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Jones

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[54] **CONTROL MECHANISMS FOR DOCUMENT-HANDLING APPARATUS**

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[73] Assignee: **Brandt-Pra, Inc.**, Cornwells Heights, Pa.

[21] Appl. No.: **671,074**

[22] Filed: **Mar. 29, 1976**

Related U.S. Patent Documents

Reissue of:

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	Appl. No.:	**273,999**
	Filed:	**July 21, 1972**

[51] **Int. Cl.**[2] **G06M 7/06**

[52] **U.S. Cl.** .... **235/92 SB**; 235/92 V; 235/92 PE; 235/92 R; 235/98 C

[58] **Field of Search** .... 235/92 SB, 92 PE, 92 V, 235/98 C; 250/561, 571

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Primary Examiner—Joseph M. Thesz
Attorney, Agent, or Firm—Louis Weinstein

[57] **ABSTRACT**

In a document-handler adapted for feeding, separating and stacking sheets and the like, control means for sensing and counting separated sheets and having a capability of counting, statistically sampling and batching and including means for anticipating jam conditions to protect the counting mechanism, as well as the sheets, from being damaged. The sensing mechanism has the capability of self-adjustment to automatically compensate for any and all conditions which affect the sensitivity of the sensing device, and further has a capability of distinguishing between separated documents and apertured or mutilated documents. In accordance with the desired operation, the electronic circuitry controls the mechanical functions to achieve the desired counting, separating, batching and statistical sampling operations.

17 Claims, 13 Drawing Figures

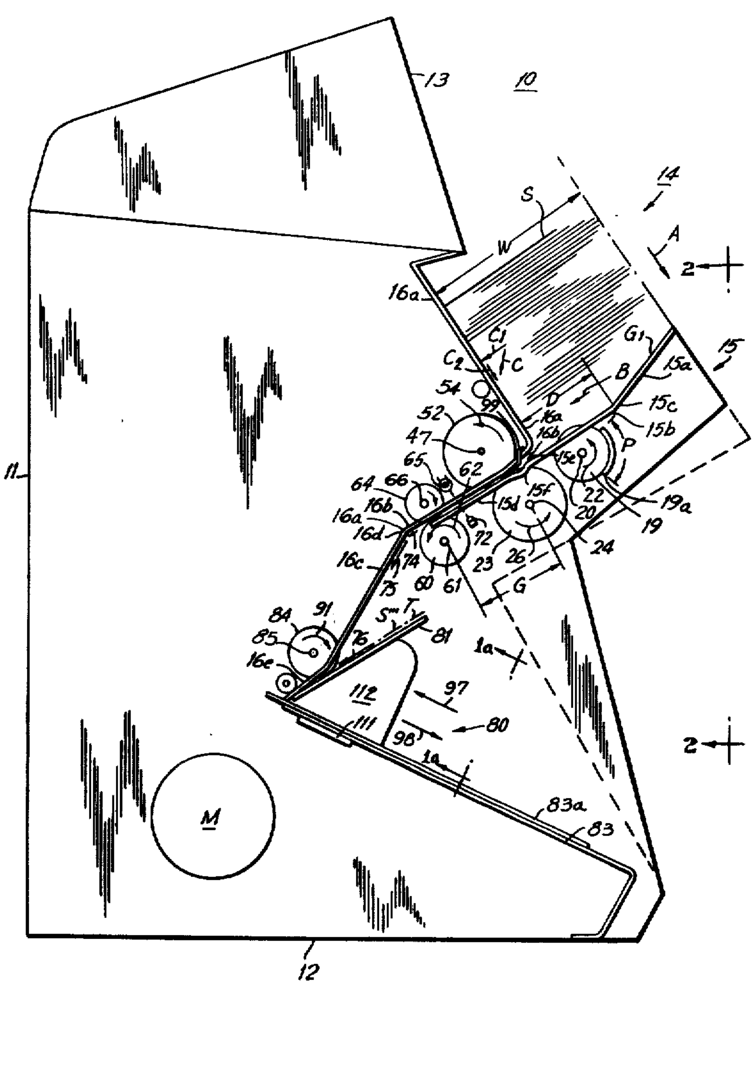
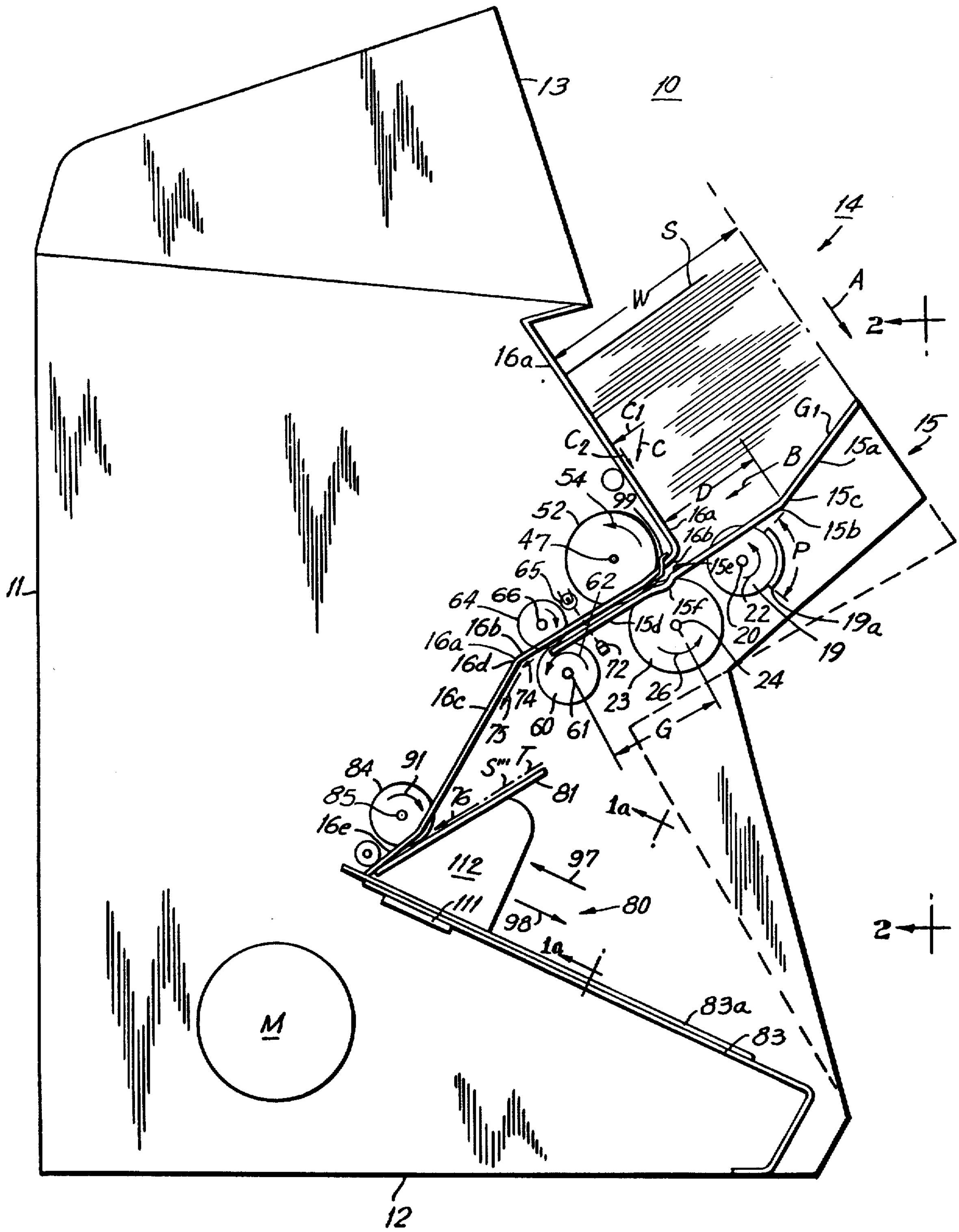


FIG. 1


10
11
12
13
14
15
A
B
C
D
G
P
S
W
M
2
1a
15a
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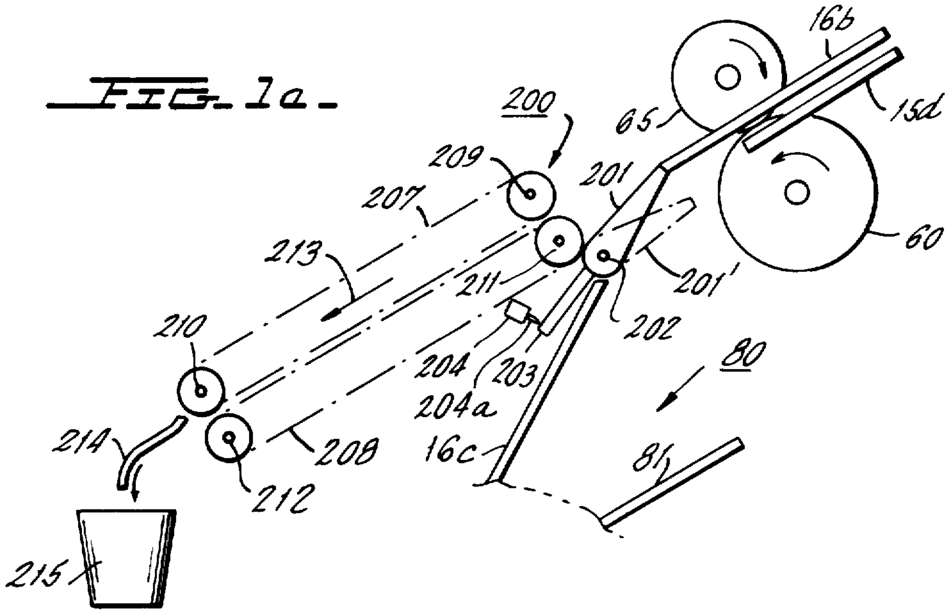
15c
15d
15e
15f
16a
16b
16c
16d
16e
19
19a
20
22
23
24
26
47
52
54
60
61
62
64
65
66
72
74
75
76
80
81
83
83a
84
85
91
97
98
99
111
112

FIG. 1a



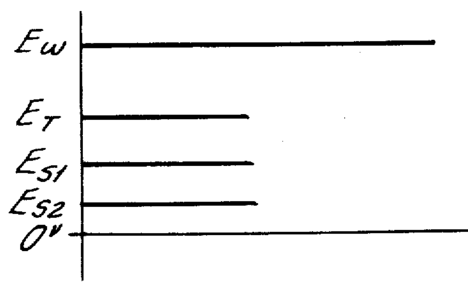


FIG. 5a

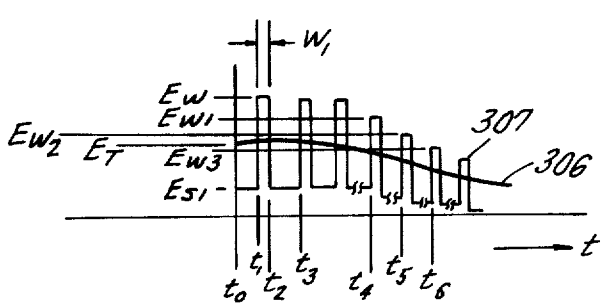


FIG. 5b

FIG. 5c

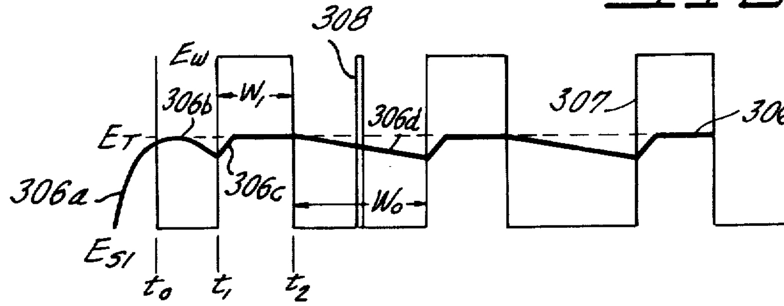
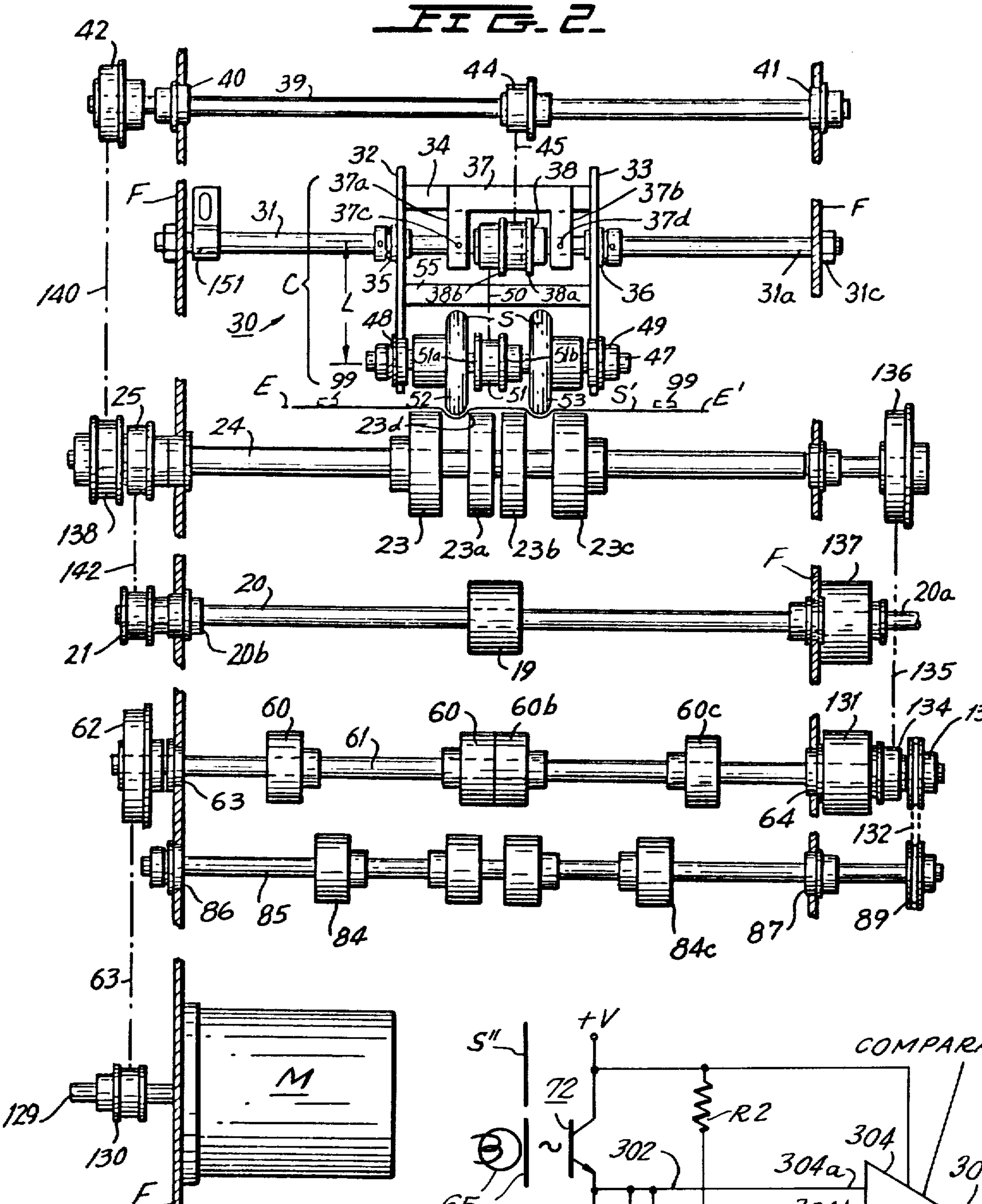


FIG. 2


42
40
39
44
41
45
32
34
37
38
33
37a
37b
37c
37d
F
31
151
55
35
36
38b'
50
38a
31a
31c
140
C
L
30
S
48
49
51a
51b
47
99
E
52
51
53
S'
E'
136
25
23d
24
138
23
23a
23b
23c
142
137
20
20a
21
20b
19
135
62
60
61
60b
60c
131
134
133
63
64
132
86
85
84
84c
87
89
129
130
M

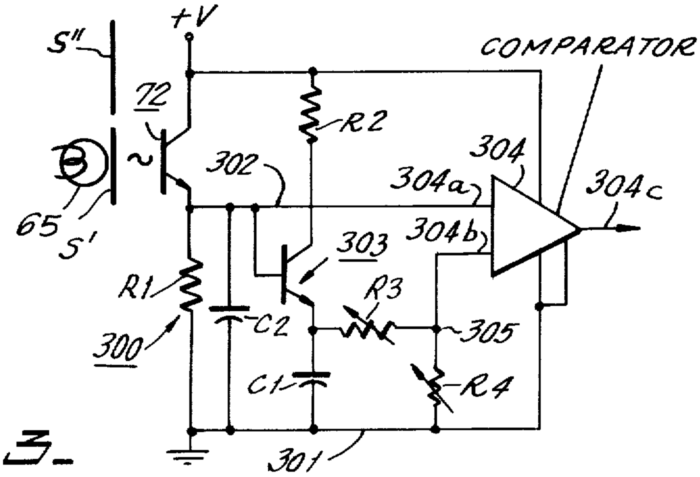

S''
+V
COMPARATOR
72
R2
304
302
304a
304c
65
S'
303
304b
R1
R3
C2
305
300
C1
R4
301

FIG. 3

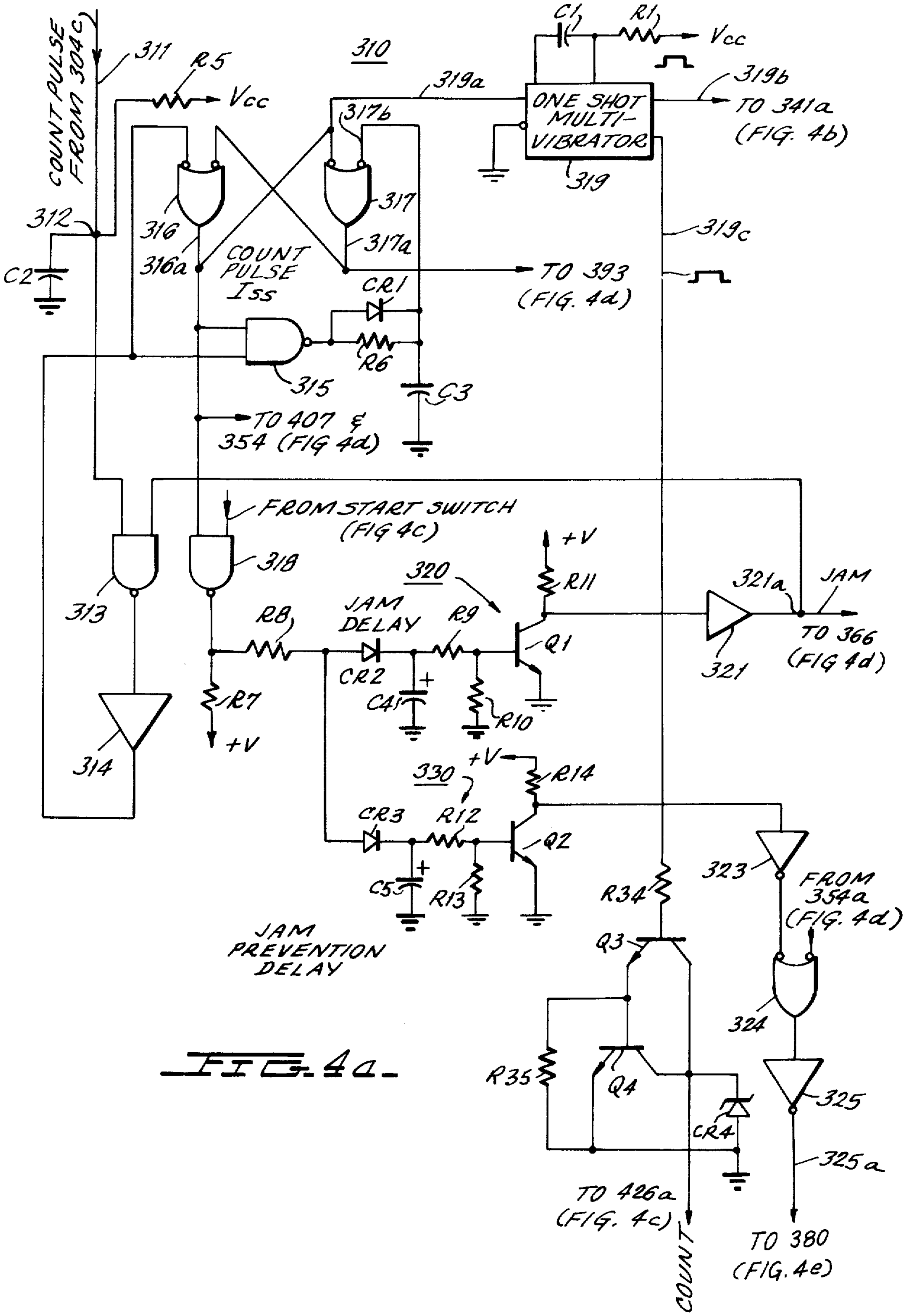

COUNT PULSE FROM 304c
311
R5
Vcc
310
C1
R1
Vcc
319a
ONE SHOT MULTI-VIBRATOR
319b
TO 341a (FIG. 4b)
319
317b
316
317
312
C2
316a
COUNT PULSE Iss
317a
319c
TO 393 (FIG. 4d)
CR1
R6
315
C3
TO 407 & 354 (FIG 4d)
FROM START SWITCH (FIG 4c)
+V
318
320
R11
313
R8
JAM DELAY
R9
Q1
321a
JAM
TO 366 (FIG 4d)
CR2
C4
R10
321
R7
+V
314
330
+V
R14
CR3
R12
Q2
323
FROM 354a (FIG. 4d)
C5
R13
R34
JAM PREVENTION DELAY
Q3
324
R35
Q4
325
CR4
325a
TO 426a (FIG. 4c)
COUNT
TO 380 (FIG. 4e)

FIG. 4a

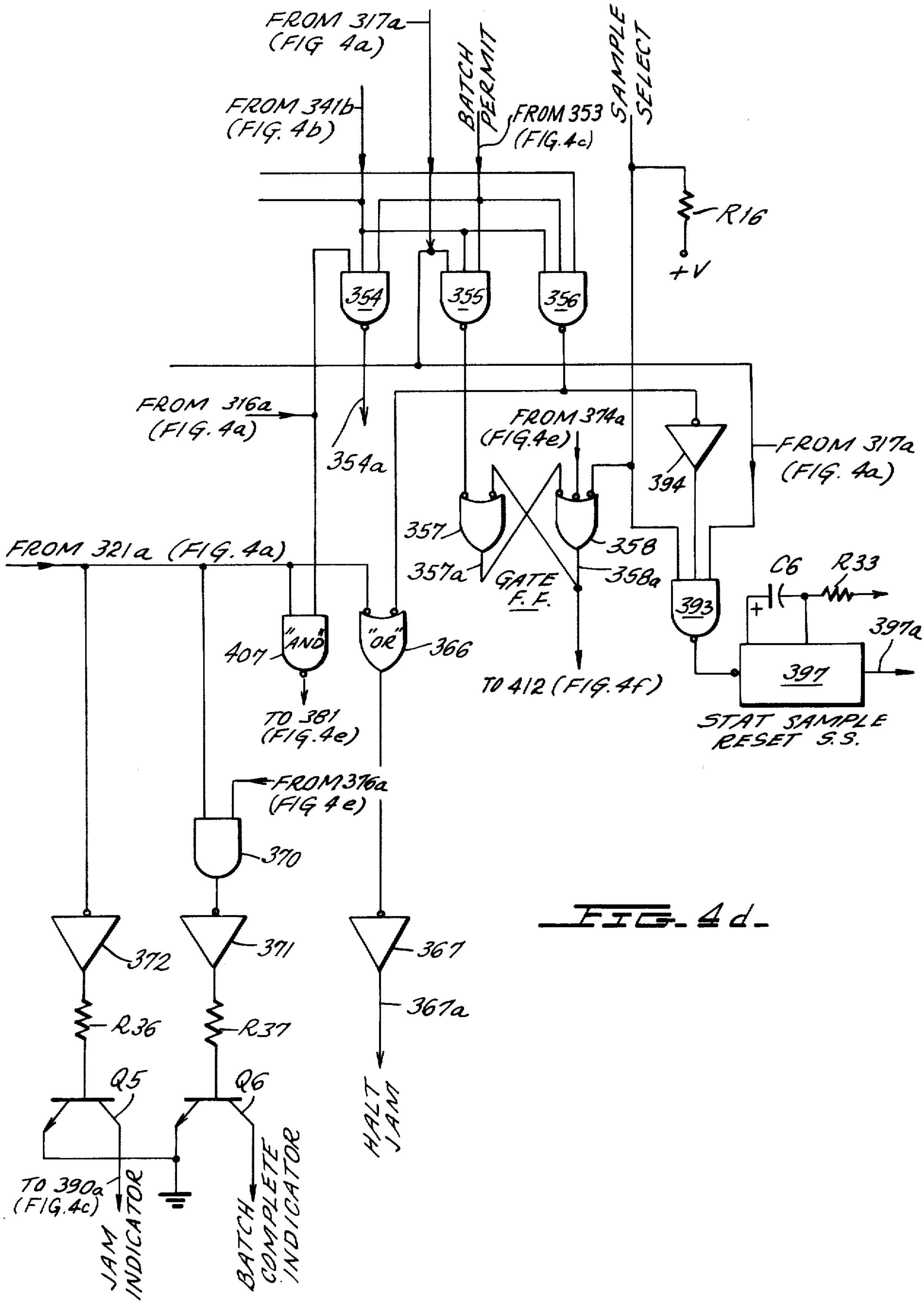

FROM 317a (FIG 4a)
FROM 341b (FIG. 4b)
BATCH PERMIT
FROM 353 (FIG. 4c)
SAMPLE SELECT
R16
+V
354
355
356
FROM 316a (FIG. 4a)
354a
FROM 374a (FIG. 4e)
394
FROM 317a (FIG. 4a)
357
358
357a
GATE F.F.
358a
FROM 321a (FIG. 4a)
"AND"
"OR"
407
366
TO 381 (FIG. 4e)
TO 412 (FIG. 4f)
393
C6
R33
397
397a
STAT SAMPLE RESET S.S.
FROM 376a (FIG 4e)
370
372
371
367
R36
R37
367a
Q5
Q6
TO 390a (FIG. 4c)
JAM INDICATOR
BATCH COMPLETE INDICATOR
HALT JAM

FIG. 4d

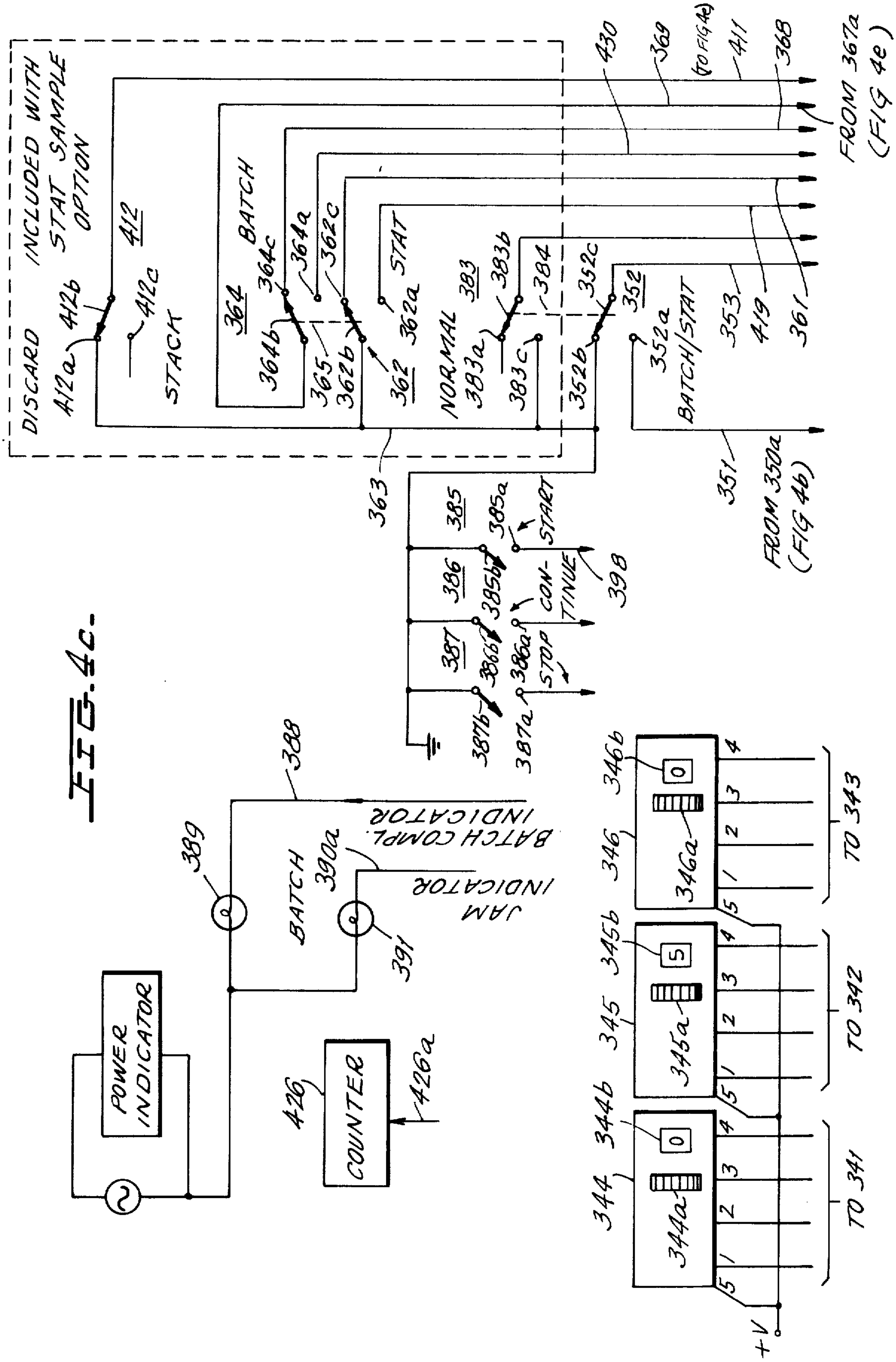

INCLUDED WITH STAT SAMPLE OPTION
DISCARD
STACK
BATCH
STAT
NORMAL
BATCH/STAT
(TO FIG 4e)
FROM 367a (FIG 4e)
FROM 350a (FIG 4b)
START
CONTINUE
STOP
BATCH COMPL. INDICATOR
JAM INDICATOR
BATCH
POWER INDICATOR
COUNTER
TO 343
TO 342
TO 341
+V

FIG. 4c.

FIG. 4b

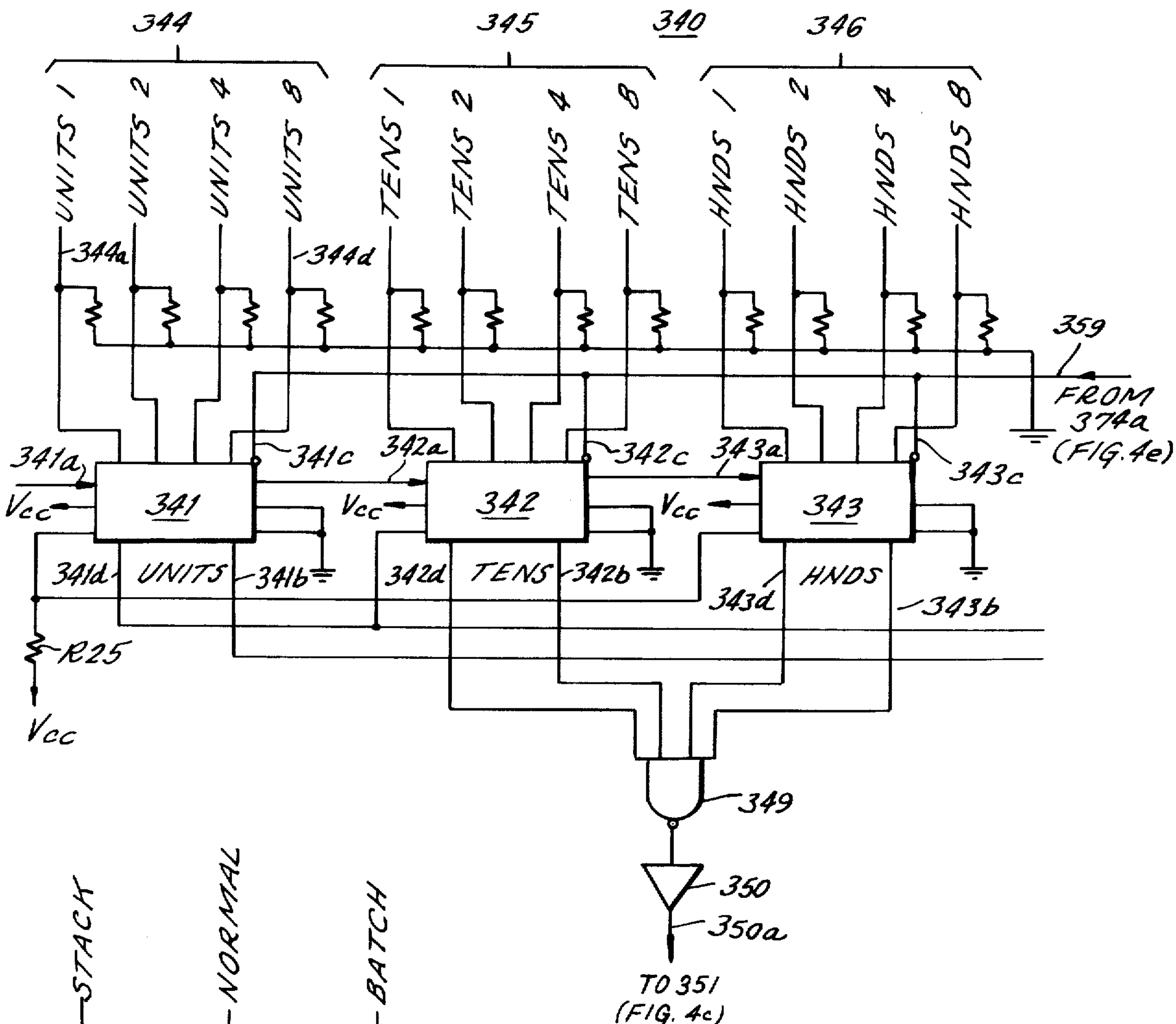

344
345
340
346
UNITS 1
UNITS 2
UNITS 4
UNITS 8
TENS 1
TENS 2
TENS 4
TENS 8
HNDS 1
HNDS 2
HNDS 4
HNDS 8
344a
344d
359
FROM 374a (FIG. 4e)
341a
341c
342a
342c
343a
343c
Vcc
341
342
343
341d
UNITS
341b
342d
TENS
342b
343d
HNDS
343b
R25
Vcc
349
350
350a
TO 351 (FIG. 4c)

FIG. 4f

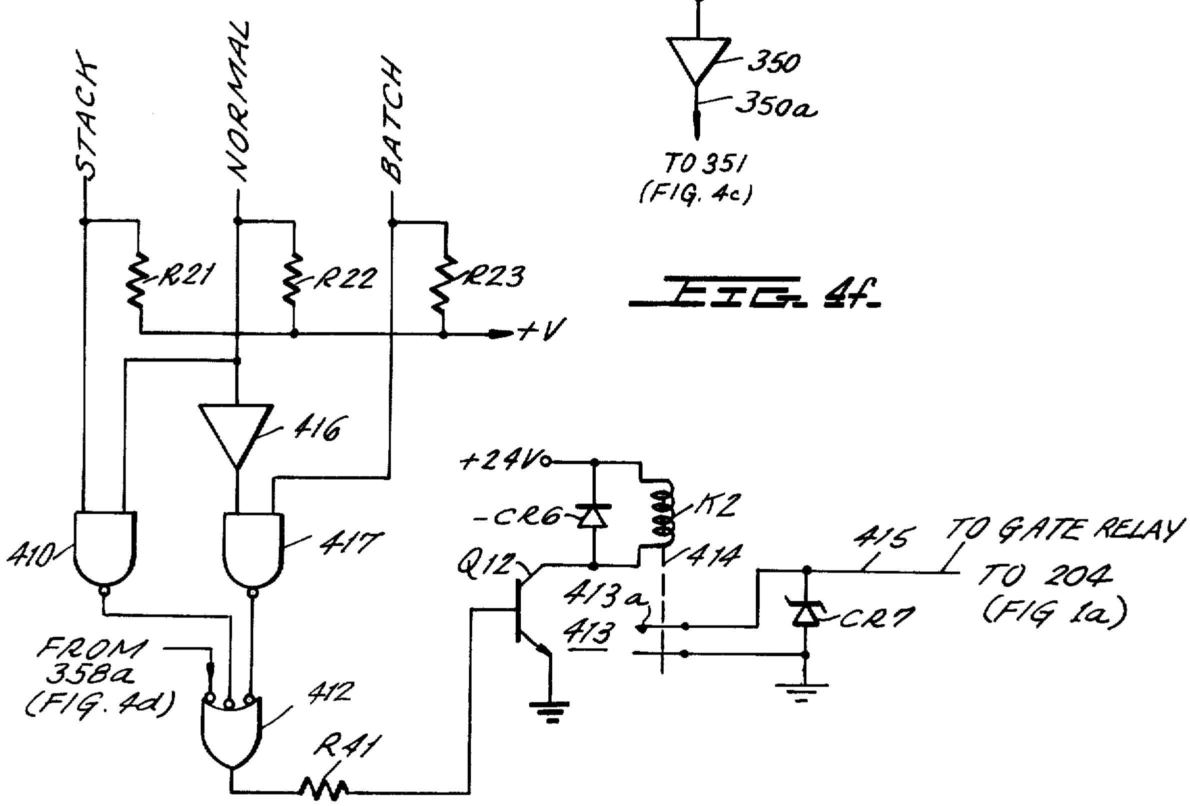
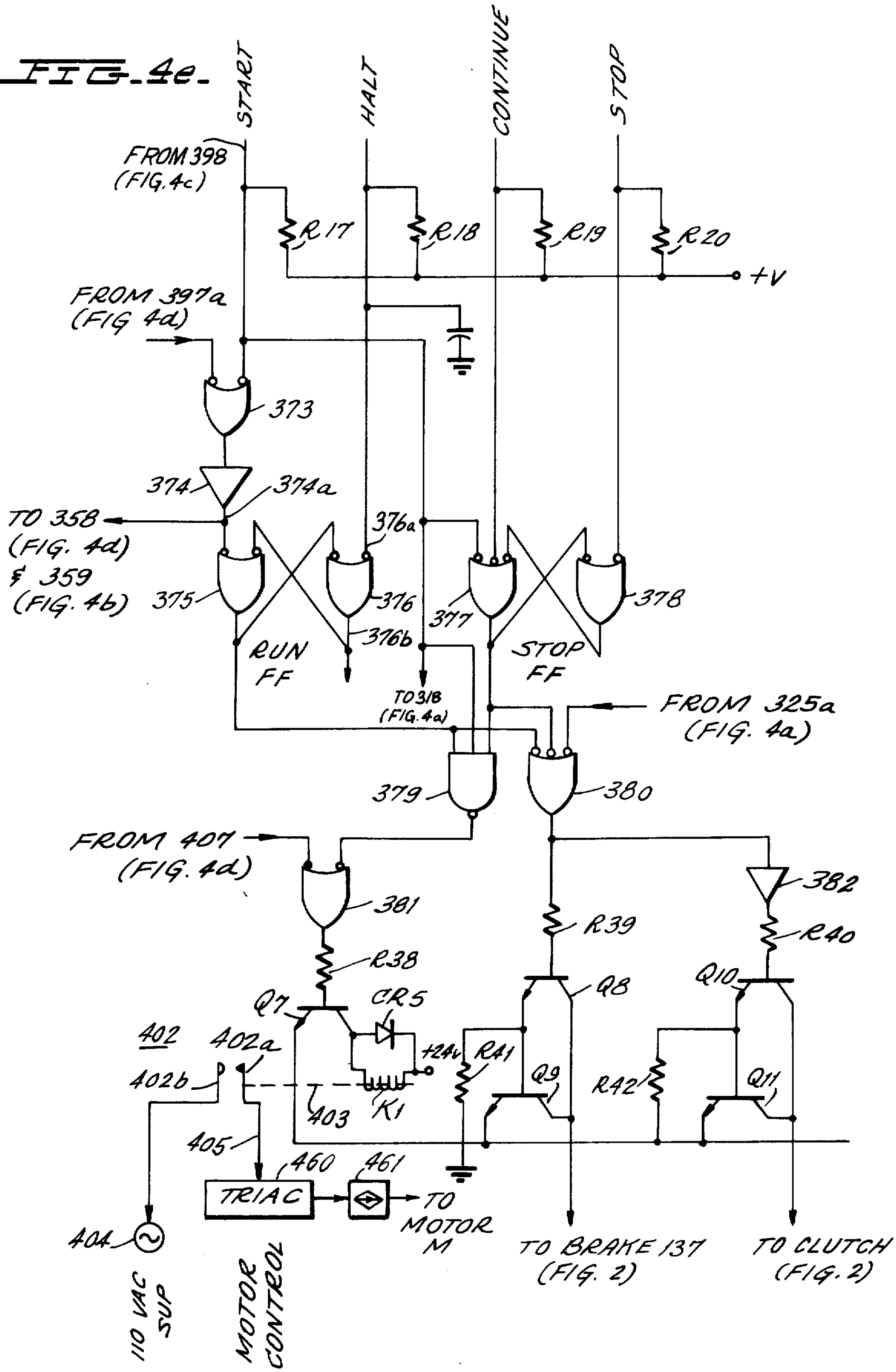

STACK
NORMAL
BATCH
R21
R22
R23
+V
416
410
417
FROM 358a (FIG. 4d)
412
R41
+24V
CR6
K2
Q12
414
413a
413
415
TO GATE RELAY
TO 204 (FIG 1a)
CR7

FIG. 4e


START
HALT
CONTINUE
STOP
FROM 398 (FIG. 4c)
R17
R18
R19
R20
+V
FROM 397a (FIG 4d)
373
374
374a
TO 358 (FIG. 4d) & 359 (FIG. 4b)
375
376
376a
376b
RUN FF
377
378
STOP FF
TO 318 (FIG. 4a)
FROM 325a (FIG. 4a)
379
380
FROM 407 (FIG. 4d)
381
382
R38
R39
R40
Q7
CR5
Q8
Q10
402
402a
402b
+24v
R41
Q9
R42
Q11
403
K1
405
460
461
TRIAC
TO MOTOR M
404
110 VAC SUP
MOTOR CONTROL
TO BRAKE 137 (FIG. 2)
TO CLUTCH (FIG. 2)

CONTROL MECHANISMS FOR DOCUMENT-HANDLING APPARATUS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

The present invention relates to electronic control means and more particularly to novel electronic control means for use with document handling equipment for feeding, separating and stacking documents which electronic equipment monitors all phases of the physical operations to provide reliable and accurate feeding, counting and stacking and to prevent jamming.

BACKGROUND OF THE INVENTION

Document handling devices are presently employed in a large number of different applications. Some examples of such document handlers are devices for counting checks, punch cards, food stamps, paper currency and bank coupons, to name just a few. The basic requirements of such devices are to provide reliable operation at relatively high operating speeds in the feeding, separating, endorsing, and stacking of the documents being handled. For example, during such high speed operations, a separation between documents may be quite small, requiring a sensing device capability of detecting such small separation distances. Due to the high speed operation, it is also important to provide means for protecting against faulty operation since if a jam were to occur with the documents fed at reasonably high rates of speed, severe damage to the mechanism, as well as the sheets, may occur before corrective measures can be taken.

It is also well known that the document feeders providing such high speed operation generate an appreciable amount of dust which, together with other ambient conditions, serves to deteriorate the sensitivity and hence the capability of the sensing means to function properly.

BRIEF DESCRIPTION OF THE INVENTION AND OBJECTS

The present invention is characterized by providing means for overcoming all of the aforementioned disadvantages through the use of [novel] sensing means having a capability of automatically adjusting its sensitivity in accordance with changes in ambient conditions. The sensing means further incorporates means for counting the documents and sensing the gap between separated documents and further incorporates means for distinguishing gaps *of at least a predetermined length* between adjacent documents from perforations *smaller than said predetermined length* provided within documents (such as punch-cards) or slits or tears and the like which may be formed as a result of partial or even severe mutilation of a document. The [same sensing means] *apparatus* further incorporates means for anticipating a jam condition by automatically halting the document handling apparatus upon failure of the sensing means to sense a gap between adjacent documents within a predetermined time period *which predetermined time period is greater than the time required for a document to pass the sensing means.*

All of the above capabilities are obtained in a control means which has the further novel capability of increasing the flexibility and effectiveness of the document handling apparatus to perform a variety of document handling operations such as, for example, endorsing, batching and statistical sampling not heretofore capable of being obtained through document-handlers and control devices which have heretofore been available.

[It is therefore one object of the present invention to provide a novel control means for document handlers and the like capable of automatically adjusting its reading sensitivity in accordance with changes in any one of a variety of ambient conditions affecting the operation.]

[Another] *An* object of the present invention is to provide novel electronic control means for document-handlers and the like having capability of distinguishing between adjacent separated documents for counting purposes while ignoring perforations, punches, slits or mutilations within a document as an erroneous indication of a separation between documents.

Another object of the present invention is to provide novel electronic control means for document-handling apparatus and the like to enhance the capability of such apparatus to perform operations such as reliable high speed counting, batching, statistical sampling and is capable of retaining an existing count and resuming counting even in the event of jams or temporary exhaustion of the supply of documents being counted.

These as well as other objects of the present invention will become apparent when reading the accompanying description and drawing in which:

FIG. 1 is a simplified elevational view of a document handling device for feeding, separating, counting and stacking paper documents and the like.

FIG. 1a shows an elevational view of a statistical sampling mechanism for use with the apparatus of FIG. 1.

FIG. 2 shows a plan view of the various feed elements of FIG. 1.

FIG. 3 is a schematic diagram of the diagram of the compensating quantizing threshold device employed for counting documents separated by the document-handler of FIGS. 1 and 2.

FIGS. 4a–4f are schematic diagrams which form the control circuitry for the document-handling device of FIGS. 1 and 2.

FIGS. 5a–5c show waveforms useful in explaining the circuitry of FIGS. 3 and 4a–4f.

DETAILED DESCRIPTION OF THE FIGURES

FIGS. 1 and 2 show, in simplified fashion a document-handling device which is described in greater detail in co-pending application Ser. No. 227,847, filed Feb. 22, 1972 and assigned to the assignee of the present invention. The detailed structure of the document-handling device of the aforementioned U.S. application will be omitted herein for purposes of simplicity, it being understood that the structure described herein is incorporated in the present application by reference thereto.

The document-handling device has the major functions of providing means for feeding sheets of varying thicknesses, sizes, finishes and the like and of accepting such dissimilar sheet sizes without first collating sheets into groups having similar dimensional and/or surface characteristics and includes means for separating and counting the sheets and stacking the sheets once separated.

Device **10** of FIGS. **1** and **2** is comprised of a housing **11** having a base portion **12** for supporting device **10** upon any suitable surface such as, for example, a table or counter. The relatively small size and light weight of the device greatly enhances its portability and facilitates handling of the device to enable its use in practically any desired location.

The housing **11** is provided with a front face **13** at its upper end which may be fitted or otherwise provided with control panels incorporating controls to be more fully described hereinbelow for turning the machine on and off, providing for statistical sampling or batch counting and the like and providing visually observable means indicating the count of the number of documents handled by the device.

Face **13** forms a portion of the front of housing **11** which is further provided with an infeed hopper **14** consisting of a plate member **15** for stacking sheets or other documents S. The stack S has a portion of its weight resting upon rearward end **15a** of plate **15** and the sheets have their forward edges resting against a plate **16a.** The inclination of the infeed stacker **14** is such that the weight of the sheets within the stack serve to retain the sheets within the infeed hopper without providing any top weight upon the stack, as well as serving to facilitate feeding of the documents from the infeed hopper, which features are described in detail in the aforementioned application and will be omitted herein for purposes of simplicity.

A picker wheel **19** mounting to rotate about shaft **20** is provided with an insert or raised portion **19a** which protrudes through a suitable opening provided in plate **15a** to engage the lowermost sheet within the stack and advance this sheet toward a drive wheel **23** mounted to rotate in a direction shown by arrow **26** about shaft **24.** Positioned above the drive wheel is a stripper wheel **52** mounted to rotate upon shaft **47** and being resiliently mounted in a manner described in detail in the aforementioned U.S. application to perform a stripping operation. Wheel **52** rotates in the direction shown by arrow **54** and serves to move documents other than the bottom-most sheet in a rearward direction so as to permit only the document to pass between wheels **23** and **52** toward an acceleration wheel assembly to be more fully described.

The coefficient of friction of the periphery of wheel **23** is greater than the coefficient of friction of the periphery of wheel **52** so that when only a single sheet passes between these wheels (as the result of either a stripping operation or the feed of only a single sheet), drive wheel **23** exerts the major influence upon the sheet causing it to be fed in the forward feed direction toward acceleration wheel **60** mounted to rotate in the direction shown by arrow **62** about shaft **61.** The acceleration wheel **60** cooperates with free-wheeling rollers **64** mounted to rotate about shaft **66.** The acceleration wheel **60** rotates at a speed greater than the rotating speed of wheel **23** causes the sheet entering between wheel **60** and free-wheeling roller **64** to be advanced toward a stacking location at a speed greater than the speed achieved by a sheet passing between wheels **23** and **52.** This operation causes a small gap to be formed between the trailing edge of the sheet feed between wheels **60** and **64** and the leading edge of the next document being fed toward wheel **60** by wheels **23** and **52.** This gap is sensed by means of a light source **65** cooperating with a light-sensitive transistor **72** or other suitable light-sensitive device which generates a count pulse when the "gap" is in the region between light source **65** and transistor **72.** Obviously, plates **15a** and **16a** are provided with suitable openings (not shown) to permit the passage of light between devices **65** and **72** when the "gap" is in this region.

Sheets advanced by acceleration wheel **60** are "kicked" into a stacker mechanism comprised of a stacker plate **81** and a kicker wheel **84** mounted to rotate about a shaft **85** in the direction shown by arrow **91** so as to neatly stack counted sheets within the stacker mechanism. The stacking plate **81** is urged in the direction of arrow **97** by suitable bias means described in greater detail in the aforementioned U.S. application. As the number of sheets in the stacker is increased, the sheets urge plate **81** in the direction shown by arrow **98** against the force of the biasing means to firmly retain the sheets within the stacker.

FIG. **2** shows the driving mechanisms employed for operating the various wheels described hereinabove in connection with FIG. **1.** The apparatus is provided with a motor M having an output shaft **129** extending through machine frame F to which motor M is securely fastened. A pulley **130** is rigidly secured to shaft **129** and drives the acceleration wheel shaft **61** by means of a belt **63** entrained about pulley **130** and a pulley **62** mounted to acceleration wheel shaft **61.** The opposite end of shaft **61** is provided with pulleys **133** and **134.** Pulley **133** is locked to shaft **61** and drives the kicker wheel shaft **85** by belt **132** which is entrained about pulley **133** and a pulley **89** locked to shaft **85.** Belt **132** is a resilient O-ring type belt and is looped in a "figure-eight" fashion to rotate shaft **85** in a direction reverse from that of shaft **61.** Thus, whenever motor M is energized, shafts **61** and **85,** which are directly coupled thereto, are rotated.

Shaft **61** is further provided with a clutch mechanism **131** which, when energized, causes the pulley **134** mounted upon clutch **131** to rotate. When deenergized, clutch **131** causes pulley **134** to be free-wheeling relative to shaft **61.** Belt **135** is entrained about pulley **134** and a pulley **136,** locked to one end of drive wheel shaft **24.** The opposite end of drive wheel shaft **24** has two pulleys **25** and **138** locked to the shaft. A belt **142** is entrained about pulley **25** and pulley **21,** which is locked to the picker wheel shaft **20.** Belt **140** is entrained about pulley **138** and idler shaft pulley **42** which is locked to the idler shaft **39.** Shaft **39** serves to impart rotation to the stripper wheels **52, 52** by means of a belt **45** entrained about pulleys **44** and **38,** respectively, locked to shafts **39** and **31.** A second pulley portion of pulley **38** imparts rotation to a pulley **51** mounted to stripper wheel shaft **47** by means of a belt **50.** This "floating mechanism" for the stripper wheels **52, 52** serves to impart rotation to stripper wheels **52, 52** while freely permitting the stripper wheel assembly **30** to "float" above the drive wheels **23–23c** in a manner which is set forth in detail in the aforementioned U.S. patent application.

Pulleys **133** and **89** are provided with semi-circular grooves around their periphery for receiving O-ring type belt **132.** All of the remaining pulleys are provided with gear-like outer peripheries for engaging teeth provided on the belts which they engage, which belts are commonly referred to as timing belts. All of the belts have been shown in FIG. **2** in phantom line fashion to facilitate and simplify an understanding of FIG. **2.**

An electromagnetic brake **137** is fastened to machine frame F and selectively engages one end **20a** of picker wheel shaft **20.** When energized, brake **137** abruptly stops shaft **20** from rotating. When deenergized, brake **137** permits shaft **20** to freely rotate.

In operation, shafts **61** and **85** continuously rotate as long as motor M is energized. Clutch **137** permits drive wheel shaft **24**, idler shaft **39**, and picker wheel shaft **20** to be selectively disengaged from motor M when it is energized. Clutch **131** and brake **137** are operated substantially simultaneously to both disengage and abruptly halt the rotation of shafts **24**, **39** and **20**, even though motor M is energized.

The advantageous features of the driving and control mechanisms for the document-handling apparatus can best be appreciated from a description of the gate assembly **200** of FIG. **1a**, which is provided for performing "statistical sampling" and/or collating operations and comprises a gate member **201** rigidly secured to shaft **202**. At least one end of shaft **202**, which extends to one side wall of the machine frame (not shown for purposes of simplicity) is fitted with a lever arm **203** rigidly secured thereto. A relay **204** has its armature **204a** coupled to arm **203** and, when deenergized, maintains the gate **201** in the solid line position. Energization of the relay causes the gate and arm to move against the force of a biasing spring (not shown) to the dotted line position **201**′.

Let **[**is**]** *it* be assumed that it is desired to count a large number of sheets while retaining only "statistical samples" of the sheets being counted (for example, every 100th sheet). The gate is maintained in the dotted line position **201**′ causing sheets advanced by the acceleration wheels **60** to pass over gate **201** and be fed between belts **207** and **208** entrained about roller pairs **209–210** and **211–212**, respectively. Belts **207** and **208** advance the sheets in the direction of arrow **213** where a curved plate **214** deflects the counted sheets into a waste container or other suitable depository **215**. As the trailing edge of the "99th" sheet clears gate **201** and enters between belts **207** and **208**, relay **204** is energized to move the gate to a solid line position **201**, causing the "100th" sheet to be moved toward stacker **80**. As the 100th sheet passes gate **201**, relay **204** is energized to cause the next sheet to be fed between belts **207** and **208**. This operation is repeated wherein the document-handling device counts the total number of sheets and retains only every 100th sheet in stacker **80**, as a "statistical simple". The remaining sheets in the depository **215** may be discarded or put to any other desired use.

Obviously, any desired statistical sample may be selected by means of an adjustable switch means to be described in greater detail in connection with the electronic control circuitry. As the gap between separated sheets is detected by sensor **72**, the counter provided in the electronic control unit to be more fully described hereinbelow has its count advanced for each gap sensed. The accumulated count in the counter is compared against the setting of the desired statistical sample to activate relay **204** so as to accumulate only the statistical samples in stacker **80** while feeding remaining sheets to the depository **215**. The clutch and brake mechanisms as described hereinabove are selectively activated by an "N−1" signal and "N+1" signal to assure the presence of a gap G of sufficient length between the sheet preceding the "Nth" sheet and the sheet immediately following the "Nth" sheet to provide sufficient time for physical movement of gate **201**. Decoding circuitry within the electronic control means generates an N−1 signal when the trailing edge of the sheet preceding the "Nth" sheet passes sensor **72**, causing the drive, stripper and picker wheels to be disengaged from the motor drive and be abruptly halted as a result of actuation of the electromagnetic brake **137** so as to "slow down" the "Nth" document. Gate **210** is moved from the dotted line position **201**′ and the brake and clutch mechanism are then released to continue the feed operation. When the trailing edge of the "Nth" sheet is sensed, the above operation is repeated in the reverse order to set the gate to the dotted line position **201**′. The feed operation is again restored until the next statistical sample approaches sensor **72**. The gate assembly described hereinabove may also be employed for collating. For example, it may be desired to stack every "odd" sheet (an original) in one pile and every "even" sheet (a carbon copy of the original sheet) in a separate stack. This may be done by operating the gate as described above between every sheet fed to the apparatus. It is also possible, for example, to stack original sheets in the stacker and, for example, five carbon copies of each original sheet in the depository **215** for further collating or processing, if desired.

The document handler in FIGS. **1** and **2** may also be employed for performing "batching" operations. For example, let it be assumed that a large number of sheets are to be piled into separate stacks with each stack containing an equal predetermined number of sheets. For example, let it be assumed that a large number of dollar bills (paper currency) are to be stacked into stacks each containing one hundred one-dollar bills. The paper currency may be stacked in infeed hopper **14** and may contain any number of bills up to the maximum capacity which can be handled by the infeed hopper. A "start" button is depressed and the mechanism begins to count bills. When the "100th" bill passes sensor **72** the counter compares its count against the matching count set into the electronic control mechanism to generate a signal after the passage of the 100th bill which energizes electromagnetic brake **137** and deenergizes clutch **131** so as to abruptly halt the picker, stripper and drive wheels while continuously rotating the acceleration and picker wheels to assure positive stacking of the 100th bill within stacker **80**. The machine then automatically turns off, at which time a stack of exactly one hundred one-dollar bills will be neatly stacked in the stacker **80**. The operation may then be repeated by depressing the "start" button to count and stack the next group of 100 one-dollar bills.

Let it be assumed that the "start" button has been depressed and that the document-handling apparatus **10** counts up and stacks 70 one-dollar **[**bils**]** *bills*, at which time the supply of bills to be counted in hopper **14** is exhausted. Whereas the stripper, drive, picker, acceleration and picker wheels will continue to rotate, no further count will be developed within the counter of the electronic control means and therefore the count of the bills already counted and stacked will remain undisturbed. The operator need only place a fresh stack of one-dollar bills in infeed hopper **14** whereupon the counting operation will continue as is described hereinabove.

Turning now to a description of the electronic control means for reliably and accurately operating the document-handling device, FIG. **3** shows the document detector **300** which is comprised of a light-sensitive transistor **72**. The emitter is activated when a gap between separated documents is detected. The collector of transistor **72** is coupled to a d.c. source +V while the emitter electrode is coupled through resistor R1 to ground bus **301.** The emitter is also connected through lead **302** to the base of transistor **303** whose collector is coupled through resistor R2 to the d.c. source +V. The emitter electrode of **303** is coupled through capacitor C1 to ground bus **301** and through resistor R3 to one input **304b** of an operational amplifier **304** which is utilized in circuit **300** as a comparator. Resistor R3 is further coupled through resistor R4 to ground bus **301.** The emitter electrode of light-sensitive transistor **72** is further coupled to the remaining input **304a** of operational amplifier **304.**

In the quiescent state, i.e., when no "gap" is sensed, transistor 72 is in the non-conductive state so that its emitter electrode will be at ground potential thereby applying a ground potential to the base of transistor **303.** The emitter of transistor 72 thus applies ground potential to input **304a** of comparator **304.** The ground potential applied to the base electrode of transistor **303** maintains **303** in the non-conductive state.

Resistors R3 and R4 form a voltage divider whose output point is the common terminal **305** therebetween. Resistor R4 has a substantially high resistance value of the order of 100 K Ohms which preferably is greater than the resistance value of resistor R3.

Before describing the operation of the detector **300,** a brief description of the characteristics of the circuit and the problems which the circuit solves will first be given.

In the handling of documents at high speed, it can be appreciated that a significant amount of dust is created in such high speed paper or document handling. The dust particles eventually come to rest upon various components of the document handler, including, but not limited to, the light source **65** and the ight-sensitive surface of transistor **72.** Dust will be accumulated gradually and after long periods of time, for example, of the order of days or weeks, such accumulations will significantly reduce the amount of light emitted by light source **65** and the amount of light which can pass through dust accumulated upon the light-sensitive surface of transistor **72.** Therefore, the threshold level above which a pulse developed by transistor **72** will be detected as a "gap" and below which threshold level an output pulse will not be detected as a "gap" will, if the threshold level is maintained constant for long periods of operation, result in the erroneous detection. The threshold level selected is a compromise between the maximum output level of the light-sensitive transistor and an output level of the light-sensitive transistor which will occur as a result of passage of light through documents which, while not being transparent, are nevertheless translucent and will permit some portion of the light from source **65** to be transmitted through the document. The threshold level will thus be adjusted accordingly dependent upon the light transmitting characteristics of the documents or sheets to be handled by the device **10** of FIG. **1.**

Other physical conditions which tend to affect the sensitivity of the detector device are heat and general deterioration of the circuit components. The effects of these physical occurrences are to gradually reduce the sensitivity of the detector until after a time period of sufficient length, a reduction in the sensitivity of the light-sensitive transistor in conjunction with maintenance of an absolutely constant threshold level will cause a detector to provide an erroneous output. It is therefore extremely important to provide a detector device with self-compensating means for adjusting the threshold level to accommodate for such gradual changes in detector sensitivity.

Let it be assumed that the device **300** of FIG. **3** is operating under ideal conditions in that light source **65** and light-sensitive transistor **72** are free of any dust or dirt particles and that light source **65** is operating to emit light of its maximum intensity capacity. Impingement of light upon the photo-sensitive emitter of transistor **72** causes the transistor to conduct, establishing a conductive path between the positive source +V and ground bus **301.** A voltage drop is thus developed across resistor R_1 having a voltage level E_w (see FIG. **5a**). Let it be assumed that the voltage of source +V is 5 volts d.c. and that the voltage drop across transistor **72** when conducting is so small as to be negligible. Thus, resistor R_1 will develop a voltage drop of 5 volts across its terminals representative of the maximum "white" condition E_w.

A +5 volt level at the emitter of transistor **72** is thus applied to the base electrode of transistor **303** causing the transistor to conduct so as to charge capacitor C_1 at a very rapid rate. The +5 volt d.c. level (E_w) is also applied to input terminal **304a** of comparator **304** for comparison against the "threshold level" in a manner to be more fully described.

Capacitor C1 charges at a rapid rate to develop a voltage E_c due to its coupling to the emitter of transistor **303** so as to charge to the level of +5 volts d.c. The voltage **[**dividier**]** *divider* network comprised of resistors R_3 and R_4 develops a voltage E_t at terminal **305** which represents the threshold level against which the output voltage level E_w will be compared. In the example given hereinabove, this level will be of the order of $3\frac{1}{3}$ volts. Operational amplifier **304** functions to generate a positive output level whenever the voltage level at its input **304a** exceeds the voltage level at its input **304b.** In the particular example, E_w is greater than E_t causing a positive level to be developed at output **304c.**

It should be understood that the resistances R_3 and R_4 may be made adjustable so as to adjustably select the threshold level E_t. For example, let it be assumed that a sheet having some light transmissive properties passes between light source **65** and light-sensitive transistor **72** (see sheet S' in FIG. **3**). Some light will pass through sheet S' causing transistor **72** to partially conduct whereby the output level at its emitter electrode will be a level equal to or less than E_t level established during the previous gap. This level will be sufficient to drive transistor **303** into conduction to charge capacitor C_1 and develop a threshold level which preferably should be greater than the level at the emitter of **72** to cause comparator **304** to be prevented from developing a positive level. It is obvious therefore that the threshold level E_t must be sufficiently greater than the lever E_{s1} so as to prohibit light passing through a light transmissive, or partially light-transmissive (i.e., translucent) document from being erroneously detected as a "gap" between the two documents.

The self-compensating feature of the circuit is obtained as follows:

As was previously mentioned, resistor R_3 and R_4 have resistive values which collectively are relatively high so that the sums of these resistances are of the order of greater than 100,000 Ohms to provide a relatively long time constant for the discharge of capacitor C_1 as will be more fully described hereinbelow.

The sheets being handled by the document handler **10** of FIGS. **1** and **2** are preferably moved at a rate of the order of 60 inches per second. Assuming the length of a document measured in the feed direction to be of the order of 3 inches, the movement of the document in passing between light source **65** and light sensitive transistor 72 will be of the order of 50 milliseconds. Considering FIG. **5c**, let it be assumed that at time t_0 the leading edge of a document S' moves between light source **65** and light sensitive transistor **72**. At this time the voltage output at the emitter electrode of transistor 72 will be at E_{s1} (assuming that the document is partially light transmissive as opposed to opaque) and will allow some light to pass therethrough. The output at the emitter electrode of transistor 72 will be at the level E_{s1} which level is applied to input **304a** of comparator **304**. Due to the low discharge rate of capacitor C_1 (to be more fully described) the level at terminal **305** of the voltage divider network will be at E_t which level is applied to input **304b** of comparator **304**, thus causing the output **304c** of comparator **304** to assume ground (0) level.

At time t_1 the trailing edge of document S' will pass out of the region between light source **65** and light-sensitive diode **72** causing resistor **72** to go fully conductive and develop a voltage level E_w at its emitter electrode. Simultaneously therewith voltage E_w is applied to the emitter electrode of transistor **303** causing capacitor C_1 to rapidly charge approximately the level of E_w. The voltage divider applies a threshold voltage level E_t to comparator **304**. Since the level E_w is greater than the level E_t, comparator **304** assumes a positive level thereby detecting the presence of a "gap" between document S' and the next document S". The level E_w is retained at the emitter electrode of transistor 72 until the leading edge of sheet S" moves into the region between light source **65** and transistor 72 at time T_2 causing the conductive state of transistor 72 to be significantly reduced thereby dropping to the level E_{s1} and causing C_1 to discharge very slightly. This level will be sustained until time t_3 when the trailing edge of document S" leaves the region between light source **65** and transistor 72 and before the leading edge of the next document (not shown for purposes of simplicity) enters into the aforesaid region.

At time t_2 when the output level at the emitter electrode of transistor 72 abruptly drops to level E_{s1}, the voltage resistance values of resistors R_3 and R_4 and the capacitance of capacitor C_1 causes C_1 to discharge at a very slow rate. For example, in one preferred embodiment, the value of capacitor C_1 and of resistors R_3 and R_4 is such as to cause capacitor C_1 to be fully discharged over a time interval of the order of 500 milliseconds. Since the time between the passage of each document is of the order of 50 milliseconds, capacitor C_1 discharges at a rate such that the voltage across its terminals is close to 90 percent of the voltage E_t.

Let it be assumed that over the passage of time, a gradual change occurs in the maximum output level at the emitter electrode of transistor 72 due to such conditions as the collection of dust or the effect of heating of the components through long continued use. It can be seen from FIG. **5b** that the level E_w will gradually decrease to a level E_{w1} at time t_4, to level E_{w2} at time t_5 and to level E_{w3} at time t_6 and so forth. Each of these reductions in the output level of emitter electrode of transistor 72 consequently reduce the voltage applied to the base electrode of transistor 303 causing capacitor C_1 to charge to a correspondingly lower value, thereby dropping the threshold level E_t accordingly, as shown by curve **306** in FIG. **5b**. It can thus be seen that the detector **300** of FIG. **3** automatically adjusts the threshold level E_t in accordance with gradual changes in the output voltage level of transistor **72**. It should be understood that waveform **307** of FIG. **5b** shows a series of pulses which occur over a substantial elapsed time which may be of the order of days or weeks.

FIG. **5c** shows a portion of waveforms **306** and **307** in greatly enlarged fashion to more clearly explain the operation of capacitor C_1 and the voltage divider network comprised of resistors R_3 and R_4. Let it be assumed that the document feeder is turned on. At this time, since no documents have been fed into the unit, light source **65** causes the capacitor C_1 to charge rapidly as shown by portion **306a** of waveform **306**. At time t_0 the first document passes through the region between lamp **65** and transistor **72** causing the output level of the emitter electrode of transistor 72 to drop to the voltage level E_{s1}. At this time, capacitor C_1 will discharge at a slow rate as shown by the waveform portion **306b** where capacitor C_1 will drop to a voltage level of the order of 90 percent of its maximum voltage **[**E_t**]** *E_w*. At time t_1, the trailing edge of the document will move out of the region between lamp **65** and transistor **72** causing the output level of transistor **72** to go to E_w. At this time capacitor C_1 will charge to its full value in a very brief time period as shown by the portion **[306b]** *306c* of waveform **306**. Capacitor C_1 will become fully charged and remain at the level E_t until time t_2 at which time the leading edge of the next document moves into the region between elements **65** and **72** causing the output level at the emitter electrode of transistor **72** to drop to the level E_{s1}. At this time the capacitor will again discharge at a very slow rate as is represented by the portion **306d** of waveform **306**. This operation is continuously repeated in the same manner as was described hereinabove for each additional "gap" sensed between the documents being handled by the device **10**. As the gradual build-up in dust or heating effects reduces the sensitivity of transistor **72**, the output level E_w will gradually be reduced as was described hereinabove causing capacitor C_1 to charge to a lower voltage level due to the reduced voltage applied to the base electrode of transistor **303**. Thus, the threshold level E_t will continue to be gradually reduced, *as represented by curve 306*, but will remain at a level which remains proportional to the maximum output level E_w, E_{w1}, E_{w2} and so forth, as the sensitivity of transistor **72** is gradually reduced. It can thus be seen that the detector of FIG. **3** fully compensates for any gradual changes in the sensitivity of the detector.

Comparator **304** is designed so as to develop an output level of zero volts during the time when the document is passing in the region between elements **65** and **72** and is adapted to develop a positive output level of the order of +5 volts during the time that a gap is detected.

To enhance the flexibility of the document-handling device **10** so as to accommodate all sorts of documents and/or sheets it is important to provide means for preventing an erroneous indication of the presence of a "gap". For example, let it be assumed that the document-handling device **10** is being employed to count punch-cards. Some of the holes punched in the punch-cards may be positioned so as to coincide with the positions of light source **65** and transistor 72 causing the output pulse or spike such as the spike **308** shown in FIG. **5c** to be developed. Since this pulse will reach the level E_w which is clearly above the threshold level E_t of waveform **306** (see waveform portion **306d**), comparator **304** at this time will develop an output level of +5 volts to indicate the presence of a "gap". Another possible way in which such a narrow pulse may be developed may result from perforations, cuts, slits or tears which may appear in a document either for deliberate reasons or because the document has become torn or multilated through handling. Such narrow pulses must therefore be prevented from being interpreted as a "gap" between adjacent documents separated by the document-handling device **10**.

As was discussed hereinabove, the elapsed time t_1-t_0 represents the time between which the leading edge of a document enters into the region between elements **65** and **72** and the time at which the trailing edge of the documents leave the aforesaid region. The circuit **310** which prevents such narrow impulses from being erroneously interpreted as a "gap" between documents is shown in FIG. **4a** and is comprised of an input terminal **311** coupled to the output **304c** of comparator **304** for receiving count pulses. Series connected capacitor C_2 and resistor R_5 are coupled in series between +5 volts d.c. and ground with their common terminal **312** coupled to input line **311** which is coupled to the output of comparator **304.** C_2 and R_5 provide filtering against high frequency noise such as that generated by motors, etc. which may be magnetically coupled into line **311.** Input line **311** is coupled to one input of NAND gate **313.** The operation of NAND gate **313** is such as to develop a high voltage level when any one or more of its inputs are low and to develop a low level when all of its inputs are at a high level. The output of NAND gate **313** is coupled to one input of inverter **314** whose output is simultaneously coupled to one input of NAND gate **315** and one input NOR gate **316.** NOR gates **316** and **317** are cross-coupled to form a "single shot filter" circuit (SS-Filter) which operates in a manner to be fully described. The output of NOR gate **316** is coupled to one input of NOR gate **317** while the output or NOR gate **317** is coupled to the remaining input of NOR gate **316.** The output of NOR gate **316** is further coupled to one input of NAND gates **315** and **318** and to the input **319a** of a one-shot multivibrator **319.** The remaining input of NOR gate **317** is coupled to one terminal of capacitor C_3 whose opposite terminal is coupled to ground. Parallel connected diode CR_1 and resistor R_6 are coupled in parallel between the output of NAND gate **315** and capacitor C_3. The output of NAND gate **318** is simultaneously coupled to the d.c. supply terminal +V through resistor R_7 and through resistor R_8 to the jam-delay and jam-prevention delay circuits **320** and **330,** to be more fully described.

The jam-delay circuit **320** is comprised of diode CR_2 and capacitor C_4 for developing a rectified and filtered d.c. level at their common terminal. A potential divider comprised of resistors R_9 and R_{10} applies a portion of this voltage to the base of transistor Q_1 whose collector is connected to the d.c. +V through resistor R_{11} and whose emitter is connected to ground. The collector is coupled to the input of inverter **321** whose output is coupled to the remaining input of NAND gate **313.**

The jam-prevention delay circuit **330** is similar in design to the jam-delay circuit **320** and is comprised of diode CR_3 and capacitor C_5 for rectifying and filtering the input applied thereto. Resistors R_{12} and R_{13} operate as a voltage divider coupling a portion of the output voltage appearing at the common terminal between diode CR_3 and capacitor C_5 to the base electrode of transistor Q_2 whose emitter is connected to ground and whose collector is coupled to +V through resistor R_{14}.

During the time when no counting is being performed a portion of the d.c. level is applied to the emitter of transistor Q_1 causing Q_1 to conduct. At this time the collector of Q_1 will be low (substantially zero volts) causing the output of inverter **321** to go high, thereby placing a high level at one input of NAND gate **313.** In the absence of any counting the output of comparator **304** is high placing a high level at the other input of NAND gate **313** causing its output to go low, which condition is reversed by inverter **314** to apply a high input to one input of NOR gate **316** and NAND gate **315.** The output of NOR gate **316** is low applying a low level to one input of NOR gate **317.** This causes the output of NOR gate **317** to go high which level is applied to the remaining input of NOR gate **316** to cause its output to go low. The presence of high and low inputs to NAND gate **315** causes its output to go high to apply a high level signal to the remaining input of NOR gate **317** causing the output of **317** to go low. This condition is sustained due to the cross-coupling of NOR gates **316** and **317** to apply a low level input to one-shot multivibrator **319.** Let it now be assumed that a document enters into the region between light source **65** and transistor **72.** This causes a low input to be applied to lead **311,** causing the output of gate **313** to go high. This condition is reversed by inverter **314** to apply a low level to one input of NOR gate **316.** This causes the output of gate **316** to go high which, in turn, applies a high input level to NOR gate **317** and to NAND gate **315.** The output of NAND gate **315** goes high causing capacitor C3 to charge rapidly to the high level through diode CR1 and causing the output of NOR gate **317** to go low. This low level is applied to the remaining input of NOR gate **316** causing its output to remain high. This high level signal is applied to input **319a** of one-shot multivibrator **319** to cause an output pulse of a predetermined pulse width to be developed at output terminal **319b.** Simultaneously therewith, a positive going pulse is developed at the remaining output **319c** of one-shot multivibrator **319** which is applied to a circuit comprised of transistors Q_3, Q_4 and Zener diode CR_4 for developing an output at the collector electrode of Q_4 employed to advance an electromagnetic counter means (FIG. **4c**) by one count.

As was described hereinabove, the output of comparator **304** remains at the low level for the duration of the passage of a document which is of the order of 50 milliseconds, after which time the level at lead **311** abruptly increases to +5 volts d.c., causing the output of gate **313** to go low and the output of inverter **314** to go high returning a high level to gates **316** and **315.** The output of gate **315** thus goes low. However, the capacitance of capacitor C_3 and the resistance value of resistor R_6 are chosen to cause capacitor C_3 to discharge at a slow rate whereby the high level at the terminal of capacitor C_3 coupled to one input of NOR gate **317** is retained thus preventing the bistable circuit comprised of NOR gates **316** and **317** changing state and thereby preventing an erroneous pulse from being applied to one-shot multivibrator **319** until capacitor C_3 has had sufficient time to discharge. The discharge rate of capacitor C_3 is appropriately adjusted so as to permit the capacitor to fully discharge during a 20 millisecond time duration which lies well within the normal time interval of a "gap" but is adjusted to prevent the capacitor from being discharged within shorter time intervals which would occur as a result of holes, tears, or other multilations in the document passing betweeen lamp **65** and detector (transistor **72**).

When the output of NOR gate **316** goes high, gate **318** is caused to develop a low level output to permit capacitor C_4 in the jam-delay circuit **320** to begin discharging. The time interval during which capacitor C_4 will be fully discharged is of the order of 100 milliseconds which is greater than the time required for the passage of one sheet through the region between lamp **65** and transistor **72** so as to maintain a high level output at the remaining input of gate **318**. Once an amount of time has elapsed which is greater than the time required for one document to pass through the sensing region without the detection of a "gap", the output of inverter **321** goes low to cause the input of gate **313** coupled thereto to go low and thereby prevent the count discriminating circuit **310** from generating any further count pulse.

Summarizing the operation of the circuits **300** and **310** of FIGS. **3** and **4a**, the objective of these circuits is to distinguish between a "gap" between the trailing edge of a document and the leading edge of the next document, as they pass the sensor **72**, and the presence of holes or tears within the body of a document, so that such "holes" will not be erroneously interpreted as a "gap" so that to prevent an erroneous count pulse from being generated. This problem is extremely important in the counting of documents which have punched codes provided therein.

Let it be assumed that the trailing edge of a document has just passed sensor **72** (FIG. **3**). Just prior thereto, capacitor C_3 (FIG. **4a**) has been fully charged. The output of comparator **304** (FIG. **3**) goes high. The output of gate **313** and inverter **314** go low and high respectively. The count pulse I_{SS} is latched with **316a** high, applying a high to one input of **315**. Since the output of inverter **314** is high, the output of gate **315** goes low causing C_3 to discharge. When C_3 discharges to a level below the reset threshold level of reset input **317b** of the single shot (SS) gate **317**, this causes the output **317a** to go high. This causes the output **316a** of **316** to go low. The interval of elapsed time typically required for C_3 to discharge from a full charge (approximately 5 V.d.c.) to the reset threshold level (approximately 0.8 V.d.c.) is of the order of 10 milliseconds. In this time interval assuming a rate of movement of documents as 60 inches per second, the trailing edge of the last document will have travelled a distance of the order of 0.60 inches.

Since the nominal gap distance between documents is of the order of 0.70 inches, the leading edge of the next succeeding document will not have arrived at sensor **72**. Since the reset level has been reached by the discharge of C_3 and the output **317a** has gone high, the output of gate **315** goes high causing C_3 to begin charging before the leading edge of the next document is detected by sensor **72**. Once the leading edge is detected the output of **304** goes low causing the output of **313** to go high and the output of **314** and the input **316b** of **316** to go low whereby the output **316a** of **316** goes high, which is applied to one input of **317** and **315**. However, the low output of **314** is applied to the remaining input of **315**, thereby maintaining a high output of **315**, thus C_3 continues to charge and becomes fully charged well before the next trailing edge passes sensor **72** (see the waveform of FIG. **5c**, for example). The above operations are then repeated for each succeeding document.

The presence of a punched hole in a passing document which punched hole may be located in the region of sensor **72**, causes the output level of comparator **304** to go high. However, the typical length of a punched hole is of the order of 0.125 inches. With the document travelling at a rate of **60** inches per second the "hole" will pass the sensor in about 1 millisecond during which time C_3 has discharged only slightly and will be at a voltage level well above the threshold level of the reset input **317b**. Thus, I_{SS} will not reset. The circuit will also prevent resetting even though an entire column of punches (typically there are a maximum of 12 positions in a column) will not cause C_3 to drop below the reset threshold level. Mutilations or holes of types other than punches holes and are of the order of 0.50 inches or less in the direction of movement can thus be prevented from being interpreted as a "gap". There is no maximum length of a gap between trailing and leading edges of successive documents. However, the minimum length of a gap is dictated by the minimum response of the circuitry and should preferably be of the order of 0.40 inches.

Jam-prevention delay circuit **330** operates in a similar fashion such that its one input terminal is coupled to +5 volts while its remaining input terminal is coupled to the output of NOR gate **136**. When the presence of a document is sensed the remaining input of NAND gate **318** goes high causing its output to go now enabling capacitor C_5 to begin discharging. If the output of NAND gate **318** does not go high during a time slightly greater in time duration than the time in which the document should be present, capacitor C_5 will discharge causing the output of transistor Q_2 to go high. This condition is inverted by inverter **323** and applied to one input of NOR gate **324** whose other input is derived from gate **354** of FIG. **4d** which functions to provide a low level signal at the input of NOR gate **324** to cause the output of NOR gate **324** to go high. This condition is inverted by inverter **325** to apply a low level signal to the input of NOR gate **380** shown in FIG. **4e** to cause the electromagnetic brake and clutch mechanisms to be operated in the manner previously described to thereby prevent any further sheets from being fed into the document-handling device to prevent the occurrence of a serious jam in the mechanism, or alternatively to halt or slow down the document-handling device during batching or statistical sampling operations.

FIG. **4b** is a schematic diagram showing the electronic counter and selector switch of the control device. The electronic counter **340** is comprised of units, tens and hundred counting stages **341, 342** and **343** electrically interconnected so as to be capable of developing a binary count representative of any decimal quantity from 000 through 999. The electronic counter accumulates one count each time it is triggered by a square pulse developed at the output **319b** of one-shot multivibrator **319**. This is applied to input terminal **341a** of units stage **341**.

Each of the units, tens and hundreds stages further includes input means coupled to appropriate input terminals in each of the stages **341, 342** and **343** which are coupled to settable thumbwheel switch assemblies mounted at the control panel **13** of the document-handling device **10** (see FIG. **1**). The thumbwheel switches **344** (units), **345** (tens), and **346** (hundreds) are each provided with a number wheel visible at the control panel of the device **10** to provide a visually observable indication of the position of each of the thumbwheels for indicating a count of any decimal number from 000 through 999. The mechanical arrangement for the thumbwheels and number wheels have been omitted for purposes of simplicity. The mechanical thumbwheel switches selectively couple a high voltage level to each of the input leads, for example, leads **344a–344d** of the units thumbwheel switch, which couple the high level voltages to associated inputs of the units counter and comparator **341.**

The thumbwheel switches provide outputs in "nines complement" form which significantly simplifies the electrical connections required in the electronic counter as will be more fully described. A typical example of nines complement is set forth in the text "Programming Business Computers" published by John Wiley & Sons, 3rd printing, Apr. 1962, on pages 449 and 450.

Effectively, in nines complement, the value of each decimal digit is subtracted from the decimal quantity "9" and a binary coded decimal "9" is, in the "nines complement" form, a decimal 9 which is interpreted as a binary coded decimal zero. The binary coded decimal form of decimal 9 is 1001 where the weighting of the binary digits from left to right is "8", "4", "2" and "1".

The manner in which the electronic counter **340** functions is set the thumbwheel switches **344–346** so that their associated number wheels (FIG. **4c**) indicate the desired batch size. However, the wiring between the thumbwheel switch settings and the inputs to the units, tens and hundreds stages **341–343**, respectively, is a binary coded decimal and "nines complement" form. For example, let it be assumed that the size of the batch is to be fifty sheets. In this particular case the hundreds, tens and units thumbwheels will be set so that the decimal numbers respectively read 050. The input levels applied to the units, tens and hundreds electronic counter stages **341–343** respectively, will be in binary coded decimal nines complement form and will read 1001; 0100; and 1001, with the left-handmost digit of each binary coded decimal group being the most significant binary bit position.

The use of the "nines complement" form reduces the number of output connections from each of the electronic counter stages to two (2) output levels per counter, namely the decimal eight and decimal one outputs respectively. In the units stage, the decimal eight and decimal one outputs are terminals **341b** and **341c,** respectively, and hence the hundreds outputs are similarly labeled as **342b** and **342c** and **343b** and **343c** respectively.

The output of each counter stage, in binary coded decimal "nines complement" form is 1001, which is the equivalent of a 0000 reading in straight binary coded decimal form. However, the straight binary coded decimal (BCD) form would require a connection of all four output stages to the peripheral logic circuitry whereas in the present arrangement only two output connections are required from each stage to sense the nines complement decimal "9" condition.

The outputs **342b** and **343d** in "tens" stage **342** and the outputs **343b** and **343d** in "hundreds" output stage **343** are all coupled to associated inputs of AND gate **349** which provides an output when the binary coded decimal nines complement output of each of the stages **342** and **343** are simultaneously in the form 1001. This output is inverted by inverter **350** whose output **350a** is coupled to input lead **351** shown in FIG. **4c** which is a schematic diagram showing the various switches and other controls provided in the operator's panel **13** of FIG. **1.**

Lead **351** is coupled to one stationary terminal **352a** of a batch/statistical sampling switch **352** provided with a second stationary terminal **352b** and a movable switch arm **352c.** When the movable switch arm **352c** engages stationary contact **352a,** the high output from inverter **350** is simultaneously coupled through lead **353** to one input of each of the AND gates **354, 355** and **356** shown in FIG. **4d.**

AND gate **354** has its remaining inputs coupled to the decimal "8" output **341b** of units counter stage **341** (FIG. **4b**) and the output **316a** of NOR gate **316** which forms the Single Shot Filter circuit (SS-Filter) with NOR gate **317** (FIG. **4a**). AND gate **354** provides an output at **354a** which is low when all of its three inputs are high indicating the units stage of the electronic counter has reached a decimal "8" state, that the tens and hundreds stages have each reached a decimal "9" state and that the output of NOR gate **316** is high indicating that the leading edge of the 49th" sheet has been sensed. This output is coupled to NOR gate **324** which provides a high output when the output of gate **354** or AND gate **354** is low (see FIG. **4a**). This condition is reversed by inverter **325** to place a low input level at NOR gate **380** of FIG. **4e** for controlling the operation of electromagnetic brake **137** and clutch **131** in a manner to be more fully described. The specific actuation of the electromagnetic brake and clutch in accordance with the logical gating circuitry of FIG. **4a** will be described in greater detail hereinbelow.

AND gate **355** has its remaining inputs coupled respectively, to the decimal "8" output **341b** of the units electronic counter stage **341** and the output **317a** of NOR gate **317** of FIG. **4a** and provides a low level output when the tens and hundreds counter stages are each in the decimal "9" state, when the unit stage output **341b** is high (indicating a decimal "8") and when the output of inverter **317** is high (indicating the absence of a document). This low level output is coupled to one input of an NOR gate **357** which is cross-coupled with NOR gate **358** to form a flip-flop (Gate FF). The output **357a** or NOR gate **357** is coupled to one input of NOR gate **358** while the output **358a** of NOR gate **358** is coupled to the remaining input of NOR gate **357.** The remaining inputs of NOR gate **358** are coupled to the start switch **385,** (FIG. **4c**) through gates **373** and **374** (FIG. **4e**) and to lead **361** of FIG. **4c** which is coupled to the stationary terminal **362a** of statistical sampling switch **362** further comprising a movable switch arm **362b** and stationary contact **362c** (see FIG. **4c**). Movable switch arm **362b** is coupled to grounded bus **363** to couple ground potential (i.e. low level) to the associated input of gate **355** when in the statistical sampling mode. Movable switch arm **362b** is ganged to the movable switch arm **364b** of batch switch **364** further comprising stationary contacts **364a** and **364c** respectively. The ganged connection is represented by dotted line **364** such that when one of the switch arms (for example, switch arm **362b**) is in the upper position engaging its stationary contact **362c,** the remaining switch arm (for example, switch arm **364b**) will engage its upper stationary contact **364c.**

Thus, when the document-handler is in the statistical sampling mode, AND gate **355** will provide a low output when the units and tens stages are both in the decimal "9" state when the unit stage is in the decimal "8" state and when the output of NOR gate **317** is high indicating the absence of a document thereby providing a low level input at NOR gae 357. This causes the output 358a of NOR gate 358 to go low, thereby applying a low level input to NOR gate 412 of FIG. 4f which functions to develop a "gate" signal in a manner to be more fully described.

The sequence of batch completion is such that, AND gate 356 has its output go low when the units counter stage 341 is in decimal "9" and when the tens and hundreds stages are also in the decimal "9" state causing its output to go low thereby applying a low level to NOR gate 366 whose other input is coupled to the output 321a of inverter 321 (see FIG. 4a) which is high so long as jam-delay circuit 320 is not timed out. The output of gate 366 goes high and is inverted by inverter 367 to apply a low level output to lead 368 which is coupled to stationary contact 364c of switch 364. When this switch is in the closed position, the low level is coupled through switch arm 364b and lead 369 to 376a of NOR gate 376 of FIG. 4e which operates in conjunction with gate 375 to form the RUN flip-flop which controls electromagnetic clutch 131, electromagnetic brake 187, Motor M, and indicator 389 in a manner to be more fully described.

Gate 370 and inverter 372 (FIG. 4d) have their inputs coupled to the output 321a (see FIG. 4a). The output of inverter 372 is coupled to the base electrode of transistor Q_5 and normally maintains transistor Q_5 non-conductive until the jam-delay circuit 320 times out, at which time the output of inverter 321 goes low causing the output of inverter 372 to go high and render transistor Q_5 conductive. Its collector electrode is coupled to lead 390a of FIG. 4c to light the jam indication lamp 391.

The remaining input of gate 370 is coupled to the output 376a of NOR gate 376 which is low when the Start button of the control unit is depressed. Thus, if the start button has been depressed, the output of gate 370 is high causing the output of inverter 371 to go low so as to render transistor Q_6 non-conductive. The collector output of transistor Q_6 is coupled through lead 388 to "batch complete" lamp 389 of FIG. 4c causing the lamp to be extinguished when a batch has not been completed.

AND gate 393 of FIG. 4d has one of its inputs coupled to lead 361 of FIG. 4c which, in turn, is coupled to the statistical sample switch 362. A second lead is coupled through inverter 394 to the output of AND gate 356 while the remaining lead is coupled to the output 317a of NOR gate 317 (see FIG. 4a) so as to develop a negative going output when the count pulse is high signifying that a document is not present in the counting region of gate 201 (FIG. 1a), when all stages of the electronic counter are in the decimal "9" state and when the sample select switch is in its upper position. This negative going signal is applied to the input of single shot 397 producing a negative pulse.

The output of gate 356 is simultaneously coupled to one input of OR gate 366 and inverter 394. The output of OR gate 366 is coupled to inverter 367, whose output is coupled to batch switch 364 and via lead 369 (when the batch switch 364 is in its upper position) to one input of NOR gate 376 resulting in a high condition to AND gate 370 thereby rendering transistor Q_6 to be conductive so as to illuminate a lamp 389 indicating the completion of a batch.

When the inputs to gate 393 are all high, a negative going pulse is applied to one-shot multivibrator 397 which functions as a pulse widening device to apply an output pulse to one input of NOR gate 373 of FIG. 4e for a purpose to be described in more detail hereinbelow.

FIG. 4e is comprised of a NOR gate 373 having one input coupled to the output 397a of one-shot multivibrator 397 (see FIG. 4d) and the remaining input coupled to lead 398 of FIG. 4c which is coupled to the stationary contact 385a of start switch 385 which further comprises a movable switch arm 385d. This is a momentary switch device which may be depressed to close switch arm 385b. However, when the switch button is released, the switch arm 385b disengages from stationary contact 385a by suitable biasing means (not shown for purposes of simplicity). This condition (the depression of the start switch) places a low level to one input of NOR gate 373 causing it to go high which condition is inverted by inverter 374 causing one input of NOR gate 375 to go low. NOR gate 375, together with cross-coupled NOR gate 376, forms a bistable flip-flop circuit (RUN FF). The output of inverter 374 is also coupled to lead 359 of FIG. 4b.

Depression of the start switch causes the setting of thumbwheel switches 344–346 to be transferred to electronic counter 340, as will be further described. When the input of NOR gate 375 goes low, its output goes high causing a high input level to be impressed upon one input of NOR gate 376 whose output goes low when no halt condition is present. The high output of NOR gate 375 is coupled to one input of AND gate 379 whose remaining inputs are coupled to start switch 385 and the output of NOR gate 377 which is cross-coupled with NOR gate 378 to form a second bistable flip-flop circuit (STOP FF). The outputs of NOR gates 375 and 377 are both high when the counter is running and the start button has been depressed and subsequently released causing the output of AND gate 379 to go low, which condition is applied to NOR gate 381 causing its output to go high rendering transistor Q_7 conductive. This condition causes solenoid coil K_1 to be energized thereby causing switch arm 402a of switch 402 to engage stationary switch arm 402b. Switch arm 402a is magnetically coupled to solenoid K_1 as designated by dashed line 403. The closure of switch arm 402a couples the a.c. supply 404 to lead 405 which is coupled to the control gate of a speed control circuit 460 comprised of a triac assembly which controls the percentage of each half-cycle of the a.c. waveform to be delivered to bridge rectifier 462 to develop a d.c. output.

The function of gate 407 (FIG. 4d) is to control the energization of motor M which is controlled by the presence of a document under the sensor except during a jam condition. This insures feed-out of any document in flow when the STOP button is depressed and when the document is the last one of a batch. Gate 407 is low to keep relay K_1 energized so long as there is no jam condition (311a - FIG. 4a) and a document is passing the sensor.

Gate 381 also energizes relay K_1 either when the START button is depressed, or the RUN FF is ON or when the STOP FF is OFF (i.e., reset).

NOR gate 380 has its output go high when any one of its inputs are low causing a high input level to be applied to inverter 382 and to the emitter electrode of transistor Q_8. Thus, whenever the document-handling device is either not in the running state or is in the "stop" state or when the jam-prevention delay circuit has timed out its output goes high causing transistors Q_8 and Q_9 to become energized so as to apply an energizing signal to the electromagnetic brake **137** shown in FIG. 2.

The inverter **382** has its output coupled to the base electrode of transistor Q_{10} which, together with transistor Q_{11} is energized to energize electromagnetic clutch **131** when the output of inverter **382** goes high, which condition occurs as an inverse function of the Q_8 and Q_9 energization logic statement.

FIG. **4f** is comprised of a gate **410** having one of its inputs coupled to lead **411** of FIG. **4c** which is coupled to the movable switch arm **412b** of switch **412** having stationary contacts **412a** and **412c**. Contact arm **412b** engages stationary contact **412c** when in the normal stacking state and engages contact **412a** when the statistical sampling state. The remaining input to gate **410** is coupled to switch arm **383b** of switch **383** which engages its upper stationary contact **383a** when in the normal state causing the output of gate **410** to go low when both of its inputs are high (when in the normal and stacking state). This low condition is applied to one input of NOR gate **412** whose output goes high so long as one of its inputs is low to cause transistor Q_{12} to conduct. This energizes coil K_2 causing switch arm **413a** magnetically coupled to coil K_2 as represented by dash line **414** to apply a ground level potential to the gate output lead **415** which energizes solenoid **204** (see FIG. **1a**) whose armature is mechanically linked to gate **201** driving gate **201** to the position which guides documents into stacker **80**. Zener diode CR_7 serves to suppress excessive back-EMF when the relay K_1 contacts are subsequently opened.

FIG. **4f** further comprises an inverter **416** whose input is coupled to the switch **383** which is low when in the statistical sampling position causing a high input to be coupled to one input of NAND gate **417**, whose other input is coupled to lead **419** of FIG. **4c** which, in turn, is coupled to the stationary contact **362a** of the statistical sampling switch **362** which is high when switch arm **362b** is connected to upper stationary terminal **362c** causing the output of gate **417** to go low and thereby sustain the energization of relay coil K_2.

Returning to a consideration of FIG. **4c**, there is shown therein the settable thumbwheel switches **344–346** each provided with a manually operated thumbwheel **344a–346a** for setting its associated number wheel so as to set any decimal number (for units, tens and hundreds) at the windows **344b–346b**, respectively. FIG. **4c**, for example, shows a setting of 050 indicating a batch or statistical sampling count of 50. Thus, each batch will contain 50 sheets or, alternatively every 50th sheet will be statistically sampled.

The control panel is further provided with electromagnetic counter means **426** for indicating the count at any given instant for either a batch count or a continuous count. The pulsing input **426a** is coupled to the collector electrode of transistor Q_4 shown in FIG. **4a**. The operator's panel is further provided with a stop switch **387** having switch arm **387b** and a stationary contact **387a**. A continue switch having movable switch arm **386b** and stationary contact **386a** is also provided.

The modes of operation will now be described:

Let it be assumed that it is desired to count a large number of sheets. Switch arm **383b** will be set in its upper position engaging stationary contact **383a** for "normal" operation. Switch arm **412b** will be in its lower position engaging stationary contact **412c** to indicate a stacking operation.

When power is initially turned on, the Jam Detection Circuit **320** (FIG. **4a**) times out and assumes the "JAM" state turning the "JAM" indicator lamp **391** on and resetting RUN-FF (FIG. **4e**) through inverter **321**, NOR gate **366** and inverter **367** (FIG. **4d**) to NOR gate **376** (FIG. **4e**). The RUN FF in the reset state keeps motor M off (through gates **379** and **381** and Q_7-FIG. **4e**); brake **137** energized (through gate **380** and Q_8-FIG. **4e**); and clutch **131** deenergized (through inverter **381** and Q_{10}-FIG. **4e**).

In the normal mode, start switch **385** is pressed and released causing switch arm **385b** to engage its stationary contact **385a** thereby applying a low level to one input of NOR gate **373** shown in FIG. **4e**. This will cause the output of NOR gate **375** to go high causing bistable flip-flop (RUN FF) comprised of NOR gates **375** and **376** to be set to its "run" state. STOP FF (FIG. **4e**) is also simultaneously reset by operation of the start button **385**. Start switch **385** also simultaneously releases the Jam Delay Circuit **320** through gate **318** (FIG. **4a**), and inhibits the motor drive through gates **379**, **381** and Q_7 (FIG. **4e**). RUN FF, being set, energizes clutch **131** and deenergizes brake **137** via gate **380**, inverter **382** and Q_8–Q_9 and Q_{10}–Q_{11}. After start switch **385** is released the second input of AND gate **397** goes high. In the "run" condition, the output of NOR gate **377** is high (see FIG. **4e**) causing the three inputs of AND gate **379** to go high causing its output to go low. This causes NOR gate **381** to go high which initiates conduction of transistor Q_7. This energizes relay coil K_1 to couple the a.c. supply through switch **402** (which is now closed) to motor M to allow it to run. As each separated document passes through the acceleration wheels **62** (see FIG. **1**) the light sensitive transistor **72** is energized to develop a count as was previously described. The count pulses appear at the output **319c** of one-shot multivibrator **319** shown in FIG. **4a** with the circuitry of FIGS. **3** and **4a** described hereinabove performing the function of automatically adjusting the desired threshold level and preventing cuts, slits, punch holes or other perforations in a document from being erroneously detected as a "gap". When a document passes sensor **72** the light level is reduced resulting in a low level output from the detector (FIG. **3**) whose output is applied to C_2 (FIG. **4a**) which provides filtering against motor generated noise in the signal and then passes through gate **313** and inverter **314** to set the integrating single shot ISS Filter (FIG. **4a**) which serves to prevent holes or mutilations in documents from falsely appearing as "gaps". The integrating single shot output is applied to one-shot multivibrator **319** whose output **319c** is applied to Q_3–Q_4 which serve as a level translator and current amplifier for driving electromagnetic counter **426** (FIG. **4c**).

Jam Delay Circuit **320** and Jam Prevention Delay Circuit **330** are prevented from being timed out so long as the time interval between the detection of "gaps" does not exceed the adjusted time outs for these circuits. In a case of time out of the Jam Delay Circuit **320** the output of inverter **321** goes low which condition is coupled to lead **430** to FIG. **4c**. In the normal condition switch arm **364** is coupled to lower stationary contact **364a** which couples this condition to lead **369** to input **376a** of NOR gate **376** of FIG. **4e** to set the bistable flip-flop comprised of NOR gates **375** and **376** to the off state causing the output of NOR gate **375** to go low which causes the output of AND gate **379** to go high. With the time out of Jam Delay Circuit **320** the output of AND gate 407 (see FIG. 4d) also goes high causing the output of NOR gate 381 to go low thereby rendering transistor Q_7 non-conductive to decouple power from the motor control device by opening contacts 402a and 402b. Also RUN FF (FIG. 4e) is reset, counting is inhibited by gate 313 (FIG. 4a) and JAM light 391 is lit.

Inverter 321 and gate 313 (FIG. 4a), together with gates 314, 317 and 318 form a "latch" which maintains the jam level as the documents are being removed and also prevent the document detector from producing spurious count pulses as it adjusts to the lower (shadowed) light level.

The counting process will continue as long as documents are supplied to the input hopper 14 (FIG. 1). The document-handling device may be stopped for any reason by depressing stop switch 387 which couples ground potential through movable contact 387b and stationary contact 387a to one input of NOR gate 378. This causes its output to go high setting the output of NOR gate 377 low which causes the output of NAND gate 379 to go high thereby setting the STOP-FF. This condition, together with a high condition at the output of AND gate 407 (see FIG. 4d) causes the output of NOR gate 381 to go low to decouple the a.c. supply from motor M. The output of NOR gate 377 is further coupled to NOR gate 380 causing its output to go high and thereby energizing the brake and deenergizing the clutch. This prevents documents being engaged by either the picker wheel, drive wheel or stripper wheel assemblies from any further movement into the document-handling device. The brake is simultaneously energized to abruptly halt the picker, drive and stripper wheels. Depressing either the CONTINUE key of the stop key will cause the STOP FF (FIG. 4e) to be reset.

The statistical sampling operation is performed in the following manner:

Switch arm 412b (FIG. 4c) is placed in the "discard" position, switch arm 362b is placed in the "stat" position and switch arm 352c is placed in the "batch/stat" position.

The thumbwheels are manipulated so that their number wheels show the size of the batch desired. As an example, FIG. 4c shows the setting where each batch is to contain 50 sheets.

The start button is depressed. The number in the thumbwheel switches is set into the electronic counter 340 as a result of the ground condition from the depression of start switch 385 being coupled through NOR gate 373 (whose output goes high) to develop a low level at the output of inverter 374 causing inputs 341c–343c of counter stages 341–343 respectively, to go low thereby causing the setting of the thumbwheel switches to be set into the electronic counter.

Release of the start button 385 causes NAND gate 379 to go low which causes the output of NOR gate 381 to go high thereby coupling power to motor M.

The setting of switches 364, 362, 383 and 352 result in high levels developed by gates 410 and 417 (FIG. 4f) and onto the inputs of gate 412 whose remaining input is quiescently in the high state (output 358A of gate 358-FIG. 4d). The output of gate 412 is low rendering Q_{12} non-conductive, thereby deenergizing relay K_2. This permits gate relay 204 to move under the force of the biassing means toward the dotted line position 201′ enabling documents to be discarded via conveyor belts 207–208 FIG. 1a).

When the tens and hundreds stages of the counter are in decimal "9" state and when the unit stage has reached the decimal "8" state, and when the state of the count pulse I_{ss} indicates that the output of gate 355 in FIG. 4d goes low a document is not present in the region of GATE 204, causing the output of gate 358 (forming one-half of the flip-flop comprised of gates 357 and 358) to go low. This level is coupled to one input of NOR gate 412 whereby the output goes high to energize transistor Q_{12} thereby coupling power to the gate relay 204 to set it to the solid line position 201 of FIG. 1b causing the sampled sheet to be stacked in stacker 80.

Just prior to the movement of the gate to the solid line position of FIG. 1b, the "sampled" sheet is slowed up by actuation of the clutch and braking mechanisms which occurs when the units stage of the electronic counter reaches a count of decimal "8". This condition is coupled through gate 354 (FIG. 4d), gates 324 and 325 (FIG. 4a) and gate 380 (FIG. 4e) to actuate the brake and clutch mechanisms 137 and 131, respectively, to slow down the "statistically sampled" sheet to provide the gate sufficient time to move.

This pulse is developed at the leading edge of the document preceding the statistical sample (i.e. the 49th document), and is active for the full duration of time that document is between the light source 65 and sensor 72.

After the passage of the trailing edge of the document preceding the statistical sample (i.e. the 49th document) the output of gate 354 goes high to actuate the clutch and brake mechanisms. Upon the occurrence of the gap between the trailing edge of the 49th document and the leading edge of the 50th document, the gate is set. As soon as this pulse is terminated and before the electronic counter is advanced by one count, gate 355 (FIG. 4d) sets the gate flip-flop (gates 357 and 358) to energize solenoid coil K_2 (see FIG. 4f) and set it to its solid state position shown in FIG. 1b. After counting the gap between the trailing edge of the statistically sampled document, the output of gate 356 goes low causing gate 393 to be enabled (see FIG. 4d) to develop a statistical sample reset pulse by multivibrator 397 which applies a low-going pulse on one input of gate 373 (FIG. 4e) resulting in a low-going pulse on the output of inverter 374 to be applied to inputs 341c, 342c, 343c, thereby re-initializing the respective counters in preparation for the following quantity of documents.

The documents following the "statistically sampled" document are again fed to the depository 215 shown in FIG. 1b until the next statistically sampled count is developed in the same way as was previously described.

In the batch operation, the switch 364b is connected to stationary contact 364c. Switch arm 352c is connected to stationary contact 352a and thumbwheel switches are set to provide the proper batch quantity.

Depressing the start button puts the contents on the count selected by thumbwheel switches 344–346 into the electronic counter through lead 359. The motor is prepped to start in the same manner as was previously described but does not start until the start button is released. This arrangement assures that the count of the count select switches 344–346 (FIG. 4c) is transferred into the electronic counter before the machine begins operation. When the START key is released, the load line 359 is no longer activated and the electronic counter 340 is free to count. As documents pass transistor 72, count pulses are applied to one-shot 319 (FIG. 4a) which causes counter 340 to increase its count.

The BATCH mode enables decoding gates 349, 355 and 356 to function. When a count of "999" is developed, Run FF (FIG. **4e**) is reset to stop the further flow of documents and turn on the Batch Complete lamp **389** (FIG. **4c**). Gate **381** (FIG. **4e**) allows motor M to run as long as there is a document under detector **72** (FIG. **3**) and so long as the Jam Detector circuit **320** has not been activated. This ensures run-out of the last document when batching or when depressing the stop key.

Documents are separated, counted and stacked in stacker **80** (see FIG. **1**) until the 50th document is detected. This causes gate **356** (FIG. **4d**) to be enabled which enables gate **366** to develop a high output which is inverted by inverter **367**. The low output of inverter **367** is coupled through switch **364** to the input of gate **367** (FIG. **4c**) which enables gates **370, 371** and transistor Q_6 (FIG. **4d**) to couple power to the lamp **389** indicating that a batch has been completed. Simultaneously therewith the output of NOR gate **375** (FIG. **4e**) goes low, causing gate **379** to go high and NOR gate **381** to go low, deenergizing transistor Q_7 and decoupling power from motor M.

Simultaneously therewith gate **356** when enabled couples a half condition through gate **366** and inverter **367** (FIG. **4d**) and switch **364** to one input of NOR gate **376** to operate the clutch and braking mechanisms.

The completed batch may then be removed from the stacker **80** and the Start button is depressed to begin counting and stacking of the next batch.

The jam protection devices anticipate potential jam conditions so as to protect the equipment from being damaged before a jamming condition can reach serious proportions.

The jam delay circuit **320** of FIG. **4a** will time out after a time interval which is less than the normal time duration between the sensing of two "gaps" causing gate **313** (FIG. **4a**) to prevent further counts to be coupled into circuit **310.** The output is also coupled to switch **364** at the operator's panel (FIG. **4c**) to provide a halt signal which is coupled into NOR gate **376** (FIG. **4e** and causes the bistable comprised of gates **375** and **376** to reverse state to energize the brake and clutch mechanisms through gates **380, 382** and transistors Q_8–Q_9 and Q_{10}–Q_{11}. Simultaneously therewith, the output of inverter **321** (FIG. **4a**) is coupled through inverter **372** and transistor Q_5 (FIG. **4d**) to lead **390** of FIG. **4c** to illuminate the jam lamp **391.** The resetting of the bistable comprised of gates **375** and **376** also causes gate **379** and one input of **381** (FIG. **4c**) to go high. When the other input to **381** is high, which occurs when gate **407** (FIG. **4d**) has its input level from inverter **321** low, the output of NOR gate **381** goes low to decouple power from motor M by opening switch arms **402a** and **402b** through the deenergization of relay solenoid K_1.

The jam prevention delay circuit **330** which has a slightly shorter time limit will time out causing transistor Q_2 to be rendered non-conductive. This high level is reversed through inverter **323** applying a low input to gate **324** causing its output to go high. This state is reversed by inverter **325** causing its output to go low. This condition is applied to one input of NOR gate **380** (FIG. **4a**) to operate the clutch and brake mechanism in the same manner as was previously described and thereby preventing a jam before its possible occurrence. The jam prevention delay circuit **330** has a shorter time out period than jam delay circuit **320** so as to activate the clutch and brake mechanisms in anticipation of a jam. The jam delay circuit **320** goes one step further in that it deenergizes motor M which is caused to time out.

It can be seen from the foregoing description that the present invention provides novel control means for document handling devices and the like which are adapted for accepting sheets or other documents, preventing more than one document from passing through the drive and stripper means and for providing a gap between the separated document for counting purposes wherein the control means provides the functions of counting small or large numbers of documents, counting batches of documents of any predetermined batch size, counting documents and retaining statistical samples of the counted documents and further provides means for protecting the equipment against damage due to delays by anticipating any potential delay and immediately deenergizing the document handling equipment and providing an alarm indication in the form of a lamp (and/or audible alarm if desired) to alert the operator to a possible jam condition.

The electronics of the control system is further adapted to provide count pulses by sensing the separation between documents before they pass through the stacker to automatically adjust for changes in ambient conditions which may effect the sensitivity of the detector and to prevent perforations or mutilations within the documents themselves from being erroneously interpreted as a "gap" between separated documents. The circuit **310** of FIG. **4a** is adapted so as to prevent such erroneous detections for mutilations or other perforations within the document passing between the lamp and light-sensitive transistor of openings as large as $\frac{3}{4}$ inch measured in the direction of feed of the documents.

Although there has been described a preferred embodiment of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited, not by the specific disclosure herein, but only by the appending claims.

What is claimed is:

1. A sensor for detecting the presence of gaps between documents fed in a first direction at spaced intervals with said gaps occurring between the trailing edge of a document and the leading edge of the next document, said sensor comprising:

- a light source positioned to one side of the path of movement of the documents;
- light sensitive means positioned to receive light of maximum intensity from said light source when the trailing edge of each document passes said light sensitive means to activate said light sensitive means and to receive light of a minimum intensity when a document is positioned between said light sensitive means and said source, said light sensitive means developing a signal at its output which varies with the intensity of light;
- energy storage means;
- first means coupled to said light sensitive means output for rapidly charging said energy storage means when said light sensitive means is activated by light of maximum intensity;
- comparator means *normally maintained at a first output signal level and* having first and second inputs for generating [an] *a second* output signal *level different from said first output signal level* when the signal level at its first input exceeds the signal level at its second input;
- said first input being coupled to the output of said light sensitive means;

second means coupled between said [first] *energy storage* means and said comparator means second input for coupling a portion of the signal level developed by said storage means to said second input;

said second means providing a discharge path for said energy storage means and being adapted to cause said energy storage means to discharge at a rate much slower than the charging rate to cause a substantial portion of the signal level developed by said storage means to be retained when said light sensitive means is deactivated due to the movement of the document past said light source;

storage means coupled to said comparator means and being charged to a first level when said comparator means develops said first output signal level and being discharged towards a second lower level when said comparator means develops an output which is at said second output signal level;

logical gating means responsive only to the simultaneous presence of said comparator means second output signal level and the discharge of said storage means to said second lower level to generate a count pulse representative of the passage of a document.

2. The sensor of claim 1 wherein said second means is a voltage divider comprised of resistance elements and said storage means is a capacitor coupled in parallel across said voltage divider;

said voltage divider forming a discharge path for said capacitor.

3. [The sensor of claim 1 further comprising] *A sensor for detecting the presence of gaps between documents fed in a first direction at spaced intervals with said gaps occurring between the trailing edge of a document and the leading edge of the next document, said sensor comprising:*

a light source positioned to one side of the path of movement of the documents;

light sensitive means positioned to receive light of maximum intensity from said light source when the trailing edge of each document passes said light sensitive means to activate said light sensitive means and to receive light of a minimum intensity when a document is positioned between said light sensitive means and said source, said light sensitive means developing a signal at its output which varies with the intensity of light;

first energy storage means;

first means coupled to said light sensitive means output for rapidly charging said first energy storage means when said light sensitive means is activated by light of maximum intensity;

comparator means having first and second inputs for generating an output signal when the signal level at its first input exceeds the signal level at its second input;

said first input being coupled to the output of said light sensitive means;

second means coupled between said first energy storage means and said comparator means second input for coupling a portion of the signal level developed by said first energy storage means to said second input;

said second means providing a discharge path for said first energy storage means and being adapted to cause said first energy storage means to discharge at a rate much slower than the charging rate to cause a substantial portion of the signal level developed by said first energy storage means to be retained when said light sensitive means is deactivated due to the movement of the document past said light source;

a bistable circuit having first and second inputs and a first output;

said *bistable circuit* first input being coupled to the output of said comparator means *for setting said bistable circuit;*

gate means having first and second inputs coupled respectively to said comparator means and [said second output] *the first output of said bistable circuit,* and having an output coupled to said *bistable circuit* second input;

second energy storage means coupled to the [output] *second input* of said *bistable circuit for resetting the bistable circuit and including means coupled to said* gate means [and being adapted] *enabling the second energy storage means* to charge rapidly and discharge slowly *under control of the gate means*;

said bistable circuit being reset when said comparator detects a gap to discharge said *second* energy storage means;

said *second* energy storage means being adapted to prevent resetting of said bistable circuit until it has discharged *to a suitable level* within a predetermined time interval thereby preventing said bistable circuit from being reset during a time interval less than the *predetermined time interval which represents the* time of passage of a gap *of at least a predetermined length* to prevent spurious pulses, developed as a document is passing said light sensitive means, from setting said bistable circuit[;], until it has been reset whereby apertures in said documents *shorter than said predetermined length* passing said detecting means are prevented from being detected as a gap.

4. Sensing means for counting documents fed in a predetermined direction at spaced intervals with a gap between the trailing edge of each document and the leading edge of the next following document comprising:

detecting means for detecting said gaps to generate a first output level during the occurrence of each gap as the trailing edge of each document passes said detecting means and a second output level as the leading edges of each succeeding document passes said detecting means;

bistable means having first and second inputs and [and] *an* output, said first input coupled to said detecting means for generating a first output level at the output of said bistable circuit when each leading edge passes said detecting means;

gate means having inputs coupled to said detector means and the output of bistable circuit for coupling a setting signal at its output to said bistable circuit second input to permit said bistable circuit to be set when the leading edge of a document is sensed by said detecting means;

energy storage means charged by the output of said gate means, means coupled to said energy storage means to prevent said second input from being reset for a predetermined time interval after the psssage of each trailing edge during which time interval said energy storage means is prevented from discharging below a predetermined level to prevent setting of bistable means due to the detection of apertures in said documents by said detection means.

5. The sensing means of claim 4 wherein the energy storage means is a capacitor adapted to charge rapidly during setting of said bistable circuit and to discharge

slowly when said first level generated by said detecting means is to prevent reset of said bistable circuit.

6. The sensing means of claim 5 wherein the capacitance of said capacitor is selected to prevent resetting of said bistable circuit when said first level persists for a time less than the interval of a gap between documents.

7. Control means for operating apparatus for counting and stacking documents comprising:

first means for receiving a stack of documents;

stacking means;

second means for separating said stack of documents and advancing said separated documents, one at a time to said stacking means whereby a gap is provided between the trailing edge of each document and the leading edge of the next document;

sensing means arranged at a predetermined location for detecting the presence of each gap to generate counting pulses;

means coupled to said sensing means for counting said documents;

jam detector means for generating a first output level when the time interval between succeeding count pulses is greater than the time required for one document to pass said sensing means, said jam detector being reset by said sensing means each time a count pulse is generated by said sensing means to normally prevent generation of said first output level;

gate means coupled to said jam detector means for preventing said sensing means for transferring count pulses to said counting means when said jam detection means generates said first output level.

8. The control means of claim 7 further comprising second gate means coupled to said jam detection means for halting said second means upon the occurrence of said first output level.

9. Control means for operating apparatus for counting and stacking documents comprising:

first means for receiving a stack of documents;

second means for separating said stack of documents and advancing said separated documents one at a time in a feed direction;

stacking means;

third means for accelerating documents advanced by second means toward said stacking means to create gaps between adjacent documents;

motor means;

clutch means for selectively coupling said second means to said motor means;

braking means for selectively halting said second means;

means coupled between said motor means and said third means for operating said third means so long as said motor means is energized;

sensing means for detecting the presence of each gap to [geneate] *generate* counting pulses;

means coupled to said sensing means for counting said documents;

settable means for setting said counter means to any predetermined count N, said settable means including first gate means responsive to said counting means for generating an output when said counting means reaches a count of N-1;

diverter gate means for normally extending into the path of movement of said documents diverting documents accelerated by said third means away from stacking means;

second gating means coupled between said gate means and diverter means for moving said diverter means out of the path movement of said documents when said first gate means detects a count of N-1;

said second gating means including means for operating said braking means and said clutch means to decouple said second means from said motor means to to abruptly halt said second means to provide sufficient time for said diverter means to move out of the path of movement of said documents;

means coupled between said sensing means and said second gating means for causing said second gating means output to terminate after a predetermined time interval to cause said braking means to be released and said clutch means to couple said motor means to said second means;

third gating means coupled to said counting means for generating an output when said counting means reaches a count of N;

means coupled between said third gating means and said diverter means for moving said diverter means into the path of movement of the documents;

said third gating means including first bistable means coupled to said brake and clutch means for decoupling said second means from said motor means and abruptly halting said second means when a count of N is achieved;

delay means coupled to said third gating means for resetting said bistable means after a predetermined interval to release said brake means and cause said clutch means to couple said motor means to said second means after said diverter means is moved into the path of movement of said documents.

10. Sensing means for counting documents fed in a predetermined direction at spaced intervals with a gap between the trailing edge of each document and the leading edge of the next succeeding document and for preventing the generation of spurious counts due to apertures, slits or other openings in said documents comprising:

means for detecting said documents to generate a first level as the trailing edge of a document passes said detection means and to generate a second level signal as the leading edge of the next succeeding document passes said detection means;

charge storing means coupled to said detection means for storing electrical energy developed by said detection means during the time that each leading and trailing edge passes said detection means and for discharging electrical energy that the gaps between documents pass said detection means;

bistable means having inputs coupled to said storing means and to said detection means for being set when the output of said detection means is at said second level and reset when said energy storing means discharges to a predetermined threshold level and the output of said detection means is at said first level;

second means coupled between said energy storage means and said detection means for enabling said energy storage means to charge rapidly after said detection means reaches said second level and for causing said energy storage means to discharge at a slow rate after said detection means reaches said first level;

said second means being adapted to permit said energy storage means to discharge to a level below said threshold level before the leading edge of the next document is detected by said detection means to permit resetting of said bistable means and being further adapted to prevent said energy storage means from discharging below said threshold level when said detection means detects openings, slits or other mutilations in said documents which cause said detection means to generate said first level output for a time duration shorter in length than the time interval for a gap to pass said detection means whereby the detection of openings, slits or other mutilations in said documents are prevented from being interpreted as the gap between documents;

means coupled to said bistable means for generating a count pulse when said bistable circuit is set.

11. The sensing means of claim **10** further comprising means coupled to said pulse generating means for accumulating a count of said pulses.

12. The sensing means of claim **10** wherein the gap distance between documents in a minimum of 0.6 inches and wherein said second means enables said energy storage means discharge below said threshold in slightly less time than the time interval during which a gap passes said detection means to prevent openings in said documents less than 0.4 inches long (measured in the direction of travel) are thereby prevented from being interpreted as a gap between documents.

13. The sensing means of claim **10** further comprising timing means coupled between said detection means and said bistable means for preventing setting of said bistable means when said bistable means has not been reset within a predetermined time interval which is greater in duration than the time required for a document to pass said detection means.

14. The sensing means of claim **13** further comprising second timing means coupled to said bistable means for generating a signal a second predetermined time after said bistable means is reset to generate a jam signal, said second predetermined time being greater in duration than the time required for the leading edges of two successive documents to pass said sensing means;

means coupled to said second timing means for halting the feeding of said documents.

15. Apparatus for detecting documents moving along a path at spaced intervals comprising:

a light source positioned on one side of said path;

a light detector positioned on the remaining side of said path and adapted to generate a signal at its output whose signal amplitude is at a first level when a document is passing between the source and the detector and is at a second level when no document is between the source and the detector;

a comparator having first and second inputs, said first input being coupled to the output of said detector;

a capacitor;

means coupled to said detector output for developing a charging current to instantaneously charge said capacitor upon the occurrence of one of said signal levels and for terminating said charging current upon the occurrence of the remaining one of said signal levels;

a discharge circuit coupled to said capacitor for discharging said capacitor at a slower rate than the charging rate of said capacitor;

said discharge circuit comprising a voltage divider circuit for applying a portion of the voltage across said capacitor to the second input of said comparator;

said comparator being adapted to generate an output *of a predetermine level* only when the signal level at its first input is greater than the signal level at its second input;

storage means coupled to said comparator means and being charged to a first level when said comparator means output is not at said predetermined level and being discharged to a second lower level when said comparator means ouput is at said predetermined level;

logical gating means responsive only to the simultaneous presence of said predetermined level at the output of said comparator and the discharge of said storage means to said second level to generate a count pulse representative of the passage of a document.

16. The apparatus of claim 1 further comprising diode means coupling said storage means to said comparator means to permit rapid charging of said storage means and resistance means coupling said storage means to said comparator means for causing the discharge of said storage means to occur at a reduced rate.

17. Apparatus for detecting documents moving along a path at spaced intervals comprising:

a light source positioned on one side of said path;

light detector means positioned on the remaining side of said path and adapted to generate a signal at its output whose signal amplitude is determined by the magnitude of the light impinging upon said detector means;

means for establishing a threshold level;

comparator means coupled to the threshold means and the output of said light detector means for generating a first output level when the amplitude of said detector means output is above said threshold level and for generating a second output level when the amplitude of said detector means output is below said threshold level;

means responsive to said detector means output for adjusting the threshold level to thereby automatically compensate for deviations in the detector means due to ambient conditions, components aging, and the like;

storage means coupled to said comparator means and being charged to a first level when said comparator means output is at one of its first and second levels and being discharged to a second lower level when said comparator means output is at the remaining one of said first and second levels;

logical gating means responsive only to the simultaneous presence of said one of said first and second levels at the output of said comparator means and the discharge of said storage means to said second level to generate a count pulse representative of the passage of a document.

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