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[56]

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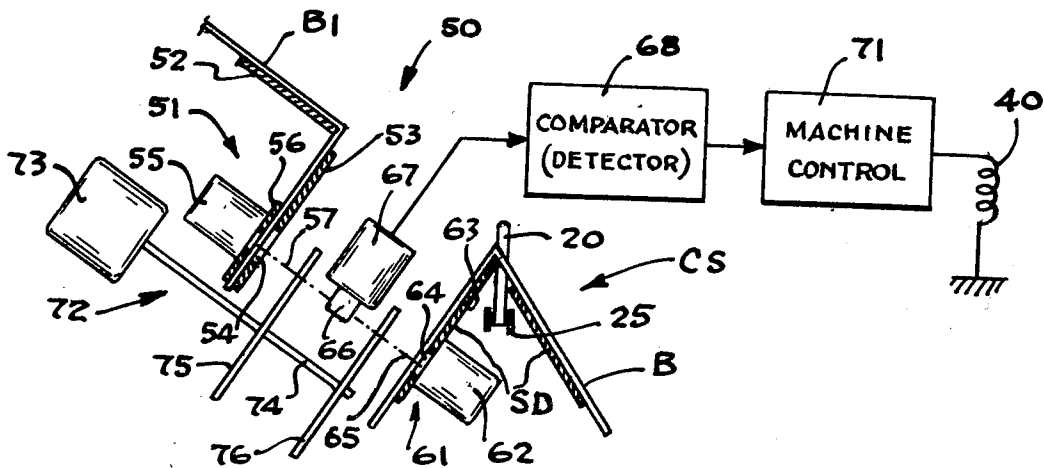
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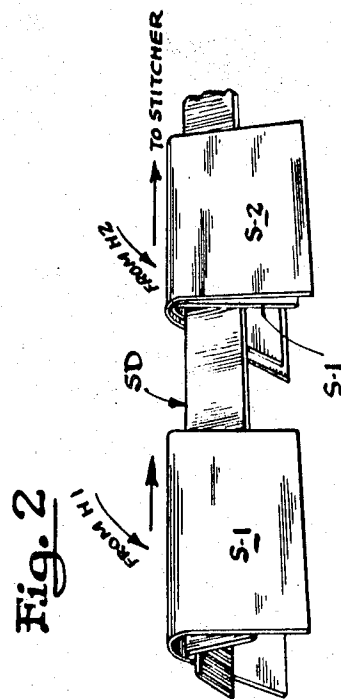
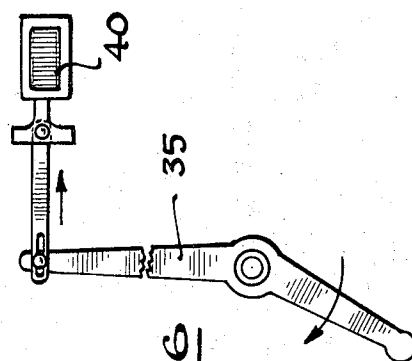
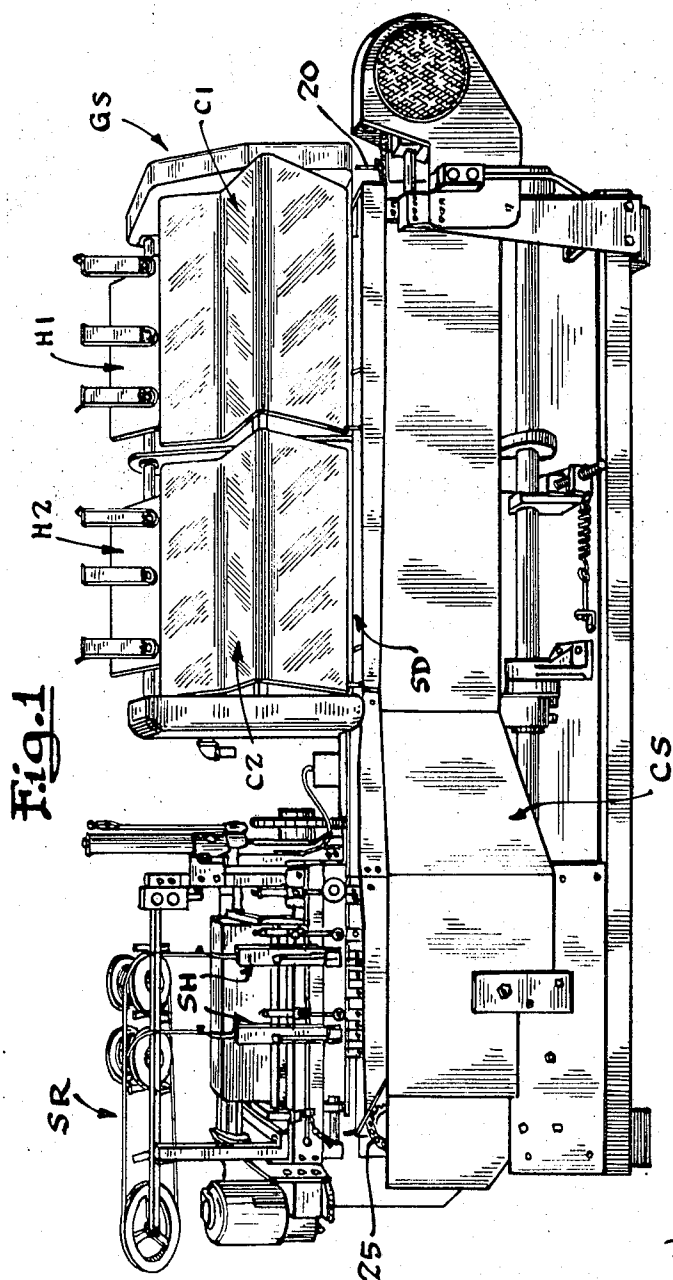
Attorney—Kinzer, Dorn and Zickert

[54] **SIGNATURE MACHINES**
17 Claims, 15 Drawing Figs.

[52] U.S. Cl. **270/56,**
270/54, 250/83.3
 [51] Int. Cl. **B65h 43/02**
 [50] Field of Search **270/54, 56,**
53, 58; 250/83.3D

ABSTRACT: A caliper system for a cyclically operable signature gathering machine in which each unbound book of signatures is probed with a beta particle beam or other beam and the energy level of the emergent beam is compared with a reference to control machine operation and prevent binding of incorrectly assembled books.





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Fig. 3

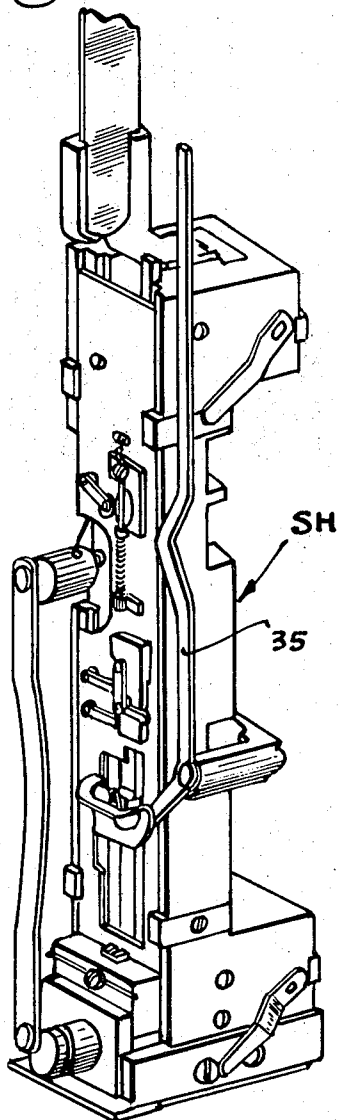


Fig. 4

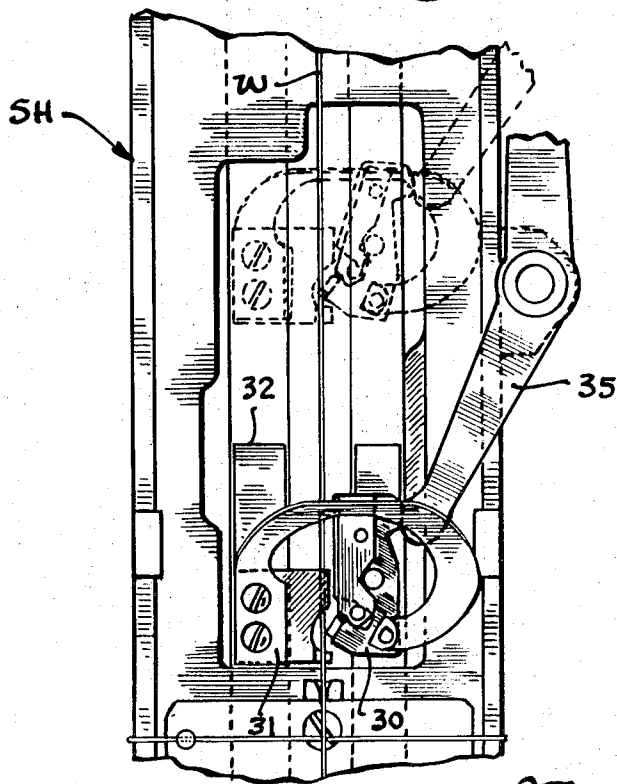
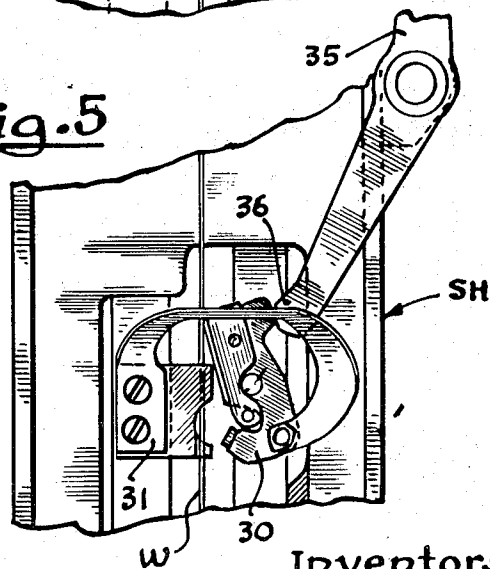


Fig. 5



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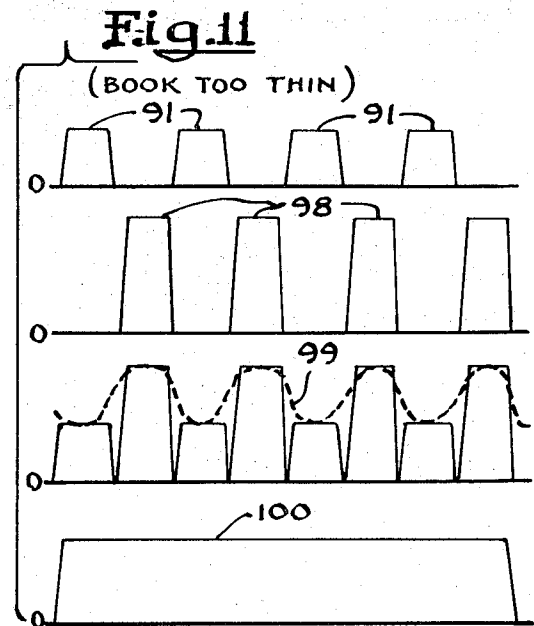
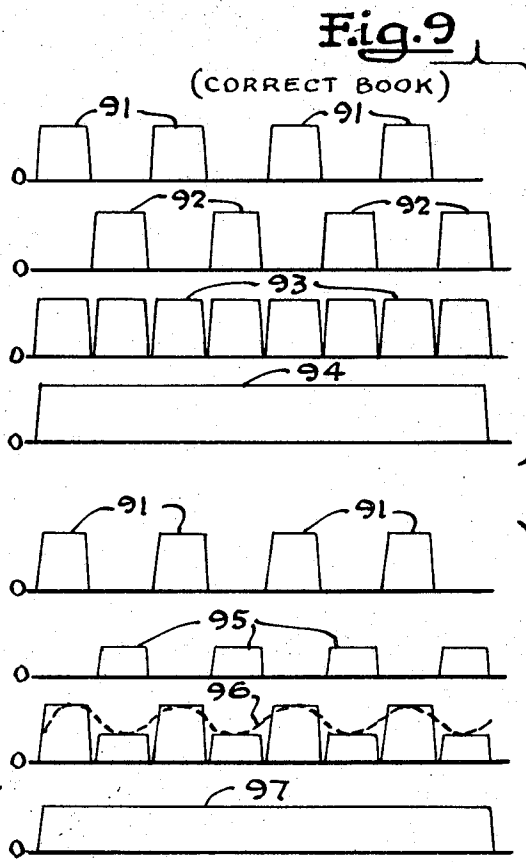
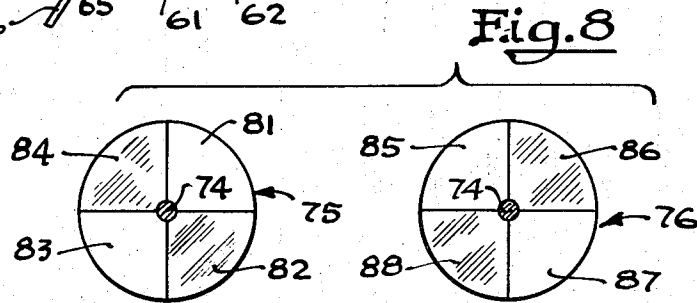
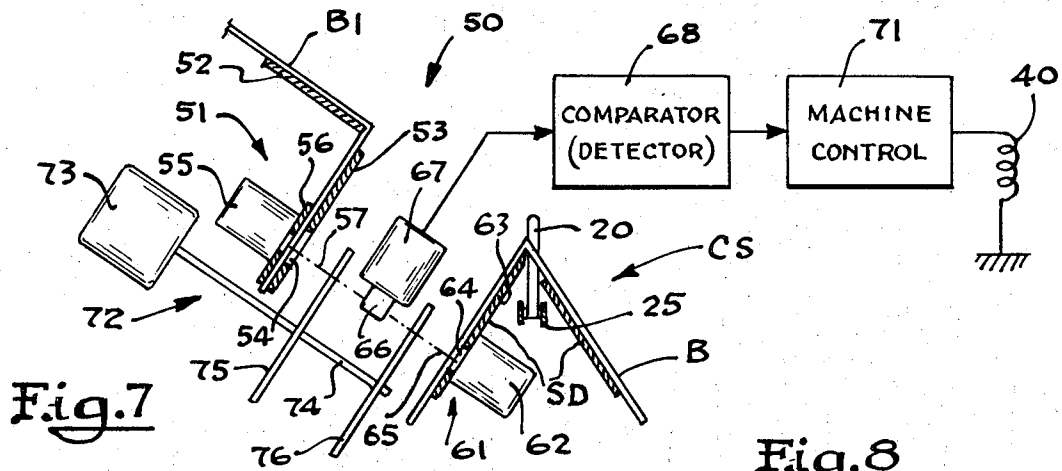
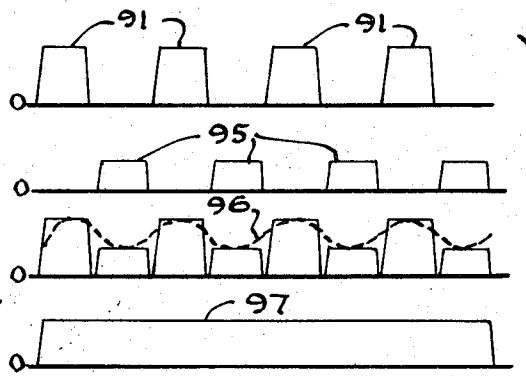


Fig. 10
(BOOK TOO THICK)



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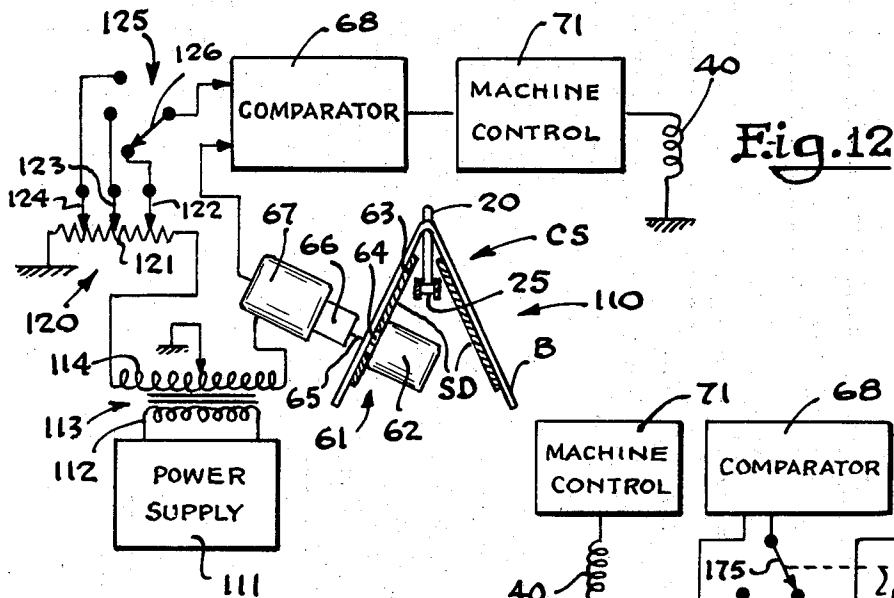


Fig. 14

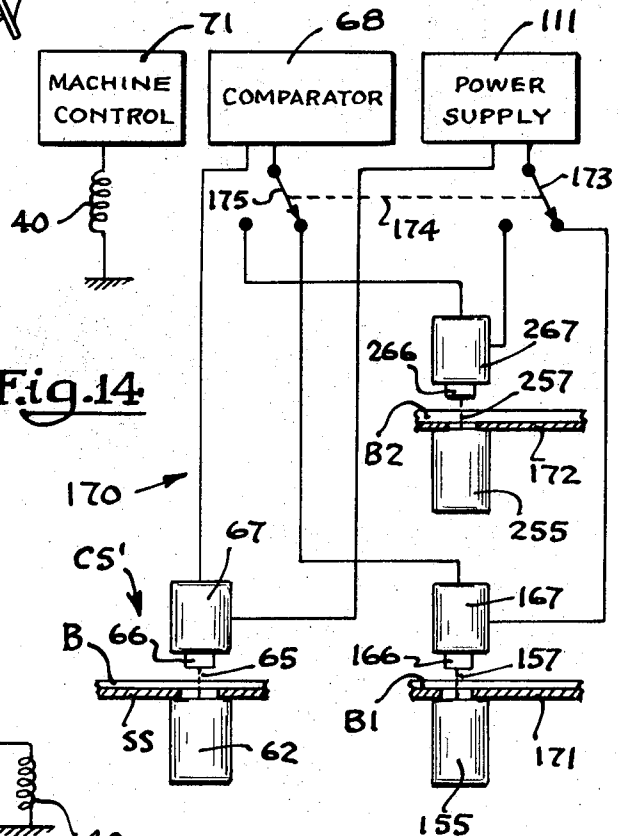
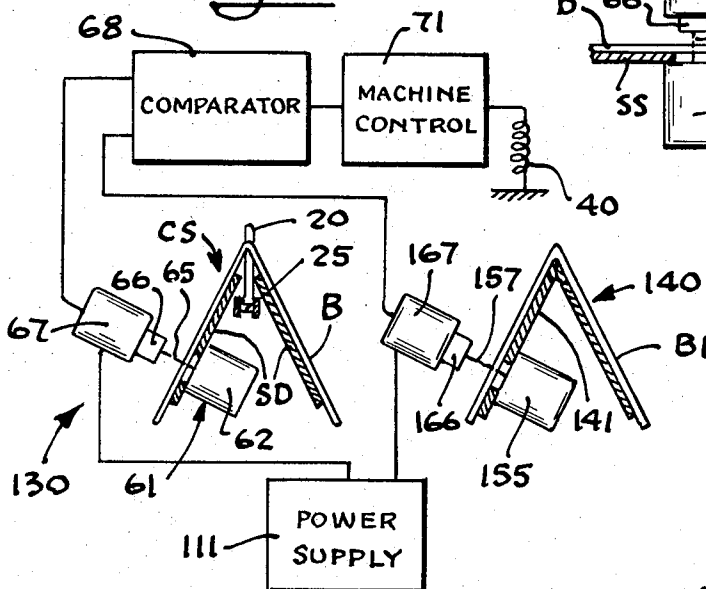


Fig. 13



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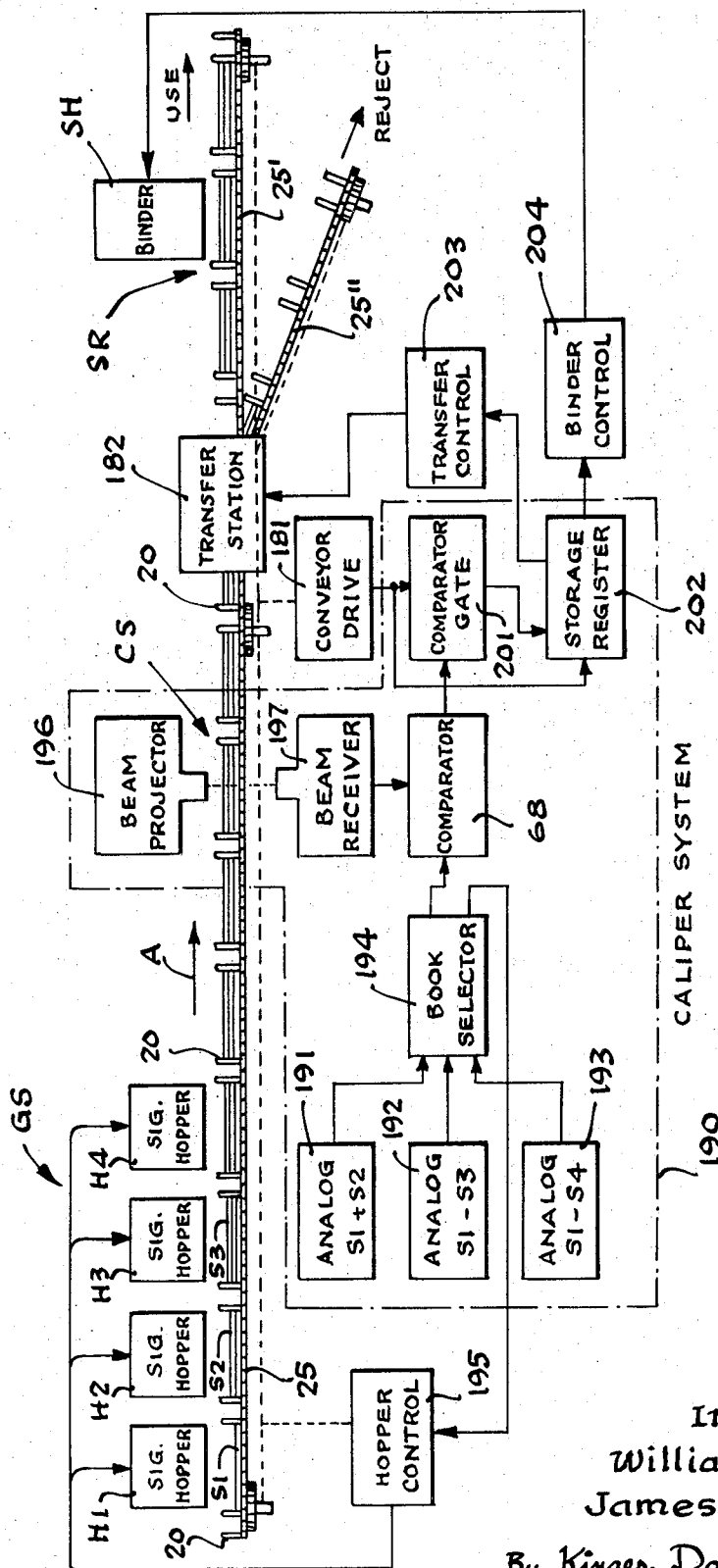


Fig. 15

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SIGNATURE MACHINES

This invention relates to signature machines where books are formed from signatures juxtaposed one on another.

Books are ordinarily composed of signatures. A signature is simply a folded sheet presenting four pages (two sheets) of the book. In the instance of small books such as magazines, newspaper supplements, entertainment guides, catalogs of limited size and the like, the signatures to comprise the book are fed from supply hoppers and are gathered, one atop another, on a conveyor. The conveyor delivers each group of signatures constituting an unbound book to a stitching or other binding station, where staples are driven through the backbone (the edge of the fold) of all of the signatures to complete a bound book, as one example of commercial application.

Staple stitching is one way of binding the signatures into a book. The staples clinch the backbone, and this is known as saddle stitching. On the other hand, the staples may be pressed through the back of the book along one side of the backbone, in what is known as side wire binding, resulting in a square backed book. Binding may also be effected with glue, a cover being glued to the backbones of the signatures, in what is known as perfect binding. The present invention is applicable to all of these different forms of binding.

It is ordinarily desirable to interrupt operation of the binding means in a signature gathering machine, in the event the unbound book delivered to the binding station is incomplete in terms of the required number of signatures. Salvage is one reason; the absence of a complete signature group affording a book represents another reason, because operation of the binder can foul the machine with fugitive staples, for example. Accordingly, it is customary to caliper each unbound book as it advances toward the binding station to determine if the book is too thick or too thin. Either departure from correct thickness requires interruption of the binding means.

Calipering is presently performed, in one practical mechanism, as a mechanical operation in which each book is gauged between a pair of rollers normally spaced from one another by a distance representing a book of correct thickness. One roller, in effect, fathoms the book thickness, sinking or rising, as it were, if the book is too thin or too thick. In response to either event a switch or other mechanical sensing device is actuated to register the occurrence of a "bad" book. Calipering naturally occurs ahead of binding, so that it is necessary to store caliper information concerning a bad book until that book arrives at the binding station. A signature machine embodying an effective mechanical caliper of this kind is disclosed in McCain U.S. Pat. No. 3,191,925.

The mechanical caliper is eminently satisfactory in many applications. But the mechanical caliper may not be able to fulfill the requirements of some publishers. Certain publishers, for example, publish expanded regional or provincial issues of their magazines. Thus, regional magazines distributed in one part of the country may require a signature content different in some respects from those distributed elsewhere. There may be literally scores of different issues, entailing considerable programming of the signature machine, but mechanical calipers are not ordinarily that flexible.

The primary object of the present invention is to enable calipering in a signature machine to be accomplished on an energy level basis in which the thickness of a book is measured by a beam of energy directed through the book as a probe. The energy level of the probing beam emerging from a book being calipered will be constant, provided the book is of correct thickness. The emergent energy level is sensed and detected for any value representative of an incorrect compilation of signatures, and the machine control is varied accordingly. Stated differently, the emergent energy level is compared to an energy reference which is an analogue of the correct book thickness. So long as the emergent energy level represents a correct book, the binding means is operated normally; but if there is a mismatch, indicated by a failure to match the energy analogue, a control signal is generated that is used to interrupt the binding means when the incorrect book arrives at the binding station.

In achieving this stated object, many useful results occur constituting further objects of the present invention. Thus, the inherent inertia of a mechanical caliper is avoided, making higher production rates possible. Caliper accuracy can be easily controlled to at least a two-sheet thickness (one signature) due to the inherent sensitivity of the energy beam caliper; in this connection, it may be noted that a mechanical caliper in most instances requires a multiplying lever to achieve practical results. Different editions run in sequence through a single signature gathering machine, entailing selectively activated and inactivated signature supply pockets, may be calipered simply by switching between different reference analogues which correspond to the particular different editions. A corollary to the last of these stated objects is that both the signature supply hoppers and the energy caliper may be programmed for remote control, which is to say that the machine may be constantly monitored to correlate the reference analogue, or the true datum level, for the probing beam of the caliper to the groups of signatures being gathered for a particular edition. When the program demands a new set of signatures for a different edition, the reference analogue or datum level may be changed automatically.

It should be emphasized that the present invention may be utilized in a known machine where the entire run of the machine may be restricted to a single edition, but nonetheless an edition which requires calipering in any event. Such a known machine is represented by the disclosures in the aforesaid McCain U.S. Pat. No. 3,087,721, and in McCain U.S. Pat. No. 3,191,925 where a mechanical caliper is used to control the stitcher heads. The preferred embodiments of the present invention may be, and in the disclosure to follow are, related to such known constructions.

In the preferred embodiment of the invention, which is designed to be as free of error as any caliper system may be, a gauge book is supported in a stationary position at the caliper station. A substance such as Strontium 90 (radioactive Sr_{90}) is positioned to direct a beam of beta particles (sometimes called beta rays) through one-half of a correctly assembled unbound book. This book and the Sr_{90} thus establish a reference energy analogue corresponding to a book of correct thickness, the analogue being represented by the energy level of the beta particles emerging from the standard book.

The energy caliper of the preferred embodiment includes a second source of Sr_{90} , at the caliper station, and the beta particles generated by atomic decay are directed through one-half of each unbound book as the book advances toward the binding station. The beta particle output of the second source of Sr_{90} thus affords a beam which probes the book being calipered. If the book being calipered is of correct thickness, the energy level of the beta particles emerging therefrom will be essentially identical to the reference energy analogue.

The two beams of particles impinge on a crystal of anthracene, or other material that is excited to luminescence by beta particle irradiation, used as a target sensing device. Choppers intercept the emergent analogue beam and probing beam of beta particles in synchronism to produce a glowing crystal of constant light intensity representing a constant signal under normal circumstances. But if the probe beam is weak (book too thick) or too strong (book too thin) the chopper effect causes the crystal of anthracene to emit what amounts to a pulsating light of lesser or greater average intensity than the normal constant intensity.

The light signal (constant or pulsing) emitted by the crystal is monitored by a photomultiplier tube and a detector network, operating as a transducer to transform the light signal from the crystal into an electrical control signal delivered to a relay or to other control device. If the control signal is steady (good books) there is no effect on the control device, but if it is a pulsating signal (pulsating light = bad books) the control device is operated to record the occurrence of a book of incorrect thickness.

Operation of the control device indicates that the calipered book should not be bound, but since calipering may be several cycles behind binding, this information is stored or otherwise delayed until the book, calipered as incorrect, arrives at the

binding station or at a transfer station that diverts the book from the binding station.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show preferred embodiments of the present invention and the principles thereof and what we now consider to be the best mode in which we have contemplated applying these principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention.

In the drawings:

FIG. 1 is a perspective view of a known machine in which the present invention may be used;

FIG. 2 is a detail view showing features of signature gathering;

FIGS. 3, 4, 5 and 6 are views showing a stitcher head and its controls to prevent wire feed;

FIG. 7 is a sectional view, partly diagrammatic, illustrating one form of the present invention;

FIG. 8 is a view of certain so-called choppers;

FIGS. 9 and through 11 are graphs showing energy profiles that may be utilized under the present invention;

FIGS. 12, 13, 14 and 15 are, respectively, views showing other embodiments of the invention, these views in part being both schematic and diagrammatic.

The signature machine illustrated in FIG. 1 comprises, at the right-hand side as viewed in this figure, a pair of signature supply hoppers H1 and H2 which are partly hidden from view by a pair of raised cover plates C1 and C2. Plates C1 and C2, when lowered, cover parts constituting means by which signatures are removed individually from each related hopper. The signatures S-1 and S-2, FIG. 2, are withdrawn from the hoppers and eventually deposited, in a spread state, on a saddle conveyor track SD located at the front of the machine below the supply hoppers. The gathering operation is fully disclosed in McCain U.S. Pat. No. 3,087,721; accordingly, only those features entailed in an understanding of the basic machine functions are described here.

A signature S-1 from supply hopper H1 is first deposited on the saddle; this signature is then advanced along the saddle toward hopper H2 by a feed lug 20 carried by a conveyor chain 25, FIG. 1. The second signature S-2 for the book is dropped, from hopper H2, on top of the first signature. As is evident in FIG. 2, signatures on the saddle are in a spread state with the folded backs (backbones) at the top of the saddle.

The foregoing describes generally parts that are located at what represents the signature gathering station of the machine, identified generally at GS in FIG. 1. A group of signatures thus gathered into booklet form are moved as a unitary body along the saddle, to the left as viewed in FIG. 1, toward the signature stitching apparatus SR, FIG. 1, and are deposited by the aforesaid feed elements in a stationary state beneath a pair of stapling heads SH identifying the location of the stitching station. It is here that staples or other fastening elements are passed through the backs of the signatures in each signature group to complete the formation of the book.

The books are formed seriatim and move sequentially to the binding station where the stitching heads or other binding means are effective to join the signatures in each group to form a complete book. Several cycles of machine operation are entailed between the gathering of signatures into one complete group, the unbound book, and binding of the book at the binding station. In order to avoid stitching or binding of an incomplete group of signatures, each group of signatures is first calipered at a caliper station. The caliper operation precedes binding by at least one machine cycle. The caliper station, for example, may be in the position CS, FIG. 1.

Before describing in detail the caliper systems constituting the present invention, we shall first explain the net effect of determining that a book (unbound signature group) of incor-

rect thickness is approaching the binding or stitching station SR, FIG. 1, such explanation being founded on the disclosure in U.S. Pat. No. 3,191,925 to McCain. In fact, FIGS. 3, 4, and 5 hereof correspond to FIGS. 12-14 of U.S. Pat. No. 3,191,925; only reference characters have been changed.

Each stitching head SH, FIG. 1 incorporates a stitching wire control as illustrated in FIGS. 3, 4 and 5. The wire W, FIG. 4, for forming the staple is fed between a pivotal feed dog 30 and a cooperating anvil 31. When the wire is gripped between the two, FIG. 4, the wire is fed downward incidental to penetrating the group of signatures and clinching a staple thereto. This occurs upon downward movement of the bender bar 32. However, by pivoting the feed dog 30 to the open or released position shown in FIG. 5, wire feed for forming a staple is interrupted. This is accomplished by actuating a bell crank lever 35, pivoting the bell crank from its normal inactive position, FIG. 5, where the lower end 36 thereof is effective on the upper end of the feed dog 30 to shift the latter to its released position. Such action is timed to occur when an incorrect book arrives at the stitching station.

Movement of the bell crank 35 to interrupt or disable wire feed in the proper cycle of the machine occurs as an incident to energizing a solenoid, as can be readily visualized, and as explained in full detail in U.S. Pat. No. 3,191,925. Nonetheless, reference may be made to FIG. 6 hereof for a schematic representation of the actuating forces involved, established upon energization of control solenoid 40. Solenoid 40 is thus representative of one form of control means ultimately responsive to the generation of a control signal at the caliper station indicative of an incorrect book. The construction of the caliper system, and the means for generating an appropriate control signal, will now be described.

The caliper system 50 illustrated in FIGS. 7 and 8, constituting one embodiment of the present invention, is located at the caliper station CS of the machine (see FIG. 1). FIG. 7 shows an unbound book B positioned at the caliper station and ready for calipering. The book B has been advanced to the caliper station by the conveyor comprising chain 25 and feed lug 20, which move the books along the saddle track SD.

Caliper system 50 includes a reference means 51 for developing an energy analogue of the correct thickness for an unbound book. In the system 50, the reference means includes a correctly assembled unbound book B1, used as a standard, supported by appropriate means such as the plates 52 and 53. Plate 53 is provided with an aperture 54 that is aligned with an energy beam source 55 supported on an apertured plate 56. In the embodiment of FIG. 7, beam source 55 comprises a radioactive material that emits a stream of beta particles; typically, the reference beam source may be Strontium 90. Other beta particle sources, such as radioactive Chlorine 36 can be employed, preferably at a low radiation level (e.g. 2-10 millicuries). Other sources of penetrating radiation can be used as desired.

Reference source 55 projects a stream or beam of particles 57 through the reference book B1. The energy level of the beam 57, as it emerges from the book B1, is a function of the thickness of the book.

Caliper system 50 further includes probe means 61 for projecting another beam of energy through each unbound book, such as the book B, that is assembled by the signature gathering machine in which the caliper system is employed. Probe means 61 comprises a beta particle source 62 that is matched to the reference source 55 and that is mounted on a plate 63 comprising a part of the saddle conveyor track SD. Plate 63 is provided with an aperture 64 through which a stream or beam 65 of beta particles is projected, the beta particle beam passing through each unbound book B as the book traverses the caliper station CS.

The two beta particle beams 57 and 65 both impinge upon a single sensing means comprising a sensing element 66. In system 50, the sensing element 66 may comprise a crystal of anthracene, sodium, or other material that luminesces when subjected to beta particle bombardment and that produces a

light output having an intensity that is a function of the energy level of the impinging beam or beams of beta particles. The sensing element 66 is located immediately adjacent a photodetection device 67 which which may constitute a photomultiplier. The photomultiplier 67 develops an electrical signal that is representative of the light output from the sensing element 66. This electrical signal is supplied to a comparator or detector circuit 68. Devices 67 and 68 comprise a comparing means for comparing the reference beam 57 with the probing beam 65 to determine whether a match or a mismatch prevails between the reference book B1 and the book being calipered. The output signal from the comparator 68 is a control signal that is indicative of a match or a mismatch condition. This control signal is applied to the control means for the machine, generally represented in FIG. 7 as a machine control circuit 71, which includes the binding control solenoid 40.

The caliper system 50 further includes means 72 for cyclically interrupting the two beta particle beams 57 and 65, with the cyclical interrupters being displaced in phase by approximately 180°. The cyclic beam interruption means 72 of the caliper system includes an electric motor or other drive means 73 having a rotating shaft 74 upon which two discs 75 and 76 are mounted. The shaft 74 is disposed substantially parallel to the paths of the beams 57 and 65. The disc 75 extends into the path of the beam 57 and the disc 76 extends into the path of the beam 65.

The two interrupter or chopper discs 75 and 76 are illustrated in FIG. 8. As shown therein, the disc 75 comprises four quadrant segments 81, 82, 83 and 84. Segments 81 and 83 are each transparent to a beta particle beam and segments 82 and 84 are each substantially opaque with respect to a beta particle beam. The other chopper disc 76 is of similar construction and includes two transparent quadrants or segments 85 and 87 and two opaque segments 86 and 88. The relative positions of the two discs on the shafts 74 are as shown in FIG. 8, from which it can be seen that the beta particle beam 57 is interrupted by the disc 75 during those time intervals in which the beta particle beam 65 is passed without substantial attenuation by the disc 76, and vice versa.

The operation of the caliper system 50 of FIG. 7 can perhaps best be understood by reference to the waveforms illustrated in FIGS. 9 through 11. In FIG. 9, the initial pulse waveform 91 represents the output signal from the photomultiplier tube 67 that is produced by excitation of the sensing crystal 66 by the reference beam 57. As shown in FIG. 9, the signal 91 is a series of constant-amplitude electrical pulses, the amplitude of these pulses being indicative of the thickness of the reference book B1.

In FIG. 9, which illustrates the operating electrical conditions for a calipered book that is of correct thickness, the electrical output signal from the photomultiplier device 67, produced by excitation of the crystal 66 from the caliper probe beam 65, is the pulse signal 92. Inasmuch as the book B has been assumed to be of the correct thickness, and the two beta particle beam sources 55 and 62 have matched outputs, it is seen that the pulses of the signal 92 are of the same amplitude as those of the signal 91. However, due to the operation of the choppers or interrupters 75 and 76, the pulses of the signals 91 and 92 are displaced 180° in phase from each other. Accordingly, the total output signal from the photomultiplier 67 corresponds to the waveform 93, having an average value as generally represented by the waveform 94.

FIG. 10 is similar to FIG. 9 but illustrates the output signal from the photomultiplier 67 for a book that is thicker than the standard book B1. The output signal 91 that is produced by the reference beam 57 remains unchanged. But the output signal from the beta particle beam probing the book being calipered, as represented by the waveform 95, is substantially reduced in amplitude. Consequently, the composite output signal from the photomultiplier 67 is a pulsating signal of varying amplitude as represented by the waveform 96 in FIG. 10 and has an average amplitude as represented by the waveform 97.

FIG. 11 represents the electrical output signal conditions for the photomultiplier 67 under those circumstances where the book B is too thin in comparison with the reference book B1. Again, the electrical signal 91 resulting from the reference beam 57 remains unchanged. The signal developed by the photomultiplier in response to the probing beam 65, as shown by the waveform 98, is substantially increased in amplitude. The composite output signal from the photomultiplier is thus a pulsating signal of varying amplitude as represented by the waveform 99 and has an average value as shown by the waveform 100.

By reference to the waveforms shown in FIGS. 9, 10 and 11, it can be seen that detection of a mismatch in the comparator circuit 68 can be readily and effectively accomplished by several different forms of comparator apparatus. Thus, by reference to FIG. 9 it is seen that the output signal 93 from the photomultiplier 67, under circumstances where the books are matched, is essentially a DC signal with recurrent spikes of very limited duration. Incorporation of a simple low pass filter in the output circuit of the photomultiplier or in the input circuit of the comparator 68 reduces the signal for matched books to a virtually constant DC signal. The cutoff frequency of the low pass filter can be established above the operational frequency of the interrupters or choppers 75 and 76 so that the filter circuit will pass the AC signals 96 and 99 representative of mismatched books. With this arrangement, a simple capacitor coupling to an AC detector circuit in comparator 68 produces an output control signal that is indicative of any mismatched book, whether too thin or too thick, at the caliper station.

On the other hand, there are significant and detectable differences between the average or DC levels of the signals for correct thick and thin books as indicated by the average signal waveforms 94, 97 and 100. Consequently, a relatively simple amplitude detector circuit can serve as the comparator circuit 68 for the system. Inasmuch as conventional and widely known circuits are available for either form of mismatch detection, no specific circuits are illustrated in the drawings.

The caliper system 50 is quite capable of detecting a difference in thickness (between the standard book B1 and the book B that is being calipered) of one sheet thickness for paper of any standard weight employed in ordinary books. The caliper system does not have the inherent inertia of a mechanical system and, with simple synchronization to operation of the conveyor of the machine, can caliper books on the fly at virtually any rate of possible machine operation. Change-over to a book of a different thickness configuration can be accomplished in a very short time interval simply by replacing the standard or reference book B1 with another book of the required thickness. It is thus seen that the caliper system 50 is inherently more rapid and more flexible in operation than mechanical caliper apparatus.

FIG. 12 illustrates a caliper system 110 constructed in accordance with another embodiment of the invention and utilizing some of the same components as the system 50 described above in connection with FIGS. 7—11. Thus, the caliper system 110 of FIG. 12 is again located at the caliper station CS and is employed to caliper each book B that is advanced to that station by the conveyor as generally represented by the saddle SD, the chain 25, and the feed lug 20. Moreover, system 110 again employs a beta particle source 62 mounted in alignment with an opening 64 in the one saddle plate 63. The beta particle source 63 is the principal operating component of a probe means 61 that projects a beam or stream of beta particles 65 through each book B requiring calipering.

The sensing means for sensing of the beam 65, in the embodiment of FIG. 12, is again a crystal or other sensing element 66 that is rendered luminescent by an impinging stream of beta particles. A photosensitive device 67, which may be a photomultiplier, is positioned adjacent the sensing element 66 and develops an output signal that is representative of the

energy level of the beam of beta particles 65 as that beam emerges from its transit through the book B.

The caliper system 110 does not include a mechanical interrupter or chopper of the kind used in the embodiment of FIG. 7. Instead, electrical means are provided for obtaining an AC output signal from the photomultiplier 67. Thus, the caliper system 110 includes an alternating current power supply 111 connected to the primary winding 112 of a supply transformer 113. The secondary winding 114 of the transformer 113 has a center tap that is returned to a unipotential point such as system ground. One end terminal of the secondary winding 114 is connected to the photomultiplier 67 to so constitute the power supply for the photomultiplier so that the output signal from the photomultiplier is an alternating current signal.

The reference means 120 in the caliper system 110 is substantially different in construction from that employed in the previously described system 50. It comprises a resistor 121 provided with a plurality of taps 122, 123, and 124, one end terminal of the resistor 121 being connected to an end terminal of the secondary winding 114 and the other end terminal of the resistor being returned to system ground. It is thus seen that the resistor 121 is energized by the same input signal as is supplied to photomultiplier 67 but with a phase difference of 180°.

Each of the taps 122—124 on the resistor 121 is connected to one input terminal of a selector switch 125 having a movable contact 126. The movable contact 126 of the selector switch is connected to one input of a comparator circuit 68. A second input for the comparator circuit 68 is connected to the output of the photomultiplier 67. As in the previous embodiment, the comparator is connected to a machine control circuit 71 that includes the control solenoid 40 for the binding means of the machine.

The caliper system 110 of FIG. 12 requires calibration. If it is assumed that the signature gathering machine in which the caliper system is employed is to be utilized in assembling books of three different thicknesses, in a given run, a correctly assembled book of one thickness is first placed in the caliper station in the position occupied in FIG. 12 by the book B. The selector switch 125 is adjusted to a first position, engaging its movable contact with one of the taps 122—124, and that tap is then adjusted until the comparator circuit 68 produces no effective output control signal to the machine control 71. Thereafter, a book of the next desired thickness is placed in the caliper station, the selector switch 125 is adjusted to afford a connection from another tap on the resistor 121 to the comparator 68, and the calibration operation is repeated. The same calibration operation is then carried out with respect to a book of the third required thickness. In this manner, the reference means 120 of the caliper system 110 is calibrated for each of the three different book thicknesses required for the projected machine run.

During the actual operation of the machine, whenever it is desired to switch from one book thickness to another, the caliper system is readily adjusted simply by operation of the selector switch 125. It is thus seen that the system 110 of FIG. 12 operates in a manner essentially similar to that of the system shown in FIG. 7 except that the energy analogue for each book thickness is afforded by the calibrated resistor 121 and its taps instead of by a second probing beam as employed in the system 50 of FIG. 7. Moreover, the requirements for the comparators of the two devices are essentially similar to each other except that the waveforms may be slightly different, because the power supply 111 may be assumed to produce a generally sinusoidal output signal rather than the sharply defined pulses illustrated in FIGS. 9—11.

In the caliper system 110 of FIG. 12, synchronized cyclic interruption of the two input signals supplied to the comparator 68 from the reference means 120 and the sensing means 66, 67 is effected by the AC power supply 111. It will be recognized, however, that similar gating can be effected in the output circuit of the photomultiplier 67; this is equally true in

the embodiments described hereinafter. And DC comparison, based on amplitude variations, can be employed as described in conjunction with FIGS. 9—11. Effective comparator circuits that may be utilized include bridge circuit detectors, differential amplifiers, and others as well known in the art.

FIG. 13 illustrates a caliper system 130 that combines certain of the principal features of the systems of FIGS. 7 and 12. The caliper station CS in system 130 is essentially similar to that of system 110 and comprises a probe means 61 including a source 62 of beta particle emission mounted upon the saddle SD and projecting a beam of beta particles 65 through one side of each book B as the book traverses the caliper station. The emergent beam 65 impinges upon a crystal or other sensing element 66 that is rendered luminescent by the beam. The light output from the sensing element 66 is converted to an electrical signal by the photomultiplier or other photosensitive device 67, which is connected to the comparator circuit 68.

In the caliper system 130, the reference means 140 is a support member 141 upon which a standard book B1 of correct thickness is supported. The reference means includes a beta particle source 155 that projects a stream of beta particles through one-half of the book B1 to impinge upon a crystal or other luminescent sensing element 166. The light output from the sensing element 166 is converted to an electrical signal by a photomultiplier or other photosensitive device 167 and the electrical signal from the device 167 is supplied to the comparator circuit 68.

In the caliper system 130 of FIG. 13, the two photomultipliers 67 and 167 are energized from a main power supply 111. Preferably, the two devices are energized in phase opposition to provide for more convenient comparison in circuit 68. It will be recognized that a mechanical chopper of the kind illustrated in FIG. 7 could be employed in the caliper system of FIG. 13.

The caliper system 130 of FIG. 13 operates in essentially the same manner as described above for the system 50 of FIG. 7 except that the two separate output signals from the photomultipliers 67 and 167 are combined and compared in the circuit 68 instead of being initially combined in the sensing means of the system. As before, a change of book thickness can be readily accomplished merely by substituting a different book for the reference book B1. As in all of the systems of the present invention, the inertia and speed limitations of conventional caliper devices are effectively eliminated or minimized by the caliper system.

FIG. 14 illustrates a caliper system 170 that is somewhat different from the systems described above and that is applied to a signature gathering machine employed for side wire binding or for perfect binding instead of saddle binding. The system is associated with a caliper station CS' in a signature gathering machine in which each book B' of signatures moves in flat condition along a support SS as the signatures are advanced through the caliper station to the binding station. The apparatus of the caliper system that is located at the caliper station CS' includes a beta particle source 62 that projects a beam 65 through an aperture in the support plate SS. That beam impinges upon a crystal or other sensing device 66 which is associated with a photomultiplier 67 as in the previous embodiments.

Caliper system 170 includes two separate reference means, each capable of developing an energy analogue of the correct thickness for an unbound book. Two stations are provided to facilitate rapid switching from a book of one given thickness to a book of a second given thickness.

The first reference means in the caliper system 170 comprises a support plate 171 upon which a first standard book B1 is supported. A beta particle source 155 is mounted upon the plate 171 and projects a beta particle beam 157 through an aperture in the plate and through the reference book B1 to impinge upon a sensing element 166. The sensing means for the first reference means includes a photomultiplier 167.

The second reference means in the system 170 comprises a support plate 172 on which a second reference book B2 that is different in thickness from the book B1 is supported. A beta particle source 255 projects a beam 257 through an aperture in the plate 172 and through the reference book B2 to impinge upon a sensing element 266. The luminescence of the sensing element 266 is detected by a photomultiplier 267.

In the caliper system 170, the photomultiplier 67 is energized from a power supply 111. The power supply is also connected to the movable contact 173 of one stage of a two-stage selector switch 174. One of the fixed contacts engageable by the movable contact 173 is connected to the photomultiplier 167 to afford an energizing circuit for that device. The other fixed contact engageable by the movable contact 173 is connected to the photomultiplier 267.

The selector switch 174 is a two stage device having a second movable contact 175. The movable contact 175 is connected to an input circuit for the comparator 68. One of the fixed contacts engageable by the movable contact 175 is connected to the output of the photomultiplier 167. The other fixed contact in this stage of the selector switch is connected to the output of the photomultiplier 267. As in the previously described embodiments, the comparator 68 is connected to the machine control circuit 71 including the binding station control solenoid 40.

It is believed that the basic operation of the caliper system 170 of FIG. 14 will be generally apparent from the description of the foregoing embodiments. With the selector switch 174 in the position shown in FIG. 14, the probe means 62 projects its beam of energy 65 through each book B as the book traverses the caliper station CS'. The energy level of the emergent beam is sensed by the sensing means 66, 67 and is converted to an electrical signal that is supplied to the comparator 68. The energy analogue of a book of correct thickness (the book B1) developed by the beam source 155 and the related sensing apparatus 166 and 167 is also supplied to the comparator. In the comparator, the two electrical signals from the reference source and the caliper probe are compared and are employed to develop a control signal that actuates the machine control 71 to inhibit the binding of any mismatched books.

To convert the circuit of FIG. 14 to caliper of books of a different thickness, the selector switch 174 is actuated to place the second reference means comprising the beta particle source 255 and the sensing means 266, 267 in operation. This is the only operation required for a change of book thickness, other than appropriate actuation of the controls in the machine itself for depositing a different combination of signatures on the conveyor for each book. Of course, if a third book of a still different thickness is to be assembled by the same machine, the book B1 can be replaced in the first reference means of the system while the book B2 is serving as the standard, so that there is no down time for the machine required in the changing or recalibration of the caliper system 170 for a book of different thickness. On the other hand, it will be apparent that any additional number of reference means can be added to the system, with the addition of further stages to the selector switch 174.

FIG. 15 shows an overall control system for a signature gathering machine that is presented to illustrate more completely the operating interrelationship between the caliper system and the machine. In the machine, as illustrated in FIG. 15, there are four signature hoppers H1 through H4 positioned at the left-hand side of the machine. A conveyor 25 driven by a conveyor drive 181 extends through most of the machine. The signature groups or books deposited on the conveyor are advanced through the machine from left to right in FIG. 15 as indicated by the arrow A. In the right-hand portion of the machine, the conveyor belt 25 terminates in a transfer station 182. Books reaching the transfer station 182 can be directed along a main continuation conveyor 25' through a binder station SR to a destination at which useable books are collected. Alternatively, the transfer station 182 may be operated to divert mismatched books along a conveyor chain 25'' to a destination for reject books.

The caliper system 190 illustrated in FIG. 15 may correspond to any of the specific systems described above in connection with FIGS. 7 through 14. The caliper 190 includes three separate reference circuits 191, 192 and 193 each capable of developing an energy analogue for an unbound book of a given thickness. By way of example, the device 191 may develop an energy analogue for a book having a thickness corresponding to the total thickness of two signatures S1 and S2. The analogue device 192 may develop an energy analogue for an unbound book having a thickness equal to that of the three signatures S1, S2 and S3. The analogue device 193 may afford an energy analogue signal corresponding to the overall thickness of four signatures, one from each of the hoppers H1-H4. The analogue devices may be beam probe devices as described above in connection with FIGS. 7, 13 and 14 or may be electrical analogue devices as described in connection with FIG. 12.

The outputs of the three energy analogue devices 191, 192 and 193 are connected to a book selector 194, which may comprise a selector switch such as the switch 174 (see FIG. 14). The book selector circuit 194 is connected to one input of a comparator 68. The book selector 194 is also connected to a hopper control device 195 that determines which of the hoppers H1 through H4 are actuated in the compiling of any given series of books.

The caliper system 190 of FIG. 15, like those described above, includes a probe means 196 for developing and projecting a beam of energy through each unbound book as the book traverses the caliper station CS. The emergent beam is sensed by a sensing means shown as a beam receiver 197, the output of which is connected to a second input circuit for the comparator 68.

The output of the comparator 68, in the embodiment of FIG. 15, is connected to a comparator gate circuit 201. The comparator gate circuit 201 has a second input that is coupled to the conveyor drive 181 so that the comparator gate may be actuated once in each cycle of machine operation. That is, the comparator gate 201 is actuated to an open condition for a given time interval each time one of the unbound books advances a full stage along the path between the signature hoppers and the output end of the machine.

The output of the comparator gate 201 is connected to the input level of a multilevel storage register 202. The register 202 may be a conventional shift register and has a shift input derived from the conveyor drive 181 so that the data stored in the register 202 is advanced one level in each cycle of machine operation. One of the intermediate stages of the storage register 202 is coupled to a transfer control circuit 203 that actuates the transfer station 182. A later stage in the storage register, which may be the terminal stage of the register, is connected to a binder control circuit 204. The binder control circuit, which may include the binding means control solenoid 40 described above, is connected to and actuates the binding means SH.

In considering the operation of the system illustrated in FIG. 15, it may be assumed that the book selector 194 is set initially for books containing only signatures S1 and S2 from hoppers H1 and H2. The book selector 194 conditions the hopper control 195 so that a signature from each of the hoppers H1 and H2 is deposited upon the conveyor represented by the chain 25 in each cycle of machine operation. The hopper control also functions to prevent discharge of any of the signatures from hoppers H3 and H4.

As each unbound book reaches the caliper station CS, the thickness of the book is sensed by the probe means 196 and the beam projected therefrom to the sensing means comprising the beam receiver 197. The output of the beam receiver is compared in circuit 68 with the signal from the electrical analogue device 191 that has been selected by the selector circuit 194. The output of the comparator is supplied through the comparator gate 201 to the initial stage of the storage register 202 and is recorded therein for subsequent use.

In each continuing cycle of machine operation, the information as to match or mismatch that was initially stored in the

first level of the register 202 is advanced through the storage register in synchronism with the operation of the conveyor drive for the machine. Three cycles later, for the machine as illustrated, the stored information actuates the transfer control 203 to direct the book along the main output conveyor 25' if the stored information indicates that the book matches the requirements of the system. On the other hand, if the stored information indicates a mismatch, the book is diverted along the auxiliary conveyor represented by the chain 25". Two cycles later, the stored information in the register 202 is supplied to the binder control 204 to inhibit or to permit operation of the binder means SH, depending upon whether a mismatch or a match situation was determined at the caliper station.

As operation of the machine continues, the book selector 194 can be actuated to select a different combination of signatures. The operation proceeds as above except that the hopper control actuates the required different combination of hoppers and the calipering operation is carried out on the basis of the different thickness requirements determined by the new signature combination. It is thus seen that the caliper system is completely integrated with the overall machine operation and affords maximum flexibility of control for the machine.

It will be apparent that a number of variations can be made in the internal connections of the control system of the system of FIG. 13 without departing in any way from the basic control operation. For example, the hopper control is shown as having a mechanical connection to the conveyor drive for synchronization of the hopper operations with the conveyor movement, but electrical synchronization may be employed if desired. The output of the comparator is synchronized with machine operations by the connection through the comparator gate 201 but the same effect can be achieved by appropriate gating of the inputs to the comparator to protect against erroneous sensing when the space on the conveyor between adjacent books is being scanned by the caliper system. The storage register is a preferred means for synchronization of the transfer station and binder operations with the functioning of the caliper system, but separate delay circuits for these two functions could be utilized. The transfer station 182 can be located after the binder station SH if desired, with appropriate reconnection of the transfer and binder controls to different levels in the storage register 202. However, none of these modifications affects the basic functioning of the system.

It will be seen from the foregoing that books are calipered on an energy basis which obviates the inertia inherent in a mechanical caliper, and because an energy beam is extremely sensitive to interference we can readily achieve error detection response in terms of a single page departure from a book of correct thickness; but more importantly perhaps, the energy caliper of the present invention affords the flexibility represented by FIG. 15. It is of course immaterial as to what mode of operation is selected to bind the books, and it follows that the exact means for disabling the binder, once an incorrect book has been calipered, may assume many different forms as is indeed the prevailing state of the art. It will be appreciated that the selector switch 125 may itself be tape controlled.

Hence, while we have illustrated and described preferred embodiments of our invention, it is to be understood that these are capable of variation and modification within the purview of the following claims.

We claim:

1. A caliper system for a cyclically operable signature gathering machine of the kind in which signatures are gathered from a plurality of supply sources into individual unbound books each containing a given number of signatures, and in which the unbound books are advanced seriatim along a predetermined path through a calipering station to a binding station comprising binding means for binding the books in their sequence of arrival, and having control means for controlling operation of the machine, said caliper comprising:

reference means for developing an energy analogue or the correct thickness for an unbound book and including means for projecting a beam of energy through a correctly assembled book employed as a standard book of correct thickness;

probe means for projecting a beam of energy through each unbound book as the book traverses the caliper station;

means for comparing the emergent beam characteristic of said energy analogue with the emergent beam characteristic of the unbound book to determine whether a match or a mismatch prevails and for developing a control signal indicative thereof; and

means for applying the control signal to the machine control means to inhibit binding of a mismatched book.

2. A caliper system for a signature gathering machine according to claim 1, in which said reference means includes a plurality of individual means for developing a corresponding plurality of separate and individual energy analogues each corresponding to a correctly assembled unbound book of a thickness different from the others, said system further comprising selective switching means for selecting any one of the energy analogues for use in the system at any given time.

3. A caliper system for a signature gathering machine according to claim 2, in which said selective switching means is also coupled to said signature supply sources in the machine to correlate the reference means and the signature contents of said unbound books.

4. A caliper system for a signature gathering machine according to claim 1, and further comprising synchronizing means for delaying application of said control signal to said binder for a given number of machine cycles to synchronize inhibition of said binding means with the scheduled arrival of a mismatched book at said binding station.

5. A caliper system for a signature gathering machine according to claim 4 in which said synchronizing means comprises a multiple level storage register, each level of the storage register corresponding to an individual sequential stage in the advancing movement of the unbound books along said path from said calipering station to said binding station, and means for applying shift signals to said shift register in synchronism with the stage-by-stage advancement of said unbound books along said path.

6. A caliper system for a signature gathering machine according to claim 5, in which the machine includes a transfer station for diverting mismatched books from said path to a different destination than the destination for matched books, and in which said machine control means includes a transfer control and a binding means control, said system further including means for applying said control signal to said transfer control from one level of said storage register and means for applying said control signal to said binding means control from a different level of said storage register.

7. A caliper system for a signature gathering machine according to claim 5 in which said reference means includes a plurality of individual means for developing a corresponding plurality of separate and individual energy analogues each corresponding to a correctly assembled unbound book of a constituency different than the others, said system further comprising selective switching means for selecting any one of the energy analogues for use in the system at any given time, said selective switching means being coupled to said signature supply sources to correlate the reference means and the signature contents of said unbound books.

8. A caliper system for a signature gathering machine according to claim 1 in which each of said reference means and probe means comprises a radioactive material affording a beam of beta particles and in which there is a sensing means comprising a sensing element that produces a signal having an intensity that is a function of the beta particle beams impinging thereon, the signal from the sensing means being delivered to the comparing means.

9. A caliper system for a signature gathering machine according to claim 8 in which said reference means includes a

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plurality of individual means for developing a corresponding plurality of separate and individual energy analogues each corresponding to a correctly assembled unbound book of a constituency different than the others, said system further comprising selective switching means for selecting any one of the energy analogues for use in the system at any given time, said selective switching means being coupled to said signature supply sources to correlate the reference means and the signature contents of said unbound books.

10. A caliper system for a signature gathering machine according to claim 8 in which said sensing means further includes means for cyclically interrupting said beam whereby the output signal from said sensing element is an alternating signal.

11. A caliper system for a signature gathering machine according to claim 10 in which said sensing element is a crystal excited to luminescence by the impinging beams of beta particles, said sensing means further including a photosensitive device positioned to receive light from the sensing element and to convert that light into an alternating electrical signal.

12. A caliper system for a signature gathering machine according to claim 8 and further comprising means for cyclically interrupting the two beta particle beams from said reference means and said probe means with a phase displacement of approximately 180° and in which said sensing element is a luminescent element excitable by beta particle bombardment and producing a light output representative of the intensity of an impinging beta particle beam, said sensing means further including a photosensitive device positioned to receive light from said sensing element and to convert that light into an electrical signal.

13. A caliper system for a signature gathering machine according to claim 12 in which said comparing means comprises a detector circuit for detecting an alternating current output from said photosensitive device to establish the presence of a mismatched book.

14. A caliper system for a cyclically operable signature gathering machine of the kind in which signatures are gathered from a plurality of supply sources into individual unbound books each containing a given number of signatures, and in which the unbound books are advanced serially along a predetermined path through a calipering station to a binding

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station comprising binding means for binding the books in their sequence of arrival, and having control means for controlling operation of the machine, said caliper comprising:

reference means for developing an energy analogue of the correct thickness for an unbound book;

said reference means including a plurality of individual means for developing a corresponding plurality of separate and individual energy analogues each corresponding to a correctly assembled unbound book of a thickness different from the others, said system further comprising selective switching means for selecting any one of the energy analogues for use in the system at any given time;

probe means for projecting a beam of energy through each unbound book as the book traverses the caliper station;

means for comparing said energy analogue with the emergent beam characteristic of the unbound book to determine whether a match or a mismatch prevails and for developing a control signal indicative thereof; and

means for applying the control signal to the machine control means to inhibit binding of a mismatched book.

15. A caliper system for a signature gathering machine according to claim 14 in which said selective switching means is also coupled to said signature supply sources in the machine to correlate the reference means and the signature contents of said unbound books.

16. A caliper system for a signature gathering machine according to claim 15 and further comprising synchronizing means for delaying application of said control signal to said binder for a given number of machine cycles to synchronize inhibition of said binding means with the scheduled arrival of a mismatched book at said binding station.

17. A caliper system for a signature gathering machine according to claim 16 in which said synchronizing means comprises a multiple level storage register, each level of the storage register corresponding to an individual sequential stage in the advancing movement of the unbound books along said path from said calipering station to said binding station, and means for applying shift signals to said shift register in synchronism with the stage-by-stage advancement of said unbound books along said path.

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