

Feb. 16, 1965

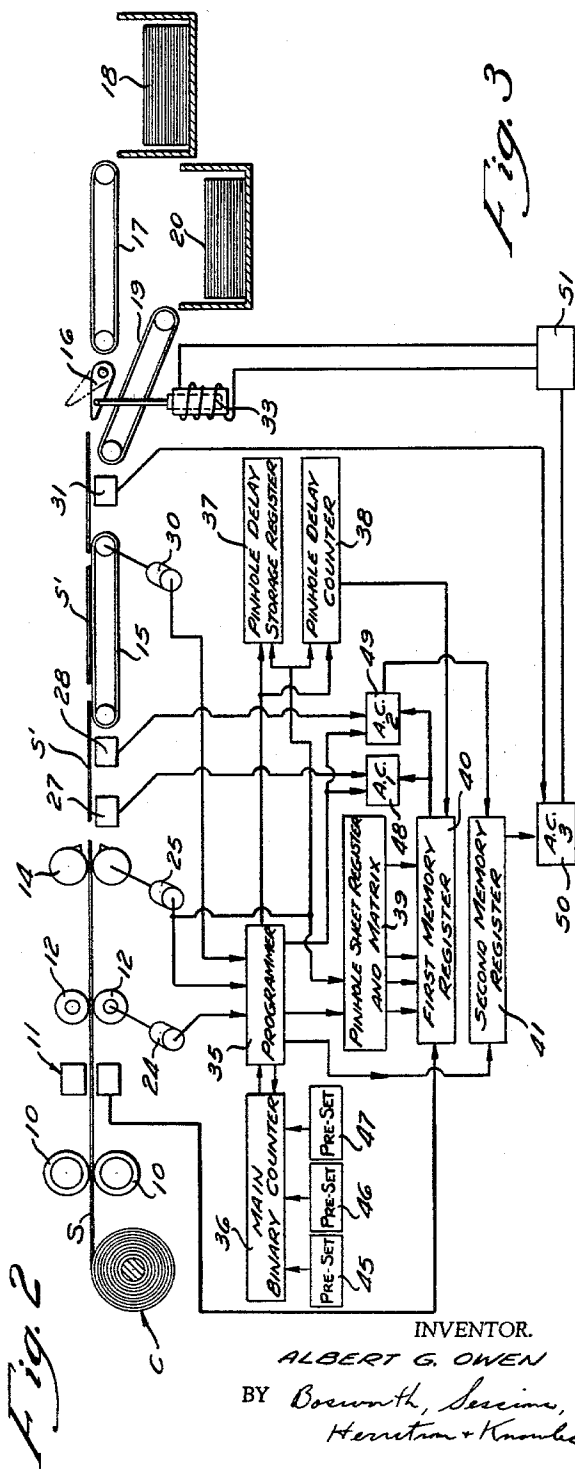
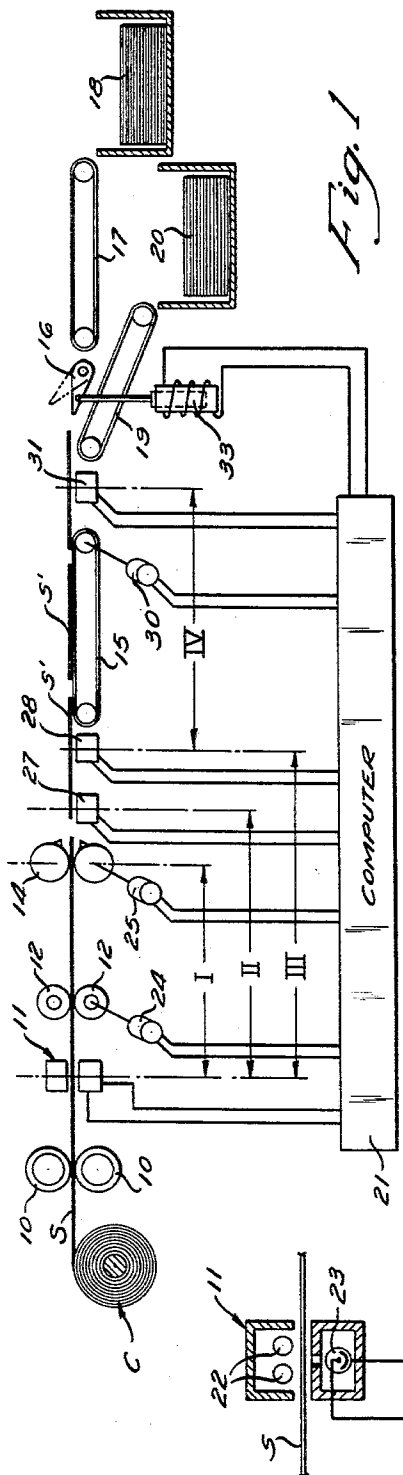
A. G. OWEN

3,169,428

SINGLE SHEET CLASSIFIER

Filed Dec. 22, 1959

4 Sheets-Sheet 1



INVENTOR.

ALBERT G. OWEN

BY *Bowman, Secombe,
Herndon & Knowles*

ATTORNEYS

Feb. 16, 1965

A. G. OWEN

3,169,428

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4 Sheets-Sheet 2

Fig. 4

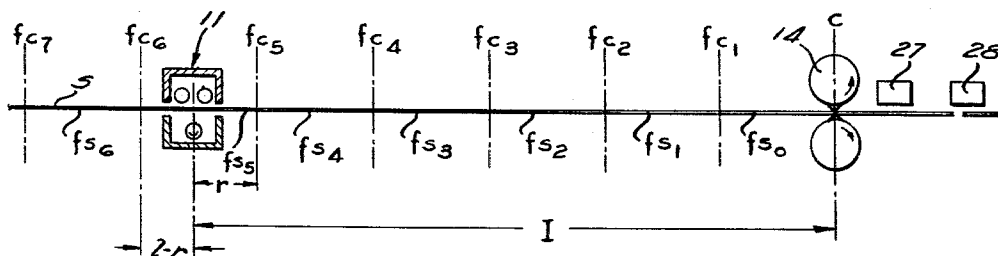


Fig. 5

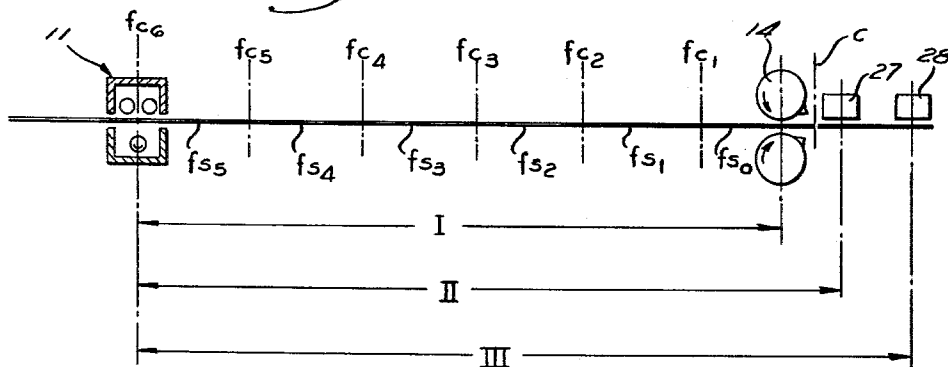
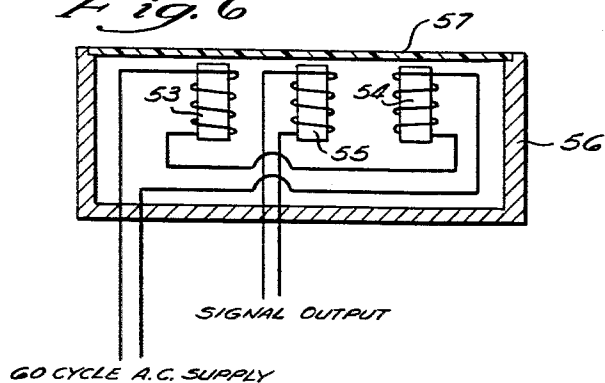


Fig. 6



INVENTOR.

ALBERT G. OWEN

BY Brewin, Sessions,
Henriksen & Knudsen

ATTORNEYS

Feb. 16, 1965

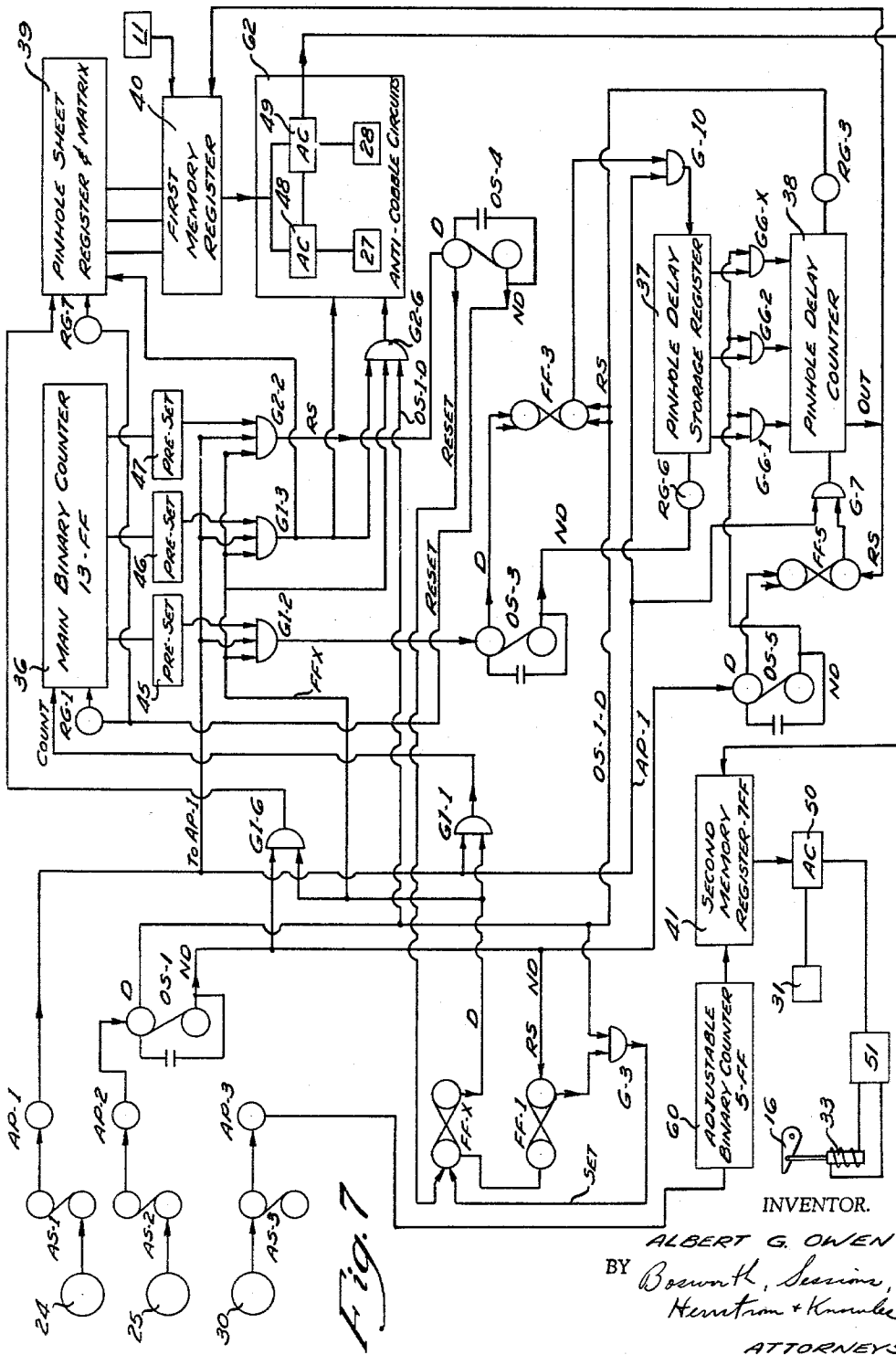
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A. G. OWEN

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4 Sheets-Sheet 4

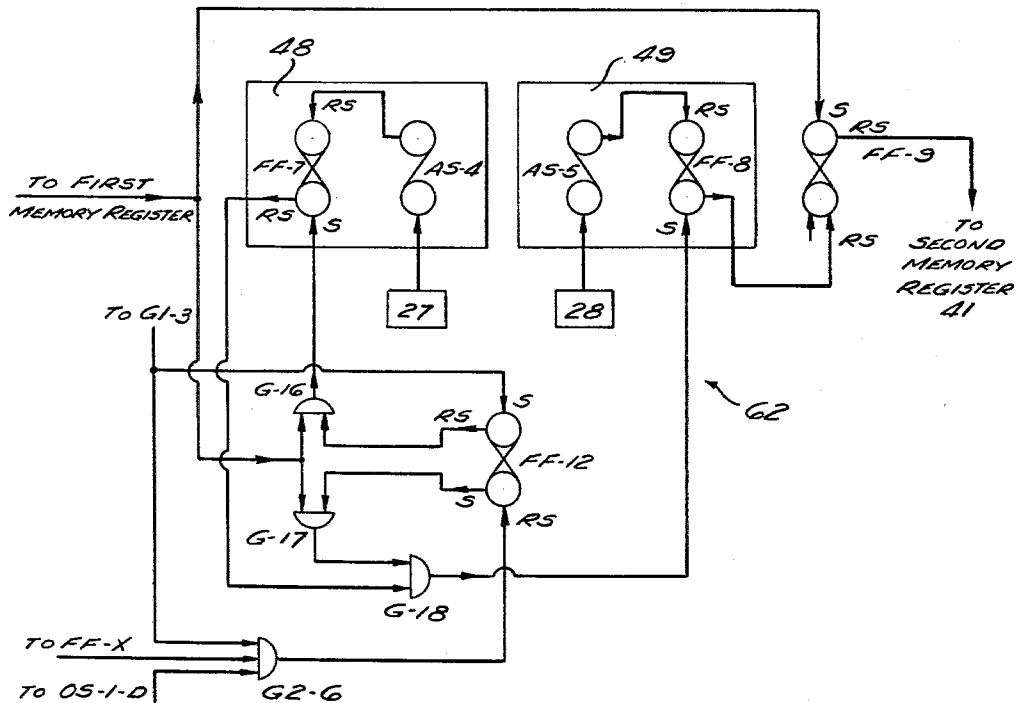


Fig. 8

INVENTOR.

ALBERT G. OWEN

BY *Bosworth, Secombe,
Herrington & Knowles*
ATTORNEYS

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3,169,428

SINGLE SHEET CLASSIFIER

Albert G. Owen, Rockville, Md., assignor to Blaw-Knox Company, Pittsburgh, Pa., a corporation of Delaware
Filed Dec. 22, 1959, Ser. No. 861,366
10 Claims. (Cl. 83-27)

This invention relates to a method and apparatus for classifying and piling sheet material and, more particularly, to a classifier especially adapted for use in classifying and piling metal strip.

At the present time it is common practice to gauge strip for thickness and inspect it electronically for pinholes while it is in strip form, shear it into sheets by a flying shear and deposit the sheets in separate piles in accordance with the characteristics of the sheets as determined by the gauge and pinhole detector. Shearing and classifying lines are operated at high speeds and difficulties have been encountered in devising classifiers that operate to divert only the sheets that are defective for one reason or another to the reject piles, while all of the "prime" sheets go to the "prime" pile. It is highly desirable to have only the defective sheets diverted; otherwise, it becomes necessary to inspect all of the sheets in the defective piles by hand in order to avoid scrapping prime sheets. Classifiers which are intended to be capable of operating in this manner are called "single sheet" classifiers in the trade. The difficulty in devising a single sheet classifier arises from the fact that the automatic inspecting operations are carried out by gauges, pinhole detectors and the like while the material is in strip form and in advance of the shear. The material is then sheared and the speed of the sheared sheets is accelerated in order to separate the sheets to make it possible to divert defective or off gauge sheets from the main stream into a separate piler. It is difficult to cause the diverter to operate at precisely the correct instant such that the sheet which is diverted is a defective sheet that has been detected in the strip many feet ahead of the diverter, and not some other sheet preceding or following the defective one.

Heretofore, attempts have been made to provide single sheet classifiers by various types of delay devices and timers that receive a signal from a gauge or pinhole detector, for example, in advance of the shear and then cause a deflector to operate to deflect the subsequently cut sheet containing the defect to a reject piler. The time delay devices are essentially analogue devices, such as magnetic memory wheels or tapes, or pin type timers; these are intended to remember the location of a defect as it travels from the gauge or pinhole detector to the deflector and actuate the deflector at the proper time. For various reasons, including slippage of the sheets in the conveyors that follow the shear, inaccuracy in the operation of the shear, and the difficulty in accurately following a defect while the rapidly moving strip is sheared into sheets and travels a distance that may be many feet, many of these timer controlled devices do not operate with sufficient accuracy and/or reliability to reject only the particular sheet bearing a defect. With some types of machines, in order to insure that every defective sheet will be rejected, it is necessary to set the machines so that two or even three sheets are rejected for every defect.

The general object of the present invention is the provision of an apparatus and a method whereby the accuracy and reliability of classification can be greatly improved so that for nearly all circumstances it is possible to operate the machine so that it rejects only the sheets containing defects. This is accomplished according to the present invention by controlling the operation of the deflector by means of a computer which in effect de-

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termines, at the instant a defect is detected, which sheet the defect will be in when the strip is subsequently cut into sheets by the shear. The computer stores this knowledge and, shortly after the sheet is cut, determines the location of the leading edge of the sheet containing the defect; thereafter the computer actuates the deflector gate at the instant that the leading edge of the sheet reaches a predetermined point in advance of the deflector to deflect only the sheet containing the defect to the reject pile.

A preferred form of apparatus embodying the invention is illustrated in the drawings in which:

FIGURE 1 diagrammatically illustrates the apparatus in greatly simplified form.

FIGURE 2 diagrammatically illustrates a typical pinhole detector.

FIGURE 3 is a block diagram showing the elements of a preferred form of my invention embodying a digital computer.

FIGURES 4 and 5 are diagrams illustrating the operation of the apparatus.

FIGURE 6 somewhat diagrammatically illustrates a preferred form of device for detecting the presence of a sheet; this type of device is hereinafter referred to as an "anti-cobble" device, and

FIGURE 7 is a diagram illustrating a preferred form of computer; and

FIGURE 8 diagrammatically illustrates preferred circuits for the "anti-cobble" devices.

As shown in FIGURE 1, the mechanical portions of the apparatus can be of generally conventional construction. In this figure a coil of strip material such as tin plate in strip form is indicated at C. The material is uncoiled by any conventional means into the form of a strip S which passes between pinch rolls 10 and then through a gauging or other inspecting device indicated in general at 11. In the drawing, this is shown as a pinhole detector because the problem of accurate classification of sheets is most acute in connection with pinholes; obviously, any other type of gauging or inspecting device capable of giving a signal on the occurrence of a defect can be employed. From the inspecting device the strip passes through measuring rolls 12 and then a rotary shear 14 which severs the strips into sheets S'. The sheets are conveyed by a conveyor 15 away from the shear, the conveyor being operated at a greater speed than the speed of the shear, so that the sheets are separated slightly, as shown. Conveyor 15 delivers the sheets to a deflector 16 which may be a solenoid operated mechanical deflector, as shown, or may be magnetic if the apparatus is intended for use with ferrous sheets. The spacing of the sheets S' by conveyor 15 gives the deflector time to operate. The normal path of the sheets is over the deflector 16 to the conveyor 17 and then to the prime piler 18. Defective sheets, in this case sheets containing pinholes, are deflected downwardly to conveyor 19 and reject piler 20, the deflector 16 being raised from the position shown in full lines to the dotted line position when a sheet containing a pinhole reaches a position immediately in advance of the deflector.

In this figure, for sake of simplicity, only a pinhole detector and two pilers are illustrated. Normally, the strip would pass through a gauge that would measure its thickness in addition to a pinhole detector; sheets containing pinholes would be deflected to one piler, over gauge sheets to another piler, under gauge sheets to another piler, and the prime sheets to the prime piler. The principles of operation, however, for the pinhole detector and gauging device are the same; the use of additional gauging devices merely multiplies the parts of the apparatus without changing the basic theory of operation.

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All of the functions of the automatic operation of the deflector are controlled by a computer 21. As appears below, this is built up of conventional computer elements which may be of either the digital or analog type but for the present only the functioning of the computer will be discussed. The construction is described below. The computer receives signals from the inspecting device 11, which in this example is a pinhole detector as shown in FIGURE 2. The pinhole detector consists of a light source 22 and a photocell 23, disposed respectively above and below the strip. The presence of a pinhole in the strip causes generation of an electrical signal by the photocell and this signal is instantaneously received and stored by the computer.

The computer also receives signals from a tachometer 24 driven by the measuring rolls 12 and from a tachometer 25 driven by the rotary shear 14. Tachometer 24 produces a signal pulse for each increment of rotation of the rolls 12 and hence for each increment of advance of the strip S through the rolls. The size of the increment that is employed is determined by the accuracy that is desired. In the example described, a signal is given for 0.050 inch of advance of the strip, but this can be smaller or larger depending upon the requirements. Tachometer 25 gives a signal pulse at the instant the shear 14 makes a cut. The signals given by the two tachometers are amplified and stored in the computer.

Beyond the shear 14 the sheets S' travel over "anti-cobble" devices indicated at 27 and 28. These are magnetic devices that produce an electrical output whenever a ferromagnetic sheet is above them. Thus, as the leading edge of a sheet passes the anti-cobble device 27, a pulse is generated which is fed to the computer. Likewise, when the leading edge of a sheet passes anti-cobble device 28, a second pulse is generated which is fed to the computer. The anti-cobble devices are small, magnetic devices and are described below. They are greatly enlarged in relation to other parts of the apparatus in the drawings.

The sheets traveling along the conveyor 15 ultimately take the speed of the conveyor. A signal proportional to the speed of the conveyor is introduced into the computer by means of tachometer 30 which is driven from one of the rolls supporting the belt conveyor 15. Tachometer 30, like tachometer 24, produces a signal pulse for each increment of advance of the belt, and hence of the sheets on the belt.

Immediately in advance of the deflector 16 there is a third anti-cobble device 31 which, like anti-cobble devices 27 and 28, produces a signal whenever a sheet of ferromagnetic material is passing over it and produces an output pulse when the leading edge of the sheet passes over it. This pulse is also fed to the computer.

As will appear in greater detail below, the computer receives and stores the information from all of these devices and, assuming a pinhole has passed beneath pinhole detector 11, the computer, when the leading edge of the sheet containing the pinhole passes over anti-cobble device 31, actuates the deflector 16 to cause the sheet to be deflected into the reject pile 20. In the embodiment of the invention shown, the deflector is operated by means of a solenoid 33 that is energized through suitable amplifiers from the output of the computer.

Certain controlling dimensions in the machine are known and the computer is supplied with the knowledge of these dimensions. These dimensions are indicated by Roman numerals in FIGURE 1; dimension I is the distance from the center line of the pinhole detector to the shear; dimension II is the distance from the center line of the pinhole detector to anti-cobble device 27; dimension III is the distance from the center line of the pinhole detector to anti-cobble device 28; and dimension IV is the distance from anti-cobble device 28 to anti-cobble device 31.

The computer functions automatically to determine the particular sheet in which a defect occurs, regardless of

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changes in sheet length, and to reject this sheet regardless of changes in the speed of the conveyor 15 or changes in the length of the sheets being classified. In order to produce these results the computer determines the precise instant that the elements of the strip that are to be cut in the future by the shear pass the center line of the pinhole detector. Thus, the computer knows at all times which future sheet is being inspected and at the instant a defect is detected by the pinhole detector, the computer knows in which sheet it will ultimately be found.

The computer also determines the number of whole sheets that can occur between the center line of the pinhole detector 11 and anti-cobble device 28 and follows by memory the defective sheet from the pinhole detector 11 to anti-cobble device 27 or anti-cobble device 28; this locates the leading edge of a sheet containing a pinhole with respect to anti-cobble device 27 or 28.

From anti-cobble device 28, the computer memory follows the leading edge of the defective sheet to anti-cobble device 31 and upon receipt of a proper signal from anti-cobble device 31, energizes the solenoid 33 to cause the deflector 16 to deflect the defective sheet onto conveyor 19 leading to reject pile 20.

FIGURE 3 of the drawings is a block diagram of a preferred form of apparatus embodying my invention and embodying a digital computer. As indicated in the diagram the principal elements of the computer comprise a programmer 35, a main binary counter 36, a pinhole delay storage register 37, a pinhole delay counter 38, a pinhole sheet register and matrix 39, a first memory register 40 and a second memory register 41. Other components include the preset devices 45, 46, and 47 associated with the main binary counter 36 and the anti-cobble temporary storage devices 48, 49 and 50 associated with the anti-cobble magnetic switches 27, 28 and 31 respectively. The output of anti-cobble storage device 50 gives a signal which is amplified by a conventional amplifier or relay 51 to provide power for energizing the solenoid 33 that actuates the deflector 16.

The function of the computer is to deliver signals at the proper times to actuate the deflector 16 to deflect all sheets containing defects to the reject pile 20 while permitting all sheets without defects to pass to the prime pile 18. The computer determines the precise instant when the solenoid 33 should be energized to actuate the deflector to deflect a defective sheet; the computer makes this determination from information supplied to it through the preset devices 45, 46, and 47 and signals received by it from the pinhole detector 11, the tachometers or pulse generators 24, 25 and 30 and the anti-cobble devices 27, 28 and 31. The functions of the various principal components of the computer are as follow:

The programmer 35 includes the temporary storage and gating devices as well as the timing functions which are necessary to make the other components shown in the block diagram perform in the proper sequence. The programmer receives input pulses from the pulse tachometers 24, 25 and 30 and also from the main binary counter. The programmer delivers output pulses to the main binary counter 36, the pinhole delay storage register 37, the pinhole delay counter 38, the pinhole sheet register and matrix 39 and the anti-cobble storage devices 48 and 49.

The main binary counter 36 receives input pulses through the programmer from tachometer 24, which, as noted above, is driven by the measuring rolls 12 and produces a signal pulse for each increment of rotation of the rolls 12 and hence for each increment of advance of the strip S; in the preferred form of the apparatus, the tachometer 24 produces a signal pulse for each 0.050 inch of advance of the strip. Before the apparatus is placed in operation, the main binary counter is supplied with information concerning dimensions I, II, and III through the preset devices 45, 46 and 47. These devices are set for counts of the pulses produced by tachometer 24 corresponding to dimensions I, II, III respectively; i.e., in

the examples shown, the three preset counts multiplied by 0.050 inch will equal the dimensions I, II, III respectively; furthermore, the number of pulses fed into the counter from tachometer 24 between successive cuts by the shear 14 constitutes a measure of the sheet length. Every time a cut is made by the shear the programmer 35 receives a pulse or "cut signal" from the tachometer 25. The pulses from the tachometer 25 are transmitted through the programmer to the main binary counter which is thus supplied at all times with knowledge of the length of the sheets being cut by the shear.

When the computer is in operation the sheet cuts as measured by tachometer 25 are matched against the preset counts supplied to the main binary counter 36. The counter then performs repetitive serial division problems in which, in effect, the preset counts, which are measures of distances I, II, and III, are divided by the sheet length, which is determined by the pulses received from tachometer 25; these calculations enable the computer to determine which sheet is at the pinhole detector, remember the location of defective sheets and to deflect such sheets at the proper time.

The manner in which the computer determines that a particular sheet contains a defect may be understood with reference to the diagram constituting FIGURE 4 which shows the strip S going through the machine at the precise instant that a cut *c* is being made by the shear 14. The strip in advance of the cut may be considered as being made up of "future sheets" fs_0, fs_1, fs_2 , etc. Actual cut *c* determines the leading edge of future sheet fs_0 . Future cut fc_1 determines the trailing edge of future sheet fs_0 and the leading edge of future sheet fs_1 . In the diagram, the leading edge of each future sheet is determined by the correspondingly numbered future cut. Thus future sheet fs_5 is shown as being inspected by the pinhole detector 11 and as soon as future cut fc_6 passes the center line of the pinhole detector 11, the inspection of future sheet fs_6 will begin. Therefore, in order to determine the precise instant when the pinhole detector ceases to inspect one sheet and begins to inspect the following sheet, the computer must know when each future cut passes the center line of the pinhole detector 11. The computer determines this by repetitively and continually dividing the length of the sheets as determined by the pulses from the tachometer 25 into the preset count supplied by preset device 45 and corresponding to dimension I. This enables the computer to determine which sheet is being inspected. This division ordinarily results in a remainder and it is the remainder that is important to the operation of the classifier. In the example shown in FIGURE 4, division of the distance I by the length *l* of the sheets leaves a remainder *r* which is equal to the distance by which the most recent future cut fc_5 has gone beyond the center line of the pinhole detector 11. The distance *l-r* is the distance between the next future cut fc_6 approaching the pinhole detector and the center line of the pinhole detector. Knowledge of this distance is required at all times in order to enable the computer to determine which sheet is being inspected by the pinhole detector.

This distance (*l-r*) is determined by delivering a signal from the main binary counter 36 to the programmer 35 as soon as the main binary counter has completed the preset count (set by 45) corresponding to dimension I. In other words, when the element of the strip that was located on the center line of the pinhole detector at the time the computer was put into operation reaches the center line of the shear, the main binary counter will have counted a number of pulses from tachometer 24 corresponding to the distance I; at that time the main binary counter produces an output signal which is supplied to the programmer. The programmer transmits this signal to the pinhole delay storage register 37. The signal starts the pinhole delay storage register to counting the pulses produced by tachometer 24. The pinhole delay storage

register also receives cut signal pulses from shear tachometer 25 through the programmer 35. The next shear signal pulse that occurs after the pinhole delay storage register starts counting causes the pinhole delay storage register to stop counting and thus this register will have stored an exact count representing the distance *l-r* between the pinhole detector and the next future cut on the strip that is located just ahead of the pinhole detector at the time an actual shear cut is made by the shear. The computation just described enables the computer to know the precise instant that the leading edge of each future sheet that will subsequently be cut by the shear passes the center line of the pinhole detector.

In order to enable the computer to identify and follow a particular sheet that contains a defect, the computer determines the nearest whole number of sheets in the distance III between the pinhole detector and the anti-cobble device 28. Assume for example, that future cut fc_6 has moved from the position shown in FIGURE 4 to the center line of the pinhole detector 11 as shown in FIGURE 5. At this instant, cut *c* will have moved to the position shown in FIGURE 5, the leading edge of sheet fs_0 being between the shear and the anti-cobble device 28. In the illustrated example, the leading edge of the sheet is approaching device 27, but under other conditions the leading edge may be beyond 27 and approaching 28. The computer determines the location of the leading edge of each sheet with respect to devices 27 and 28 as described below. In the example, there are six whole sheets between the center line of the pinhole detector and the anti-cobble device 28. The computer repetitively and continuously determines this number from the pulses delivered by the shear tachometer 25, the incremental pulses furnished by tachometer 24 and the pre-set information furnished the computer through pre-set device 47. The answer to this problem, is supplied by the main binary counter through the programmer to the pinhole sheet register and matrix 39, for this is the number of sheets that must be counted to follow the passage of a sheet containing a defect from the pinhole detector to the anti-cobble device 27 or anti-cobble device 28 as the case may be.

As noted above, the pinhole delay storage register is repetitively supplied with a count corresponding to the distance *l-r* which is the distance between the next future cut approaching the center line of the pinhole detector at the instant that the shear is making a cut. In operation of the apparatus, every shear cut indicated by a pulse from tachometer 25 causes the pinhole delay counter 38 to reset to zero and then receive the count stored in the pinhole delay storage register and count out this count. This counting process, in effect, gives a signal or pulse which is delayed with respect to the actual shear cut signal by a period of time corresponding to the distance *l-r*. At the end of the delay, a signal pulse is transmitted by the pinhole delay counter 38 to the first memory register 40. If the future sheet passing through the pinhole detector between two successive pulses supplied to the memory register 40 by the pinhole delay counter 38 is free from pinholes, then the computer has nothing more to do with respect to that future sheet. If the future sheet contains a pinhole, the computer must remember its passage and follow it to the shear and the anti-cobble devices 27 or 28. This is accomplished by supplying the pinhole signal from the pinhole detector 11 to the first memory register 40. The memory register then knows which future sheet is passing through the pinhole detector at that time the signal is received from the pinhole detector and, therefore, the first memory register has located the pinhole within a particular sheet. Thereafter, each pulse supplied by the pinhole delay counter 38 to the memory register 40 causes the memory register to advance one step. Each of these steps correspond to one sheet length since the pulses are derived from the shear tachometer 25.

The pinhole sheet register and matrix 39 has previously stored information concerning the whole number of sheets between the pinhole detector 11 and anti-cobble device 28 and supplies this information to the first memory register 40; thus, the memory register is told how many steps to count off before bringing out a signal indicative of the defective sheet to anti-cobble device 27 or 28 as required. If the programmer has previously determined that anti-cobble device 27 is to be used, then the signal from the first memory register 40 indicating the presence of a defective sheet is delivered to anti-cobble temporary storage device 48 at the instant that the first memory register has counted off the number of sheets between the pinhole detector and the first anti-cobble device. This signal is given to the storage device 48 before the sheet reaches anti-cobble device 27. In the example given in FIGURE 5, the signal would reach storage device 48 when the leading edge of the sheet reaches the point indicated by cut c. The signal is temporarily stored in the storage device 48 and when the leading edge of the defective sheet reaches anti-cobble device 27, the storage device 48 transmits the signal to anti-cobble storage device 49. As before, anti-cobble storage device 49 temporarily stores this signal and delivers it, at the instant that the leading edge of the defective sheet reaches anti-cobble device 28, to the second memory register 41, which, as appears below, is utilized to actuate the deflector 16 at the proper time.

If, on the other hand, the programmer has previously determined that only anti-cobble unit 28 must be used then the signal from memory register 40 is delivered directly to anti-cobble storage device 49 and at the instant that the defective sheet reaches anti-cobble unit 28 a signal is given to the second memory register 41. In this case, anti-cobble unit 27 is not used. By this means the second memory register receives a pulse at the instant that a defective sheet reaches the second anti-cobble device 28 regardless of the length of the sheets or the speed of operation of the apparatus.

From the foregoing, it will be evident that by these operations, the computer determines in which sheet a defect occurs, thus making it unnecessary for the computer to remember the precise location of the defect, and also determines the precise instant that the leading edge of a sheet containing a defect reaches anti-cobble device 28. With this information, it becomes a comparatively simple task for the computer to actuate the deflector 16 at the proper time to deflect the sheet containing a defect to the reject pile 20.

In order to accomplish this result, the second memory register 41 is supplied with information in the form of a number of counts representing the distance on the machine between anti-cobble device 28 and anti-cobble device 31, which is positioned immediately in advance of the deflector 16. The second memory register is stepped by pulses derived from tachometer 30 through programmer 35. Tachometer 30 is driven at a speed proportional to the speed of conveyor 15 on which the sheets are carried. Hence, memory register 41 is stepped at speeds proportional to sheet speeds at all times. When memory register 41 completes its count, it means that the leading edge of a sheet containing a defect has moved from anti-cobble device 28 to a position immediately in advance of anti-cobble device 31. At this point, the second memory register 41 gives a signal to anti-cobble storage device 50 and when the sheet containing the defect reaches anti-cobble device 31, the signal given by the magnetic switch causes storage device 50 to transmit the signal to the power amplifier 51 which actuates the deflector 16. By this means, the deflector is actuated at precisely the correct instant to deflect the sheet containing a defect to the reject pile 20. Sufficient accuracy in operation of the deflector in a typical tin plate classifier is obtained with a tachometer 30 that delivers a pulse for each inch of travel of conveyor 15. Other services or different

designs of machines may require shorter increments or may operate satisfactorily with greater increments.

FIGURE 6 illustrates a preferred construction for the anti-cobble devices 27, 28, and 31 which detect the presence of a ferrous sheet above them. As shown in FIGURE 6, each of these devices may comprise a pair of primary coils 53 and 54, connected in series and energized from a suitable A.C. source, and a secondary coil 55, which is connected to one of the anti-cobble storage devices 48, 49, or 50 as the case may be. The coils are aligned transversely of the direction of movement of the sheets and are contained within a suitable box 56, preferably composed of non-magnetic material and having a cover 57 of non-magnetic material and preferably constructed of a phenolic plastic or the like over which the sheets slide in their passage through the apparatus. The cover 57 is relatively thin so that the sheets pass close to the ends of the coils 53, 54, and 55. In the absence of a sheet the coupling between the primary coils 53 and 54 and the secondary 55 is slight, but the presence of a ferrous sheet near the upper ends of the coils increases the coupling between the primary and secondary coils and thus produces an output signal which is delivered to the associated anti-cobble storage device 47, 48 or 49 whenever a sheet is passing over the anti-cobble device 27, 28, or 31. Thus, each of these devices gives a signal as soon as the leading edge of a sheet reaches its coils 53, 54, and 55, and the output continues until the sheet has passed beyond the device.

It will be evident that other types of detecting devices could be used for this purpose. For example, devices embodying photo cells could be used; devices of this type would be suitable in apparatus designed for classifying non-ferrous sheets.

As noted above, the computer is preferably constructed of conventional elements that operate in manners well-known to those skilled in the computer art. It is, therefore, thought that the description previously given is sufficient to enable persons skilled in the computer art to construct a computer for carrying out the required functions and that the foregoing description constitutes a complete compliance with the patent statutes. However, the diagrams constituting FIGURES 7 and 8 and the following description are given in order to provide a further disclosure of a preferred embodiment of the invention.

FIGURE 7 illustrates primarily the elements that go to make up the programmer section of the computer and the connections between the programmer and the other components. The computer is made up of conventional transistorized plug-in circuits which are indicated in conventional fashion in these figures. Circuits of the type referred to can be obtained from various commercial sources, one such source being Engineered Electronics Company of Santa Ana, California. The circuits are illustrated and described in Engineered Electronics Company Catalog No. TR-758.

In the diagrams constituting FIGURES 7 and 8, the units indicated as "AS" are squaring amplifiers that are used to convert a signal having an unusable wave front to a square wave signal having the required steep wave front needed to operate the components of the system. The units designated as "AP" are pulse amplifiers that give the necessary power to drive the loads. The units designated "OS" are one shot multivibrator units that give an instantaneous and a slightly delayed output signal. The units indicated as "RG" are reset generators for giving the necessary reset signals to the counters. Gates are indicated by "G"; all of the gates shown are "AND" type gates except for G-18 which is an "OR" gate. The units indicated by "FF" are flip-flops.

In addition to the flip-flops shown in FIGURES 7 and 8, cascaded flip-flops are utilized in the main binary counter 36, the pinhole delay storage register 37, the pinhole delay counter 38, the pinhole sheet register 39, and the memory registers 40 and 41; it is conventional

to construct counters and storage registers of these types from flip-flops.

In operation the main binary counter is supplied with counts through preset devices 45, 46, and 47 corresponding to dimensions I, II, and III. The adjustable binary counter 60, which forms part of the second memory register 41, is also supplied with a preset number of counts as described below. This counter receives pulses from tachometer 30, and in the example given, tachometer 30 produces a pulse for every inch of travel of the conveyor 15 on which the sheets are carried from the shear. The computer receives a pulse from tachometer 24 for each increment of advance of the strip (in the example given this being 0.050 inch), receives a pulse from tachometer 25 for every cut made by the shear, and receives a pulse from tachometer 30 for each increment of advance of the conveyor 15 and the sheets deposited on the conveyor, in the present example, the increments being 1.0 inch. The computer also receives signals from the gauging device 11, which in the preferred form shown herein is a pinhole detector, although any other appropriate gauging or inspecting device may be employed. From these pulses and signals and the preset information, the computer performs the functions necessary to enable it to operate the deflector 16 at the proper instant to deflect a sheet containing a defect to the reject pile.

The pulses produced by the tachometers 24, 25, and 30 are shaped into a square-wave front form by the squaring amplifiers AS-1, AS-2, and AS-3, respectively, and the square wave pulses are amplified by amplifiers AP-1, AP-2, and AP-3, respectively, to give the necessary power to operate the computer.

At the start of the operation of the computer, the flip-flop FF-1 is in the "set" position and gives an enabling signal to gate G-3. The next signal from tachometer 25 indicating a shear cut is shaped by AS-2 and amplified by AP-3, and energizes one shot multi-vibrator OS-1. The instantaneous signal from OS-1 resets FF-1 and is applied to gate G1-6. The delay signal is transmitted to gate G-3 which is enabled, and this delayed pulse is transmitted through FF-X to previously enabled gate G1-6. The signal from flip-flop FF-X is also transmitted to gates G1-2, G1-3, G2-2 and G2-6. The delayed signal from OS-1 to gate G1-6 starts the pinhole sheet register and matrix 39 to counting the number of sheets in distance III between the center line of the pinhole detector 11 and the anti-cobble device 28. With this circuit, at the start of a cycle the first cut made by the shear is not counted, the counting starting with the second cut which represents one sheet.

The instantaneous signal from OS-1 also operates OS-5. The instantaneous signal from OS-5 energizes gates G6-1, G6-2, etc. to drop the stored counts in the pinhole delay storage register 37 into the pinhole delay counter 38. The delayed signal from OS-5 sets flip-flop FF-5 to energize gate G-7. With gate G-7 energized pulses from tachometer 24 through AS-1 and AP-1 are supplied to the pinhole delay counter 38 which then starts to count. The pinhole delay counter then counts out the count received from the pinhole delay storage register. When the count has been completed the pinhole delay counter gives an output pulse which resets FF-5 and de-energizes G-7 to stop the counting operation. This signal is also transmitted to the first memory register 40, with the result that the information stored in the memory register is advanced one stage for each sheet cut signalled by tachometer 25.

When gate G1-1 is enabled at the beginning of the operation, pulses from tachometer 24 are transmitted to the main binary counter 36 which begins to count off the preset counts representing the distances I, II, and III set into the counter by preset devices 45, 46, and 47. At the same time the enabling of gate G1-6, as noted above, starts the pinhole sheet register and matrix

39 to count the number of shear cut signals received from tachometer 25. When the first preset count representing the distance I is completed by counter 36 gate G1-2 is enabled which activates OS-3. The instantaneous signal from OS-3 resets the pinhole delay storage register 37, and the delayed signal from OS-3 sets FF-3 which enables gate G-10 and causes the pinhole delay storage register 37 to count the pulses from tachometer 24.

The first shear cut pulse or signal from tachometer 25 that occurs after the pinhole delay register 37 has started counting resets FF-3 and stops the counting of pulses from tachometer 24 in the pinhole delay register 37. When the pinhole delay register has completed its count, this count is stored and it is this count that indicates the proper delay intervals of the shear cut signal for the pinhole detector 11; i.e., this count represents the distance $l-r$ shown in FIGURE 4.

After the completion of the count corresponding to distance I, the main binary counter 36 continues to count ahead. When the count corresponding to distance II is reached an enabling signal is given to gate G1-3 and when the count corresponding to distance III is reached an enabling signal is given to gate G2-2. Enabling G1-3 permits a signal to be transmitted to the pinhole sheet register and matrix 39 and resets this register which has been receiving pulses through G1-6 from tachometer 25. The number of such sheet cut pulses occurring during the time that the main binary counter has been counting to preset count 46 is thus determined and stored in the pinhole sheet register and matrix.

Also, upon completion of the count corresponding to dimension II and the consequent enabling of G1-3, a signal may be given to gate G2-6 and to a flip-flop FF-12 in the anti-cobble selector circuits; these circuits are illustrated in FIGURE 8 and are indicated in general in FIGURE 7 by reference character 62.

At this time the computer determines the location of the leading edge of the sheet approaching the anti-cobble devices 27 and 28 with respect to these devices. When the preset count corresponding to dimension II is completed, the further counting operation causes a completion of the count set by preset device 47 and corresponding to dimension III. If a shear cut signal is received from tachometer 25 between the time of completion of preset count corresponding to dimension II and preset count corresponding to dimension III, the leading edge of the sheet is between anti-cobble device 27 and anti-cobble device 28, and anti-cobble device 28 should be utilized. However, if no shear cut signal should occur between the completion of count II and count III, then the leading edge of the sheet is in front of anti-cobble device 27, and that device should be utilized in controlling the operation.

Thus, by the apparatus so far described, the computer knows the whole number of sheets between the center line of the pinhole detector 11 and the anti-cobble device 28 and knows the location of the leading edge of the sheet with respect to devices 27 and 28; in the drawing this is sheet fs_0 , which is approaching device 27. Also, through the operation of the pinhole delay storage register and the pinhole delay counter, the computer knows the precise instant that the leading edge of each future sheet that will subsequently be cut by the shear passes the center line of the pinhole detector.

As previously explained, the counting process in effect, gives a signal or pulse which is delayed with respect to the actual shear cut signal by a period of time corresponding to the distance $l-r$. At the end of the delay a signal pulse is transmitted by pinhole delay counter 38 to the first memory register 40. If the future sheet passing through the pinhole detector between two successive pulses supplied to the memory register 40 is free from pinholes, then the computer has nothing to do with respect to that future sheet. If, however, the pinhole detector 11 should give a signal indicative of a defective sheet in that

period of time, then the memory register must receive that signal and step it through the memory register one step for each pulse delivered by the shear tachometer 25. In as much as the pinhole sheet register and matrix 39 has previously determined the whole number of sheets between the pinhole detector 11 and the anti-cobble device 28 and supplied this information to the memory register 40, the memory register counts off this number of steps and then supplies a signal pulse to the anti-cobble units.

Referring to FIGURE 8, the completion of counts corresponding to dimension II and the resultant enabling of gate G1-3 sets flip-flop FF-12 and also gives an enabling signal to gate G2-6. Setting of FF-12 enables gate G-16 and permits the pinhole signal, if any, that is delivered from the memory register 40 to be delivered to FF-7 in anti-cobble storage device 43. Should a shear cut signal occur before preset count III is reached, then gate G2-6 will be energized by OS-1 which resets FF-12, enables gate G-17 and causes the pinhole signal from the first memory register 40 to be channelled through gate G-18 to anti-cobble device 49 where it sets flip-flop FF-8.

If anti-cobble storage unit 43 was set as previously described, then the leading edge of the sheet passing over the anti-cobble device 27 gives a signal which is shaped by AS-4 and resets FF-7, causing anti-cobble device 49 to be set. Likewise, the leading edge of the same sheet passing over anti-cobble device 28 causes FF-8 to be reset and this in turn resets FF-9.

The output signal from the first memory register sets FF-9 at the same instant that the signal was fed to anti-cobble device 48 or 49. This stores in FF-9 the fact that a pinhole signal is passing over the anti-cobble units 27 and 28, and the storage is continued while the apparatus decides whether 27 or 28 will be utilized to locate the leading edge of the pinhole containing sheet. This decision is indicated by the resetting of FF-9 at which time FF-9 will deliver a signal to the second memory register 41. The second memory register 41 receives a pulse at the instant that a defective sheet reaches the second anti-cobble device 28 regardless of the length of the sheets or the speed of operation of the apparatus.

The second memory register 41 is a simple shift register which is capable of receiving and delivering serial information. The pinhole signal is delivered, as stated above, to the register at the time the leading edge of the sheet passes the second anti-cobble device 28, and the pinhole signal is advanced through the register by a signal derived from tachometer 30 through AS-3, AP-3 and the adjustable binary counter 60. This counter may be adjusted to give an output pulse for a preset number of input pulses supplied to it by the tachometer 30. Thus, in the example given, the tachometer 30 produces a pulse for each inch of advance of the conveyor 15, and the adjustable counter 60 could be set to give a pulse to the second memory register every sixteen inches, for example. Each signal indicative of a pinhole-containing sheet is then stepped through the second memory register in accordance with the signals received from the adjustable binary counter and the tachometer 30, and is delivered to the anti-cobble device 50 as the sheet is approaching anti-cobble device 31. Anti-cobble device 50 is constructed in the same manner as anti-cobble devices 43 and 49. It is set by a signal pulse received from the second memory register 41 and reset when the leading edge of the pinhole containing sheet passes over the anti-cobble device 30. This gives a signal to the amplifier 51 which energizes, in the example given, the solenoid 33 and actuates the deflector 16 to deflect the pinhole containing sheet to the reject pile.

As indicated in FIGURE 7, the completion of the count III by the main binary counter enables gate G2-2 and provides a signal to OS-4 to reset FF-X and thus the first shear cut signal derived from tachometer 25

after the completion of the count will reset FF-1 and initiate a new computation cycle.

From the foregoing, it will be evident that the apparatus repetitively performs the calculations required to enable a classifier embodying the invention to accurately and reliably separate sheets containing defects such as pinholes or having over or under gauge characteristics from prime sheets. The operation is simplified and the accuracy enhanced because of the fact that the computer only has to remember the particular sheet and not the particular location of a defect. Because of the fact that the leading edge of the sheet containing a defect is accurately located by the anti-cobble device 28 when the second memory register 41 starts its operation, the apparatus operates with a high degree of reliability and with little likelihood of cobbles or jams. The apparatus is able to locate defects accurately, because the sheet in which a defect occurs can be determined with a high degree of accuracy; the accuracy of this determination is controlled by the size of the increments represented by the pulses delivered by tachometer 24. In the present instance, each increment is 0.050 inch but if a greater degree of accuracy is required the size of the increments could be reduced to any practical value. Reduction in the size of the increments increases the counting capacity required by the main binary counter and the storage capacity required by the pinhole delay storage register, but the apparatus in general remains the same. Since the computer performs its functions repetitively in response to pulses from the tachometer, it automatically adjusts itself to changes in sheet length and changes in speed of the conveyors.

Those skilled in the art will appreciate that various changes and modifications can be made in my invention without departing from the spirit and scope thereof. While a digital computer is preferred, computers of the analogue type also could be employed. One type of computer is disclosed in detail, but those skilled in the art will appreciate that other computer circuits for carrying out the same functions could be devised without difficulty. While apparatus is described in connection with rejecting sheets of tin plate containing pinholes, it is to be understood that the apparatus is adapted to other materials and other types of inspecting operations. The essential characteristics of the invention are defined in the appended claims.

I claim:

1. A method of shearing strip material into sheets and classifying sheets so sheared in accordance with a characteristic of the material determined while it is in strip form, which includes the steps of continuously moving the strip material through an inspecting device at high speed, thereafter shearing the moving strip into sheets, determining at the instant each sheet is cut from the strip the distance between the inspecting device and the next future cut to be made in the strip that is approaching the inspecting device, and thereby determining at the instant a given characteristic is detected by the inspecting device which sheet subsequently to be cut from the strip will have said characteristic, following the position of said sheet having said characteristic in its passage from the inspecting device to a fixed point beyond the shear by means of one memory device, determining independently of the operation of the shear the instant that the leading edge of said sheet having said characteristic reaches said fixed point beyond said shear, following the position of said sheet having said characteristic from said fixed point to a point adjacent a deflector by means of a second memory device, and operating said deflector to separate said sheet having said characteristic from sheets that do not have said characteristic.

2. A method of shearing strip material into sheets and classifying sheets so sheared in accordance with a characteristic of the material determined while it is in strip form, which includes the steps of continuously mov-

ing the strip material at high speed through an inspecting device, thereafter shearing the moving strip into sheets, determining at the instant a given characteristic is detected by the inspecting device which sheet subsequently to be cut from the strip will have said characteristic, following the position of said sheet having said characteristic in its passage from the inspecting device to the shear by means of one memory device, determining independently of the operation of the shear the instant that the leading edge of said sheet having said characteristic reaches a fixed point beyond said shear, following the position of said sheet having said characteristic from said fixed point to a point adjacent a deflector by means of a second memory device, and operating said deflector to separate said sheet having said characteristic from sheets that do not have said characteristic.

3. In an apparatus for inspecting and shearing strip material into sheets and classifying the sheets in accordance with a characteristic of the material determined while it is in strip form having means for guiding the material in strip form, means for shearing the material, means for conveying sheets sheared from the strip away from the shearing means, deflecting means located in the path of travel of said sheets beyond said shear for deflecting sheets to predetermined paths in accordance with a characteristic of the sheets as determined while the material is in strip form and comprising inspecting means for producing an output signal in response to a characteristic of the material in strip form; means independent of the shear producing a signal pulse for each increment of advance of said strip from said detecting means toward said shear, means producing a signal pulse for each cut made by said shear, and means for determining from the distance between said detecting means and said shear and from said signals which sheet to be subsequently cut from the strip is being inspected by said detecting device at any given instant and thereby, at the time that a given characteristic in said strip is signalled by said detecting means, determining which sheet to be subsequently cut from said strip has said characteristic, means for remembering the location of said sheet having said characteristic in its passage through the apparatus both before and after said defect containing sheet is cut from said strip, and means for operating said deflecting means to separate sheets having said characteristic from sheets that do not have said characteristic.

4. Apparatus according to claim 3 wherein the sheet containing the given characteristic is located by a com-

puter that repetitively determines at the instant each cut is made by the shear the distance between the next future cut approaching the inspecting device and the center line of the inspecting device.

5. Apparatus according to claim 4 having a first anti-cobble device disposed immediately beyond the shear and a second anti-cobble device disposed near but beyond said first anti-cobble device, said anti-cobble devices being adapted to detect the presence of sheets adjacent them, and wherein the computer is provided with means for repetitively determining the nearest whole number of sheets between the inspecting device and one of said anti-cobble devices.

6. Apparatus according to claim 5 wherein the computer contains a first memory device for following the location of a sheet having the given characteristic from the inspecting device to the second anti-cobble device.

7. Apparatus according to claim 6 wherein the computer contains a second memory device for following the location of a sheet from said second anti-cobble device to a point adjacent said deflecting means, said computer having circuit means for transferring a signal indicative of sheets having said characteristic from said first memory device to said second memory device at the time the leading edge of the sheet having said characteristic reaches said second anti-cobble device.

8. Apparatus according to claim 7 wherein the computer is a digital computer.

9. Apparatus according to claim 8 wherein the inspecting device is a pinhole detector.

10. Apparatus according to claim 9 wherein the anti-cobble devices are magnetic devices for detecting the presence of a ferrous sheet above them.

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