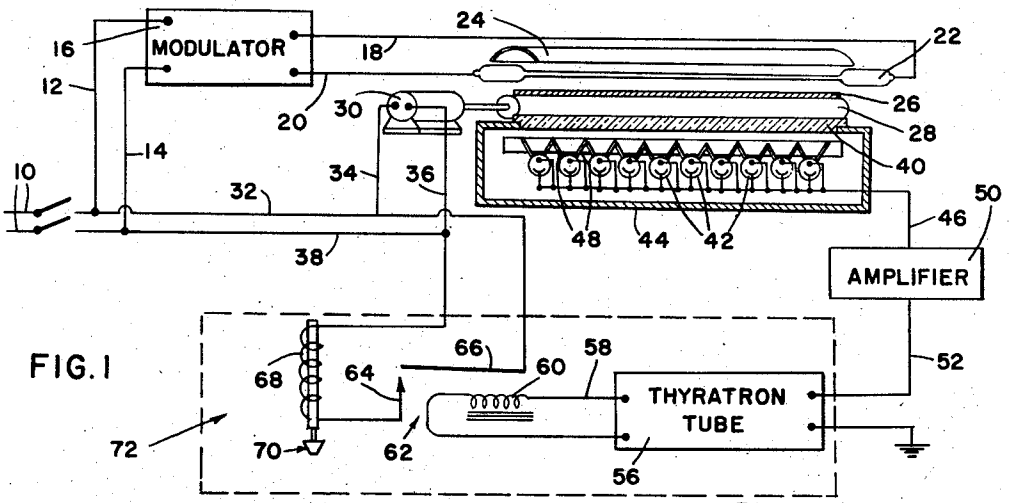


FIG. 1

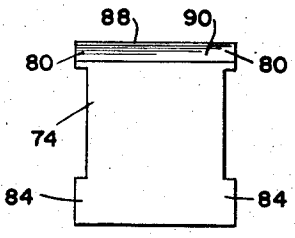


FIG. 4

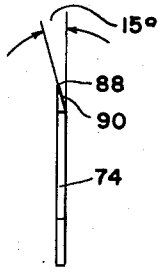


FIG. 5

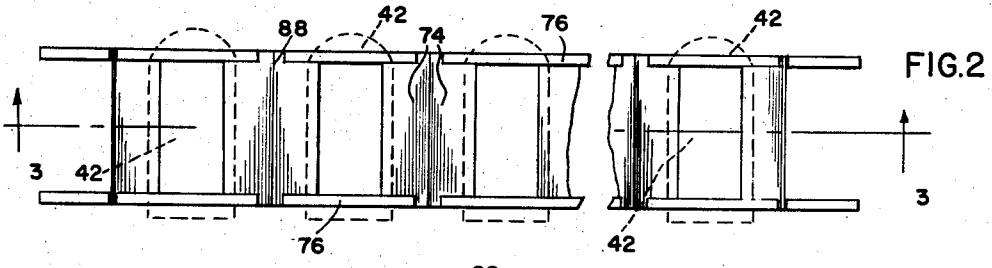


FIG. 2

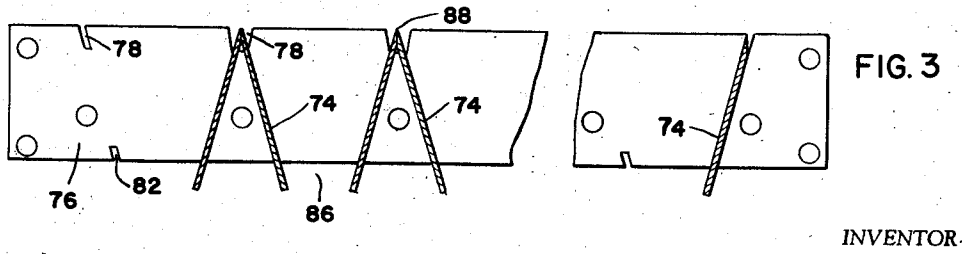


FIG. 3

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United States Patent Office 2,892,951 Patented June 30, 1959

2,892,951

DETECTING APPARATUS

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Application July 11, 1956, Serial No. 597,268

7 Claims. (Cl. 250—220)

This invention relates to apparatus for detecting light transmission through material traversing a predetermined path and is particularly intended for the detection of pin holes in sheet material, such as tin plate. One of the difficulties encountered with existing equipment involves the loss of the light intended to produce a response to the presence of a pin hole. When collimated light is employed in such apparatus, the occurrence of a pin hole at any substantial angle to the vertical will not be detected and the imperfect portion of the tin plate or material will not be marked or discarded.

Moreover, because of its lack of sensitivity, most conventional apparatus has been limited in its operation to a tin plate speed of below approximately 50 feet per minute.

It is among the objects of this invention to overcome these difficulties by using convergent reflecting means in conjunction with a light source and photosensitive means. Moreover, by using ultra violet light and appropriate filters to exclude light of other wave lengths, stray light from other sources will no longer present a problem.

In accordance with the present invention, the optical path preferably excludes lenses so that uncollimated light from the source will be transmitted through any pin holes which may exist, independent of their orientation, and then to the reflecting means and photosensitive means.

The apparatus of the present invention comprises a light source, photosensitive means responsive to light from the source, the source and responsive means being disposed on opposite sides of the path of the material under observation, amplifying means having an input circuit connected with the responsive means and an output circuit for energizing an actuator in response to light transmission through the material, and reflecting means convergent towards said photosensitive means interposed between said path and said photosensitive means. The reflecting means preferably comprises a plurality of plane surfaces. An optical filter is preferably interposed between the path of the material under observation and the reflecting means to exclude light of undesired wave lengths. The light source preferably produces ultra violet light which is readily passed by the optical filter and to which the light responsive means and associated amplifier will be sensitive. The actuator preferably includes a relay, which may be of the thyratron type, for actuating the usual marking device and/or gate for separating imperfect material from that which is satisfactory. The photosensitive means preferably includes a plurality of interconnected photomultiplier tubes each provided with one of the converging reflecting means.

The pin hole detecting apparatus is combined with means for feeding the tin plate along its predetermined path so that the operation will be properly synchronized.

A more complete understanding of the invention will follow a description of the accompanying drawings wherein:

Fig. 1 is a somewhat diagrammatic showing of a circuit embodying the present invention;

Fig. 2 is a fragmentary plan view of a reflector assembly;

Fig. 3 is a section along line 3—3 of Fig. 2 with some of the reflectors removed;

Fig. 4 is a front elevation of a reflector; and

Fig. 5 is an end elevation of a reflector.

A supply circuit comprising an alternating current source **10** is connected by leads **12** and **14** with a modulator **16** wherein modulations at an elevated frequency usually exceeding 2000 cycles per second, and preferably above 3000 cycles per second, are produced and delivered through leads **18** and **20** to a mercury lamp **22** serving as a source of ultra violet light. To facilitate starting, the lamp may contain neon in association with the mercury. Inasmuch as there are two light pulses for each cycle, if the frequency delivered by the modulator is 4000 cycles for example, the light pulses will be produced at the rate of 8000 pulses per second. A reflector **24** is provided for the lamp so as to redirect stray light downwardly towards the tin plate or other material **26** under observation. This material is fed in the usual manner as depicted for example in the disclosure of the patent to Rendel, 2,576,043, dated November 20, 1951. For simplicity of illustration, a feed roll **28** has been depicted in the attached drawing as driven by a motor **30** energized through leads **32**, **34**, **36** and **38** from the source **10**, as in copending application Serial No. 305,007, now Patent No. 2,758,712, filed August 18, 1952, of which this is a continuation-in-part.

Arranged below the tin plate or other material under observation, an optical filter **40** is provided to exclude any light whose wave length varies appreciably from that of the source **22** operating at its predetermined modulated frequency. Below the filter **40**, photo-multiplier tubes **42** are arranged in a bank within a housing **44** and connected in parallel by means of a cable **46** containing suitable conductors, to the input of an amplifier **50** which is sharply tuned to the rate of the light pulses produced by the source **22** and its modulator **16**. The output of this amplifier is connected through leads carried by a cable **52** with a thyratron tube or relay **56** whose output is in turn connected through a lead **58** to the winding **60** of a relay **62** whose fixed and movable contacts **64** and **66** respectively, are connected with the source **10** through leads **32** and **38** in series with a winding **68** of a marking device **70**. The thyratron **56**, relay **62** and marking device **70** have been considered to constitute an actuator **72**, which of course could eliminate some of these parts and substitute others. For example, as indicated in the Rendel patent to which reference has already been made, a gate or deflector might be employed with or in lieu of a marking device.

Moreover, timing mechanisms and other instrumentalities such as those depicted and described by Rendel are contemplated for association with the components illustrated here in diagrammatic form.

Interposed between the path of the material **26** undergoing observation and the photomultiplier tubes **42**, reflecting means **48** are mounted providing reflecting surfaces converging towards the photomultiplier tubes so as to direct substantially all of the light passing through the material under observation to the photomultiplier tubes with a minimum of loss.

The individual reflectors **74**, as shown in Figs. 2 to 5 inclusive, are of substantially "I" configuration in elevation as shown in Fig. 4 and have their surfaces directed towards the light source in divergent relationship as shown in Fig. 3, adjacent reflectors being disposed at an included angle of approximately 30°.

The reflectors are mounted in a pair of notched strips **76**, the upper notches **78** receiving the overhanging flanges **80** and the lower notches **82** receiving the lower over-

hanging flanges 84. Each reflector 74 constituting a pair converges towards its photomultiplier tube 42, as shown in Fig. 2, to provide a gap 86 through which collected and reflected light will be transmitted to such tube. Adjacent reflectors of successive pairs meet in substantially a linear edge 88 resulting from the beveled portions 90 formed on their upper flanges 80. Under these circumstances, there will be substantially no light reflected back towards the source from the reflectors, but instead, all of such light will be transmitted to the photo-multiplier tubes for which it is intended.

Whereas only one specific form of the invention has been illustrated in the drawings, those skilled in the art will recognize the many variations and applications which have already occurred to the present inventor. Accordingly, the scope of this invention should not be restricted to the illustrated example beyond the scope of the appended claims.

I claim:

1. Apparatus for detecting light transmission through material traversing a predetermined path comprising a light source, a row of photosensitive devices responsive to light from said source, said source and devices being disposed on opposite sides of said path, amplifying means having an input circuit connected with said devices and an output circuit for energizing an actuator in response to light transmission through said material, and reflecting means providing a pair of reflecting surfaces between each pair of said devices, the reflecting means being interposed between said path and said devices, and said surfaces of each pair diverging substantially from a line towards adjacent ones of said devices respectively.

2. Apparatus as set forth in claim 1 wherein said reflecting means comprises a plurality of substantially plane surfaces.

3. Apparatus as set forth in claim 1 wherein said photosensitive devices are interconnected photomultiplier tubes.

4. Apparatus as set forth in claim 1 wherein an optical filter is interposed between said path and said reflecting means.

5. Apparatus as set forth in claim 1 wherein said light source produces ultra violet light.

6. Apparatus as set forth in claim 1 wherein uncollimated light rays from said source are transmitted to said reflecting means.

7. Apparatus for detecting light transmission through material traversing a predetermined path comprising a light source, a row of photosensitive devices responsive to light from said source, said source and devices being disposed on opposite sides of said path, modulating means controlling said source to produce pulsations of light at a predetermined frequency, amplifying means sharply tuned to said frequency, said amplifying means having an input circuit connected with said devices and an output circuit for energizing an actuator in response to light transmission through said material, and reflecting means diverging substantially from a line interposed between said path and said devices towards adjacent ones of said devices respectively.

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