My invention relates to apparatus for sorting sheet materials, as for example steel plates, according to their conformity to a prescribed thickness. The production of steel plates is accomplished by a well-known process. A wide band coming from a steel mill is first wound on a reel. Thereafter it is unwound again and straightened. The steel is then cut into plates of a pre-determined length. The plates are straightened and given any other desired treatment such as oiling. Lastly the finished plates are stacked. There are unavoidable differences in thickness in the various steel plates due for example to changes in distance between the rollers used in processing the steel. Such variations in thickness which also affect the weight may be quite large, and it becomes necessary to sort the plates according to thickness. The plates may be sorted by skilled operators depending upon touch. In this way the plates which are too thick, and the plates which are too thin may be stacked separately from the plates which are of the proper size. This type of sorting however, may be very time consuming and is very often inaccurate because of fatigue of the operator. Some electro-mechanical sorting systems have been developed to replace operator sorting, such systems employing electro-mechanical thickness measuring equipment adapted to move the plates in a radial direction and stack them according to thickness. Such systems are however generally very complicated in both construction and in operation.

It is a prime object of my invention to provide apparatus which will eliminate the foregoing difficulties and provide effective means for sorting lengths of sheet material according to their conformity to a prescribed thickness.

In accordance with the invention, suitable thickness measuring means are provided for actuating a device for marking the metal with colors according to whether the thickness is greater or less than prescribed values. Subsequently, these color markings are scanned by photo-electric means, the sensitivity of the photoelectric means being influenced by the color of the markings. Sorting means are controlled according to the operation of the photoelectric means and rendered effective to separate the plates according to the thickness. If desired, the apparatus may be adapted to put several marks on each plate so as to guarantee a proper sorting of the plates. Of course, any suitable mechanically known system may be provided for sorting the plates according to the operation of the photoelectric means. Preferably a color marking which will disappear after a short period of time should be employed. It is desirable that the color dry quickly, and that its luminosity remain constant between the time of application and the time of sorting. It is also preferable that the color peel off by itself and be of such a composition so as not to stain the metal surface.

While the invention has particular application to the sorting of steel plates it has general application to the sorting of lengths of various sheet materials, metal and non-metal, wherever a sorting problem of the described type is present.

The invention will be more fully set forth in the following description referring to the accompanying drawing, and the features of novelty will be pointed out with particularity in the claims annexed to and forming a part of this specification.

The drawing is a diagrammatic illustration of apparatus adapted according to the features of my invention to the sorting of steel plates.

In the drawing, reference character 1 designates the sheet metal which may as hereinbefore mentioned be unwound from a reel. The sheet metal is passed through suitable cutting devices for trimming the longitudinal edges, and is then moved by means of the rollers 2 through a continuous measuring non-metal 3. The thickness of the metal by detection in an ionization chamber of unabsorbed rays from a radioisotope passing through the material. The measuring device 3 is of the type shown in my co-pending application Serial No. 473,602, filed December 3, 1954, and is connected with circuitry corresponding to that shown in the said application for providing either positive or negative D.C. signals according to whether the thickness of the sheet metal exceeds or is less than prescribed maximum and minimum values. Such circuitry which is diagrammatically illustrated at 4 connects with the polarized relay 5 which is caused to operate contact arm 6 in one direction or the other to close the contact 6a or 6b according to whether the relay is energized by a signal of positive or negative polarity. A positive signal which indicates that the sheet thickness exceeds the prescribed maximum value closes contact 6a, whereas a negative signal which indicates that the sheet thickness is less than the prescribed minimum value closes contact 6b. In the absence of a signal indicating that the thickness is within the prescribed limits, contact arm 6 is suspended between contact points a and b so that contacts 6a and 6b are open.

A relay 5 and switch 7 jointly control the operation of the paint spraying means for marking the sheet metal with one color or another according to whether it is oversize or undersize in thickness. The paint spraying means includes the electro-magnetic devices 8 and 9 for actuating the valves 10 and 11 respectively in paint supply lines. Paint of one color supplied through the supply line 12 is sprayed on the sheet metal when the valve 10 is actuated by the electro-magnetic device 8, and paint of another color supplied through the supply line 13 is sprayed upon the sheet metal when the valve 11 is actuated by the electro-magnetic device 9. The electro-magnetic devices are actuated when switch 7 is positioned to close contact 7a provided either contact 6a or 6b is also closed. Assuming the contact 6a is closed indicating excessive thickness of the sheet material, and the contact 7a is then closed, coil 14 of the electro-magnetic device 8 is energized over the circuit extending from the D.C. voltage source +E over line 15 including the coil 14, line 16, and contact 7a to ground, whereupon the plunger 17 is actuated to open the valve 10 in line 12 and cause paint of a select color to be sprayed upon the metal surface.

If the contact 6b is closed indicating that the metal is less in thickness than the prescribed minimum, and contact 7a is then closed, coil 18 is energized over the circuit extending from the voltage source +E over line 19 including coil 18, line 16, and contact 7a to ground, whereupon the plunger 20 is actuated to open the valve 11 in line 13 causing the metal surface to be sprayed with paint of another select color. Operation of the switch 7 is controlled by the arm 21 which is mounted on the movable head 22 of a shear 23 for cutting the sheet material.
into pre-determined lengths, the switch 7 being positioned to close the contact 7a whenever the shear is operated to sever the sheet metal into plates.

The sheet metal is moved under the movable head 22 of the shear by means of the rollers 2 which are driven through a chain drive 24 by the constant speed motor 25 connecting through mechanical connections 26 with one of the rollers. As shown the motor 25 connects through the gear reduction box 27 with the cam 28 for actuating contact arm 29. The arm 29 is positioned periodically so as to close contact 29a and energize an electro-magnetic clutch 30 over line 31. Upon energization of the electro-magnetic clutch 30 the drive wheel 31 of the shear 23 is connected to an operating motor 32 wherever the movable head 22 is actuated through arm 33 to drive the cutting tool 34 through the sheet metal. The motor 25 thus serves to time and synchronize the conveying, painting and cutting operations.

It will be obvious that each time the shear 23 is operated thereby closing contact 7a, the sheet metal may be sprayed with one color or another depending upon whether the plate is oversize so that contact 6a is closed, or undersized so that contact 6b is closed. If the thickness of the metal is within prescribed maximum and minimum values contacts 6a and 6b are open and the shear passes the plate to a spraying means without having either color applied since the energizing circuits for the coils 14 and 20 of the electro-magnetic actuating devices are open at contacts 6a and 6b respectively. Accordingly, each plate severed by the shear has an appropriate marking, depending upon the size, of one color or another according to whether the plate is oversize or undersized, and no marking at all, if the thickness of the plate is within the prescribed maximum and minimum values.

After shearing, the plate is moved at a somewhat more rapid rate by the rollers 35. As will become apparent hereinafter the motor 25 also serves to time and synchronize with the conveying operation the separation of the cut lengths of material in accordance with the particular color applied. The rollers 35 are driven through chain drive 36 by the motor 25 connecting through mechanical connections 37 and 38 and gear reduction box 39 with one of the rollers. The plate is moved under a light source 40 and a phototube 41 which are arranged so that light from the source 40 falls upon the markings on the plate, if any, and is reflected to the phototube. Operation of the phototube is dependent upon the amount of light reflected to it which in turn is dependent upon whether or not the plate is marked, and if marked upon the color of the marking.

As shown the phototube 41 is connected to the grid of amplifier 42 which has relays 43 and 44 connected in its plate circuit. A steady current flows in the plate circuit and the relay coils in the absence of any marking on the plate passing under the light source, however the current changes when light is reflected to the phototube from a marking on the plate, and the resultant current is dependent upon the color of the marking. The colors with which the plate is marked are preferably so selected that a marked increase in current in the plate circuit results when the light is reflected from a marking on the steel plate. The colors should also be such that there is a significant difference in current in the plate circuit for the respective markings. The relays 43 and 44 are so selected and are of such sensitivity that while neither relay is picked up unless light is reflected from a color marking on the plate, the relay is picked up whenever light is reflected from a marking denoting an oversized plate whereas both relays 43 and relay 44 are picked up whenever the light is reflected from a marking denoting an undersized plate.

Picking up the relay 43 closes the contact 45a to energize the coil 46 of electro-magnetic device 47 over the circuit extending from the D.C. voltage source +E over line 48, contact 49a, and line 50 through the coil 46 to ground. Upon energization of the coil 46, the plunger 51 is moved against the spring 52 to position the idler roller 53 such that the oversize plate is moved along the line 54 on the idlers 55 and deposited at 56. When both relays 43 and 44 are picked up as an undersized plate passes under the light source 40 the coil 57 of the electro-magnetic device 47 is energized over the circuit extending over the D.C. voltage source +E over contact 57a, line 58, and the coil 57 to ground. The relay 44 opens the circuit for the coil 46 at contact 49a so that coil 46 is de-energized. Upon energization of the coil 57 the plunger 51 is moved against the spring 52 to a position such that the undersize plate is moved along the line 59 on the idlers 60 and deposited at 61. A plate not marked does not affect the relays 43 or 44 as it passes under the light source 40. The relays maintain their normal de-energization status so that the contacts 45a and 45b are open and coils 46 and 57 of the electro-magnetic device are de-energized.

The normal position of the plunger is such that the plate passes over the idler 53 which is connected thereto for deposit at some suitable place as for example at the end of the line of rollers 35. It will be understood that the coils of electro-magnetic device 47 are only diagrammatically shown and that in practice that coils are arranged with one partially superimposed on the other so that the plunger assumes a desired position upon energization of one or the other coil.

It should be understood that this invention is not limited to specific details of construction and arrangement thereof herein illustrated and that changes and modifications may occur to one skilled in the art without departing from the spirit of the invention.

What is claimed is:
1. In material cutting machinery including means for conveying a continuous strip of material to a cutting station, means for cutting said strip to predetermined lengths, means for conveying the cut material from said station and means for timing and synchronizing the operations of the aforementioned means, sorting apparatus comprising measuring means disposed in proximity to and subjecting to measurement the material for producing a signal in accordance with the thickness or density of the representative portion of material it then so subjects, three-position switching means controlled according to the operations of said measuring means for reflecting the thickness or density of said subjected portion as respectively within predetermined minimum and maximum tolerances, and means discriminatively responsive to said markings for selecting for separation from the conveying means and from one another sets of lengths of cut material having thickness or density respectively less than said minimum and greater than said maximum tolerances, means controlled according to the operations of said switching means for cutting means for discriminatively marking such of said portions as have thickness or density respectively less than said minimum and greater than said maximum tolerances.
2. In material cutting machinery including means for conveying a continuous strip of material to a cutting station, means for cutting said strip to predetermined lengths, means for conveying the cut material from said station and means for timing and synchronizing the operations of the aforementioned means, sorting apparatus comprising a source of radiation disposed in proximity to the material for continuously subjecting the moving material to inspection, means for picking up whenever a signal derived from measurement reveals a condition of the material indicating that the thickness or density of such material is below predetermined minimum and maximum tolerances, and means for receiving from said inspected portion unaltered radiation indicative of the thickness or density of such portion, means for receiving from said inspected portion a signal derived from measurement thereof which indicates thickness or density of such material, means for controlling according to the operation of said radiation receiving means for reflecting the thickness or density of said subjected portion as respectively within predetermined minimum and maximum tolerances.
minimum tolerance and greater than said maximum tolerance, means controlled according to the operation of said switching means and said cutting means for discriminatively marking such of said portions as have thickness or density respectively less than said minimum and greater than said maximum tolerances.

3. Apparatus as in claim 2 wherein the radiation source subjects portions of continuous strip to radiation and wherein the radiation receiving means receives radiation from such subjected portions of continuous strip.

4. The apparatus as in claim 2 wherein the radiation source subjects portions of continuous strip to radiation, the radiation receiving means receives radiation from such subjected portions of continuous strip and wherein the marking is applied to a portion of continuous strip subsequent to the time such portion has been subjected to radiation.

5. Apparatus as in claim 2 wherein the marking means is a means for applying differing colors to the material according to the material being of a thickness or density less than the minimum and greater than the maximum tolerances and wherein the marking responsive means includes photoelectric means discriminatively responsive to the marked colors.

6. In material cutting machinery including means for conveying a continuous strip of material to a cutting station, means for cutting said strip to predetermined lengths, means for conveying the cut material from said station and means for timing and synchronizing the operations of the aforementioned means, sorting apparatus comprising a radio isotope disposed on one side of the continuous strip in spaced relation therefrom for continuously subjecting the continuous strip from portion to portion thereof to radiation, a radiation detector disposed on the opposite side of the continuous strip in spaced relation therefrom and substantially opposite said radio isotope for detecting unabsorbed radiation determinative of the thickness or density of such subjected portion, polarized relay means controlled according to the operation of said radiation detector for reflecting the thickness or density of said subjected portion as respectively within predetermined minimum and maximum tolerances, less than said minimum tolerance and greater than said maximum tolerance, means controlled according to the operation of said relay means for initiating and continuing application of paint to portions of continuous strip previously subjected to radiation, said paint having one of two colors according to the then to be painted portion of continuous strip being reflected by said relay means as respectively less than said minimum or greater than said maximum tolerances, means operable according to the operation of said cutting means for discontinuing operation of said paint applying means at a predetermined time in the cutting cycle and before the arrival at the cutting station of the beginning of the portion painting of which is then being discontinued, a source of light disposed in proximity to the cut lengths of material and a photoelectric tube disposed on the same side of the cut lengths for receiving light reflected from said light source, said photoelectric tube being discriminatively responsive to said colors, and circuit means responsive to the operation of said photoelectric tube for selecting for separation from the conveying means and from one another sets of lengths of cut material having thickness or density respectively more than said maximum and less than said minimum tolerances.

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