Sept. 16, 1947. J. W. BRYCE 2,427,383

STATISTICAL MACHINE CONTROLLED BY MAGNETIC, FREQUENCY CODED RECORDS

Filed July 29, 1941 8 Sheets-Sheet 1

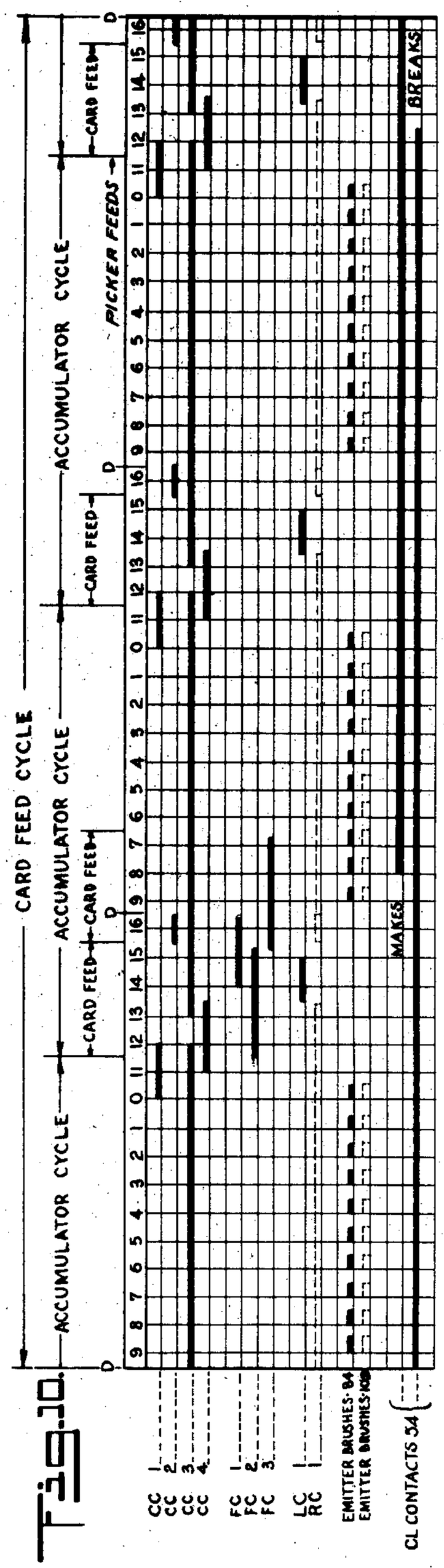


Fig. 10.

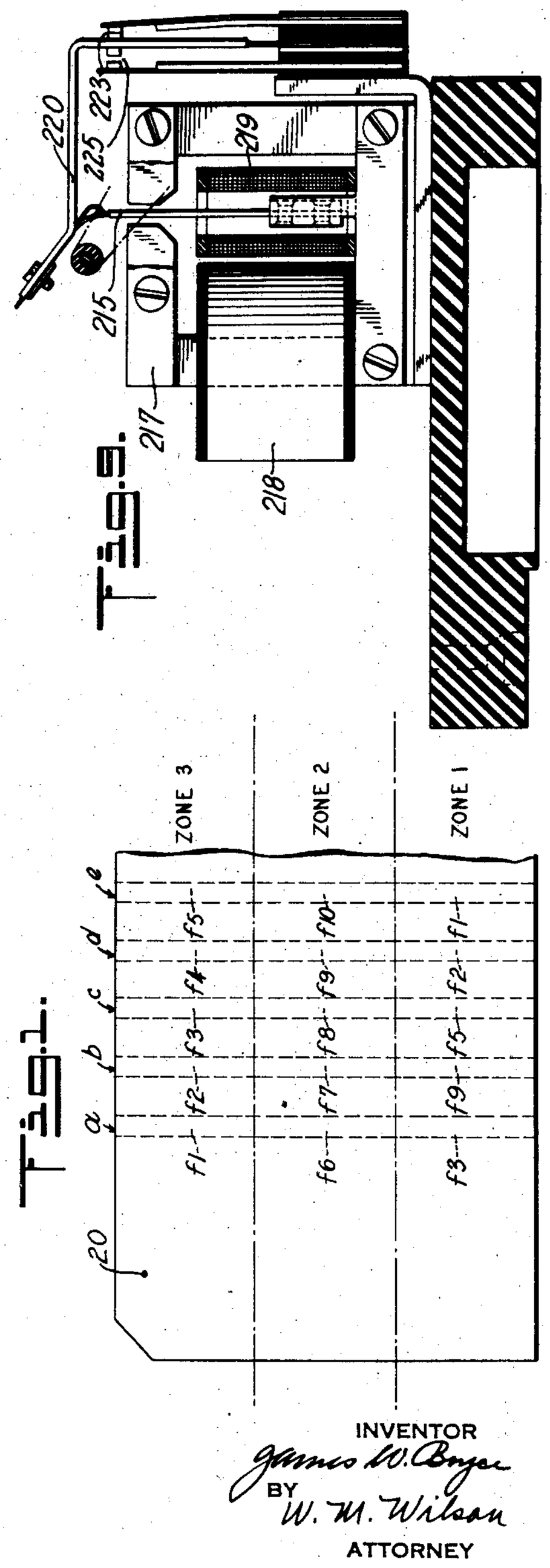


Fig. 9.




Fig. 8.

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STATISTICAL MACHINE CONTROLLED BY MAGNETIC, FREQUENCY CODED RECORDS

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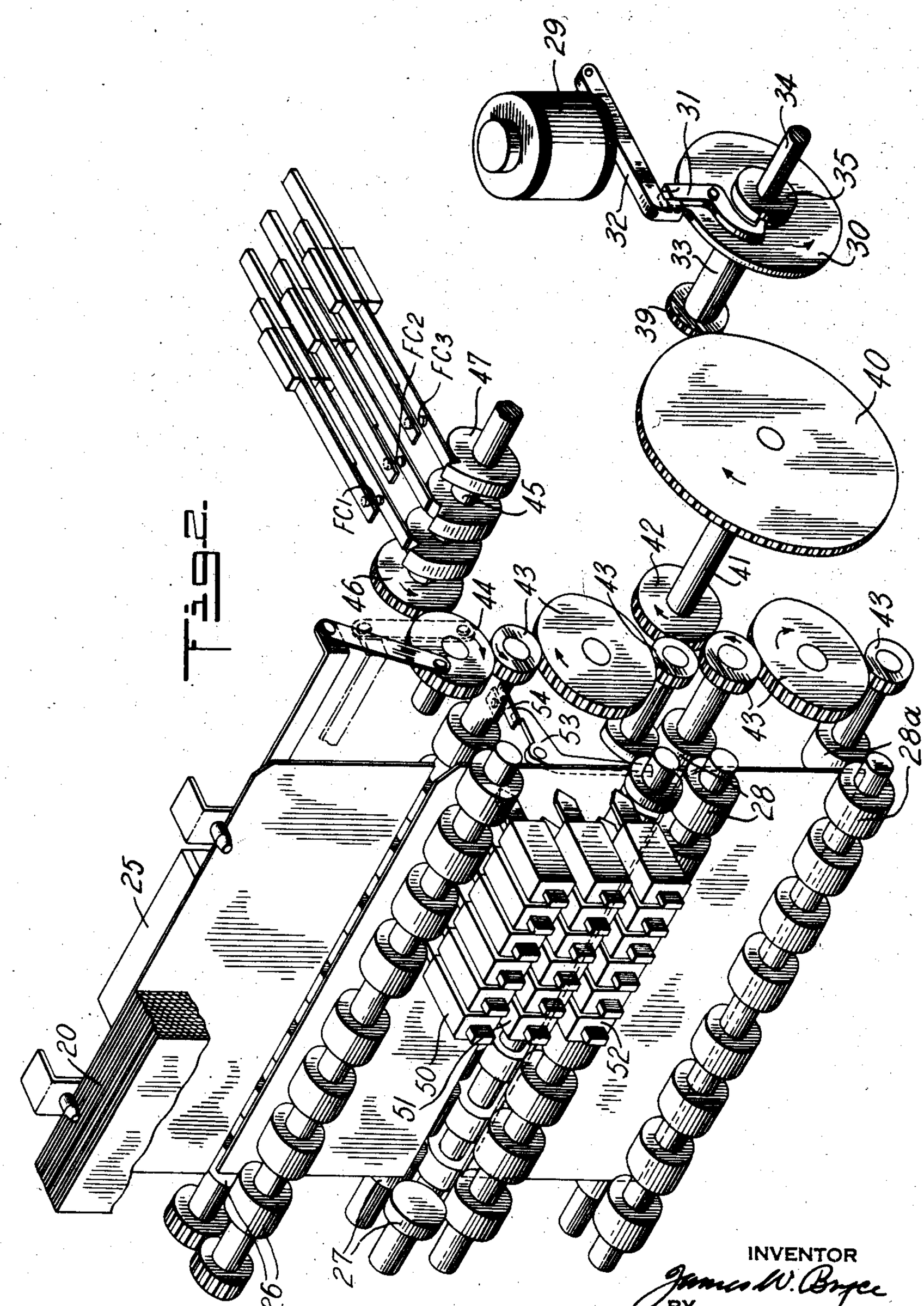
Fig. 2.

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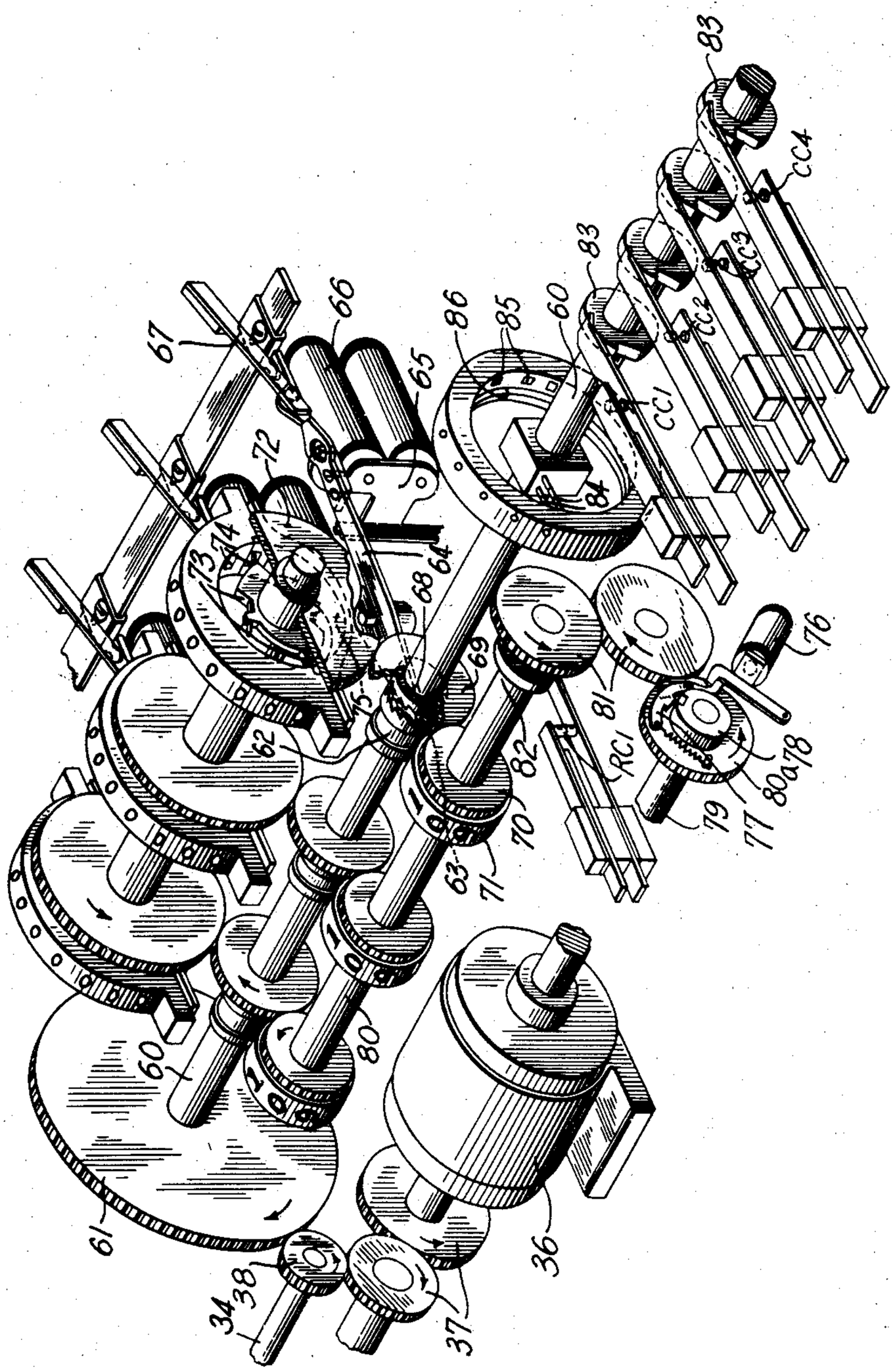


FIG. 3.

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STATISTICAL MACHINE CONTROLLED BY MAGNETIC, FREQUENCY CODED RECORDS

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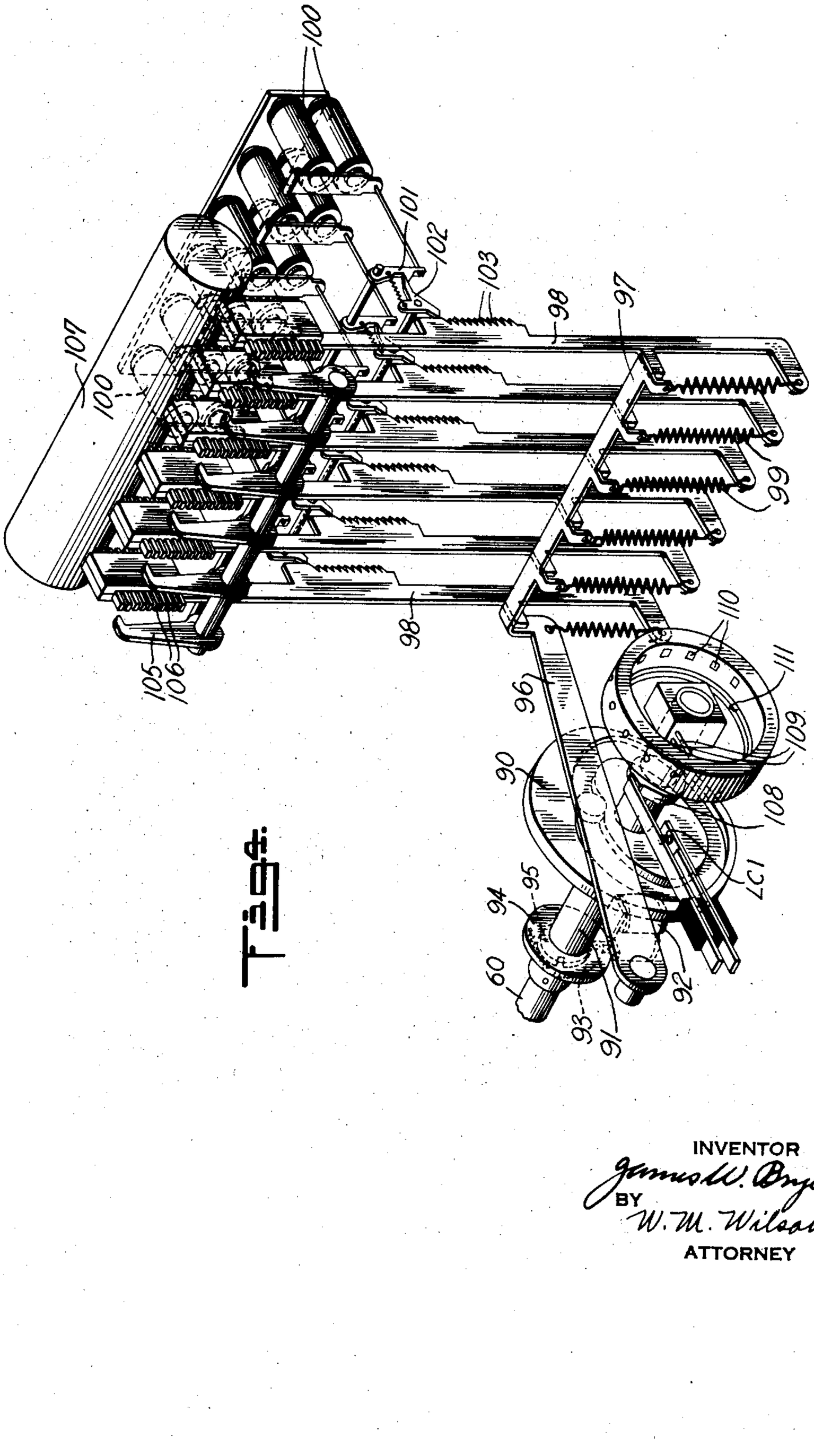


Fig. 4.

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STATISTICAL MACHINE CONTROLLED BY MAGNETIC, FREQUENCY CODED RECORDS

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Fig. 5.

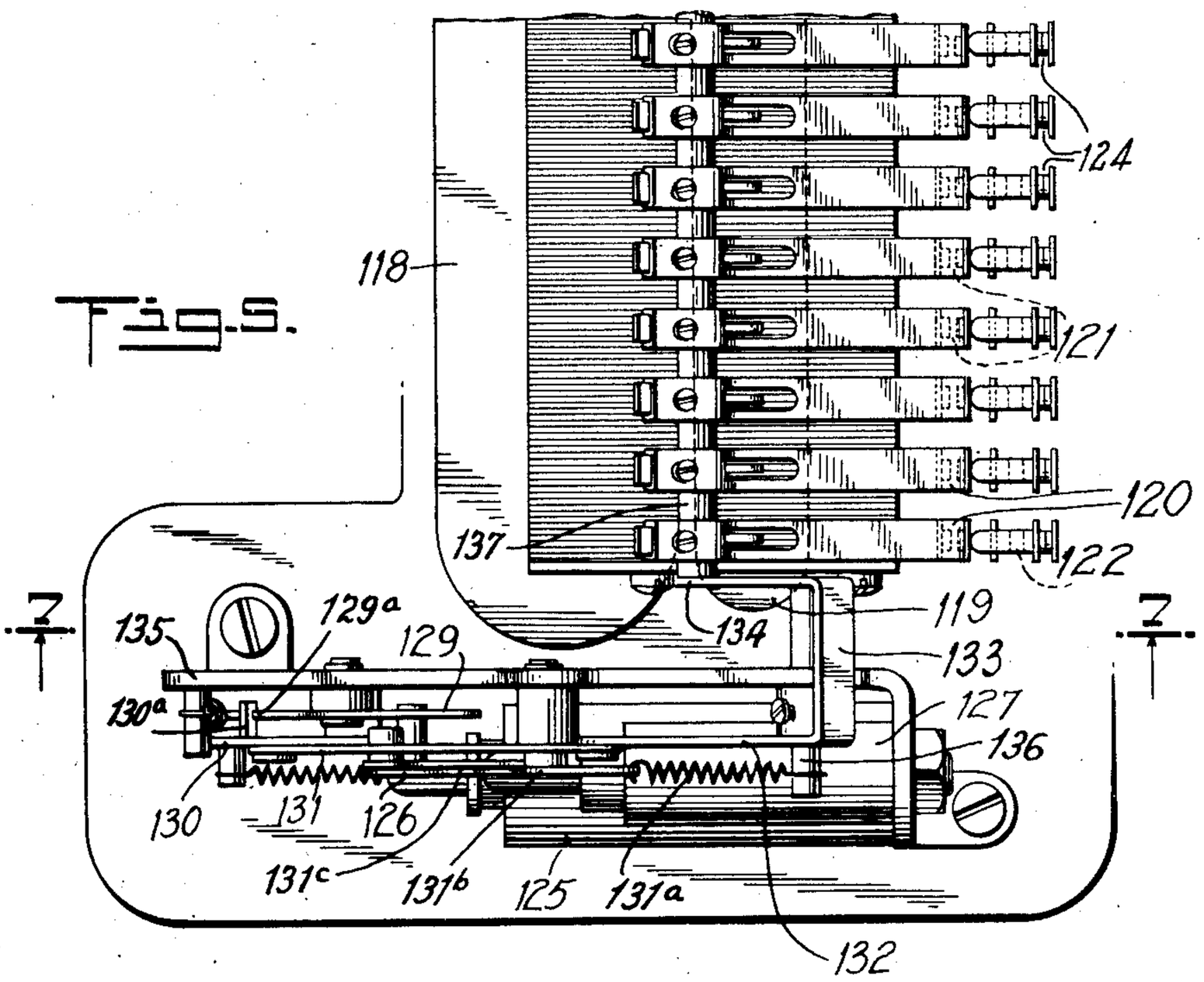
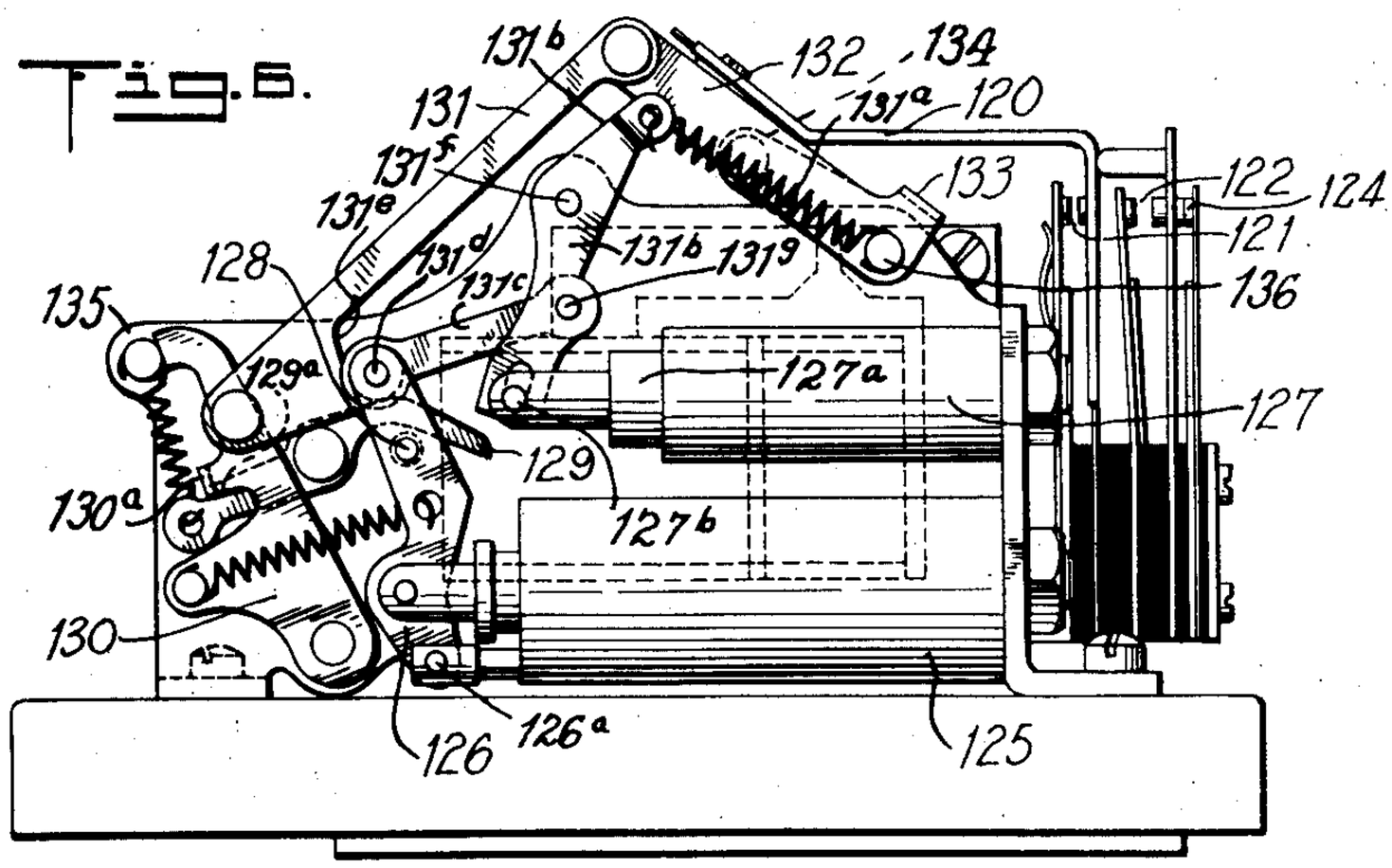



Fig. 6.

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STATISTICAL MACHINE CONTROLLED BY MAGNETIC, FREQUENCY CODED RECORDS

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Fig. 7.

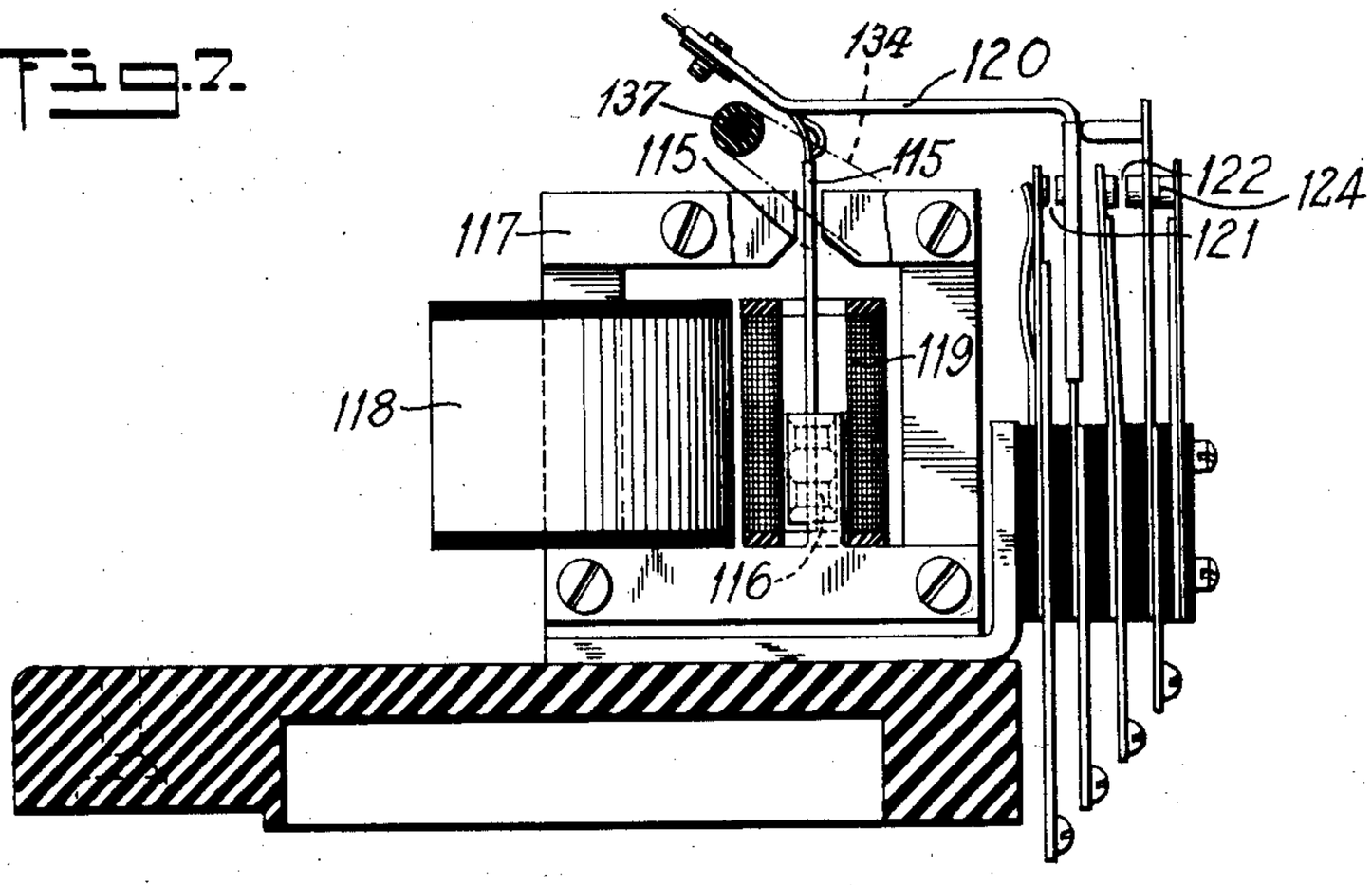
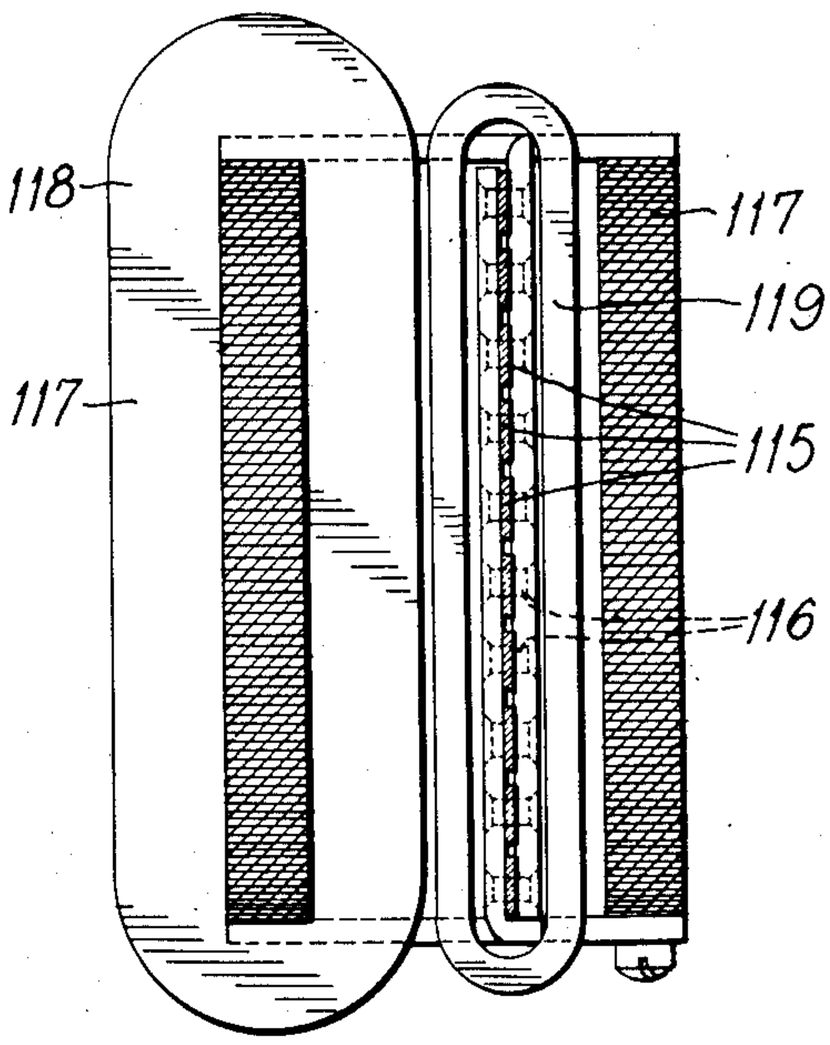



Fig. 8.

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STATISTICAL MACHINE CONTROLLED BY MAGNETIC, FREQUENCY CODED RECORDS

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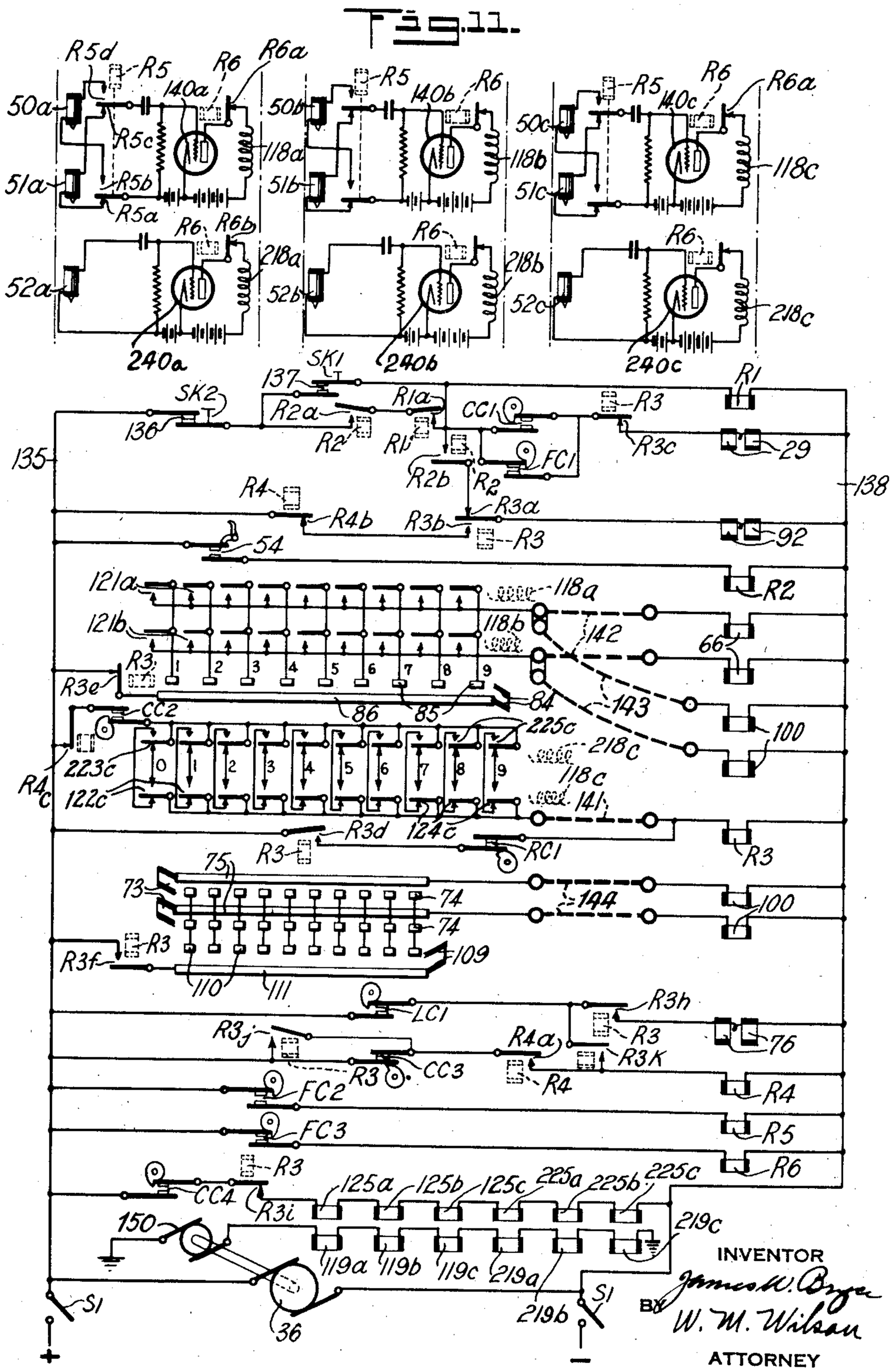
Fig. 11.

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STATISTICAL MACHINE CONTROLLED BY MAGNETIC, FREQUENCY CODED RECORDS

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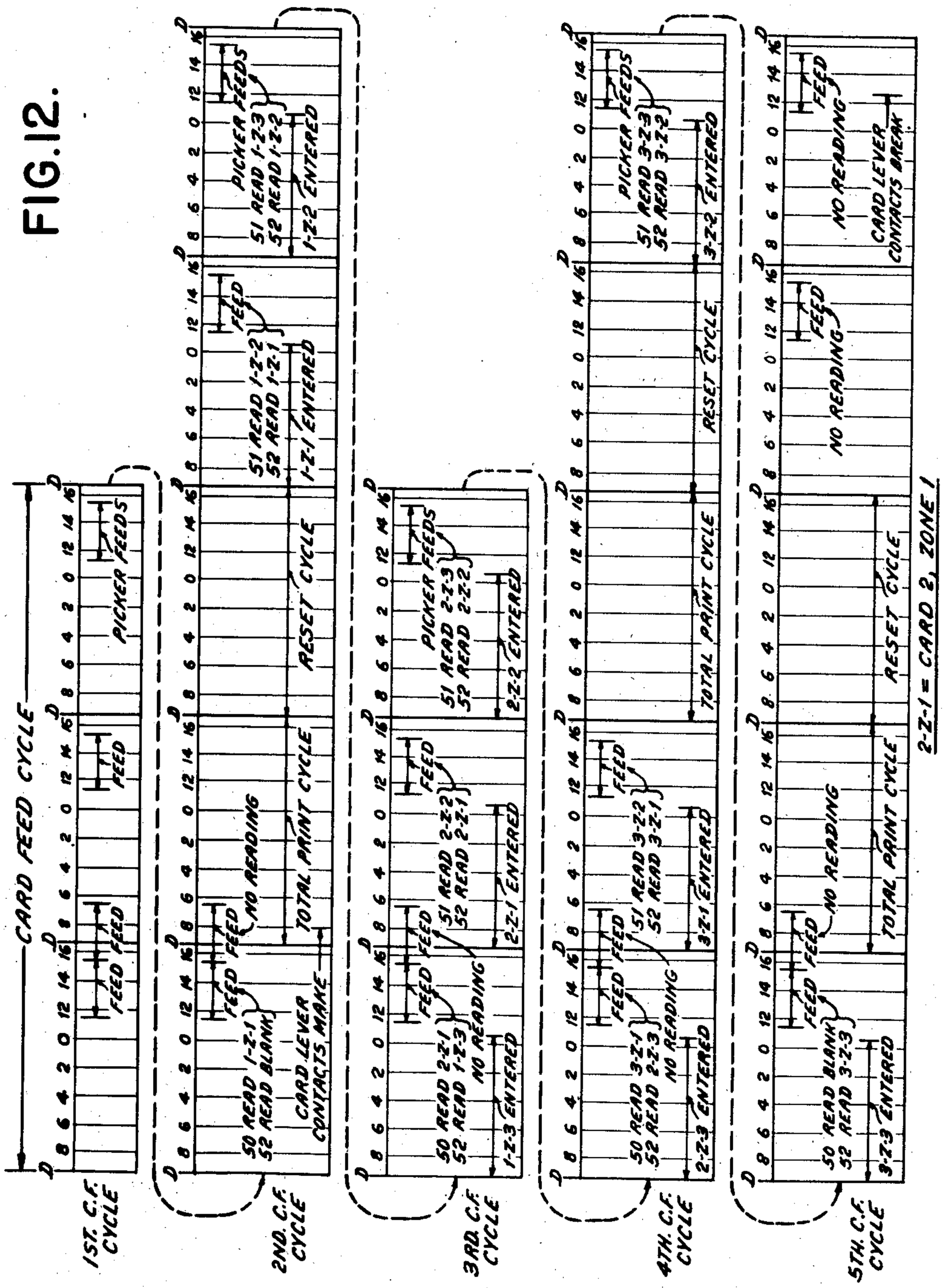
FIG. 12.

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Patented Sept. 16, 1947

2,427,383

# UNITED STATES PATENT OFFICE

2,427,383

## STATISTICAL MACHINE CONTROLLED BY MAGNETIC, FREQUENCY CODED RECORDS

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Application July 29, 1941, Serial No. 404,495

4 Claims. (Cl. 235—61.7)

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This invention relates to improvements in record controlled statistical machines and more particularly to imrpovements in such machines whereby they are adapted to be controlled by individual records provided with data designations formed by magnetic impressions which are retained by the records. This application is a continuation in part of copending application Serial No. 286,443, filed July 25, 1939.

It is now suggested to provide the control elements or records with magnetic impressions for representing the data, which impressions are formed by subjecting the records to magnetic fields of varying intensities. Due to the characteristics of the records, which are formed from suitable magnetizable materials, the magnetic impressions formed thereon can be retained for any desired period and utilized for controlling the statistical operations of the machines.

In the copending application Serial No. 145,031 filed May 27, 1937, now Patent No. 2,254,931, provision is made whereby record cards, which have differentially positioned magnetic impressions formed thereon for representing the data, are used for controlling the statistical operations of the machines in accordance with the discrete magnetic impressions formed at the various index point positions on the records.

In the present application provision is made whereby the statistical operations of the machines are controlled by magnetic impressions formed upon the records, which impressions are not differentially located on the records in various index point positions but instead are formed magnetically by being subjected to magnetic fields the lines of force of which are varied at different frequency rates; thus, the impressions retained therein are formed in different frequency ranges for representing the different data. The magnetic impressions are similarly positioned on the records with respect to each other so that in the instant application differentiation of the data designations is not made by the disposition thereof at different positions on the record.

In order to illustrate and describe the invention briefly, provision is made whereby recordings of the impressions in different frequencies are designated to represent the different data values. For example, a magnetic recording in a frequency of the order of "*f*1" may represent the numerical data "one," a recording in frequency "*f*2" represents the numeral "two" etc.

The individual records bearing the magnetic impressions or recordings are then fed past suitable sensing devices such as reproducing magnets

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whereby electromotive forces corresponding to the different magnetizations of the record are generated in the sensing magnets thereby producing electrical impulses or oscillations of different frequencies corresponding to the frequencies of the recordings representing the data. Various control circuits are then established for controlling the desired statistical operations. In the instant case, a plurality of tuned reed relays are provided, which relays are responsive solely to impulses of predetermined frequencies. These relays are conditioned in accordance with the sensed data designations in order to select and complete certain control circuits for energization at a subsequent time. Upon energization of the said selected circuits suitable data accumulating and listing control means are called into action to effect manifestation of the sensed data. Novel automatic control circuits are also provided whereby the automatic statistical operations are interrupted upon detection of a change in the classification data recordings of successive records.

Accordingly, an object of the present invention resides in the provision of a statistical machine controlled by records bearing data designations in the form of magnetic impressions which are recorded in different frequencies to represent the data and having means for controlling the statistical operations of the machine in accordance with the data recorded on the records.

Another object of the present invention resides in the provision of a statistical machine controlled by records bearing data designations in the form of magnetic impressions which are recorded in different frequencies to represent the data and having tuned devices which are responsive to the sensing of the magnetic impressions for controlling the statistical operations of the machine in accordance with the data sensed.

Another object of the present invention resides in the provision of means for selecting predetermined circuits from a group representing the data sensed on the magnetized records and controlling the statistical operations of the machines in accordance with the selected circuits and sensed data.

Another object of the present invention resides in the provision of means for selecting predetermined circuits from a group to represent the data sensed on the magnetic records and energizing the selected circuits at different times for controlling the statistical operations of a machine in accordance with the data sensed.

Another object of the present invention resides

in the provision of a statistical machine controlled by records bearing data designations in the form of magnetic impressions which are recorded in different frequencies to represent the data and having means for comparing the data sensed on two successive records for effecting predetermined operations of the machine upon disagreement of the sensed data.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a partial view of a fragmentary section of a specific type of machine control element.

Fig. 2 is an isometric view of the record feeding and sensing means.

Fig. 3 is an isometric view of the data accumulating means.

Fig. 4 is an isometric view of the data printing means.

Fig. 5 is a plan view of one type of control relay means.

Fig. 6 is a front elevation of the relay means.

Fig. 7 is a section on lines 7—7 of Fig. 5.

Fig. 8 is a detailed section of part of the relay means.

Fig. 9 is a section similar to the one shown in Fig. 7 showing a modified form of the relay means.

Fig. 10 is a timing chart of certain control elements of the machine.

Fig. 11 is a wiring diagram showing the circuit connections of the machine.

Fig. 12 is a chart of a typical sequence-of-events from the feeding in of the first card to the feeding out of the last card in the hopper.

*Control records*

Referring now to Fig. 1 a preferred type of control record is shown to comprise a record card 20 which is similar to the well known type of record cards adapted for use in the Hollerith statistical system. The record card may comprise a sheet of suitable non-magnetic material, such as paper, which is impregnated with granular magnetic material such as iron filings; or, if preferred the record card can be made by depositing finely divided metal powder in the paper pulp so as to be incorporated therein before the manufacture of the magnetizable paper stock. Another type of record card which can be used is one similar to the record described in the said copending application which comprises a multiply card having a wafer or foil of magnetic material formed between two layers or plies of suitable paper stock.

The record card shown in the instant application is a three zone record so that the data designations can be formed in any of the zones desired. The individual zones are indicated in Fig. 1. Each zone is sub-divided into individual columns which are designated by the reference characters *a*, *b*, *c*, etc. It is noted that the columns extend vertically across the entire zone. During recording operations the magnetic fields are directed to the desired columns to subject these portions of the zones to the varying lines of force initiated by the recording magnets. The different magnetic impressions or recordings formed on the records are then retained in the particular columns designated in Fig. 1. The method of and means for recording the data designations on the said cards are described in



a copending application Serial No. 286,441, filed July 25, 1939, now Patent No. 2,247,905. In order to represent different data the recordings are formed in different frequencies, for example, for the numerical data "1 to 9" the recordings in the individual columns are formed in individual frequencies *f*1 to *f*9 to extend vertically across the zone to represent the different numerical values. The different data designations are indicated generally in Fig. 1 by the representations *f*1 to *f*10 which allude to the frequencies of the recordings or impressions formed in the related columns. The number represented in zone 1 by the magnetic recordings is —39521, in zone 2 the number represented is —67890, and in zone 3 the number represented is —12345.

Thus, it is seen that each card in effect comprises three individual records each of which is provided with various magnetic recordings to represent the classification and amount data. Any column, or group of columns, may be used for class numbers, for the purpose of auto control operations of the usual kind. Likewise any desired columns may be used for amount data, by means of appropriate plugging, as will be illustrated by an example later on. Before describing the controlling operations effected by the described records the individual units of the machine will be described.

*Record feeding and analyzing means*

Referring now to Fig. 2 a well known type of record card feeding means is shown and comprises a reciprocating card picker 25 for feeding the record cards 20 singly from the stack to the first pair of feed rolls 26 whence they are fed through the pairs of feed rolls 27, 28 and 28*a* to a discharge hopper suitably disposed with respect to the last mentioned rollers. Two different positions of the card picker are shown in full lines and dot and dash lines, respectively. The operations of these elements are under control of the magnet 29 which, when energized, lifts its armature latch 32 and releases certain parts of the clutch mechanism comprising the clutch plate 30 and pawl 31. As long as the said magnet is energized the sleeve 33 is rotated by the shaft 34 due to the cooperation of the released pawl and clutch disc 35 which is secured to shaft 34. This shaft is rotated continuously as long as motor 36 (Fig. 3) is energized, by means of the gearing generally indicated by 37 and gear 38 secured to one end of the said shaft. The sleeve 33 at one end is secured to the clutch plate 30 and at the other end to gear 39 which in turn is in constant mesh with gear 40 (secured to shaft 41). The ratio of gears 39 and 40 is such that for one revolution of gear 39 the gear 40 is rotated one quarter of a revolution. The said pairs of feed rolls are driven by means of the gear 42 secured to shaft 41 and the gearing generally indicated by the reference character 43, part of which gearing in turn is effective to drive the gear 44 and the connected card picker 25. The ratio of the described gearing is such that for each quarter of a revolution of gear 40 the record card is fed a distance equivalent to one zone of the record card. A cam shaft 45 is provided to be rotated one revolution for each complete revolution of gear 40, by means of gears 44 and 46, the latter being secured to the said cam shaft which rotates the cam members 47 secured thereto for controlling the operations of the associated contacts FC1 to FC3. As the card is fed through the described feeding unit it passes under three groups of reading or sens-

ing magnets 50, 51 and 52 successively and in the order mentioned. The groups of magnets are spaced vertically one card zone distance apart, and the magnets in each group are spaced horizontally to correspond to the spacing of the columns in the card zones; thus, in each group of magnets, there is one for each columnar position of a record zone.

In Fig. 2 the space between card one (the lowest card in the feed rollers) and card two is equal to the length of one zone; thus, the leading edge of card two follows the leading edge of card one at a distance of four zone lengths. Three of these zone lengths are occupied by three successive records, while the fourth is a blank space—a condition which requires certain adjustments of the reading mechanism, to be described presently, to provide for comparison of records at different spacings, for auto control purposes. Card three will be fed by the picker 25 when a gap of one zone length has opened up between the trailing edge of card two and the leading edge of card three.

It should be mentioned that suitably disposed in the card feeding unit is a card lever 53 which actuates the card lever contacts 54 so that the contacts are closed as long as cards are fed through the said unit. This condition is obtained by having the length of the effective portion of card lever 53, namely the portion adapted to engage the cards, greater in length than the spacing between cards. For a more detailed description of the elements of the well known card feed unit, reference may be made to U. S. Patent No. 1,976,617.

*Data accumulating means*

Referring now to Fig. 3 the data accumulating means will be briefly described and is shown to comprise in part a main drive shaft 60 driven by the gears 38 and 61, the latter gear being secured to the said drive shaft. The accumulator drive shaft is rotated continuously, as long as motor 36 is energized, and in timed relationship with the described card feeding drive means. The ratio of gears 38 and 61 is such that the latter is rotated a quarter revolution for each complete revolution of gear 38.

The shaft 60 has slidably mounted thereon but keyed for rotation therewith a plurality of clutch elements 62, one for each denominational order of the accumulator. The element 62 is provided with a groove in which fits the end of an arm 63 of a suitably pivoted lever 64, which lever is normally held in the position shown by means of the armature 65 of the magnet 66. Upon energization of the magnet the associated armature is displaced thereby releasing the lever 64 which is positioned by the leaf spring 67 to cause the clutch element 62 to move into engagement with cooperating teeth 68, said teeth being integral with gear 69 which is loosely mounted on shaft 60. Gear 69 is then effective to rotate gear 70 and displace the associated accumulator index wheel 71, said gear 70 and wheel 71 being rotatably mounted on shaft 80. Also driven by gear 69 is a gear 72 which is displaced in the same manner as index wheel 71. The ratio of gears 70 and 72 is such that the latter will turn through half a revolution for each revolution of gear 70.

Carried by and insulated from gear 72 is a pair of electrically connected brushes 73, one of which cooperates successively with the conducting segments 74 while the other cooperates with an arcuate conducting strip 75. The relationship of the parts is such that, when the index wheel 70 is in its zero position, one of the brushes 73 is in contact with the zero segment and the other brush is in contact with the conducting strip, thus forming an electrical connection between the two. The positioning of the said brushes provides a convenient electrical readout mechanism for controlling total printing operations and the electrical circuits involved in these operations will be more fully explained in connection with the circuit diagram.



It is to be understood that the accumulator control magnets 66 may be energized at various points in the machine cycle. This energization may take place upon initiation of differentially timed impulses corresponding to the various data designations sensed on the records. For example, upon initiation of timed impulses representing the numeral "9," the control magnet is energized to effect tripping of the clutch element 62 to position the related index wheel 70 and brushes 73 nine steps before a declutching operation is effected by the control elements of the machine. For further detailed description of the accumulator control elements reference may be made to the said patent referred to hereinabove, wherein such well known accumulator operations as denominational order transfer, restoration of the clutch elements and magnet armatures to normal position, and resetting of the accumulator mechanism are specifically described.

The resetting mechanism is shown in a simplified form and comprises generally a reset clutch magnet 76 which when energized effects release of the pivoted pawl 77 so as to cooperate with the clutch element 78 which is secured to an extension shaft 79 of the motor 36. Gear 80*a*, loosely mounted on shaft 79, is now rotated by the said shaft to drive the shaft 80 by means of the gearing 81, thereby causing the individual index wheels 70 to be reset to the normal zero position. In order for the reset shaft 80 to be rotated at the same speed as accumulator shaft 60 a suitable gear reduction unit should be provided ahead of gear 80*a*. To simplify the illustration it can be assumed, as is well known, that the gear reduction is included in the motor 36 so that the extension shaft 79 is rotated at half the speed of the shaft opposite thereto. Control cam 82 is secured to shaft 80 and rotated thereby for controlling the operation of the associated contacts RC1, the purpose of which will be described later. A plurality of control cams 83 are also secured to shaft 60 for controlling the operations of the related contacts CC1 to CC4. In addition thereto, brushes 84 are carried by and insulated from shaft 60, one of which cooperates with the conducting segments 85 while the other cooperates with the arcuate conducting strip 86. This device is generally known as an impulse emitter and is used in the instant application for the initiation of timed impulses for controlling the energization of the accumulator magnets 66 which will be described more in detail in connection with the circuit diagram.

*Data printing means*

The printing or listing unit comprises a printing control cam 90 secured to sleeve 91, which sleeve is rotatably supported by the main drive shaft 60. The operation of the printing unit is under control of the magnet 92 which when energized effects release of the pivoted pawl 93

and clutch plate 94 secured to sleeve 91 (which plate supports the said pawl) so that the pawl engages the clutch element 95 which is secured to shaft 60, thereby causing the sleeve 91 and printing control cam 90 to be rotated in timed relationship with the described control elements of the accumulator.

The member 96 is shown to cooperate with and be actuated by a cam groove in the printing control cam so that the printing bail 97 is effective to impart an upward movement to the typebars 98 by means of the resilient connections such as springs 99 which are secured to the typebars and the said bail.

By virtue of the said spring connections, the typebars may be interrupted without interfering with the upward movement of the printing bail which has an invariable extent of movement controlled by the printing control cam. Energization of any one of the magnets 100 is effective to rock the related spring pressed pivoted latch 101 thereby causing the associated pawl 102 to be released so that it may swing into engagement with teeth 103 and interrupt further upward movement of the corresponding typebar 98. The energization of the magnets 100 may be effected by the timed impulses initiated by the emitter device associated with the accumulator, and due to the synchronously timed operation of the control elements of the printing means with those of the accumulating means the data listed by the printing means corresponds in value to the data accumulated, in the event the corresponding control magnets are energized by the same timed impulses.

Associated with each typebar 98 is a printing hammer 105 which is actuated to strike the positioned type elements 106, which are presented to the printing platen 107, immediately after the positioning of the member 96 to the upper extremity of its movement. For further detailed description of the control elements and operation of the printing unit, which is well known, reference should be made to the patent mentioned hereinabove.

Control cam 108 is secured to sleeve 91 and rotated thereby for controlling the operations of the associated contacts LC1. Carried by and insulated from the extremity of the said sleeve is a pair of electrically connected brushes 109, one brush of which engages the conducting segments 110 while the other engages the arcuate conducting strip 111. The timing is such that a brush successively engages each of the segments 110 as a corresponding type element approaches the printing position opposite the platen, the purpose of which will be understood as the description progresses.

*Tuned reed relays*

There are two tuned reed relays for each column of the record cards, controlled by the reading magnets in a manner which will be described later. The construction of these relays will be explained briefly, with reference to Figs. 5 to 9. A more detailed description will be found in U. S. Patent No. 2,113,617. The relay shown in Figs. 5 to 8 is one of those associated with the reading magnets 50 and 51, while the relay shown in Fig. 9 is one of those associated with reading magnets 52. They differ only in respect to the number of their contacts. The relay shown in Figs. 5 to 8 comprises a group of ten vibratory reeds 115 anchored individually to extension members 116 of yoke 117 so that the free ends



of the reeds can be vibrated in an air gap provided in the yoke. The said extension members engage the reeds at different positions in such a way that each reed has a different but definite period of vibration. The ten different frequencies of the reeds match, respectively, the ten frequencies *f*1 to *f*10 of the magnetic records shown in Fig. 1.

When electrical impulses or oscillations of different frequencies are impressed upon the main coil 118 which surrounds one of the sides of the yoke the reeds tuned to such frequencies are vibrated. A biasing coil 119 is provided to surround the reeds, which coil is constantly energized by a low frequency current for normally holding the reeds in vertical positions so that the free ends thereof are held steady and substantially in the center of the air gap in the yoke.

Individual contact arms 120 are provided for each reed and are arranged so as to be supported by the free ends of the reeds as shown so that the related contacts 121 and 122 normally are held open, and contacts 124 closed. Upon energization of the main coil 118 and upon vibration of the selected reeds 115, the related contact arms 120 drop from the free ends of the reeds thereby causing the said associated contacts 121 and 122 to be closed, and contacts 124 to be opened.

Reset means are provided to restore the contact arms from the said displaced positions to the normal positions, resting upon the free ends of the associated reeds as shown, and generally comprises a reset magnet 125 which upon energization causes arm 126 to be partially rotated in a clockwise direction about its pivot 126*a*. This action is retarded slightly by the dash pot 127 and associated linkages, including a piston 127*a* articulated by a pin 127*b* to an arm 131*b* pivoted at 131*f* to a bracket 135, and a link 131*c* pivotally connected by a pin 131*g* to lever 131*b* and by a pin 131*d* to arm 126. As the said arm approaches its limit of travel in a clockwise direction, the stud 128 which is formed on the arm cams pawl 129 out of a latching position to release the spring urged arm 130. Said arm 130 normally is held in a latched position by means of a shoulder 129*a*, formed on pawl 129, cooperating with a bent-over portion 130*a* of arm 130. The released arm 130, by means of link 131, causes the arm 132 of a U-shaped bracket 133 to be rocked clockwise about a pivot stud 136 on bracket 135. The arm 134 of the bracket 133 has rigidly extending from it an insulated rod 137, which extends under the contact arms 120 in position to engage any displaced arm and restore it to a position in which it can be latched by the related reed 115.

Upon deenergization of reset magnet 125, the spring 131*a* rotates arm 131*b* (in a clockwise direction, in Fig. 6) and pushes the link 131*c* to the left, as viewed in Fig. 6. The pivot stud 131*d* is provided with an extension which projects into the plane of the link 131, the latter being provided with a shoulder 131*e*. As the link 131*c* is moved to the left, the extension of said pivot stud 131*d* bears against the shoulder 131*e* and causes the arm 130 to be moved sufficently, so that the bent-over portion 130*a* can be latched by the shoulder 129*a* of the spring-urged pawl 129.

In Fig. 9 parts corresponding to the reed 115, yoke 117, etc., in Fig. 7, are identified by reference numbers 215, 217, etc. This relay is provided with normally closed contacts 223 and normally open contacts 225, the former being opened and the latter closed, respectively, whenever the associated tuned reed is set into vibration. Relays

of the type shown in Figs. 5 to 8 are diagrammatically represented at 118*a*, 118*b*, and 118*c* in Fig. 11. The subscripts *a*, *b*, and *c* indicate that the relays are associated with columns *a*, *b*, and *c*, respectively, of the record cards. The other relays pertaining to columns *d*, *e*, etc., are not shown in Fig. 11. Relay 118*a* can be controlled by either reading magnet 50*a* or 51*a*, the transfer being effected by a relay R5, whose contacts R5*a* and R5*c* normally connect reading magnet 51*a* in the input circuit of an amplifier 140*a*, the output circuit of which contains the relay coil 118*a*. When relay R5 is energized the input circuit of said amplifier is transferred through contacts R5*b* and R5*d* to the reading magnet 50*a*. The relay coils 118*b*, 118*c*, etc., are disposed in the output circuits of related amplifiers 140*b*, 140*c*, etc., whose input circuits can be similarly transferred by the contacts of relay R5 from reading magnet 51*b*, 51*c*, etc., to reading magnet 50*b*, 50*c*, etc. The relays 118*a*, 118*b*, etc., control the entry of amounts into the accumulator and it will be seen from an illustrative example to be described presently that for this purpose zone 1 of the record cards is read by magnets 50 and zones 2 and 3 are read by magnets 51.

Relays of the type shown in Fig. 9 are represented in Fig. 11 by coils 218*a*, 218*b*, and 218*c*. These are controlled by related reading magnets 52*a*, 52*b*, and 52*c* through conventional amplifier circuits as shown. There is a similar relay, amplifier, and reading magnet unit for each of the reading magnets 52 and they are employed in conjunction with the units associated with the reading magnets 50 or 51, for auto control purposes. The reason for having two alternatively utilized rows of reading magnets 50 and 51 separated from the row 52 by two zone lengths and one zone length, respectively, is that sometimes the auto control comparison is made between two successive zones on one card (in which case reading magnets 51 are used in conjunction with reading magnets 52) whereas at other times the comparison is made between two zones on different cards, separated by a gap of one zone length (in which case magnets 52 read zone 3 of the leading card as magnets 50 read zone 1 of the following card). Therefore, zone 1 is invariably read by magnets 50 and zones 2 and 3 are read by magnets 51.

*Operation of the machine*

As shown in Fig. 10, a normal "card feed cycle" has four "card feed" steps. The card feed cycle is the time required for the card to feed the distance between the leading edge of one card and the leading edge of the next card. The card feed step is the time required to feed the length of one zone. The revolutions of the accumulator shaft are designated D—D in Fig. 10. The accumulator shaft cycle is divided into sixteen points, numbered respectively 9, 8—1, 0, 11, 12—15, 16, the letters D being positioned between the 16 and 9 points, corresponding to the points at which the print clutch pawl 93 engages the notch in disk 95. Fig. 10 also shows a cycle designated "Accumulator cycle," which is the same length as the accumulator shaft cycles D—D, but starts at the 11½ point, where card feed for reading begins. Each accumulator cycle includes a card feed step during which the data in one zone is read into the relays 118, while the data in another zone is read into relays 218; an auto control test of the class data in said relays; and, if the class data agree, an entry of the amount data stored in relays 118 into the accumulator, and recording of said amount data by the printing mechanism. Immediately following the first card feed step, there is an idle card feed step, during which there is no reading of the record. Thus, during the three revolutions of the accumulator shaft 60 constituting one card feed cycle, the card feed clutch dog 31 is engaged during four different revolutions of the shaft 34, to cause four card feed steps.

On the fourth card feed step, the picker 25 feeds a card from the hopper to a position where the first card feed step of the following card feed cycle will feed the first zone of the card past the line of magnets 50 for reading. During the said first card feed step the line of magnets 52 will read the third zone of the preceding card, for comparison of its class data with the class data of the zone then being read by the magnets 50. During the second card feed step, there is no reading of the record. On the third card feed step the second zone of the card is read by the row of magnets 51 and the first zone is read by the magnets 52. On the last card feed step the third zone of the card is read by the row of magnets 51 and the second zone by the magnets 52.

The sequence of events in a normal card feed cycle will first be described, with reference to Figs. 10 and 11, then a total print and reset operation, and finally a complete sequence from the starting of the machine to the feed out of the last card. When the machine is in normal, item entering operation, the contacts R1*a*, R2*a*, and R3*c* are closed. Under these conditions, each time the contacts CC1 close at the 0 point in the accumulator cycle, a circuit is completed from line 135, through contacts 136 of stop key SK2, contacts R2*a*, R1*a*, CC1 and R3*a*, and feed clutch magnet 29, to line wire 138, energizing said magnet and releasing the feed clutch dog 31. One and one-half points later, the dog engages the notch in disk 35 and the feed clutch executes one revolution, at the end of which it may be stopped by the latch 32, contacts CC1 having opened in the meantime. During the first card feed step of each card feed cycle, however, the contacts FC1 close and hold the card feed clutch magnet circuit closed at the end of the first card feed step, thus initiating the second card feed step immediately. The contacts FC1 close only once during a card feed cycle.

It will be assumed that the machine is plugged, as shown in Fig. 11, for cards having amount data in columns *a* and *b* and class data in column *c*. The contacts 121*a* and 121*b* of relays 118*a* and 118*b* are plugged by conductors 142 to two accumulator magnets 66, and by conductors 143 to two print magnets 100. The sets of contacts 122*c*, 124*c*, and 223*c*, 225*c*, pertaining to the tuned relays 118*c* and 218*c*, are plugged by connector 141 to auto control relay R3. The card feed cycle starts with the reading into the accumulator, and with the printing of the amounts stored in the relays 118 during the reading of zone three of the preceding card. Emitter brushes 84 travel over contacts 85 and, through whatever contacts 121*a* and 121*b* are closed, complete circuits as follows: from line wire 135, through normally closed contacts R3*e*, segment 86, brushes 84, contact points 85, contacts 121*a* and 121*b*, conductors 142, accumulator magnets 66, to line wire 138; also through conductors 143 and print magnets 100 to line wire 138, energizing said magnets. The accumulator and the printing mechanism

operate in well known manner to accumulate and print the amounts.

At the 0 point contacts CC1 close, to start the first card feed step of the new card feed cycle, in the manner described. At the 11 point contacts CC4 close, completing a circuit from line wire 135 through said contacts, normally closed contacts R3*i*, the resetting magnets including magnets 125*a*—125*c* and 225*a*—225*c*, to line wire 138, energizing said magnets. These magnets eliminate the settings of the relays 118 and 218 and are held energized during the first half of the card feed step following, in order to hold up the contact arms 120 and 220 until the selected reeds are set in vibration, in a manner to be described shortly. When the resetting magnets are deenergized half-way through the card feed step, the contact arms 120 and 220 pertaining to reeds which are vibrating drop below the normal, supported position and transfer their contacts. The contacts FC2 close at the beginning of the first card feed step and remain closed throughout said step energizing relay R5, which transfers the input circuits of the amplifiers 140*a*, 140*b*, 140*c* to the reading magnets 50*a*, 50*b*, and 50*c*. During the first card feed step, the latter reading magnets are reading the first zone of a card, that is, the magnetic records generate in the windings of magnets 50 alternating E. M. F.'s of certain frequencies designating the values represented by the records. These E. M. F.'s cause the amplifiers 140 to generate amplified currents of the same frequencies in their output circuits, which include the relays 118. A single reed of each relay will accordingly be set in vibration and the corresponding contact arm 120 will drop. At the same time the magnets 50 are reading the values in zone one into relays 118, magnets 52, operating through amplifiers 240 in a similar manner, read the values in zone 3 of the preceding card into relays 218. While the relays 218*a* and 218*b* take settings, as well as the relay 218*c*, only the latter relay is effective, because the machine is plugged for group control on column *c*. Any other column may, however, be used for the purpose, by appropriate plugging. At the 14 point contacts FC1 close, so that the second card feed step will follow immediately after the first.

The contacts CC2 close at the 15½ point that is, at the end of the first card feed step, to compare the settings of the relays 118*c* and 218*c* pertaining to the columns used for class identification. The auto control circuit will be traced later, in describing a total taking cycle. For the present it will be assumed that the closure of contacts CC2 has no effect, due to agreement of the class data.

At the beginning of the second card feed step contacts FC3 close, energizing relay R6. The contacts R6*a* and R6*b*, and corresponding contacts in the output circuits of all the amplifiers 140 and 240, open, removing the relays 118 and 218 from the influence of reading magnets 51 and 52. (Relay R5 is deenergized at the beginning of the second card feed step, transferring the input circuits of the amplifiers 140 back to the magnets 51.) Contacts FC3 remain closed throughout the second card feed step, so no reading is taken during this time.

Following the test of the auto control circuit, by closure of contacts CC2, at the end of the first card feed step, and upon finding the class data in agreement, the traverse of brushes 84 over the contacts 85 results in circuits being completed, as previously traced, to energize accumulator magnets 66 and print magnets 100, at differential times corresponding to the particular contacts in the groups 121*a* and 121*b* which were closed as a result of the reading of the first zone of card during the first card feed step.

At the next 0 point, contacts CC1 close to initiate the third card feed step. One point later, the reading of the values in relays 118 into the accumulator and printing mechanism being completed, contacts CC4 close and eliminate the settings of said relays. The third card feed step begins a half point later and the data in zone two of the record is read by magnets 51 and set up in relays 118, in the manner previously explained, contacts R5*a* and R5*c* being closed at this time. Simultaneously the data in zone one of the record is read by magnets 52 and set up in relays 218. At the end of the third card feed step contacts CC2 close again, to test the class data. Upon finding agreement, the traverse of brushes 84 over contacts 85 reads into the accumulator and printing mechanism the amounts represented in the relays 118. During the remainder of the card feed cycle the contacts CC1 close to initiate the fourth card feed step, the contacts CC4 close to reset the relays 118 and 218, the third zone of the card is read by magnets 51 as the second zone is read by magnets 52, the data being stored in the relays 118 and 218, respectively. On this card feed step the picker 25 feeds another card from the hopper. Finally, contacts CC2 close, to test the class data.

*Total and reset cycles*

If a change in the class data is detected, a total print cycle is automatically initiated and card feeding is interrupted. For this purpose, the contacts 122*c*, 124*c* of relays 118 and contacts 223*c* and 225*c* of the corresponding relays 218 are interconnected in pairs, in the manner shown for the column *c* relays in Fig. 11. If, for instance, during the first card feed step, relay 118*c* has received from column *c* of zone one a 3, while relay 218*c* has received from zone three of the preceding card a 2, when the contacts CC2 close at the end of a card feed step the following circuits will be completed: from line wire 135, through normally closed contacts R4*c*, said contacts CC2, contacts 225*c* and 124*c* for the value 2, also 223*c* and 122*c* for the value 3, connector 141, and auto control relay R3 to line wire 138, energizing said relay. A holding circuit for relay R3 is immediately completed by the closure of contacts R3*d*, through normally closed contacts RC1. Contacts R3*c* open to prevent further card feed steps. Contacts R3*i* open, preventing the energization of resetting magnets 125 and 225 and thus holding the settings of relays 118 and 218. Contacts R3*b* close, completing a circuit from line wire 135 through normally closed contacts R4*d*, said contacts R3*b* and print clutch magnet 92, to line wire 138, energizing said magnet. The clutch dog 93 engages the notch in disk 95 at the next D point and shaft 91 begins to rotate. Contacts R3*f* close, extending a circuit from line wire 135 to segment 111, so that brushes 109, in traveling over segments 110, will complete circuits at differential times through contacts 74, brushes 73, segments 75, conductors 144, and total print magnets 100, to line wire 138. Thus the total standing in the accumulator at the time the group change was detected is printed.

Contacts R3*h* and R3*k* close when relay R3 is energized, preparing circuits to be completed by the closure of contacts LC1 at the 13½ point, fol-

lowing the total read-out period. The completion of these circuits, which include the reset clutch magnet 76 and relay R4, energizes said magnet and said relay. A holding circuit for the magnet and the relay is completed by the closure of contacts R4*a*, these circuits extending from line wire 135 through contacts R3*j*, now closed, said contacts R4*a* and relay R4, also through contacts R3*k* and R3*h* and magnet 76, to line wire 138. Contacts R4*b* open, deenergizing print clutch magnet 92, which latches up at the following D point. Contacts R4*c* open, disabling the auto control circuits which would otherwise be tested by closure of contacts CC2 shortly thereafter. Following the energization of magnet 76 the resetting clutch dog engages the notch in disk 78 at the next D point and shaft 82 rotates, restoring the accumulator index wheels 71 and read-out brushes 73 to zero position. The contacts CC3 open at the 12 point, following the total read-out period, but without effect on the holding circuits of magnets 76 and relay R4, since contacts R3*j* are still closed at this time. At the 13½ point following, contacts RC1 open the holding circuit of auto control relay R3 and all of the contacts of said relay return to the positions shown in Fig. 11. The following circuit is completed by the closure of contacts R3*a*: from line wire 135 through contacts 136, R2*a*, R1*a*, R2*b*, all closed at this time, said contacts R3*a* and print clutch magnet 92, to line wire 130*a*, energizing said magnet. The print clutch engages at the next D point. Contacts R3*h* and R3*k* open, deenergizing reset clutch magnet 76, which latches up at the next D point. Contacts R3*e* close, extending a circuit from line wire 135 to segment 86, so that brushes 84 become effective to read into the accumulator and printing mechanism the amounts held in the relays 118 through the total printing and resetting cycles. Contacts R3*j* open, rendering the holding circuit of relay R4 subject to the contacts CC3, which open at the next 12 point, deenergizing relay R4. Meanwhile, contacts R3*c* having closed, contacts CC1 initiate the second card feed step at the end of the period in which the amount is read into the accumulator and printing mechanism from the relays 118. The machine is now once more in normal item entry condition.

*A complete sequence*

Referring to Fig. 12, a complete sequence will now be described, from the start of the machine until the feed out of the last card. The machine will be assumed to be plugged as in Fig. 11 and to have three cards in the hopper, which have only one class change, namely, between zones 1 and 2 of card 3. The line switches S1 are closed, starting motor 36. Alternator 150 supplies a low frequency biasing current to the biasing windings of relays 118 and 218, including the windings 119*a*—119*c* and 219*a*—219*c*.

The start key SK1 is depressed and held down for some time. A circuit is thus completed from line wire 135 through contacts 136 of stop key SK2, contacts 137 of the start key, and relay R1, to line wire 138, energizing said relay. Contacts R1*a* close, partially preparing a holding circuit to be completed later. On the next closure of contacts CC1 a circuit, previously traced, is completed to energize the feed clutch magnet 29. The card feed mechanism may have latched up, when the machine was last operated, at the end of any one of the four card feed steps which constitute the card feed cycle. Accordingly, there will be either, 3, 2, 1, or no idle steps of the card feed mechanism, preceding the fourth step in the card feed cycle, in which the picker 25 feeds card 1 from the hopper.

On the second card feed cycle, the initial traverse of the brushes 84 over the contacts 85 will have no effect, the relays 118 being in zero condition. On the first card feed step of the second card feed cycle, the magnets 50 will read zone 1 of card 1, as indicated by the notation in Fig. 12 "50 read 1—Z—1." At this time the magnets 52 will read nothing. The values read from zone 1 are stored in relays 118. At the end of the first card feed step, contacts CC2 close, completing a circuit through the auto control relay R3, as previously traced. The auto control relay is invariably energized at the end of the first feed step of the first card, because the class number set up in the relay 118 appertaining to the class column has no counterpart in the corresponding relay 218. A total print cycle is thus initiated, in the manner previously described. The second card feed step follows the first immediately, but no reading occurs on this step. Part way through the second card feed step, that is, just before the card feed step in which the classification data of zones one and two of the first card will be compared, the card lever closes contacts 54, energizing relay R2. Contacts R2*a* close and maintain an extension of line wire 135 to contacts CC1 and FC1, and a holding circuit for relay R1, as long as the card lever contacts are closed. The start key SK1 can now be released. The total print cycle is followed by a reset cycle.

At the end of the reset cycle the amount stored in the relays 118, from card 1, zone 1, is entered in the accumulator and recorded by the printing mechanism. Shortly thereafter, the third card feed step begins, during which magnets 51 read zone 2 of card 1 and the magnets 52 read zone 1 of card 1. The contacts CC2 test relays 118 and 218 for agreement. No discrepancy being found, the fourth feed step follows, during which magnets 51 read zone 3 of card 1 as magnets 52 read zone 2 of card 1.

The third card feed cycle is a normal cycle in which no class change is detected and the card feed steps take place without interruption. The sequence of entry into the accumulator and printing mechanism and reading of the records is shown in the sequence chart.

In the fourth card feed cycle a discrepancy is found between the class numbers at the end of the third card feed step, that is, between zone 2 and zone 1 of card 3. This causes a total print cycle and a reset cycle to intervene, the entry of the amount read from zone 2 being deferred until the end of the reset cycle.

At the beginning of the fifth card feed cycle, the amount stored in relays 118 from zone 3 of card 3 is entered in the accmulator and printed by the printing mechanism. During the first card feed step which follows, the magnets 50 read a blank, since it was assumed that there were only three cards in the hopper. At the same time magnets 52 read zone 3 of card 3 and set the relays 218 accordingly. This results in a discrepancy being detected between the relays 118*c* and 218*c*, when the contacts CC2 close at the end of the first card feed step, which throws the machine into a total print cycle, followed by a reset cycle. There is no entry at the end of the reset cycle, because no values stand in the relays 118. The third and fourth card feed steps take place in regular order and soon after the begin-

ning of the fourth feed step the card lever contacts 54 open. Relay R2 is deenergized, opening the holding circuit for relay R1, which is also deenergized. The connection of contacts CC1 to line wire 135 being broken, magnet 29 remains deenergized and the card feed mechanism ceases to operate. It can, however, be operated for any number of steps required to feed the last card all the way out, by holding down the start key SK1.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a single modification it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A machine for manifesting data recorded on a magnetic record sheet by columns of magnetic recordings which designate different data characters by different frequency characteristics, sensing means comprising a sensing device for each column responsive to magnetic frequency records, means for relatively moving the record sheet and sensing means at a uniform rate to cause the sensing means to sense their respective columns concurrently, individual storage units, one for each sensing device, each storage unit including a set of contacts and means responsive to the different frequencies which may occur on the record for selectively operating said contacts, means connecting the sensing means to the respective storage units so as to transmit the frequencies sensed thereby, a cyclically operable emitter comprising a series of contacts and means for supplying potential thereto in sequence, multi-column manifesting means comprising a differentially operable data manifesting unit for each storage device, electrically responsive control means for each data manifesting unit, means including the contacts of the respective storage units for selectively connecting the control means of the different data manifesting units to said emitter contacts, means for operating said data manifesting units concurrently under control of their respective control means to manifest the data, and means for restoring the storage units after each manifestation.

2. A machine for manifesting data recorded on a magnetic record sheet by columns of magnetic recordings which designate different data characters by different frequency characteristics, sensing means comprising a sensing device for each column responsive to magnetic frequency records, means for relatively moving the record sheet and sensing means at a uniform rate to cause the sensing means to sense their respective columns concurrently, individual storage units, one for each sensing device, each storage unit including a plurality of tuned devices resonant, respectively, to the different frequencies which may occur on the records, and settable devices controlled by the respective tuned devices, means connecting the sensing means to the respective storage units so as to transmit the frequencies sensed thereby, multi-column manifesting means comprising a differentially operable data manifesting unit for each storage device, means for concurrently operating said data manifesting units, under control of the settable devices of the respective storage units, when the latter have been set to manifest the data stored in the storage units, and means for restoring the storage units after each manifestation.

3. In a machine controlled by records whereon different data characters are represented by recordings having different frequency characteristics, means for feeding the records in sequence, dual sensing means responsive to magnetic frequency records for concurrently sensing two successive records fed by said feeding means, said feeding means being adapted to feed the records past said sensing means at a uniform rate, a storage unit for each sensing means, each storage unit including a group of tuned devices selectively responsive to the different frequencies which may occur on the records and a switch for each tuned device, the switches being operable by the respective tuned devices, means connecting the sensing means to the respective storage units so as to transmit the frequencies sensed thereby, means comprising an electric circuit the completion of which is determined by the joint control of switches pertaining to tuned devices in both groups, for comparing the data sensed on successive records by said sensing means, and means controlled by said comparing means, upon detection of a disagreement of the compared data, for stopping said feeding means.

4. In a record controlled machine, three record sensing devices at three different stations, means to feed records to be compared past said sensing devices in succession, the spacing, in the line of feed, being different between different pairs of successive records, said sensing devices being located so that two successive records will be sensed concurrently by one of said sensing devices and by one or the other of the other two sensing devices, comparing means partially controlled by said first sensing device, means to render the other two sensing devices effective alternatively to control said comparing means jointly with said first sensing device, and control means controlled by said comparing means.

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