May 26, 1959 H. A. TOULMIN, JR 2,888,570

APPARATUS FOR CONTROLLING MACHINES AND PROCESSES

Filed April 26, 1955

FIG. 1

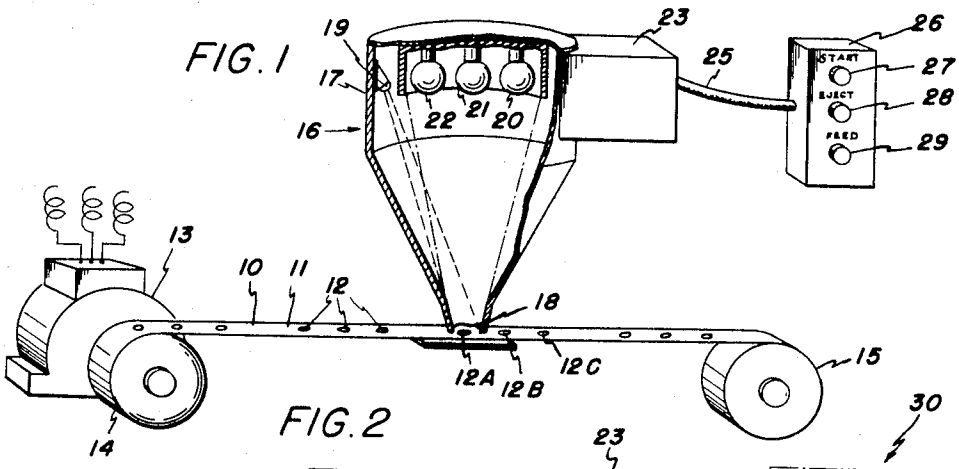


FIG. 2

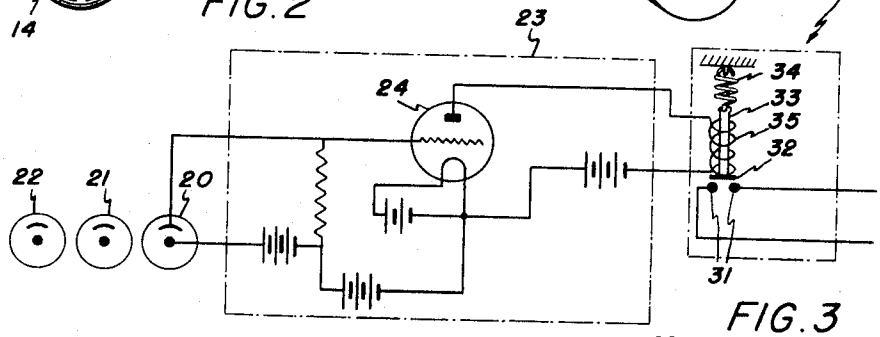


FIG. 3

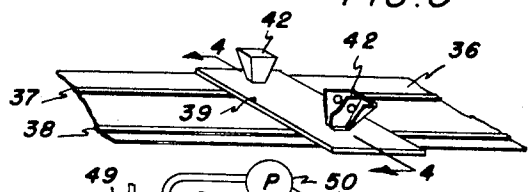
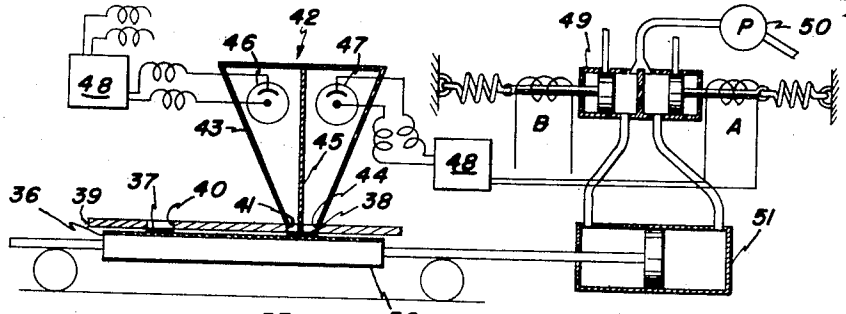


FIG. 4



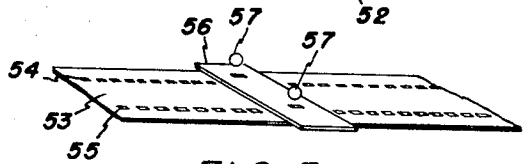


FIG. 5

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APPARATUS FOR CONTROLLING MACHINES AND PROCESSES

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The present invention relates to the control system, more particularly to a method and apparatus for regulating various industrial processes and the like through the use of control tapes.

Since the inception of the machine age, industry has sought methods of automatically operating the various machinery employed. These methods have taken many forms. The basic objective of these methods is the elimination of the human element in controlling the operation of the machine. By elimination of the human element, the cost of operation may be reduced and accuracy of the processes may be increased. Today the automatic operation of industrial machinery is termed "automation."

In the past, use has been made of perforated paper tapes which are adapted to cooperate with a suitable sensing apparatus. The perforations in the tape through the agency of the sensing apparatus serve to initiate and cease various operations of machinery. Fingers which were received into the perforations or light passing through the perforations are examples of some of the sensing means employed.

While use of perforated tapes was economical, it was apparent that certain disadvantages were also connected therewith. Chief among these disadvantages was the fact that the paper was prone to tearing at the perforations. This resulted in inaccuracies and shutdowns of machinery to enable the tape to be repaired.

In addition, the paper tape was susceptible to expansion and contraction. This, in turn, varied the relationship between the various perforations and gave rise to inaccurate regulation of industrial processes. In machine operations and the like the inaccuracies introduced by the expansion and contraction of the paper tape resulted in a high rejection rate of the articles being machined.

Other control devices such as perforated cards, chains used primarily in the operation of looms, and cams of various kinds were also employed. While the use of each of these control means was adequate, they were not generally considered to be satisfactory.

The present invention proposes the use of a novel and improved form of a control tape. This control tape has various advantages as compared with the prior art control means, and also tends to eliminate some of the disadvantages associated with perforated paper tapes and the like.

In the present invention the control tape essentially comprises an inextensible opaque strip which has colored luminescent control areas upon a surface thereof. Sensing means comprising light responsive elements are energized by the colored luminescent control areas. A light responsive means for each of the colors of the control areas is provided.

The light responsive means, in turn, are connected to suitable control circuits. Each of the circuits is connected to operate a process or operation of an industrial machine or the like. Each of the color control areas corresponds to a predetermined process to be carried out by the machine involved. The control areas may be of various sizes and shapes and, if desired, two or more control areas may be sensed by the sensing apparatus simultaneously to initiate concurrent operations.

By employing colored luminescent areas several advantages are immediately apparent. Since there is no physical contact between the control tape and the sensing means, the control tape of this invention will have a longer life with resultant lower maintenance costs. In addition, the absence of any perforation or disfiguration will result in a stronger and more accurate tape.

The basic teaching of this invention may be applied to other industrial processes. Among these is maintaining a moving belt or the like in lateral alignment. Also, counting on speed regulation of a moving belt through the use of luminescent control areas thereon is also disclosed in this invention. In all these situations the absence of physical contact between the control tape and the moving belt with the sensing apparatus results in lower maintenance costs and more accurate results.

It is, therefore, the principal object of this invention to provide a novel and improved method and apparatus for controlling industrial processes and the like.

It is another object of this invention to provide unperforated control tapes.

It is a further object of this invention to provide an improved control tape especially adapted to actuate electronic tubes.

It is an additional object of this invention to provide an inextensible control tape capable of accurate and dependable operation.

It is still another object of this invention to provide a control system wherein colors are employed to regulate industrial processes and the like.

Other objects and advantages of this invention will become readily apparent upon reference to the following description when taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a perspective view of the control tape and sensing apparatus of this invention with a portion of the sensing apparatus removed to show the details thereof;

Figure 2 is a circuit diagram of the amplifying circuit employed between the light responsive elements and the control circuit;

Figure 3 is a perspective view of structure employed to maintain a moving belt in lateral alignment;

Figure 4 is a sectional view along the lines 4—4 of Figure 3; and

Figure 5 is a perspective view of an arrangement for measuring or regulating the speed of a moving belt.

Proceeding now to the drawings, more particularly to Figure 1, wherein like reference symbols indicate the same parts throughout the various views, **10** indicates a control tape constructed in accordance with the teachings of this invention. The control tape **10** is in the form of a ribbon or strip. The tape is opaque and inextensible. By way of example, the tape may be constructed of a thin metallic ribbon such as aluminum, of a suitable plastic, or of a nylon construction. There exist other suitable materials which would result in an opaque and inextensible tape.

The control tape may be of the type which is wound about a reel or it may be of the endless belt type. In the event that the number of operations which is desired to be regulated is small, the endless belt type would be preferable.

The control tape has an upper surface **11** upon which is arranged a plurality of control areas **12**. Each of the

control areas comprises a colored luminescent material. The luminescent material should be of the type which will glow in either daylight or artificial light.

In order to form a control area a suitable dye or pigment may be positioned on the upper surface 11 of the control tape in the desired shape of the control area. The coloring matter may be organic or inorganic in nature. The dyestuff of pigment should have the desired color characteristics, such as employing chrome yellow to result in a yellow color.

A layer of transparent material containing a fluorescent dye is then placed upon the dye or pigment. The transparent material may be made of a material such as glass or any clear phenol formaldehyde resin. The resulting control area will be the same color when viewed in either daylight or artificial light.

The dye which may be employed in the transparent layer is a suitable inorganic pigment. The most common pigments employed for this purpose today are the pertinent activated metal sulfites.

It is to be understood that the above described control area is by way of example and numerous other methods forming luminescent areas will be readily apparent to one skilled in the art.

Reference to Figure 1 will reveal that the color control areas are positioned in alignment upon a control belt. This, however, is not limiting of the pattern into which the control areas may be arranged. The control areas may be of various lengths and several areas may be placed abreast of each other in order to simultaneously initiate various operations.

An electric motor 13 drives a reel 14 upon which the control tape 10 is wound. The control tape is originally wound upon a reel 15 which is rotatably positioned in order to enable the control tape to be unwound therefrom.

The sensing apparatus is indicated at 16 and essentially comprises a casing 17 having an opening 18 at the lower end thereof and positioned immediately above the surface 11 of the control tape. A light source 19 is mounted within the casing. This light may be of the ultra-violet or daylight type.

A plurality of light responsive means 20, 21 and 22 are also positioned within the casing 17. The light responsive means 20 through 22 each comprises a photoelectric cell which is energized by a particular wave length of light. The number of cells within the casing corresponds to the number of colors of the control areas. Consequently, the wave length of light reflected by a particular control area will energize that photoelectric cell which has been previously selected so as to be responsive to that particular wave length.

Each of the light responsive means 20 to 22 is connected to a suitable amplifying circuit which is housed within the amplifier casing 23. The amplifying circuit is of the type comprising a suitable discharge device such as an electronic tube indicated at 24.

There is a control cable 25 leading from the amplifier casing 23 to a control box 26 of the machine which is to be operated. The control cable 25 houses the electric leads extending from the amplifier circuits.

In order to illustrate the application of this invention, the control box 26 is described as being mounted upon a conventional hydraulic press. The hydraulic press is of the type wherein movement of the platen is initiated by closing the starting circuit. At the completion of the downward working movement and the upward return movement of the platen, it is desired to eject the article within the press. Subsequently, a work blank must be fed into the press prior to the initiation of the work cycle. Consequently, three steps will be necessary in this operation—start, ejection and feed. A control box 26 contains push buttons 27, 28 and 29 which are connected to the various circuits for initiating the above three discussed processes. The push buttons are for manual operation of

the processes. In addition, there is an electrical contact arrangement, such as indicated at 30, in Figure 2, which closes the control circuit associated with each of the push buttons. This arrangement comprises a pair of stationary contacts 31, which are adapted to be closed by a movable contact 32. The movable contact 32 is mounted upon a reciprocable armature 33, which is biased by means of a spring 34 to maintain the stationary contacts 31 open. There is a coil 35 surrounding the armature 33. The coil 35 is a component of the start control circuit which is, in turn, connected to the amplifying circuit connected to the light responsive means 20.

Consequently, energization of the light responsive means 20 will result in energization of the coil 35. This, in turn, will cause a downward movement of the armature 33 and will result in closing the contacts 31. The closing of these contacts will initiate the work cycle of the press.

It is pointed out that while the normal position of the power contacts 31 is open, a control circuit could also be employed with the contacts in normal closed position and energization of the motor responsive means will result in opening of the contacts.

Each of the light responsive means 21 and 22 is similarly connected to an amplifying circuit to the corresponding push buttons 28 and 29.

With the structure of the control system in mind, the operation thereof will presently be described.

Movement of the control tape 10 will result in positioning the control area 12A, which is red in color, beneath the opening 18 of the sensing apparatus. As the light responsive means 20 had been previously selected to be responsive to the wave of light given off by the red areas, the light responsive means will be immediately energized. Closing of the circuit through the light responsive means 20 will result in the coil 35 being energized through the amplifier circuit. Closing the contacts 31 will initiate the start of the hydraulic press.

The movement of the control tape is regulated so as to position the next control area 12B, which is green in color, under the sensing apparatus, after a sufficient interval of time to prevent the completion of the work cycle of the press. The control area 12B will accordingly result in energization of the light responsive means 21. The light responsive means 21 will, in turn, through its amplifier system initiate the operation of the ejection mechanism to eject the article from the press.

Subsequent positioning of the control area 12C, blue in color, will result in operation of the feed mechanism to position a work blank within the press. This feeding operation will complete the cycle and the subsequent control area to be positioned beneath the sensing mechanism would be a red control area 12A.

The above described application of this invention is basic but simple since it involves only three operations. However, by employing a considerably greater number of colors on the control tape and a corresponding number of light responsive means within the sensing mechanism, the complexity and number of operations which may be regulated will be greatly increased.

Proceeding next to Figures 3 and 4, there is illustrated therein a method for maintaining a moving belt in alignment. The moving belt is indicated at 36 and may be cloth which is being fed into a textile printing machine. There are luminescent lines 37 and 38 positioned adjacent the edges of the belt 36. The luminescent lines are of a constant width. Positioned above the belt 36 is a plate 39 having slots 40 and 41 therein which register with the luminescent lines 37 and 38 respectively.

Positioned above each one of the slots 40 and 41 is a sensing mechanism 42. The sensing mechanism 42 comprises a casing 43 which has an opening 44 in the lower end thereof. The opening 44 is similar in size to the slots 40 and 41.

There is a dividing plate or barrier 45 longitudinally bisecting the slot 40 and extending upwardly to the

top of the casing **43**. There are light responsive cells **46** and **47** positioned upon each side of the barrier **45**. Each of the cells **46** and 47 is connected to a suitable amplifying circuit indicated at **48**, which is similar to the circuit illustrated at Figure 2, to a hydraulic valve **49**. The hydraulic valve **49** has a pair of plungers therein, each of which is operated by a coil which is energized by one of the light responsive means **46** and **47**. The hydraulic fluid is pumped from a source of fluid pressure **50** through the valve **49** to a hydraulic motor **51**, which is connected to a laterally movable roller **52** which supports the belt **36**. Movement of the hydraulic motor **51** will result in movement of the roller **52** and subsequent lateral positioning of the moving belt **56**.

The slotted plate **39** is closely spaced above the belt **36**. The edges of the luminescent lines **37** and **38** correspond with the edges of the slots **40** and **41** with which the lines are associated. Consequently, any lateral movement of the belt will result in a portion of the belt being exposed to slots **40** and **41**. Consequently, one of the light responsive means will be exposed to luminescent material upon one side of the barrier **45**. The other cell, however, will be exposed to only a portion of the luminescent stripe.

Should there be a lateral movement of the moving belt toward the left, the amount of light received by the cell **47** from the narrowed width of the exposed luminescent stripe will be insufficient to maintain energization of the cell **47**. This, in turn, will cause de-energization of the coil A associated with the hydraulic valve **49**. Consequently, pressure will be reduced on the right hand side of the piston and the hydraulic motor **51** which will cause movement of the piston toward the right. The roller and correspondingly the moving belt will be moved toward the right to bring the luminescent stripe in perfect registration with the slot **41**. When the line is in registration with the slot, cell **47** will then again receive sufficient light from the luminescent stripe to be energized and result in movement of the hydraulic valve to its neutral position to cease operation of the hydraulic motor. The same sequence is, of course, followed should the moving belt shift laterally toward the right.

Through the use of the above described sensing mechanism which comprises light responsive means, it can be seen that realignment of movement of the belt is virtually instantaneous. Consequently, the aligning structure disclosed in this invention is faster acting and more accurate than prior art mechanical aligning arrangements.

The aligning arrangement of this invention may be used to considerable advantage in the textile industry where it is desired to feed textile material in perfect alignment to the machine. This will insure proper positioning of the printed pattern upon the material which in turn, will considerably reduce the production of faulty printed cloth.

Proceeding to Figure 5, there is illustrated therein an arrangement for measuring or regulating the speed of a moving belt. In this arrangement the moving belt at **53** has dashed luminescent lines **54** and **55** adjacent the edges thereof. A slotted plate **56** which is similar to the plate **39**, illustrated in Figures 3 and 4, is spaced above the belt **53**. Light responsive means **57** are positioned above the plate **56** in registration with the slots thereof. The slots within the plate are similarly aligned with the luminescent lines **54** and **55**. If it is desired to use this arrangement for counting, the light responsive means **57** will, in turn, be connected to a suitable amplifying circuit to counting mechanism.

The periodic passage of the luminescent control areas of the lines **54** and **55** will successively energize the light responsive means **57**. Each energization will be recorded by the counting mechanism. By positioning the luminescent areas of the dash lines at predetermined intervals, it will be possible to determine precisely at any given instant the amount of material which has passed beneath the light responsive means **57**.

By connecting the light responsive means **57** to a suitable speed regulating mechanism, this arrangement may be used to closely regulate the speed at which the belt **53** is passed beneath the plate **56**.

Thus it can be seen that the present invention provides an improved apparatus and structure for controlling industrial processes and for regulating and measuring moving strip material. While the control tape has been described as being operated with industrial machinery, it is pointed out that many chemical processes can be readily controlled in this manner. In the textile industry, the operation of looms may also be controlled by control tapes having colored luminescent control areas thereon.

The use of colored luminescent control areas gives rise to a wider scope of control through the use of a narrow control tape. Not only is it possible to employ the basic colors, but various combinations of these colors which result in many shades may be employed to energize sensing mechanism.

The manufacture of control tapes having colored luminescent control areas thereon is inexpensive and the resulting product offers considerable advantages over the conventionally used perforated paper tape, primarily longer life and greater accuracy.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions, and, accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

What is claimed is:

1. In a control system, a moving opaque strip, a line of luminescent material thereon, plate means covering said strip, said plate having an aperture therein registering with said line, sensing means responsive to the line uncovered by said aperture, and means actuated by said sensing means to laterally control said strip to maintain said strip and apertures in alignment.

2. A control system comprising an opaque tape, colored luminescent control areas of different colors on said tape, and means for sensing said control areas, said means comprising a light source and light responsive means individually responsive to each of the colors of said control areas.

3. A control system comprising an inextensible opaque tape, means for moving said tape, a plurality of luminescent control areas of different colors arranged in a predetermined pattern on said tape, means for sensing said colored areas, said sensing means comprising a common light source and a plurality of light responsive means, and means for selectively registering control areas with said light responsive means, there being one each light responsive means for each of the colors of said control areas, and a control circuit for each of said light responsive means.

4. In an arrangement for aligning a moving belt having a luminescent stripe thereon, a plate positioned on said belt, said plate having an aperture registerable with said stripe and having the same width, a plate-like barrier upstanding from said plate and bisecting said aperture longitudinally of said stripe, first and second light responsive means on each side of said barrier, and means operable by one of said light responsive means when a portion of the belt is exposed through said aperture for realigning said belt to bring said stripe into registration with said aperture.

5. In a control system, the combination of, a movable opaque tape, fluorescent control areas of various colors on one side of said tape, a light source to energize said fluorescent control areas, light-responsive means individually responsive to each of the various colors of said fluorescent control areas, and a housing enclosing said

light source and light-responsive means and having an opening registrable with the colored control areas on the tape.

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