Aug. 9, 1966 A. G. OWEN 3,264,916

SHEARING LINE, SINGLE SHEET CLASSIFIER

Filed Sept. 20, 1963 6 Sheets-Sheet 1

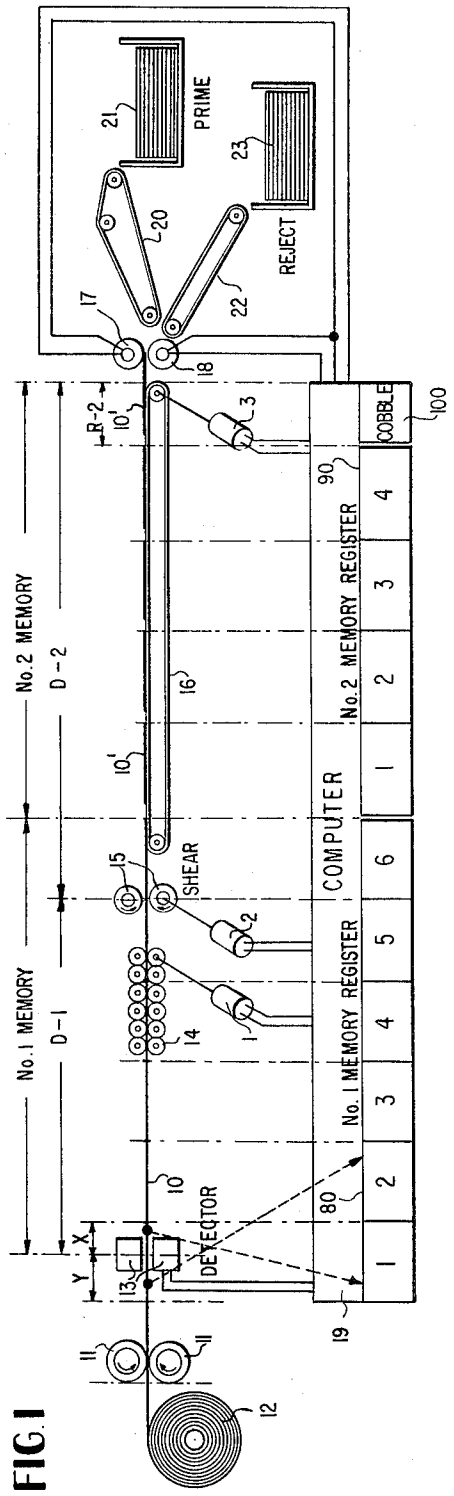


FIG. 1

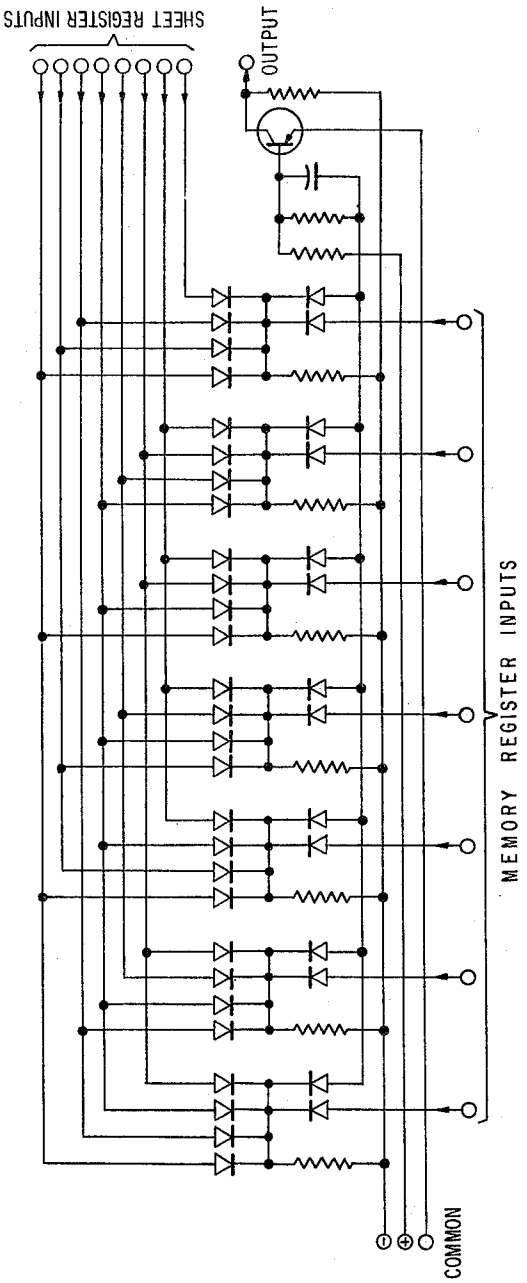


FIG. 14
"SM-7"

INVENTOR.
ALBERT G. OWEN
BY Rupert J. Brady
ATTORNEY

SHEARING LINE, SINGLE SHEET CLASSIFIER

Filed Sept. 20, 1963 6 Sheets-Sheet 2

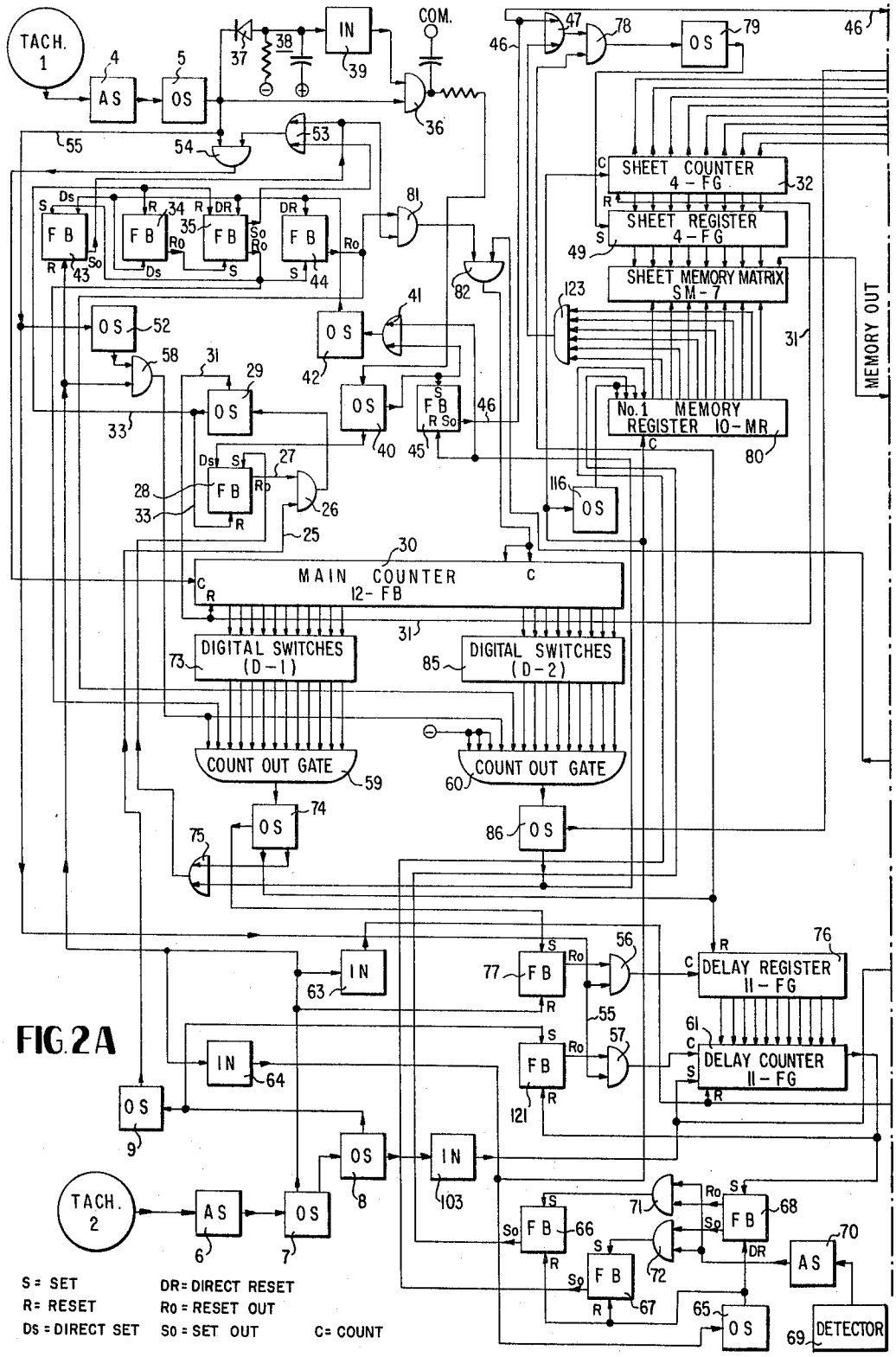


FIG. 2A

SHEARING LINE, SINGLE SHEET CLASSIFIER

Filed Sept. 20, 1963 6 Sheets-Sheet 3

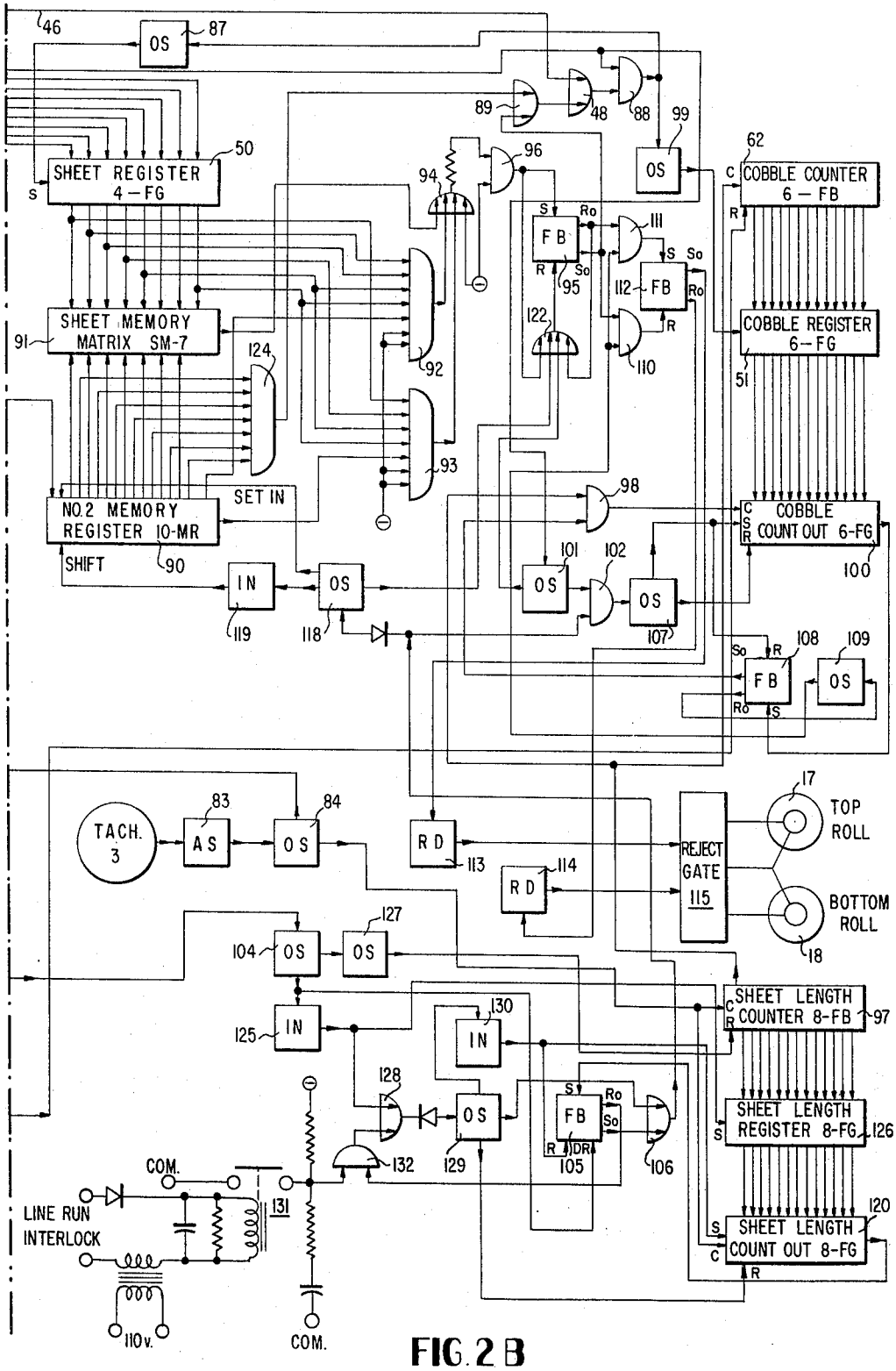


FIG. 2B

SHEARING LINE, SINGLE SHEET CLASSIFIER

Filed Sept. 20, 1963 6 Sheets-Sheet 4

FIG. 3
"FB"

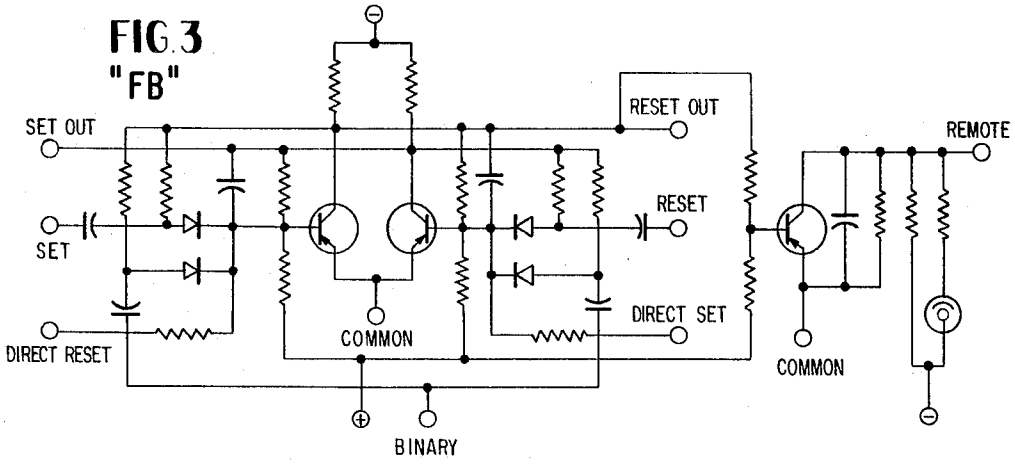


FIG. 4
"FG"

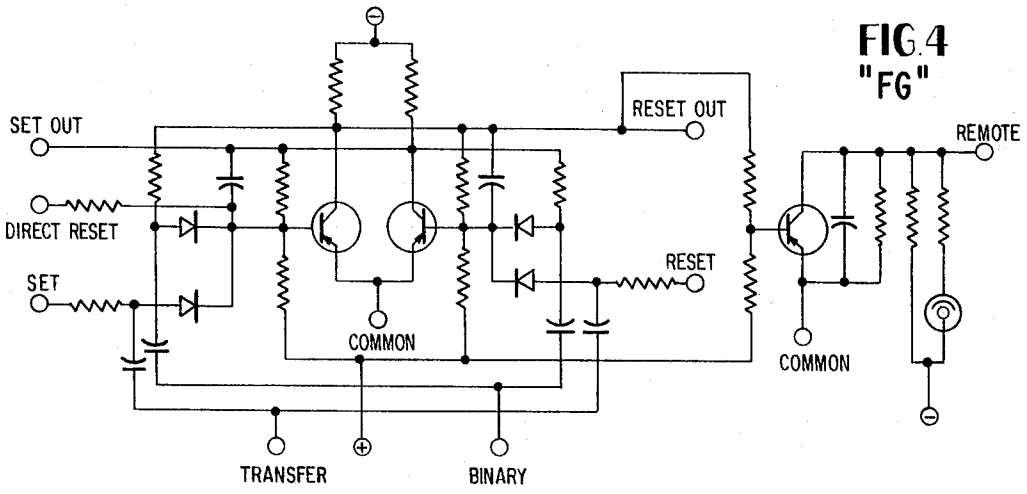
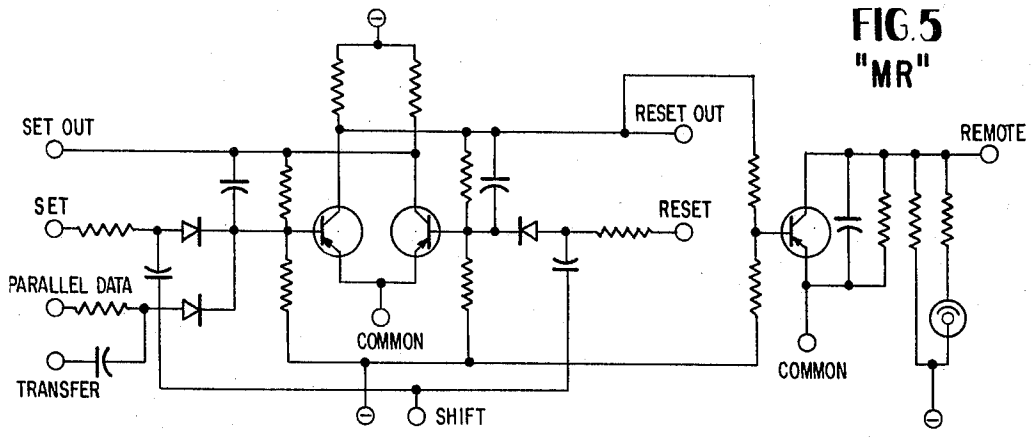


FIG. 5
"MR"



SHEARING LINE, SINGLE SHEET CLASSIFIER

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FIG. 7
"OS"

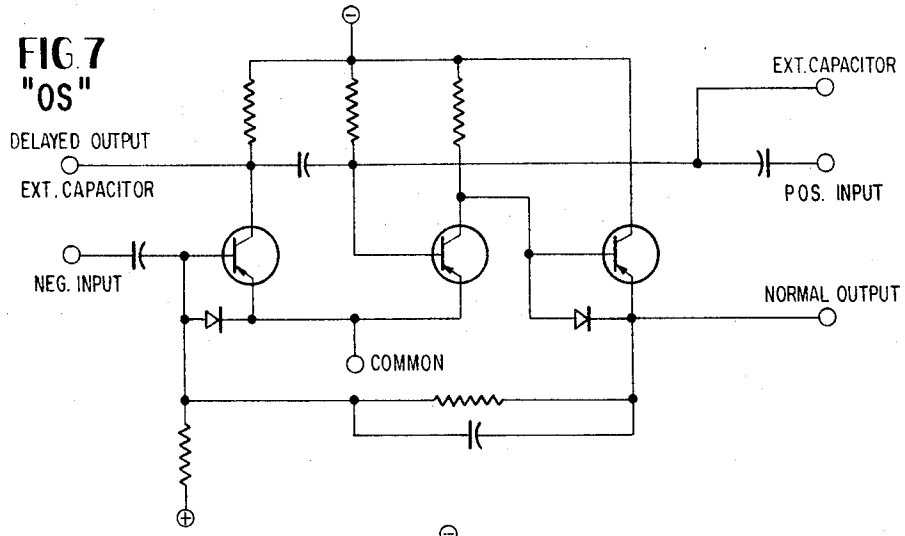


FIG. 8
"AS"

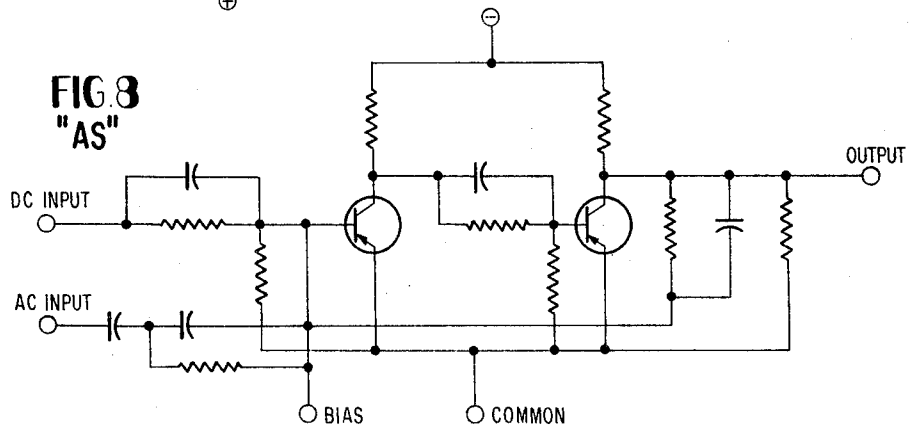


FIG. 6
"RD"

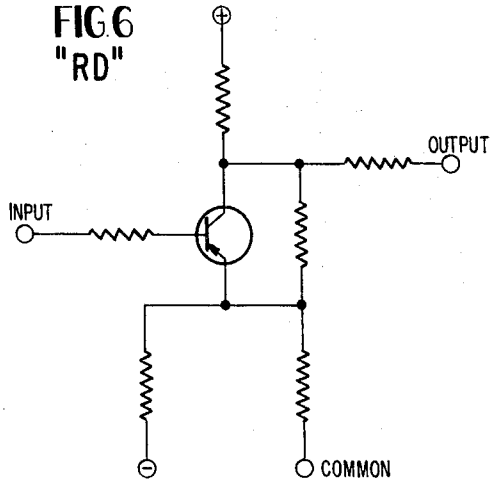
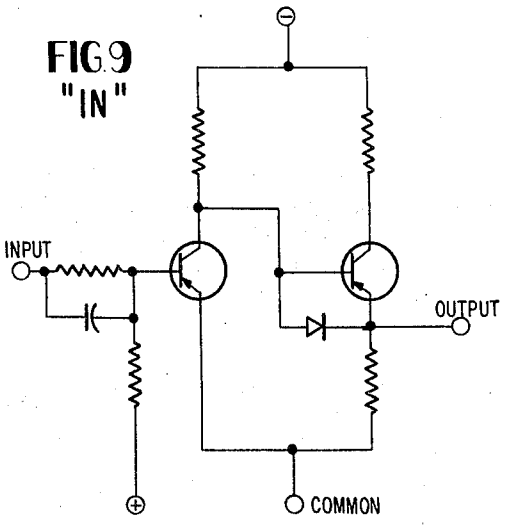


FIG. 9
"IN"



Aug. 9, 1966 A. G. OWEN 3,264,916
SHEARING LINE, SINGLE SHEET CLASSIFIER
Filed Sept. 20, 1963 6 Sheets-Sheet 6

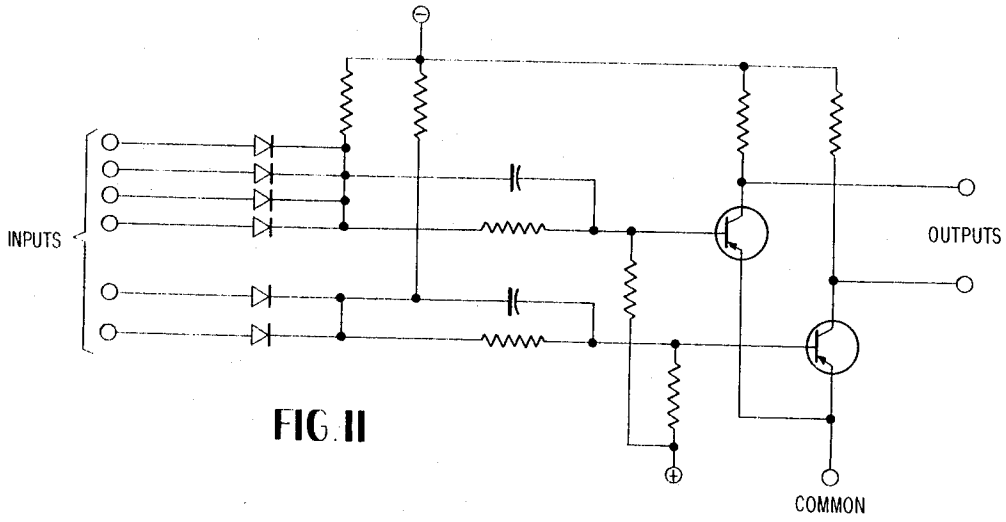


FIG. 11

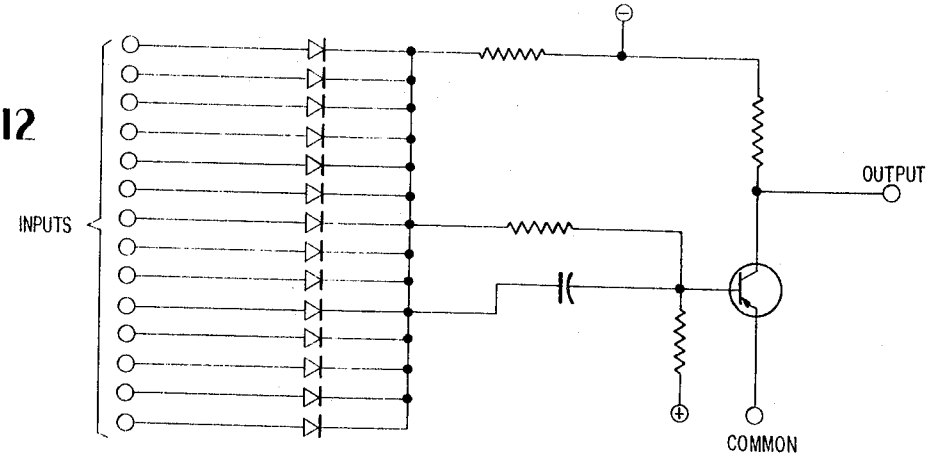


FIG. 12

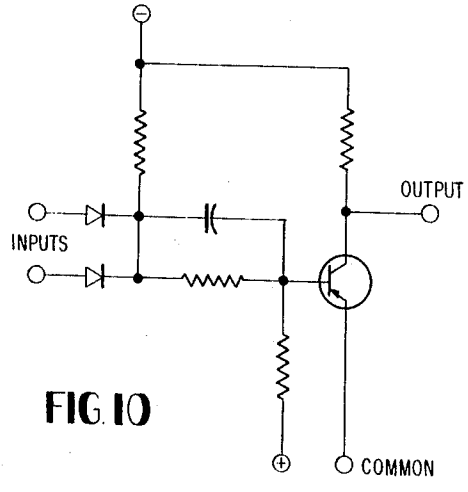


FIG. 10

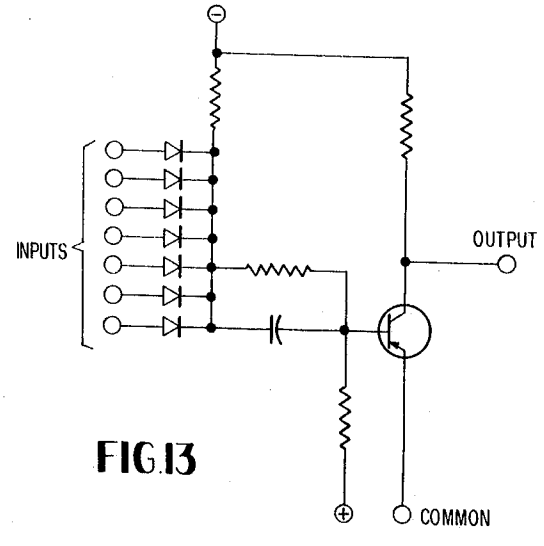


FIG. 13

United States Patent Office 3,264,916 Patented August 9, 1966

3,264,916

SHEARING LINE, SINGLE SHEET CLASSIFIER

Albert G. Owen, 4409 Driftman Drive, Monroeville, Pa.

Filed Sept. 20, 1963, Ser. No. 310,278
18 Claims. (Cl. 83—80)

The application is a continuation-in-part of my copending application Serial No. 861,366, filed December 22, 1959, now Patent No. 3,169,428, granted February 16, 1965.

This invention relates broadly to apparatus for inspecting and classifying sections sheared from strip material and more particularly to an improved single sheet digital classifier for high speed shearing lines.

All single sheet classifiers, for high speed shearing and classifying lines, have in the past operated on a two step principle; namely to locate the fault as a point on the strip, which was then memorized as a point to the shear, and then to locate the fault with respect to the sheared sheet, locate the leading edge of this sheet and memorize the faulty sheet to the reject gate. The only changes in the art have been the improvement in the hardware.

Digital circuits are not suitable for this method, because the resolution attainable with the magnetic memory wheel cannot be duplicated by digital circuits except at a cost that makes the digital approach prohibitive. While the magnetic memory wheel systems also require digital circuits, the all digital approach is the more desirable system.

The design of an all digital single sheet classifier requires an entirely different approach. By determining the sheet in which a detected fault occurs at the same instant the fault is detected, it is possible to memorize the faults from the point of detection to the reject gate as one step, and in increments of sheet length with a resolution equal to or better than the magnetic memory wheel.

To accomplish this function, the computer determines the points at which the strip will be sheared and relates this information to the pinhole detector or gage, which then makes it possible to determine the quality of the sheet at the pinhole detector or gage before shearing. The information of prime and reject sheets is then followed to the reject gate in increments of sheet length, at which point actual classification takes place.

An all digital single sheet classifier operating in this manner is described and disclosed in my copending patent application Serial No. 861,366, filed December 22, 1959, for "Single Sheet Classifier" now Patent No. 3,169,428, and the present invention is an improvement of the system disclosed therein, the disclosure of which is in incorporated herein by reference.

In the digital computer single sheet classifier disclosed in application Serial No. 861,366 the digital distance Y, $(1-r)$, that is the distance between the next future cut approaching the pinhole detector and the center line of the pinhole detector, was used by the computer to actually locate the next future shear cuts in the strip material at the instant these future shear cuts passed the center line of the inspecting device, or pinhole detector. Thus the strip was inspected at the pinhole detector as sheets before they were sheared, that is as sheets subsequently to be sheared from the strip. The characteristics of the strip or the pinhole faults were thus located with respect to the sheet in which they would appear after shearing but in advance of the actual shearing operation.

The digital classifier of application Serial No. 861,366 operated successfully for many applications of the system but was unsuccessful and did not operate properly whenever an even number of whole sheet lengths were contained in the distance between the inspecting device or pinhole detector and the shear. This is due to the fact

that the shear measuring rolls 14, designated 12 in the previous application, commonly referred to as the leveling rolls, which determine the length of the cut sheets and which also drive tachometer 1, (24), do not make perfect rolling contact with the strip due to the high speed of the strip, and the resulting friction slippage between the measuring rolls and strip causes a continual though small change in the computed value of Y, $(1-r)$. The continuously changing computed values from the computer causes the computer memory registers to be continuously recalibrated and the information therein continuously shifted which results in erroneous rejection of prime sheets while allowing the faulty sheets to be passed to the prime pile of the classifier.

The contingency of an integral number of sheets in the length of the strip between the pinhole detector and the shear can occur over approximately five to seven banks of the range of possible sheet lengths for a shear, the number of banks depending on the shortest and longest possible length of sheets cuts on any given shear. Thus a shearing line operated by a single sheet classifier such as disclosed in application Serial No. 861,366 is limited to specific ranges of sheet lengths which it can cut if it is to operate properly.

It is therefore an object of the present invention to provide a new and improved digital single sheet classifier for high speed shearing lines which rejects only faulty or defective sheets and eliminates erroneous rejection of prime sheets for all ranges of sheet lengths that can be sheared by a line.

Another object of the invention is to provide a new and improved digital computer single sheet classifier for high speed shearing lines which operates efficiently and accurately even when there are an integral number of sheet lengths between the fault-detecting means and the shear.

Another object of the invention is to provide a new and improved single sheet classifying computer for shearing lines, the accuracy of which is directly proportioned to the accuracy of the defect-detecting apparatus and in which tachometer slippage errors have a negligible effect on system accuracy.

Still another object of the invention is to provide a shearing line computer controlled single sheet classifier providing a novel arrangement for retaining and using the faulty sheet information in the computer for clearing the classifier conveyors of cut sheets even while the shearing operation is shut down.

A further object of the invention is to provide a construction of digital computer controlled single sheet shearing line classifier in which the length of a sheet and the gap between adjacent sheets leaving the shear is continuously recalibrated to minimize the normal error caused by the speed difference between the strip and conveyor following the shear.

Still a further object of the invention is to provide a new and improved single sheet classifier which eliminates the need of any means for sensing sheet edge on the output side of the shear, thus reducing system maintenance problems.

Other and further objects of the invention reside in the accuracy of sheet rejection provided by the system, the manner in which all normal errors of transfer from the strip to the output conveyor are eliminated except that of slippage between the sheet and belt, and further objects and advantages of the system will become apparent to those skilled in the art from a review of the specification hereinafter following by reference to the accompanying drawings, in which:

FIG. 1 is a schematic diagram of the single sheet classifier of the invention connected to a shearing line;

FIGS. 2A and 2B when disposed in side-by-side relation present a schematic logic diagram of the single sheet classifier of the invention;

FIG. 3 is an electrical schematic diagram of one type of flip-flop circuit (FB) used in the single sheet classifier;

FIG. 4 is a schematic diagram of another type of flip-flop circuit (FG) used in the computer circuits;

FIG. 5 is an electrical schematic diagram of another type of flip-flop circuits (MR) used as a shift register in the computer circuits;

FIG. 6 is an electrical schematic diagram of a relay driver circuit (RD) used in the computer circuits;

FIG. 7 is an electrical schematic diagram of a one shot multivibrator circuit (OS) used in the circuits of the single sheet classifier;

FIG. 8 is an electrical schematic diagram of a conventional type Schmidt squaring amplifier (AS) used throughout the classifier circuits;

FIG. 9 is an electrical schematic diagram of an inverter power amplifier (IN) used in the computer circuits;

FIGS. 10, 11, 12 and 13 are electrical schematic diagrams of standard D.C. gates which are utilized both as AND or OR gates throughout the classifier circuits; and

FIG. 14 is an electrical schematic diagram of a standard type memory matrix circuit (SM–7) used in connection with the computer circuit memory registers.

In the schematically illustrated shearing line of FIG. 1, a strip of material **10**, such as tinplate or the like, is fed through pinch rolls **11** from coil **12**, past an inspecting device **13**, over measuring or leveling rolls **14** (designated **12** in the previously mentioned application) and to the rotating shear **15**, which shears the strip into sheets **10'** of a predetermined length. Immediately upon being sheared the sheets **10'** are deposited on entry conveyor **16** which travels at a speed faster than strip **10** so as to form gaps between adjacent sheets on the conveyor. This conveyor then delivers the sheets to a deflecting device such as a pair of magnetic rolls **17** and **18**, of known design, which carry out the commands of the digital computer single sheet classifier of the invention, indicated generally at **19**. The digital computer **19** memorizes the fault information, such as pinholes, detected by inspecting device **13** prior to the shearing operation and advances this stored information with the travel of the material to a point of classification after the shearing operation for use in separating defective and prime sheets.

When defective sheets enter the magnetic rolls the classifier from the previously stored information energizes magnetic roll **18** to deflect these sheets onto conveyor **22** for deposit in reject pile **23**, whereas magnetic roll **17** is energized by the classifier to deflect prime sheets onto conveyor **20** for deposit in prime pile **21**.

Throughout the following specification the inspecting device **13** is referred to as a pinhole detector for descriptive purposes only and it is to be understood that other type sensing devices, such as thickness gages, etc., can be used, and that a combination of different type inspecting devices, such as a pinhole detector and a thickness gage, can be used simultaneously with the single sheet classifier of the invention without changing the basic operation of the classifier or departing from the scope of the invention. As will become evident to one skilled in the art, the use of additional inspecting devices merely requires the addition of plural parallel channels in the digital computer.

In the computer classifier in order to compensate for the variations in the sheet gap length on the entry conveyor following the shear, the memory system has been divided into two sections; one Memory Register **80** to follow the strip from the pinhole detector to the shear (D–1), and another Memory Register **90** to follow the sheets from the shear to the reject gate (D–2). Since the strip protruding from the shear over the entry conveyor **16** cannot accelerate and move with the entry conveyor until the instant it is sheared as a sheet from the strip, the transfer of information from the memory **80** prior to the shear, to the memory **90** following the shear does not take place until the sheet is sheared and dropped on the conveyor **16**. Thus the only error in the transfer of information from one memory to the other is the slippage of the sheet on the entry conveyor **16** during the period of acceleration, which is a small amount and which may be compensated for in part by increasing the measured distance D–2 before insertion into the computer.

The computer **19** compares the predetermined lengths of the sheets being cut to the digital distance represented by D–1, which is the distance from the center line of the pinhole detector **13** to the shear **15** at initial closing contact with the strip **10**. This comparison, in the example as illustrated in FIG. 1, will show four integral sheet lengths in the count D–1 with distance X as the remainder. Distance X is immediately subtracted from the digital length of one sheet which results in the digital distance Y being determined by the computer, and which represents the digital distance that the incoming future shear cut precedes the center line of the pinhole detector at the exact instant an actual shear cut is made.

The computer has four problems to solve in order to set up the memory system in the computer to classify the sheets having pinholes from the prime sheets:

(1) The maximum number of integral sheet lengths in the strip length D–1.

(2) The strip length Y that a future shear cut or sheet edge precedes the pinhole detector at the instant the shear makes a cut.

(3) The maximum number of integral sheet lengths between the shear and the reject gate or in the line distance D–2.

(4) The line distance R–2 between the leading edge of the last integral sheet in line distance D–2 and the terminating point of distance D–2 just prior to the reject gate.

The answer to problem 1 is used to determine the length of the memory register from the pinhole detector to the shear, that is, the number of bits this register will possess. The answer to problem 2 is used to govern the point of fault insertion into the pinhole detector memory **80**. The answer to problem 3 is used to determine the length or the number of bits in the memory register **90** from the shear to the reject gate, and the answer to problem 4 is used to position the sheet in front of the reject gate just prior to operation of this gate.

This information is the total required to accurately determine the sheet containing the fault at the pinhole detector, and to memorize the leading edge of the sheet to the proper reject gate.

Due to the fact that the leveling rolls **14** on the shear do not make perfect friction contact with the strip **10**, tachometer **1**, which is driven by these rolls, will give a continuously varying signal which can cause the computer to error in the event an even number of sheets were in the strip between the pinhole detector and the shear, as previously mentioned in connection with the system of application Serial No. 861,366. To compensate for this possible error, in accordance with the teaching of the present invention, the pinhole information is entered into the first or second bit of memory register **80**, and may possibly be entered into both bits in the event an even number of sheets occurs between the pinhole detector and the shear.

Referring to the schematic diagram of FIG. 1, the insertion of pinhole information into No. 1 Memory Register **80** is illustrated by the dotted lines. To effect proper insertion of fault information into this memory two decisions must be made with the passage of each future sheet under the pinhole detector **13**. The first decision is made when the future sheet edges or future shear cuts pass the pinhole detector **13**. At that time any subsequent pinhole informa-

tion, such as in the distance X, is entered into the first bit of memory register 80 until the second decision is made. The second decision is made when the shear 15 actually makes a cut. At that time any pinhole information subsequent to a shear cut signal, such as in the distance Y, is entered into the second bit of memory register 80 as indicated. The memory registers shift at the instant of each shear cut as signaled by tachometer 2, and any pinhole or fault information previously entered into the first bit the memory register 80 is moved or shifted into the second bit of the memory register, and, therefore, the second bit of the memory register will contain all information relative to the particular future sheet shown in FIG. 1 as being under the pinhole detector 13. In contrast to this operation, in the classifier of application Serial No. 861,366, the memory was shifted as future shear cuts passed under the pinhole detector center line. The advantages of the new arrangement set forth herein will become aparent from a study of the ensuing description.

Applying the foregoing fault information insertion process literally to the schematic diagram of FIG. 1 would seem to indicate that information of pinholes is one memory bit unit ahead of the strips. To prevent this occurrence, the fault information is held by the computer upon receipt from the pinhole detector and is then inserted into the memory register 80, immediately following a shift signal from tachometer 2. The same result can be obtained by making the memory register one bit longer.

By way of example, if there are two holes in one sheet, one in the X portion of the sheet, and one in the Y portion of the sheet, the hole in the X portion of the sheet would be seen first by the pinhole detector 13, and this hole information is placed into the first bit of No. 1 Memory Register 80. At the instant that an actual shear cut is made, which is the position the line is depicted at in the schematic diagram of FIG. 1, the information of the hole in the X portion of the sheet is shifted to the second bit of the memory register. When the hole in the Y portion of the sheet is detected by the pinhole detector it will also be inserted into the second bit of the memory register 80. Thus, information on both holes ends up in the same bit in the memory register and is shifted from bit to bit upon each shear cut as the particular future sheet in the strip progresses towards the shear.

It will be seen that if there is an even number of sheets in the line distance D–1, the signal from tachometer 2 and the signal from the computer indicating a future shear cut is passing the center line of the pinhole detector will coincide. In actual practice the signal of the future shear cut will appear to move ahead and behind the signal of tachometer 2 due to slippage between the strip and leveling rolls 14, causing the pinhole signal to be first placed in the first bit and then the second bit of memory register 80 could cause an error in rejection of the proper sheet, except for one reason. The pinhole detector is provided with a window not less than three-quarters of an inch wide, which will cause the detector 13 to actually see a slot (signalwise) in the strip, instead of a hole. Therefore, variances between coincidence of the signal from tachometer 2 and the future shear cut signal will be lost or covered by this "slot" signal from the pinhole detector, and therefore two sheets will be rejected, regardless of the tachometer 1 error. Therefore, the sheet containing the pinhole will be rejected because the small error in the computer is lost in the large error in the pinhole detecting stage. As is well known, it is a rule of thumb in single sheet classification that any hole appearing closer than half the distance across the pinhole detector window from the edge of a sheet will cause two sheets to be rejected, thus insuring that all sheets in the prime pile are actually prime sheets.

The foregoing explains how the error in calculation of distance Y by the computer, due to tachometer 1 slippage error, is compensated for, but there is likewise an error in the calculation of the number of integral sheets between

the shear 15 and the pinhose detector 13 when there is an even number of sheets between the shear and the detector, since this number will shift back and forth one digit. This error will cause the calibration of the memory register to be in error also.

This problem is solved by causing the memory registers to refuse to accept any re-calibration once a bit of pinhole information is received until it has been processed and passed through the register. Therefore, the calibration in effect at the time the pinhole was detected was correct at that time for that particular pinhole information positionwise and since it is not changed while the bit is passing through the memory register no error in processing will occur.

As has been previously described, the strip is followed with the No. 1 Memory Register 80 from the pinhole detector to the shear and to a point one sheet length past the shear to minimize the error of transfer from the No. 1 Memory Register 80 to the No. 2 Memory Register 90 which follows the sheets from the shear to the reject gate. For this reason the No. 1 Memory Register 80 is made one bit longer than would otherwise be the case and as shown in FIG. 1, the No. 2 Memory Register 90 is one bit less than normal. For example, it would be four bits or units long instead of five bits long. The only error in transfer of information between the two registers 80 and 90 is the slippage of the sheet 10' on the entry conveyor 16 during acceleration.

In the previously described system in application Serial No. 861,366, it was necessary to locate the leading edge of the sheets coming out of the shear at the instant the information came out of the memory register. Since in that system, the point at which the sheet edge was located at that time could be any part of a sheet length that passed the shear, depending on the ratio of sheet length to the line distance D–1, it was necessary to have some means following the shear to perform this sheet edge-locating function. This was always accomplished in the past with two photocells after the shear, two being necessary because the ratio of the shortest to the longest sheet length was always more than two. This has always been a source of persistent maintenance troubles in the art since sheet wrecks invariably strike these cells and throw them out of adjustment rendering the classifier inoperative. With the system of the present invention it is possible to do away with this annoyance, since the sheet edge is always coincident with the shear knives 15 at the instant the information of pinholes is received from the No. 1 Memory Register 80, and therefore the No. 2 Memory Register 90 may start at the shear knives and will never change under any circumstances.

When the No. 2 Memory Register has followed the faulty sheet to its limit (bit No. 4) the fault information is then transferred into a "hold" circuit where it is held until the anticobble counter 62 has counted-off the remaining distance R–2 to the reject roll. This R–2 count is the answer to the fourth problem the computer is required to solve.

Since the memory system is divided into two memory registers 80 and 90, and since for purposes of synchronizing the two memory registers to operate simultaneously in shifting information through the system the shear cut information from tachometer 2 operates both memories, some means must be provided to operate the No. 2 Memory Register 90 in the event that the front end of the shearing line, which includes the shear 15, is shut down. It is common practice when a line is shut down in the middle of a coil run for any number of reasons to always clear the classifier conveyors of all sheets that have been cut before re-starting the front end of the line and resuming the shearing operations. Therefore, some means is needed in the system to operate only the second section of the memory system during the clearing process so that all information of faulty sheets that may already be in memory 90 will not be lost and therefore enable all

sheets between the shear and reject gate to be properly classified. This function is performed by the sheet length counter **97** and the line run interlock and the associated circuitry as more fully explained hereinafter following.

The individual circuits used throughout the single sheet classifier of the invention are all standard type circuits as illustrated in FIGS. 3–14, the operations of which are readily apparent to one skilled in the art. Therefore, each of the circuits will be discussed only briefly as it is deemed unnecessary to discuss these standard well-known circuits in detail. Throughout the logic diagram of FIGS. 2A and 2B the various blocks are designated with reference letters corresponding to the type of circuit contained within the blocks.

Only three basic standard circuits are used in the digital computer classifier of the invention and these are the bi-stable multivibrator circuit, more commonly known as the flip-flop circuit and will be referred to as such throughout the specification, the mono-stable multivibrator circuit, commonly referred to as the one shot multivibrator, and the D.C. gate. All other circuits used in the classifier such as the squaring amplifier (AS), the inverter power driver (IN) and the relay driver (RD) are used to aid the three basic circuits. The sheet memory matrix circuits (SM–7), such as shown in FIG. 14, are merely combinations of standard D.C. gates to perform specific functions and such combinations are well known in the art.

Three basic configurations of the flip-flop circuit designed without a common emitter resistor in order to achieve greater stability are used throughout the classifier, and these are the FB or binary flip-flop circuit shown in FIG. 3, used primarily for counting and holding actions; the FG or gated flip-flop shown in FIG. 4, used primarily for count memorizing registers; and the MR or shift register flip-flop shown in FIG. 5, used almost entirely for shift register memory functions. All the flip-flops require positive signals to actuate them.

The FB flip-flop circuit as shown in FIG. 3 includes a "binary" input for counting functions, "set" and "reset" inputs for single actions for use in memory holding functions, and "direct set" and "direct reset" inputs for resetting a group of flip-flop circuits in a counter to zero. This circuit contains a pair of outputs labeled "set out" and "reset out."

The FG flip-flop circuit shown in FIG. 4 includes a "binary" input for counting functions and gated "set" and "reset" inputs for insertion of information from another counter or register, which eliminate the need for external gates. The built-in gates are of the A.C. pulse type. The circuit contains a pair of outputs including a "set out" and a "reset out" terminal.

The MR flip-flop circuit shown in FIG. 5 and used mainly in the shift registers or memories of the classifier include gated "set" and "reset" inputs for the "shift" function, and a single gated "set" input for insertion of information into the circuit, regardless of its position in the register. The outputs are basically the same as those on the other flip-flop circuits.

The RD relay driver circuit shown in FIG. 6 includes a single transistor with a single input arranged to be driven by any other circuit, and a single output which fluctuates both above and below common or ground potential. As shown in the logic diagram these circuits are used to fire the thyratron circuits in the reject gate which controls the energization of the top and bottom magnetic rolls **17** and **18** for which purpose both positive and negative voltage with respect to ground are required.

The OS one shot multivibrator circuit of FIG. 7 is used extensively throughout the classifier as a timing device to program computer functions. However, in a few instances, as will become apparent to one skilled in the art, it is sometimes used to eliminate a D.C. signaling action in favor of a pulse. This circuit includes a negative and a positive input and provision for an external capacitor to adjust the timing of the circuit. The "normal" output includes an emitter follower amplifier as shown, for driving the reset function of a counter. The "delayed" output occurs after the predetermined time interval built into the circuit. Thus, the OS circuit may be driven with either positive or negative pulses and either positive or negative output signals may be utilized from either output.

The AS squaring amplifier shown in FIG. 8 is a conventional Schmidt circuit with the common emitter resistor eliminated for greater stability and for greater signal amplitude. The functions of this circuit in the computer is to receive a signal of any wave front and of any amplitude and convert this signal to a suitable wave front amplitude so as to be compatible with the other digital circuits and thus be able to drive any of them. The biasing inputs make it possible to polarize the amplifier so as to respond only to signals of one polarity or the other and to respond only to signals of certain minimum amplitudes and this makes it possible to unsensitize this unit to other signals within certain limits.

The IN inverter amplitude shown in FIG. 9 is primarily a power amplifier whose main function in the classifier is to drive a long shift register or to reset a counter or a group of counters which comprise a load normally too great to be driven directly by an OS one shot multivibrator circuit, such as shown in FIG. 7. The inverter circuit has only one input and one low impedance output and may be driven with either a positive or negative signal with the signal phase being reversed 180 degrees at the output relative to the input.

Several forms of D.C. gates are shown in FIGS. 10, 11, 12 and 13 with all these circuits being basically identical with the exception of the number of gate inputs that are made available on each type. Each gate includes a collector output amplifier which reverses the phase of the incoming signal 180 degrees and which insures no loss of amplitude of the signal as it passes through the gate. These gates, therefore, may directly drive any of the other digital circuits and are capable of driving several circuits in parallel. The D.C. gates may be used either as AND gates or OR gates. A negative input pulse is a "YES" and a positive input is a "NO." When used as AND gates, all inputs must be negative before coincidence is obtained to open the gate which then delivers a positive output signal. When used as OR gates a postive signal on any input will actuate or open the gate and deliver a negative output signal provided all other inputs are negative. Any one positive input signal will block any action by the other inputs in either an AND or OR functioning of the gate. The D.C. gates may also be utilized as phase reversers to convert negative to positive signals and vice versa, depending on the needs of the application. The only A.C. gates employed in the classifier are those built into their associated circuits as previously mentioned.

FIG. 14 discloses the sheet memory matrix circuit SM–7 which in essence is a group of multiple input D.C. AND gates, the inputs of which are buffered to form one common input which in turn drives a single transistor output. The matrix circuits in the computer function to use information from a count register, such as the sheet registers, to control the useful length of a shift register, such as the memory registers, so as in effect to allow the computer to control and calibrate the shift registers length.

Referring to the schematic logic diagram, when the shearing line is first started it is necessary to calibrate the computer because normally the flip-flop circuits will be in all different states and if they are not all in their proper state then computer cannot operate through its computing cycle. Also, there may be some bits of information in the memory registers that are real, caused by line shut-down during a coil run, such as might be occasioned by change of sheet length, or not real which can be inadvertently entered during line shut-down and start-up and by other events. This information will lock out any com-

putation by the computer and prevent start-up of the classifier system as long as it remains in the computer memories; therefore, it is essential to calibrate the computer when it is turned on to discard this unwanted information.

The digital computer classifier of the invention is provided with two sets of digital switches 73 and 85 connected between the output of main counter 30 and AND count out gates 59 and 60, respectively. These may be ordinary ON–OFF switches and by means of switches 73 the line distance D–1, that is, the distance between the pinhole detector and the shear, is set into the computer in the form of a binary code. The line distance D–2, that is, the distance between the shear and a point just short of the reject gate, is set into the computer in the form of a binary code by means of digital switches 85. This information which is set in on switches 73 and 85 is the only information set into the computer prior to starting the line.

As the line and classifier are started digital tachometer 1 feeds a pulse for approximately every 0.040 inch of strip passing through the leveling rolls 14, which drive the tachometer, to squaring amplifier 4. This amplifier shapes the pulses to match the circuits of the computer and the wave fronts of these signals are then sharpened up and have power added thereto by one shot multivibrator circuit 5. The output of multivibrator 5 is fed directly to AND gate 36 which obtains a second input from multivibrator 5 through diode 37, the resistor-capacitor integrating circuit indicated generally at 38 and inverter amplifier 39. The pulses that are feeding through diode 37 build up a charge on the capacitor of integrating circuit 38 causing gate 36 to become blocked so that an output signal from gate 36 is obtained only at each start-up of the line.

The function of the pulse output from gate 36 is to set all key circuits in their proper state so that the computer can go through its computation cycle and also to insure or force one complete computation cycle immediately, regardless of whether or not there are any bits of information in the memories. The output of the gate 36 triggers one shot multivibrator 40 which sends a signal to directly set flip-flop circuit 28 in a position so as to start the calibration cycle with the next shear cut signal from digital tachometer 2. In the set position of flip-flop 28 input 27 of AND gate 26 is enabled. The main function of multivibrator circuit 40 is to reset the flip-flop circuit of the computer programmer to the correct state and this is done by an instantaneous signal from multivibrator 40 which opens OR gate 41 which in turn triggers one shot multivibrator 42 which directly sets flip-flop circuits 43 and 34, and directly resets flip-flop circuits 35 and 44, thus preparing them for the start of a calibration cycle. Flip-flop 45 is also set by the delayed output from multivibrator 40 and in turn by means of output 46 it unlocks OR gates 47 and 48 to permit calibration of sheet register 49, sheet register 50, and cobble register 51. Thus the programmer is set to start off with flip-flop 35 and all other key circuits are set to the proper state by the output signal of gate 36 which comes from tachometer 1, so that the computer will not lock itself out.

The computer is now ready for a calibration cycle. Digital tachometer 2, driven by the rotating shear 15, furnishes information of actual shear cuts by providing a pulse each time the shear blades close and sever a sheet 10′ from the strip 10. Thus tachometer 2 gives sheet length information. The next signal from tachometer 2 is fed through squaring amplifier 6 and one shot multivibrator 7 in which it is amplified and shaped to make it acceptable for triggering the other circuits. The output of multivibrator 7 triggers one shot multivibrator circuit 8, the output of which triggers one shot multivibrator 9 to supply a signal on input circuit 25 of AND gate 26. Multivibrators 7, 8 and 9 and one shot multivibrator circuit 52 form an anti-coincidence circuit to prevent signals from tachometer 1 and tachometer 2 from interfering with one another. Gate 26 is thus unlocked since the other input 27 was previously enabled by flip-flop 28, as described, or at the end of the previous computing cycle.

The output of gate 26 drives one shot multivibrator 29 which simultaneously resets the main counter 30 to zero, and resets the sheet counter 32 to zero, by means of output 31. The delayed output 33 of multivibrator 29 resets flip-flop 28 to block gate 26, since no more shear signals are required for starting the cycle, and resets flip-flop circuits 34 and 35 of the programmer.

As flip-flop 34 is reset it sends a pulse output to set flip-flop 35 into position for the first half of the computation cycle.

During this time strip travel information pulses from tachometer 1 have been feeding over line 55 to one shot multivibrator 52 and to one of the inputs to each of AND gates 56 and 57. In turn multivibrator 52 enables one input of AND gate 58 which passes a pulse to enable one input on count out gate 59 and one input on count out gate 60 when gate 58 is opened and flip-flop 43 of the programmer is reset by the instantaneous output shear pulse from multivibrator 7. Flip-flop 43 is immediately set by flip-flop 35 and sends an output signal to OR gate 53. The instantaneous output of multivibrator 7 also resets the series of flip-flops which comprise the delay counter 61 and resets the series of flip-flops which comprise the cobble counter 62, through inverter amplifier 63.

As flip-flop 35 in the programmer is set it feeds an output signal to OR gate 53 which as well as the signal from flip-flop 43 enables OR gate 53 to maintain AND gate 54 in an open state to supply strip travel information or tachometer 1 pulse count to pulse main counter 30 which is a gating counter consisting of a series of flip-flop circuits connected in the usual way, well known in the art. Thus main counter 30 starts to count, being driven by tachometer 1 and at the same time sheet counter 32 consisting of a series of flip-flop circuits connected in the usual manner starts to count, being driven by shear cut pulses from tachometer 2 fed from the output of multivibrator 7 through power inverter amplifier 64. The shear count signal from amplifier 64 also triggers one shot multivibrator 65 which simultaneously resets flip-flops 66–67 and sends a direct reset signal to flip-flop 68. Flip-flop 68 determines which flip-flop circuit 66 or 67 will receive the pinhole or defect information from pinhole detector 69 which feeds this information through squaring amplifier 70 to shape the signal, to AND gates 71 and 72. The decision of flip-flop 68 is to determine which half of the sheet is being inspected by the pinhole detector. When flip-flop 68 is reset by a shear signal its output enables AND gate 72 to pass the pinhole information to set flip-flop 67, while when flip-flop 68 is set by the output of the delay counter 61 which occurs after the counter counts out the distance Y, its output enables AND gate 71 to pass the pinhole information to set flip-flop 66.

No. 1 Memory Register 80 comprises a plurality of MR shift register circuits or bits connected in the usual way, well known in the art. As previously stated, this register must have one more bit than the number of integral sheets between the pinhole detector and the shear but for exemplary purposes only this register is shown in the logic diagram as comprising ten bits. The shear count signal from amplifier 64 is also connected to shift each bit in memory register 80 and in addition is connected through one shot multivibrator 116 to simultaneously set the first and second bits of the memory register 80. As the line comes up to speed the fault information from the pinhole detector is thus present at AND gates 71 and 72. When a future sheet edge or future shear cut passes beneath the pinhole detector 69 the output of delay counter 61 sets flip-flop 68 which enables gate 71 so that all pinhole information detected subsequent to the signal will pass through gate 71, flip-flop 66, and be entered in the first bit of memory register 80, thus entering pinhole information contained in distance X of a sheet in the first memory

bit. Upon occurrence of the next shear signal, such as when the line is in the position shown in FIG. 1, flip-flop 68 is reset, blocking gate 71 and enabling gate 72, so that all subsequent pinhole information in the distance Y passes through gate 72, setting flip-flop 67 and is entered in the second bit of memory register 80 into which the information from the first bit was also shifted at the occurrence of the shear signal from tachometer 2. Thus all information on the future sheet being inspected ends up in the second bit of the memory and all information on a particular sheet is in a bit one greater in number than the number designation of the sheet in front of the shear. For example, in FIG. 1, sheet four is shown just in front of the shear but information on this sheet is found in the fifth bit of memory register 80.

Main counter 30 and sheet counter 32 continue to count, with the sheet counter tallying up the number of sheets contained in the count of the main counter. The main counter continues to count and supply successive inputs to count out gate 59 through the digital switches 73 by which the distance D–1 from the center line of the pinhole detector to the shear was manually inserted into the computer in the form of a binary code. Two inputs to gate 59 were previously enabled by gate 58 and flip-flop 35 in the programmer and when the remaining inputs to count out gate 59 are enabled by the main counter indicating that the present count distance D–1 has run out in the main counter 30, the gate passes a signal to one shot multivibrator 74. At that instant multivibrator 74 sends an instantaneous output signal to open OR gate 75 which in turn sets flip-flop 28 again enabling input 27 to AND gate 26 signifying the completion of the first half of the computation cycle.

At the instant multivibrator 74 receives a signal from count out gate 59 it opens AND gate 78, which was previously enabled by flip-flop 45, which in turn triggers one shot multivibrator 79 which in turn sets the series of flip-flop circuits comprising sheet register 49. At this time Sheet Counter 32 which is comprised of a series of flip-flops connected in the usual manner and which was started from zero at the beginning of the first half of the computation cycle will have tallied up and stored the number of integral sheets in the line between the pinhole detector and the shear, that is the number of whole sheets in distance D–1, the answer to Problem No. 1. When sheet register 49 is set by multivibrator 79 the count in sheet counter 32 is dropped into sheet register 49 and stored for the No. 1 Memory Register 80, so that this register stores the number of integral sheets in the distance D–1.

Multivibrator 74 also simultaneously resets to one less than zero the plurality of flip-flop circuits comprising delay register 76, which are connected in the usual manner, and sets flip-flop 77 which opens AND gate 56 and allows tachometer 1 pulse count on line 55 to pass to the delay register and start it counting. On the occurrence of the next shear signal from tachometer 2 flip-flop 77 is reset by the signal from multivibrator 7, thus blocking gate 56 and stopping the count in delay register 76 which now registers the distance Y, that is the distance between the center line of the pinhole detector and the next incoming future shear cut approaching the pinhole detector, the answer to Problem No. 2. The distance Y is therefore stored in delay register 76 which can act both as a counter and a register since it is not called upon to perform both functions at the same time.

The computer is now ready for the second half of the computation cycle. Once again the shear signal from tachometer 2 triggers multivibrator 29 through amplifier 6, multivibrators 7, 8 and 9 and gate 26 to reset main counter 30 and sheet counter 32 to zero and simultaneously reset flip-flop 28 to block gate 26, and reset flip-flops 34 and 35 in the programmer by means of output 33. Flip-flop 43 is also reset by multivibrator 7 which simultaneously resets flip-flop 77 to block gate 56 and reset delay counter 61 and cobble counter 62 to zero through inverter power amplifier 63. Now as the second half of the computing cycle is started, signals from tachometer 1 must pulse the main counter 30 for one sheet length beyond the shear since the No. 1 Memory Register 80 extends one sheet length past the shear, as schematically illustrated in FIG. 1. Since the first sheet on the conveyor 16 following the shear moves at strip speed, and not at the speed of conveyor 16 until it is sheared, the main counter 30 which follows the strip travel must be driven by signals from tachometer 1 at the start of the second half of the computation cycle until one sheet length has been counted off by counter 30. Thus as flip-flops 34 and 35 are reset causing the setting of flip-flop 43, the latter through OR gate 53 and AND gate 54 continues to let tachometer 1 signals run the main counter 30 for one sheet length.

As flip-flop 35 is reset it sets flip-flop 44 which enables one input to count out gate 60 and enables one input of AND gate 81. Upon receipt of the next shear signal from tachometer 2 flip-flop 43 is reset blocking AND gate 54 by means of OR gate 53 to prevent tachometer 1 signals from reaching counter 30, and opening AND gate 81, which in turn through an inverter circuit (not shown) opens AND gate 82 since signals from tachometer 3 had already enabled the other gate input.

Tachometer 3 is driven by entry conveyor 16, which follows the shear and which runs at a speed greater than strip speed in order to create a gap between adjacent sheets as they are sheared at 15 and deposited on the conveyor. Digital tachometer 3 is similar to digital tachometer 1 and 2, but whereas tachometer 1 produces a pluse for each 0.040 inch of strip travel, tachometer 3 produces a pulse for each 0.32 inch of strip travel.

Signals from tachometer 3 are fed through squaring amplifier 83, one shot multivibrator 84 and through AND gate 82 after one sheet length has passed the shear and tachometer 1 pulses to main counter 30 are blocked by AND gate 54. Thus as the sheet is sheared and dropped on the entry conveyor, signals from tachometer 3 are fed through AND gate 82 to pulse main counter 30 at a faster rate and pick up the counting-off of the distance D–2, that is the line distance between the shear and a point just short of the reject gate, so that the counter is pulsed at the speed of the sheared sheet. In the first half of the computing cycle flip-flop 35 of the programmer was enabling count out gate 59 but now during the second half of the computing cycle programmer control has been shifted from flip-flop 35 to flip-flop 44 so that count out gate 59 is disabled and flip-flop 44 enables count out gate 60. The output of AND gate 58 also enables one of the inputs of count out gate 60 in a manner as previously described. The line distance D–2 between the shear and reject rolls is entered by binary code on the digital switches 85 and main counter 30 continues to count, pulsed by signals from tachometer 3, to supply successive inputs to count out gate 60 through the digital switches 85 until the preset count D–2 entered on the switches is satisfied, at which time AND count out gate 60 opens and triggers one shot multivibrator 86. Multivibrator 86 sends an instantaneous output signal to again operate OR gate 75 to set flip-flop 28 and enable one input to AND gate 26, thus setting up the system for the next incoming shear signal which will start the next computation cycle. At the same time multivibrator 86 resets flip-flop 45 to stop the forced calibration of the memory register on an initial start-up computation, and triggers multivibrator 42 through OR gate 41 to reset the programmer flip-flops for a new computation cycle.

The following is a brief detailed summary of the sequence of operation of the programmer circuitry:

(1) Tachometer 1 signal through multivibrator 5, amplifier 39 and gate 36, pulses multivibrator 40.

(2) Instantly multivibrator 40 directly sets flip-flops 45 and 28 and also pulses multivibrator 42.

(3) Multivibrator 42 directly resets flip-flops 44 and 35, and directly sets flip-flops 34 and 43.

(4) The programmer circuitry is now set up to start, and flip-flop 43 is allowing main counter 30 to count and the circuitry is awaiting a shear signal from multivibrators 7, 8 and 9. The tachometer 2 shear signal from multivibrator 7 instantly resets flip-flop 43, stopping count into main counter 30.

(5) The delayed shear signal received from multivibrators 7, 8 and 9 through gate 26 pulses multivibrator 29 which instantly directly resets main mounter 30 and sheet counter 32.

(6) The delayed signal from multivibrator 29 resets flip-flops 28, 34 and 35.

(7) Flip-flop 35 sets flip-flop 43 to restart main counter 30.

(8) Flip-flop 35 is immediately set by flip-flop 34 to enable gates 53 and 54 to cause main counter 30 to count. Gate 53 is also enabled by flip-flop 43.

(9) The next tachometer 2 shear signal from multivibrator 7 resets flip-flop 43 disabling one input of gate 53, which is, however, still enabled by flip-flop 35.

(10) The count out signal at gate 59 pulses multivibrator 74 which instantly pulses gate 75 to set flip-flop 28.

(11) The next shear signal to gate 26 resets main counter 30 and sheet counter 32 as before through multivibrator 29 which again resets flip-flops 34 and 35.

(12) Flip-flop 35 sets flip-flop 43 to again enable gate 53 and also sets flip-flop 44 for the second half of the cycle.

(13) Flip-flop 43 also disables gates 81 and 82 to keep the signals from tachometer 3 out of main counter 30.

(14) Main counter 30 is now counting from tachometer 1 signals, from multivibrator 5 and gate 54.

(15) The next shear signal from multivibrator 7 resets flip-flop 43, disabling gate 53 and enabling gates 81 and 82 to allow signals from tachometer 3 to pulse main counter 30.

(16) Completion of the count in the main counter 30 pulses count out gate 60 and multivibrator 86 to pulse gate 75 and again set flip-flop 28, which completes the computation cycle.

As previously stated, the sheet counter 32 was set to zero again at the beginning of the second half of the computing cycle and is again pulsed by shear signals from tachometer 2 through inverter amplifier 64, to register a count of the total number of whole sheets in the line distance D–2 when count out gate 60 triggers multivibrator 86 to give the answer to Problem No. 3. The normal output of one shot multivibrator 86, in FIG. 2A, triggers one shot multivibrator 87 in FIG. 2B through AND gate 88, the other input of which was previously enabled by OR gate 48. OR gate 48 was energized by flip-flop 45 at start-up or by OR gate 89 at the end of the previous computation cycle. The output signal from multivibrator 87 sets the series of flip-flop circuits comprising sheet register 50, causing the count in sheet counter 32 to be dropped into sheet register 50 and stored for the No. 2 Memory Register 90 so that this register stores the number of whole sheets in the line distance D–2.

The classifier illustrated will be required to read a sheet count range up to ten sheets and since sheet memory matrix 91 connected between sheet register 50 and No. 2 Memory Register 90 can only read a sheet count range of from two to eight, AND gates 92 and 93 are connected between sheet register 50 and No. 2 Memory Register 90 as shown to read the nine and ten sheet counts respectively. Thus these gates are connected in the same manner as the matrix 91 and in effect are an extension of the matrix, with the outputs of matrix 91, AND gate 92 and AND gate 93 buffered or combined by OR gate 94 which delivers the No. 2 Memory 90 output information to flip-flop 95 through polarity reversing gate 96.

No. 2 Memory Register 90 is comprised of a series of MR shift register circuits as shown in FIG. 5, connected in the usual manner, well-known in the art. The first bit in this register is a receiving bit which receives information on a particular sheet from the last used bit of No. 1 Memory Register 80 through matrix 117 as the sheet is sheared from the strip and dropped on entry conveyor 16. The remaining bits are travel bits through which this information is shifted in unison with the travel of the sheets by the shear signal from tachometer 2, with the first travel bit or second bit of the memory registering the travel of one sheet length and a gap. Because the No. 2 Memory Register 90 has been made one bit shorter to eliminate sheet transfer errors, if you are going to come out of memory register 90 for two sheets beyond the shear this information comes out of the first travel bit or second bit of the memory. If you are going to come out of memory register 90 for three sheets past the shear this information comes out of the second travel bit or third bit of the memory, and so on.

During normal operation, the shear signal of the tachometer 2 from amplifier 103 is fed to shift each bit in memory register 90 through one shot multivibrator 104, amplifier 125, OR gate 128, multivibrator 129, OR gate 106, one shot multivibrator 118 and power amplifier 119. In addition, multivibrator 118 sets the first bit of memory register 90 to receive transfer information from No. 1 Memory Register Matrix 117. The other associated circuitry around flip-flop 105, as explained later in the specification, is used to allow the sheet length count out counter 120 to pulse the No. 2 Memory Register 90 when the front end of the line and the shear are shut down to thus enable the line to be cleared of sheared sheets with these sheets being classified with the information already stored.

Problem No. 4 is also solved during this portion of the second half of the computation cycle by the cobble counter 62. As previously mentioned, this problem is to determine the distance R–2, which is the line distance remaining in the distance D–2 from the leading edge of the last whole sheet in this distance and the preselected point in front of the reject gate at the instant the shear is making a cut. This distance R–2 normally contains a gap plus a partial sheet length.

The purpose of the cobble counter portion of the system is to eliminate the need for photocell detectors, or the like, in front of the reject gates or rolls for energizing the same. By means of the cobble counter the system is able to accurately position the sheets in front of the reject gate at the instant the reject gate is to operate, herefore eliminating the need for an external device such as a photocell, a magnetic sensing switch, etc., which tells the reject gate exactly when to operate. The cobble counter 62 consists of a series of flip-flops connected in the normal manner and must be able to count in the range of not less than zero and not more than one sheet length. As previously stated, cobble counter 62 is reset to zero by every shear cut signal from tachometer 2 through amplifier 6, multivibrator 7 and inverter amplifier 63. Signals from tachometer 3 are fed from multivibrator 84 to pulse sheet length counter 97 which is an eight bit-flip-flop counter. A reduced count signal is fed from the second bit of sheet legnth counter 97 to AND gate 98 and cobble counter 62 to pulse the counter, causing it to count continuously until being reset by the next shear cut signal from tachometer 2. The reduced count signal from the sheet length counter 97 compensates for the sheet gap gain of the faster speed entry conveyor 16 over the one sheet beyond the shear since the sheet has not yet come up to the speed of the entry conveyor. The output from count out gate 60 occurs at some point between two consecutive shear cut signals from tachometer 2 and the resultant output from multivibrator 86 triggers cobble register 51 through AND gate 88 and one shot multivibrator 99, provided gate 88 has been enabled by OR gate 48 from either the start-up circuitry or OR gate 89 from a previous computer cycle.

Cobble register 51 consists of a series of flip-flop circuits and has the same number of bits as cobble counter 62. As this register is triggered it stores the count that cobble counter 62 has reached at that time for future use by cobble count out counter 100. At this instant the cobble counter will have totaled a count extending from a shear signal from tachometer 2 to termination of the count-off of line distance D–2 signalled by count-out gate 60 and this count represents the line distance R–2 as indicated in FIG. 1 which is the remaining distance in line distance D–2 from the leading edge of the last whole sheet in this distance to the end of distance D–2. Thus the answer to problem No. 4 is stored in cobble register 51.

The output of multivibrator 86 also simultaneously triggers one shot multivibrator 101 which enables one input of AND gate 102. Upon occurrence of the next shear cut signal, a shear cut signal is sent from tachometer 2 through amplifier 6, multivibrators 7 and 8, inverter amplifier 103, multivibrator 104, flip-flop 105, and OR gate 105 to open AND gate 102 which triggers one shot multivibrator 107. Multivibrator 107 simultaneously sets cobble count out counter 100 and resets flip-flop 108 which unblocks AND gate 98 allowing tachometer 3 signals from sheet length counter 97 to start cobble count out counter 100, which is gated by the stored count in register 51, counting out the distance R–2. Thus on every shear cut cobble count out counter 100 receives from cobble register 51 the correct distance to count out and proceeds to count out this distance. Upon completion of counting the distance R–2 counter 100 sends a count completion signal to set flip-flop 108, which blocks gate 98 to stop counter 100, and triggers one shot multivibrator 109 which enables one input to each of AND gates 110 and 111 the other inputs of which are connected to holding flip-flop 95 in the output of the computer memory circuit and which has been holding reject or prime sheet information while the cobble count out counter 100 has been counting. Counter 100 waits for the next shear cut signal and then again starts counting out the distance R–2.

Flip-flop 95 has thus already enabled an input to either gate 110 or 111 depending upon whether the information therein, with respect to the sheet approaching the reject gate, is "prime" or "reject," so multivibrator 109 will cause one of these gates to open to either set or reset flip-flop 112 connected to their output circuits, which in turn energizes either relay driver circuit 113 or relay driver circuit 114 to trigger standard thyratron circuits in reject gate 115 to energize either top magnetic roll 17 to divert the sheet to prime pile 21, or energize bottom magnetic roll 18 to divert the sheet to reject pile 23 if pinhole faults are contained in the sheet. Thus, as a sheet approaches the reject gate for classification at the end of the line information as to whether this sheet is a prime sheet or a faulty sheet is held in flip-flop 95 for operating the reject gate to make proper disposition and classification of the sheet, and cobble count out counter 100 causes the reject gate to be operated just as the proper moment so that no cobbles or wrecks will occur on the line. This then is the manner in which the answer to Problem No. 4 is eventually utilized by the computer.

At the completion of the computation cycle the computer has stored in delay register 76 the distance Y, in sheet register 49 the number of whole sheets in distance D–1, in sheet register 50 the number of whole sheets in distance D–2, and in cobble register 51 the distance R–2.

The points of future shear cuts on the strip approaching the pinhole detector are located at the pinhole detector by means of the Y information computed and stored in delay register 76, since this stored count represents the strip length by which the next future shear cut precedes the pinhole detector at the instant the shear 15 makes a cut. Upon occurrence of the next shear cut signal from tachometer 2, the series of flip-flops, connected in the usual manner, which comprise delay counter 61, are set thus causing the complement of count Y to be inserted therein from delay register 76. The shear cut signal is fed from tachometer 2 through amplifier 6, multivibrator 7, and amplifier 63 to reset counter 61 and then the delayed signal from multivibrator 7 drives multivibrator 8 and amplifier 103 to set the complement of the stored count into the flip-flops of counter 61.

At the same time, the output signal from multivibrator 8, which drives multivibrator 9 to start a new computation cycle, set flip-flop 121 which unlocks AND gate 57 and allows the tachometer 1 pulses on circuit 55 to pulse delay counter 61 causing it to count to run-out, that is, causing it to count out the distance Y. At the end of the count which signifies that a future shear cut is at the center line of the pinhole detector, the delay counter sends an output signal to reset flip-flop 121 to block gate 57 and stop the counter until the next shear cut signal is received from tachometer 2. The output of counter 61 also sets flip-flop 68, as previously described to allow pinhole information to be inserted in holding flip-flop 66 during inspection of the front portion X of the sheet. The next shear cut signal resets flip-flop 68 so that pinhole information is inserted into holding flip-flop 67 during inspection of rear portion Y of the sheet, while the information in flip-flop 66 is set into the first bit of memory register 80. This holding action keeps the movement of information through memory register 80 and movement of the strip in synchronism. Information is shifted from flip-flop 67 in the same manner.

As stated, delay counter 61 is a run-out counter. Such a counter normally functions by inserting the complement of the count desired into the counter and allowing the counter to run out the count or count until all bits of the counter are in the "zero" state. The complement of the count may be had in a binary counter by reversing each digit and adding one count. In delay counter 61 this operation is accomplished by starting delay register 76 at "zero" minus one count. The recorded count Y in this counter will thus be one count less than the actual count Y. When the reverse of this count is dropped into delay counter 61 to gate the same, this inserted count will likewise be one count larger than would normally be the case. In this way the equivalent of the complement of the delay register is stored count plus one count is inserted into delay counter 61.

The No. 1 Memory Register 80 and No. 2 Memory Register 90 are controlled by their respective sheet count registers 49 and 50 and associated matrixes 117 and 91, respectively.

Thus if the sheet count register 49 or 50 shows a stored count of four, then this informaiton will cause the associated matrix 117 or 91, which are a series of D.C. gates connected between the sheet registers and their associated memory registers, to extract the pinhole information from the fourth bit of the respective memory register 80 or 90.

In practice, No. 1 Memory Register 80, carrying information from the pinhole detector to the shear, as previously stated, must have one additional bit for the fractional portion of the sheet in the strip length from the pinhole detector to the shear. Thus, if the strip length D–1 contains four and a fraction sheets, memory register 80, as shown in FIG. 1, must be five units long. Additionally, since it is desired to memorize sheet information to a point one sheet length past the shear, to eliminate sheet transfer error, memory register 80 must be one additional bit longer than would be required to cover the distance D–1 in FIG. 1 or six bits in length.

If matrix 117 call for four bits of memory register 49 due to the stored sheet count of four in sheet register 49 which gates matrix 177, the pinhole information will actually be extracted from the sixth bit of No. 1 Memory Register 80. However, the matrix can read sheet counts of from two to eight but is required to read sheet counts of from one to seven. Sheet register 49 is therefore con-

nected to add one to the actual sheet count in order to accommodate the matrix and, therefore, the matrix will call for five units of memory when four are required with the pinhole information actually being extracted from the sixth bit of memory register 80 to account for the two additional bits needed for the fractional portion of a sheet at the pinhole detector in distance D–1 and for the extra sheet length past the shear. Thus, whenever sheet counter 32 says four, sheet register 49 or 50 will say five.

The output of No. 1 Memory Register 80 is fed through matrix 117 directly into a receiving bit of No. 2 Memory Register 90. As previously indicated, since memory register 80 was one unit longer than necessary to memorize one sheet length past the shear memory register 90 is one bit shorter than would normally be the case, but since the first bit of memory register 90 is not a memorizing bit, matrix 91 is connected to the actual bits called for. Thus, if matrix 91 calls for four sheets the information on this sheet will be extracted from the fourth bit of memory register 90.

The information extracted from No. 2. Memory Register 90, through matrix 91 and AND gates 92 and 93, is used to set holding flip-flop 95 through OR gate 94, and this flip-flop holds the information as to whether or not the sheet approaching the reject gate is prime or reject, while the cobble count out counter 100 counts out the distance R–2 that remains between memory regiser 90 and the reject gate as previously described. The output signal from cobble count out counter 100 indicating the completion of counting out the distance R–2 energizes AND gates 110 and 111. Th other input to one of these gates was previously enabled by the information in flip-flop 95.

If reject information is stored in flip-flop 95, flip-flop 112 will be set to the proper state to deenergize top magnetic roll 17 and energize bottom magnetic roll 18 through delay drivers 113 and 114 of reject gate 115 to divert the sheet into reject pile 23. As long as information of sheets to be rejected appears at the output gate 94, the shear cut signal from tachometer 2 cannot reset holding flip-flop 95 and thus flip-flop 112, multivibrator 118 and OR gate 122 due to the signals to this gate from the output of AND gate 96 and flip-flop 95. This then prevents operation of the rolls more than once for a run of faulty sheets and the energization on the rolls is only reversed when prime sheet information is indicated at the output of gate 94.

When OR gate 94 is cleared, holding flip-flop 95 is reset by multivibrator 118, followed by the resetting of flip-flop 112, after a cobble count of R–2 is counted out, thus restoring the magnetic rolls to their original state for passing sheets to the prime pile 21.

Thus, fault information with regard to future sheets to be sheared from the strip is followed by memory register 80 from the pinhole detector to one sheet beyond the shear, and as the sheet is severed and dropped onto the entry conveyor the fault information is transferred to memory register 90 to follow the sheet from its sheared state to the reject gate and cause the gate to operate the magnetic rolls or other suitable mechanism to classify it in a prime or reject pile. Both memory registers 80 and 90 are simultaneously pulsed or shifted by shear cut signals from tachometer 2.

It has been previously explained how the entry of pinhole information into either of, or both of, the first two bits of the No. 1 Memory Register 80 will prevent erroneous classification of sheets when there are an even number of sheets in the system and the computer does not know, for example, whether to indicate if there are 3.99 sheets or 4.01 sheets between the pinhole detector and the shear due to the slippage between the strip and leveling rolls 14 which drive tachometer 1. Thus once the computer is calibrated some means must be provided so that it will not be re-calibrated in the middle of a calculation cycle so that the sheet information originally inserted in the sheet registers 49 and 50 from sheet counter 32 cannot change, that is, for example, cannot switch back and forth, indicating three sheets, then four sheets, then three sheets again, etc. To prevent errors in calculation due to this cause AND gates 123 and 124 are provided. AND gate 123 is connected to the outputs of the bits in No. 1 Memory Register 80 to detect if any information is contained in these bits, and thus in the No. 1 Memory Register. Gate 123 operates when it detects information in memory register 80 and, through gates 47 and 78, blocks any recalibration of sheet register 49. In like manner, AND gate 124 whose inputs are connected to the outputs of the bits in No. 2 Memory Register 90 operates when it senses information in this register and operates through gates 89, 48 and 88 to block any recalibration of sheet register 50 and cobble register 51. Thus if any information is progressing through memory registers 80 and 90, the sheet registers and cobble register are locked out so that they cannot change the calibration with respect to the information already in the system.

It may be necessary to add one or more flip-flop circuits in series with flip-flop 44 so as to force more than one calibration cycle from the system when the line has started up so that the computer system continues to calibrate by control of these flip-flops until the front and rear portions of the line have had a chance to come up to speed and the entire system is working under normal operations.

The sheet length counter 97 performs the function of continuously determining the length of one sheet, plus one sheet gap, on the entry conveyor 16. This distance is the length of each bit in memory register 90. This distance will not only vary with sheet length, but also with the speed ratio between the entry conveyor 16 and the strip 10. This unit is necessary in order that No. 2 Memory Register 90, which carries all information of pinhole sheets from the shear to the reject gate may be pulsed when the shearing section of the line is shut down with the entry and classifier conveyors 16, 20 and 22 running to remove all sheets left on the classifier conveyors at shut down.

Sheet length counter 97 is comprised of a series of flip-flop circuits connected in the usual manner with the counter being pulsed by signals from tachometer 3 fed through amplifier 83 and multivibrator 84. The shear cut signal from tachometer 2 drives one shot multivibrator 104 and inverter amplifier 125 to set the series of flip-flops comprising sheet length register 126 upon the occurrence of each signal from tachometer 2. Thus the sheet length counter matches the speed of tachometer 3 against the speed of tachometer 2 and in so doing determines the length of a sheet and a gap. Sheet length counter 97 continues to count the pulses from tachometer 3 and upon the occurrence of a signal from tachometer 2 sheet length register 126 is set and the count at that time in sheet length counter 97 is thus dropped or set into sheet length register 126 and stored. Thus the measurement is completed each time a sheet is sheared from the strip and register 126 is recalibrated each time a shear cut is made. After register 126 is set, a delayed tachometer 2 signal from multivibrators 104 and 127 resets each of the flip-flops in sheet length counter 97 to zero to restart the counting cycle. Multivibrator 104 also resets the flip-flop 105 to prevent this circuit from "locking out" and rendering the system inoperative under certain conditions.

In normal operation, signals from tachometer 2 pulse No. 2 Memory Register 90 through multivibrator 104, amplifier 125, OR gate 128, one shot multivibrator 129, OR gate 106, multivibrator 118 and amplifier 119. One shot multivibrator 129 also resets the series of flip-flops comprising sheet length count out counter 120 and then a delayed signal from multivibrator 129 through inverter amplifier 130 sets the sheet length count out counter 120

which inserts the complement of the stored count in sheet length register **126** therein in a manner similar to that discussed with regard to delay register **76** and delay counter **61**. The delayed signal from amplifier **130** also resets flip-flop **105**. Sheet length count out counter **120** is a run-out type counter pulsed by the same signals from tachometer **3** that pulse sheet length counter **97**. Sheet length count out counter **120** will thus count to run-out, that is, count out the number which was stored in sheet length register **126** and at the end of this count an input signal is sent to set flip-flop **105**.

Depending on whether the distance of the sheet length, plus one sheet gap, is increasing or decreasing, OR gate **106** will receive a signal from sheet length count out counter **120** through flip-flop **105** to pulse No. 2 Memory Register **90** or a shear cut signal from multivibrator **129** to pulse memory register **90**. Either signal will pulse the memory register and will then nullify the other signal in order that memory register **90** will not be pulsed twice erroneously. The first signal to the gate **106** will have precedence and block the gate to the other signal. Thus this circuitry determines priority as to whether or not memory register **90** will be pulsed by signals from tachometer **2** or signals from sheet length count out counter **120**.

When the shear section of the line is shut down, the contacts of line run interlock relay **131** close enabling AND gate **132** to pass an output signal from flip-flop **105** through OR gate **128** to operate multivibrator **129**. Multivibrator **129** resets sheet length count out counter **120** as previously described, and then with a delay signal sets the stored count from register **126** therein and resets flip-flop **105** in readiness to receive the count out signal from sheet length count out counter **120** which will pulse memory register **90** through flip-flop **105** and gate **106**. Thus when relay **131** indicates that the shearing section of the line is shut down, sheet length counter **97** and its associated circuitry takes over the function of shifting No. 2 Memory Register **90** and operating the other circuits so that the information in the memory can be used to complete classification of all cut sheets on entry conveyor **16**.

When the line is again started, relay **131** blocks AND gate **132** and enables OR gate **125** so that the sheet length count out counter **120** cannot operate multivibrator **129** through flip-flop **105**.

When the shear is shut down sheet length counter **97** is inoperative in that, while it is running aimlessly no information can be transmitted from it to sheet length register **126**, since there is no tachometer **2** signal to set such information into the register. Therefore, the calibration of sheet length register **126** does not change and since the sheets to be run off, on entry conveyor **16**, cannot physically change their position with respect to one another no recalibration is necessary. Once the shear portion of the line starts again recalibration of sheet length register **126** again continuously takes place.

While the invention has been described in a certain preferred embodiment it is realized that modifications can be made and it is to be understood that no limitations upon the invention are intended other than those imposed by the scope of the appended claims.

What is claimed as new and desired to be secured by United States Letters Patent, is as follows:

1. In apparatus for classifying sheet material moving at high speed including shear means for cutting said sheet material from a strip in predetermined lengths, and deflecting means for sorting the sheet material in accordance with the characteristics of the sheets, the combination comprising, a detector disposed to respond to a characteristic in said material while in strip form, first means producing signals representative of the advancement of the strip from said detector toward the shear means, second means producing signals representative of operation of the shear means, means for determining from said signals which sheet to be subsequently cut from the strip is being inspected by said detector at any given instant and thereby at the time a given characteristic in the strip is signaled by said detector determining which sheet to be subsequently cut from the strip has said characteristic, first memory means operated by said signals for remembering the location of the sheet having the characteristic in its passage through the shear means, third means producing signals representative of the advancement of the sheared sheets away from said shear means, second memory means connecting to said first memory means for following the location of the sheet having the characteristic in its passage from the shear to the deflecting means, means for determining from said first, second and third means the number of sheets between the shear means and deflecting means for controlling said second memory means, and means operated by said second memory means for operating said deflecting means to classify sheets having the characteristic from sheets that do not have the characteristic.

2. In apparatus for classifying sheet material moving at high speed as set forth in claim **1**, the combination including means comparing signals from said third means and signals from said second means for providing a signal to operate said second memory means and classify all cut sheets when the operation of the shear means and advancement of the strip are stopped.

3. In apparatus for classifying sheet material moving at high speed as set forth in claim **2**, in which said signal provided by said means comparing signals from said third and second means is representative of a sheet and a sheet gap on the output side of the shear means.

4. In apparatus for classifying sheet material moving at high speed of the type including shear means for cutting said sheet material into predetermined lengths from a strip moving at high speed, means for conveying the sheet material away from the shear means, and deflecting means in the path of the sheets for deflecting them to predetermined paths in accordance with characteristics of the sheet determined while the material is in strip form comprising, inspecting means producing a signal in response to a characteristic of the material while in strip form, means producing a signal pulse for each increment of advance of the strip from said inspecting means toward the shear, means receiving said signals and determining which sheet to be subsequently cut from the strip is being inspected by said inspecting means at any given instant and thereby at the time a given characteristic in said strip is signaled by said inspecting means determining which sheet to be subsequently cut has said characteristic, means producing signals representative of shear cuts, memory means adapted to receive signals from said inspecting means and from said means producing shear cut signals to advance the signals from said inspecting means through said memory means each time a sheet is cut from the strip to remember the location of sheets having the characteristic in their passage through the apparatus both before and after the sheets containing the characteristic are cut from the strip, and means connected to receive signals from said memory means for operating the deflecting means to accurately separate sheets having the characteristic from sheets that do not have said characteristic even when there are an integral number of sheets between said inspecting means and the shear means.

5. In apparatus for classifying sheet material as set forth in claim **4** in which said means receiving said signals produces a future shear cut signal each time a future shear cut line on the strip passes said inspecting means, and means controlled by said future shear cut signal and said shear cut signals connected to pass signals from said inspecting means to said memory means.

6. In apparatus as set forth in claim **5** in which said means connected to pass signals from said inspecting means to said memory means includes delay means to

maintain advancement of the strip and advancement of characteristic signals relative thereto through said memory means in unison.

7. In apparatus for classifying sheet material as set forth in claim 4 in which said memory means comprises a first memory portion for following said strip as sheets subsequently to be cut therefrom to the point the sheets are cut from the strip, and a second memory portion for following the cut sheets to the deflecting means.

8. In apparatus for classifying sheet material as set forth in claim 7 in which said first memory portion comprises a plurality of memory units one greater in number than the number of integral sheet lengths between said inspecting means and one sheet length beyond the shear means.

9. In apparatus for classifying sheet material as set forth in claim 8 in which said means receiving said signals produces a future shear cut signal each time a future shear cut line on the strip passes said inspecting means, said plurality of memory units including first and second units for receiving said signal from said inspecting means, and means controlled by said future shear cut signals and said shear cut signals connected to insert said signal from said inspecting means simultaneously into said first and second units upon substantial coincidence of the future shear cut signal and the shear cut signal.

10. In apparatus for classifying sheet material as set forth in claim 8 in which said means receiving said signals produces a future shear cut signal each time a future shear cut on the strip passes said inspecting means, said plurality of memory units including a pair of units for receiving said signal from said inspecting means, and means controlled by said future shear cut signals for inserting signals from said inspecting means in one of said units of said pair and controlled by said shear cut signals for inserting signals from said inspecting means in the other of said units of said pair when more than an integral number of sheet lengths exists between the inspecting means and the shear means.

11. In apparatus as set forth in claim 10 in which said means producing signals representative of shear cuts is connected to shift said plurality of memory units, whereby the characteristic signals of a particular sheet subsequently to be cut from the strip is in one unit of said plurality of memory units, greater in number than the number designation of the future sheet position between the inspecting means and the shear.

12. In apparatus as set forth in claim 4 in which said memory means includes calculating means for determining the number of integral sheet lengths between said inspecting means and the shear, said memory means being responsive to said calculating means, and gating means connected between said calculating means and said memory means preventing the latter from responding to a redetermination by said calculating means after said memory means has received signals from said inspecting means.

13. In apparatus as set forth in claim 7 in which said second memory portion comprises a plurality of memory bits one fewer in number than the number of integral sheets between the shear means and deflecting means.

14. In apparatus for inspecting and shearing strip material traveling at high speed into sheets of the type having means for shearing the material, means for conveying sheets sheared from the strip away from the shearing means, deflecting means in the path of travel of the sheared sheets for deflecting the sheets to predetermined paths, a single sheet classifier for classifying the sheets in accordance with a characteristic of the material determined while in strip form comprising, inspecting means producing a signal in response to a characteristic of the material in strip form, means producing a signal for each increment of advance of said strip toward the shearing means, means producing a signal each time a sheet is sheared from the strip, first memory means for following the location of future sheets in the strip having the characteristic signaled by said inspecting means to the time of shearing, means for determining from said signals which sheet to be subsequently cut from the strip is being inspected by said inspecting means at any given instant and controlling said first memory means, pulsing means producing a signal for each increment of advance of the means conveying sheets away from the shearing means, second memory means for following the location of sheared sheets having the characteristic from the time of shearing to the deflecting means, means for calculating from said pulsing means and said previously mentioned signals the number of integral sheets between the shearing means and deflecting means and controlling said second memory with the calculation, and means controlled by said second memory means for operating the deflecting means to accurately separate sheets having the characteristic from sheets not having the characteristic even when there are an integral number of sheet lengths between said inspecting means and the shearing means.

15. In apparatus as set forth in claim 14 in which said first memory means comprises a plurality of portions, and including means for inserting the characteristic signaled by said inspecting means in one portion of said plurality of portions of said first memory means upon receipt of a signal from said means producing a signal each time a sheet is sheared, and in another portion of said first memory means upon receipt of a signal from said means for determining from said signals, when more than an integral number of sheet lengths exists between said inspecting means and the shearing means.

16. In apparatus as set forth in claim 15, and said means producing a signal each time a sheet is sheared from the strip connected to shift said first and second memory means, whereby all characteristics signaled by said inspecting means on the sheet subsequently to be cut from the strip being inspected by said inspecting means are shifted into said another portion of said plurality of portions and advanced through said memories in separate portions in unison with strip travel.

17. In apparatus as set forth in claim 14 in which said means producing a signal each time a sheet is sheared from the strip is connected to shift said second memory means whereby the leading edge of sheets on the means for conveying sheets sheared from the strip away from the shearing means are located by said means producing the shear signal.

18. In an apparatus for inspecting and shearing strip material traveling at high speed into sheets of the type 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 in the path of travel of the sheared sheets for deflecting the sheets to predetermined paths, a single sheet classifier for classifying the sheets in accordance with a characteristic of the material determined while in strip form comprising, inspecting means for producing an output signal in response to a characteristic of the material in strip form, means producing a signal pulse for each increment of advance of said strip from the inspecting means toward the shearing means, means producing a signal pulse on each operation of said shearing means, means for determining from said signals which portion of which sheet to be subsequently cut from the strip is being inspected by said inspecting means at any given instant when more than in integral number of sheet lengths exists between said inspecting means and the shearing means, first memory means having a plurality of units, means for entering characteristic information signaled by said inspecting means for different portions of a sheet to be subsequently cut from the strip into different units of said first memory means and combining this information and passing it through the remainder of said plurality of units in unison with the passage of the

location of the sheet having said characteristics till it is sheared from the strip, second memory means connected to said first memory means for following the location of the sheared sheet having the characteristic to the deflecting means, and means controlled by said second memory means for operating said deflecting means to classify sheets having said characteristic from sheets not having said characteristic.

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