Aug. 8, 1944. A. H. DICKINSON 2,355,282

TRANSMISSION SYSTEM FOR STATISTICAL DATA

Filed Feb. 3, 1939 7 Sheets-Sheet 1

FIG.1.

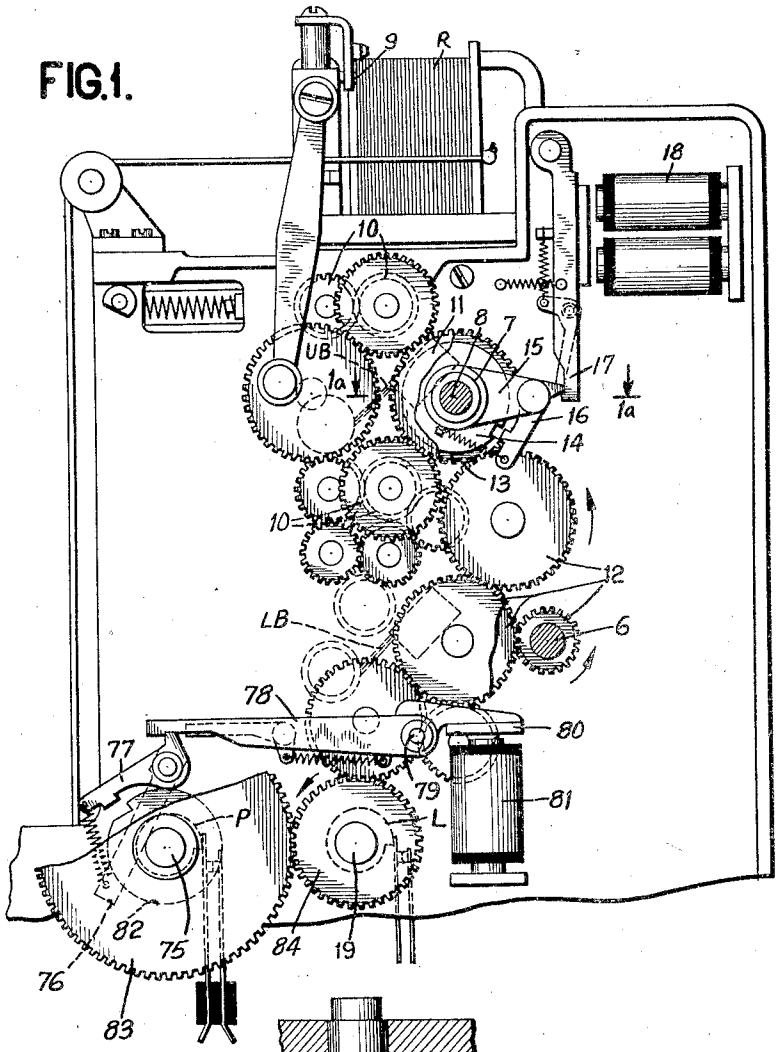
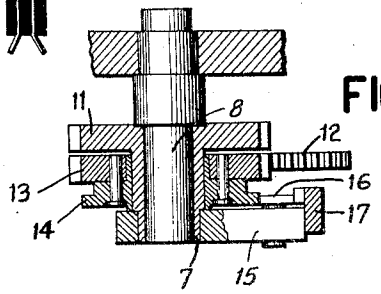


FIG.1a.



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TRANSMISSION SYSTEM FOR STATISTICAL DATA

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FIG.6.

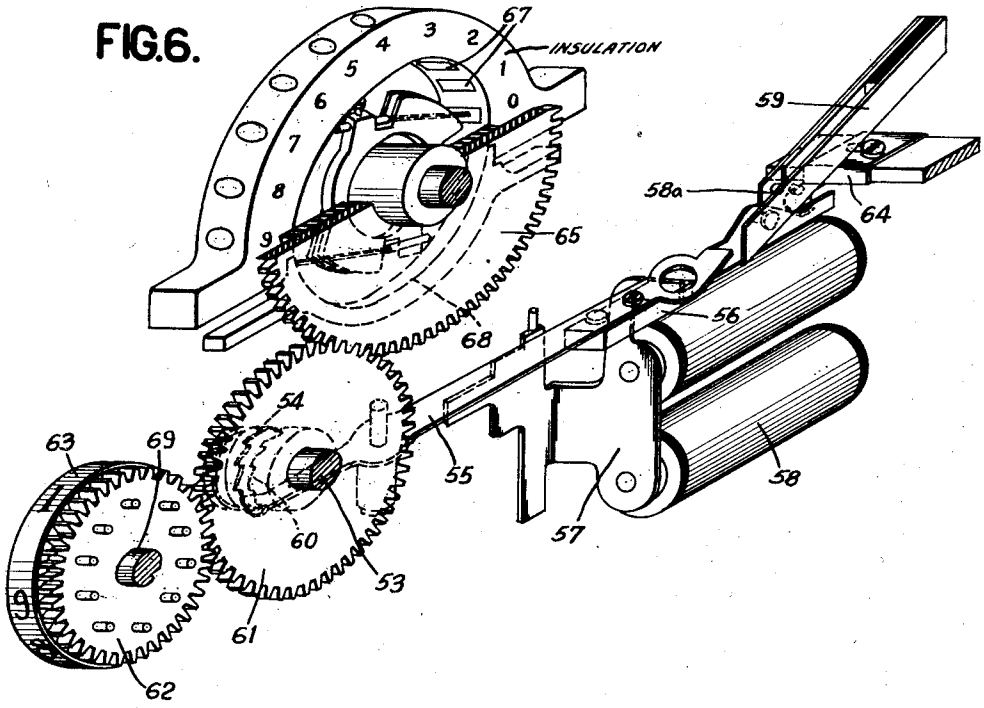
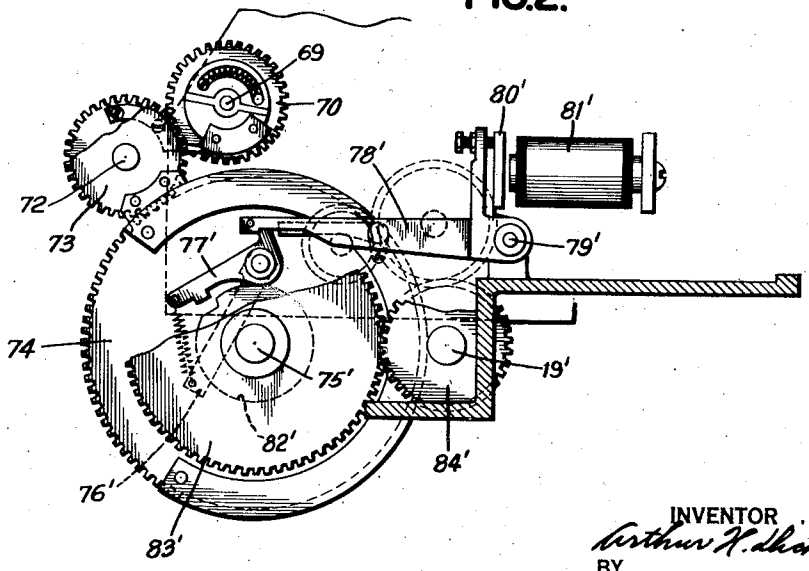


FIG.2.



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TRANSMISSION SYSTEM FOR STATISTICAL DATA

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FIG.3.

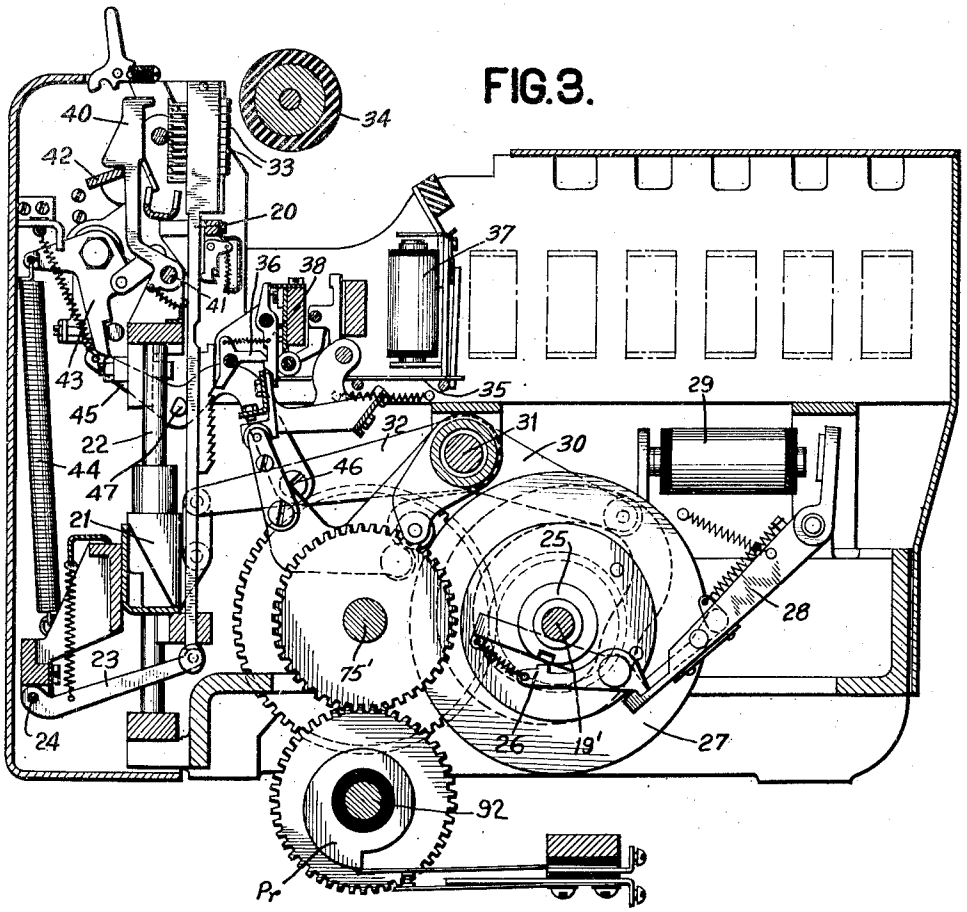
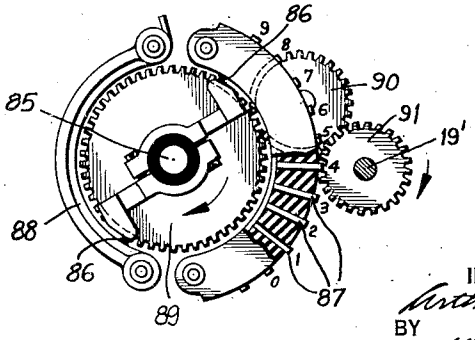


FIG.4.



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TRANSMISSION SYSTEM FOR STATISTICAL DATA

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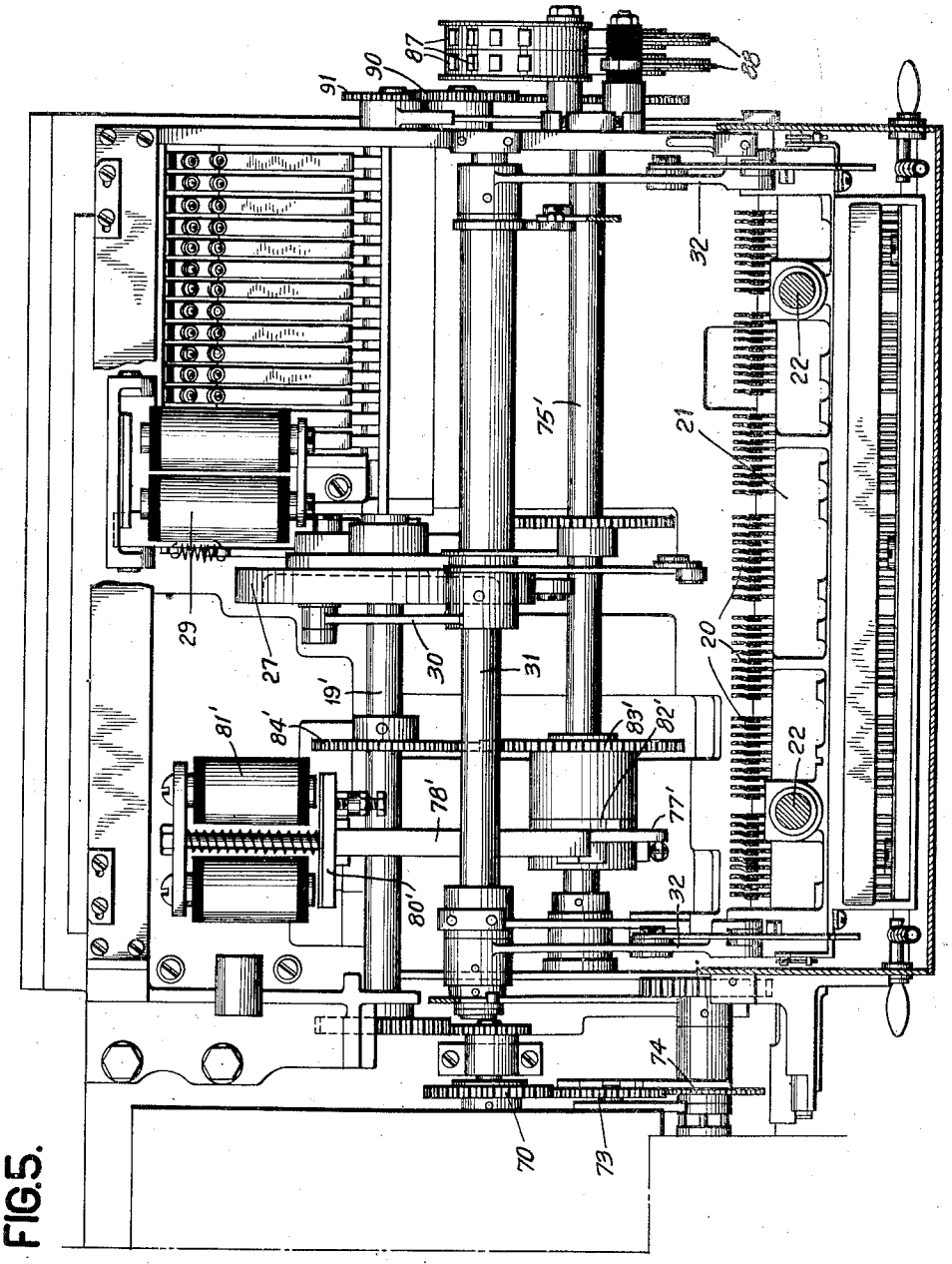

FIG.5.

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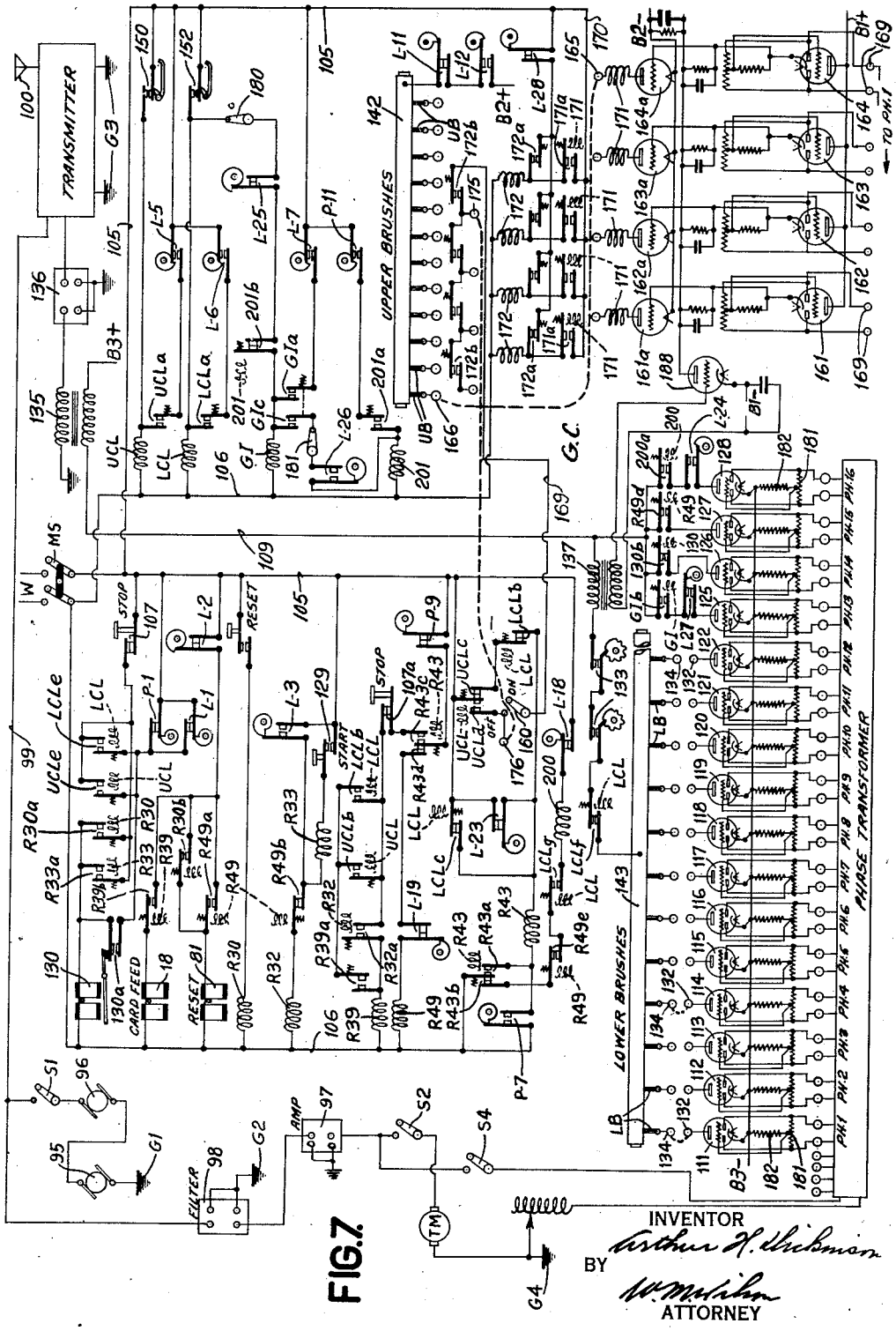

FIG. 7

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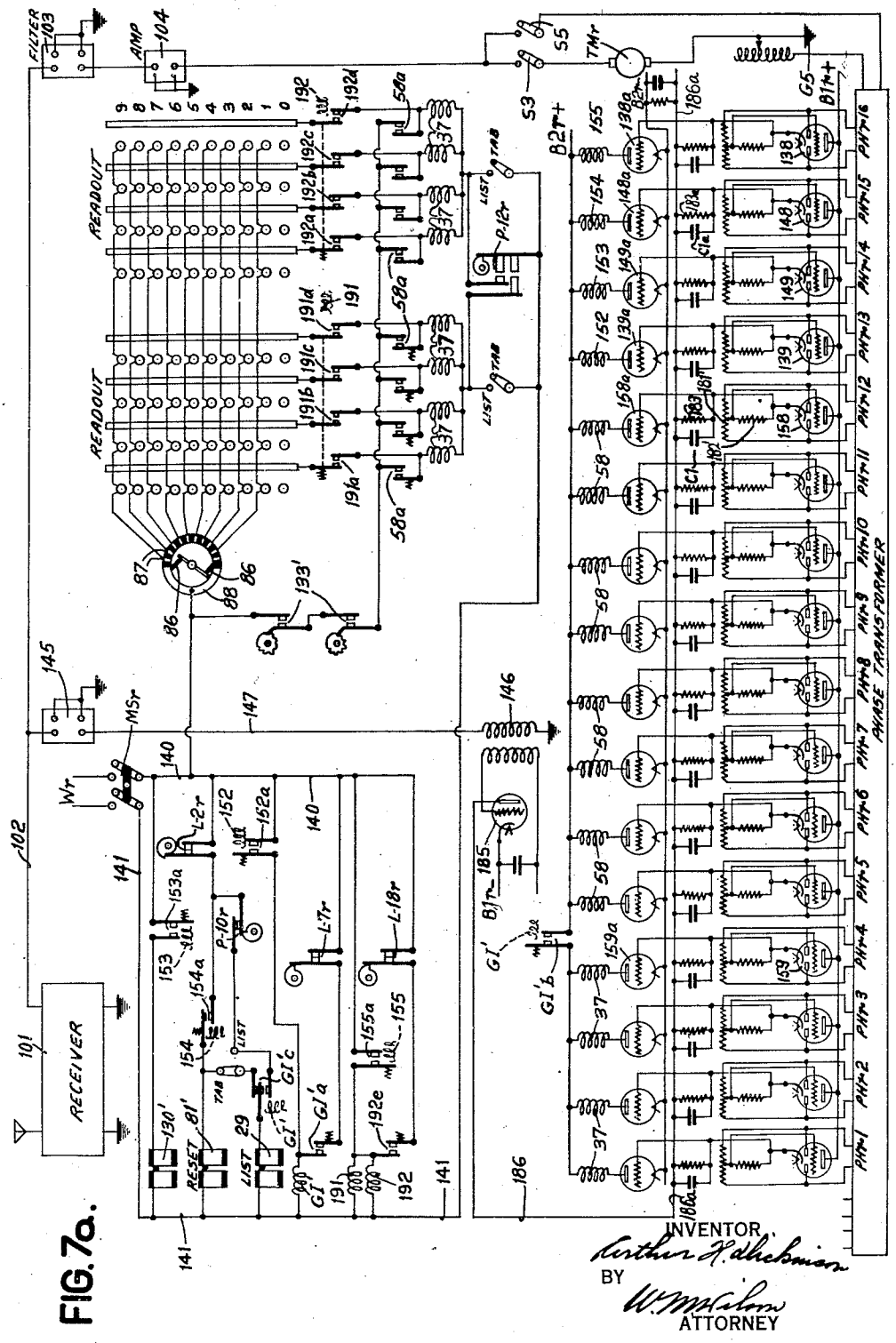

FIG. 7a.

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TRANSMISSION SYSTEM FOR STATISTICAL DATA

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FIG. 8.

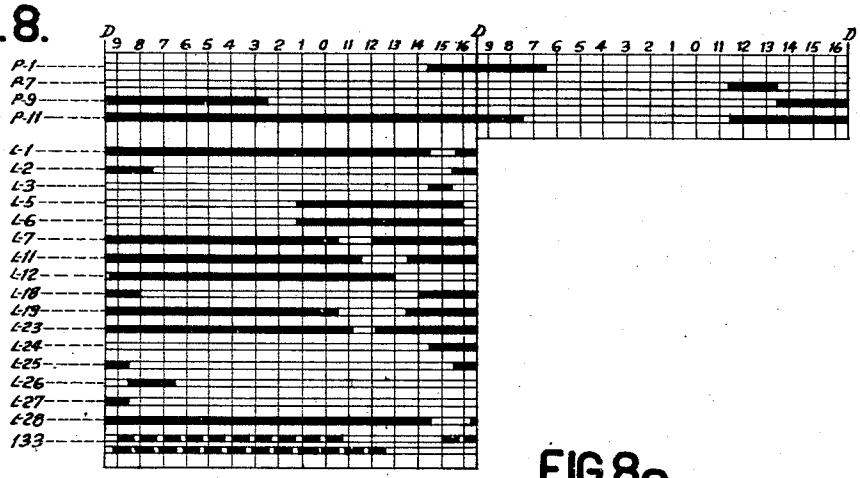
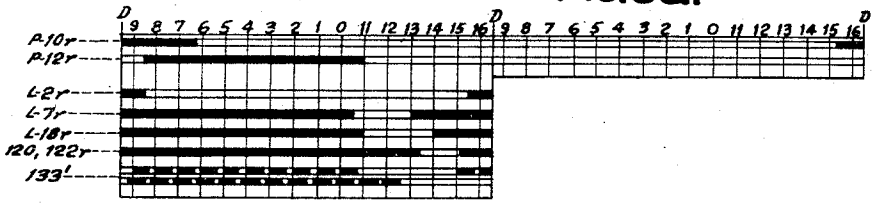


FIG. 8a.



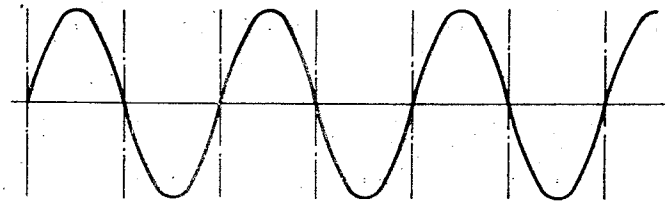


FIG. 9.

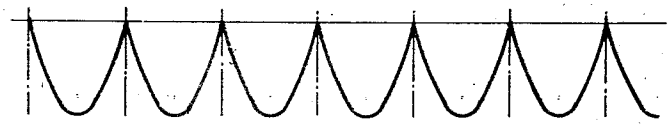


FIG. 9a.

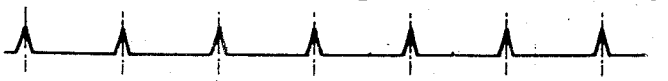


FIG. 9b.

FIG. 10.

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UNITED STATES PATENT OFFICE

2,355,282

TRANSMISSION SYSTEM FOR STATISTICAL DATA

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Application February 3, 1939, Serial No. 254,411

9 Claims. (Cl. 235—61.7)

This invention relates to transmission systems for statistical data and, more particularly, to systems of the type wherein data accumulating and recording units are provided at a secondary station to be operated in accordance with data transmitted from a primary station.

It is the general object of the present invention to provide novel means for transmitting concurrently a plurality of orders of statistical data to a distant point over a single transmitting medium.

A more specific object of the invention is the provision for columnar separation of a plurality of columns of data to be transmitted by assigning a different electrical phase relationship to each column.

Another object is to provide means for effecting digit separation in accordance with differential time while attaining columnar separation of the data in accordance with different phase relationships.

Still another object of the invention is to provide means to form a succession of impulses which by their phase differences represent different columns of statistical and control data, to transmit these impulses simultaneously, and to separate the same into component impulses to effect entry into, and operation of, accumulating and recording units of an accounting machine.

A further object is the provision of means whereby different phases are used to distinguish one column of data from another irrespective of the differential time at which they become effective.

A still further object is to provide means whereby a plurality of different phases representing columns of statistical data are employed to modulate a carrier wave for simultaneous transmission and, upon transmission, are separated from the latter and further separated into distinct impulses for effecting control of an accounting machine at a distant point.

It is also an object of the invention to provide record control of the operations of a distantly located accounting machine in their proper sequence by signals of different phase relationships.

Another object resides in the provision of automatic group control means which is responsive to a series of impulses of different phase relationships transmitted simultaneously to compare these impulses with control indicia appearing on record cards to effect control of both transmitting and receiving units in accordance with record groups.

An additional object is the provision of means whereby corresponding phase relationships are established for corresponding columns of record cards presented successively at a sensing station and the time at which like phase relationships are established on successive record cards is compared by automatic group control means to control accumulating, total taking, and resetting operations of an accounting machine at a distant point.

In the usual electrical tabulating and accounting machines, the general circuit pattern comprises a single circuit extending to an analyzing unit where the record card, by its passage therethrough and the data indications it bears, causes a number of parallel circuits to be completed to the automatic group control, accumulating, and recording units, the parallel circuits thereupon combining over a single circuit for the return to the source of power supply. According to the present invention, however, a plurality of sources of energy are provided and are transmitted simultaneously under record control over a single medium, whereupon the original plurality of electrical characteristics are reestablished as distinct impulses for the control of accumulating and recording units. The fact that a single carrier medium rather than parallel circuits is utilized becomes particularly advantageous where the accumulating and recording units of an accounting machine are remotely located with respect to its card feeding and analyzing unit. It is to be remembered, nevertheless, that the present invention is equally applicable to an accounting machine of the usual compact structure.

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 an outside view of the record feeding and analyzing mechanism showing the card feed and reset clutching devices, which mechanism is located at the transmitting station.

Fig. 1*a* is a detail section on line 1*a*—1*a* of Fig. 1.

Fig. 2 is a detail view of the controlling devices of the accumulator resetting mechanism at the receiving station.

Fig. 3 is a central section of the printing mechanism at the receiver.

Fig. 4 is a detail of an impulse emitting commutator associated with the printing mechanism.

Fig. 5 is a plan sectional view showing the main driving and operating mechanism for the printing unit.

Fig. 6 is a view of one order of the accumulator.

Fig. 7 is a representative diagram of the circuits associated with the transmitter.

Fig. 7*a* is a diagram of the circuits at the receiver.

Fig. 8 is a timing chart of the circuit closing devices utilized in the circuits at the transmitter.

Fig. 8a is a timing chart of the circuit closing devices employed in the receiver circuits.

Figs. 9, 9a, and 9b show the relationship of the wave shapes of the currents energizing the various units of the system.

Fig. 10 illustrates the relationship of the out-of-phase impulse wave forms for one embodiment of the invention.

The machine to which the features of the present invention are applied is similar to that shown in the U. S. Patent #1,976,617 issued to C. D. Lake and G. F. Daly on October 9, 1934. That patent illustrates and explains in more extensive detail the manner of organization and mode of operation of the various units of a well known type of accounting machine. In the present application, these units will be explained in only as much detail as will be necessary to point out the manner in which the objects of the present invention may be realized.

Before setting forth the general operation of the machine, the various mechanical units will be described and their relationship pointed out thereafter.

Card feeding mechanism

The card feeding mechanism shown in Fig. 1 is identical with that shown and described in the aforementioned patent except that provision is made in the form of a clutching device for interrupting the card feeding operations without stopping the main drive shaft. As described in the said Lake & Daly Patent 1,976,617, the main drive shaft, which is the shaft 13 in the patent, is normally held stationary in a certain angular position, known in the art as the "D" position. Upon energization of a solenoid, it is released and clutched to a constantly running pulley member. Similar arrangements are utilized in accordance with the present invention to start the main drive shafts of the independently located card feeding and manifesting mechanisms from corresponding "D" positions at the same instant, by clutching them simultaneously to two synchronized motor drives, in a manner to be explained. The analyzing brushes are indicated at UB and LB, and a stack of record cards R are successively advanced by picker 9 to pairs of feed rollers 10 which serve to advance the cards past the upper and lower brushes UB and LB in succession. The shafts upon which rollers 10 are mounted are provided with gears at their extremities, arranged as shown in Fig. 1 for operation by a main driving gear 11 which is freely mounted upon a shaft 8 and which has connection with an arm 15 through a sleeve 7 (Fig. 1a). Arm 15 carries a spring-pressed clutching dog 16 normally held in the position shown by an armature latch 17 which is adapted to be controlled by clutch magnet 18. Between gear 11 and arm 15 are located gear 13 and clutch driving disc 14 freely rotatable upon the sleeve 7. Gear 13 has connection generally designated 12 with main drive shaft 6 which is in operation as long as it is clutched to the driving pulley, as described in the Lake and Daly Patent 1,976,617. Energization of magnet 18 causes dog 16 to be tripped into engagement with disc 14, and the card feeding mechanism thereupon causes the records T to be advanced past the brushes UB and LB. Card feeding operations continue as long as magnet 18 remains energized.

During total taking cycles of operation to be explained later, magnet 18 is deenergized and thus card feeding will not take place during such cycles.

Printing mechanism

The printing mechanism is shown in Fig. 3 where type bars 20 are carried by cross-head 21 which is slidable vertically on rods 22. Spring-pressed arms 23 pivoted to the cross-head at 24 have their free ends butting the lower extremity of the type bars so that, as the cross-head moves upwardly, the type bars are urged in the same direction. The reciprocating movement of the cross-head is controlled from shaft 19' corresponding to shaft 19 of Fig. 1, the latter being continually driven from the main operating shaft 6 at the transmitter, whenever the main clutch is engaged, and the former being driven from a corresponding shaft (not shown) at the receiver which is kept in synchronism and constant phase relationship to shaft 6, in a manner to be described hereinafter. Shaft 19' has secured thereto a clutch driving element 25 notched to cooperate with a clutching dog 26 carried by and pivoted to listing cam 27. Clutch releasing arm 28 cooperates with dog 26 to hold the parts in the position shown when magnet 29 is deenergized. Energization of magnet 29 causes arm 28 to rock in a counterclockwise direction releasing dog 26 for engagement with element 25 whereupon the listing cam rotates with shaft 19' and, through follower arm 30, effects the rocking of shaft 31.

Secured to shaft 31 are arms 32 whose free ends have link connection to the cross-head 21 causing the latter to be reciprocated once for each revolution of the listing cam. As the type bars move upwardly, the type elements 33 successively pass the printing position opposite platen 34 and ratchet teeth 35 successively pass the toe of the stop pawl 36. Energization of printing magnet 37 effects the tripping of latch 38, permitting stop pawl 36 to engage one of the ratchet teeth 35 and thus positioning the corresponding type element opposite the platen.

Associated with each type bar 20 is a spring-pressed printing hammer 40 pivoted at 41. The hammer normally rests against an operating bail 42 also pivoted at 41, the bail being operatively connected to a tripping member 43 which is biased in a counterclockwise direction by a spring 44. The lower extremity of one arm of member 43 is in latching cooperation with an arm 45 pivoted at 46 to the cross-head operating lever 32. As the lever 32 is rocked in a clockwise direction to elevate the cross-head 21 and the type bar 20, the pivot 46 is moved upwardly therewith and causes the tripping member 43 to be rocked clockwise against the action of spring 44. The connection between the bail 42 and the member 43 is such that the bail is rocked counterclockwise away from the type elements 33. As the lever 32 reaches its utmost extremity of travel, a pin 47 carried by arm 45 brings about the release of the tripping member 43 so that the latter is rocked rapidly in a counterclockwise direction by the action of spring 44. The hammer bail 42 is concurrently rocked in a clockwise direction against the hammers 40 causing the latter to strike the type elements 33 which are in a printing position to effect printing therefrom.

Accumulating mechanism

The adding mechanism is identical to that shown and described in patent referred to and the description thereof will accordingly be limited to a brief explanation of its manner of operation. The accumulator drive shaft 53 (Fig. 6) is geared directly to the main drive shaft at

the receiver (not shown) which corresponds to, and is kept in synchronism and constant phase relation with shaft 6 at the transmitter (Fig. 1). The annular relationship between the teeth on the main clutch ratchets and the armatures of the synchronous motors TM and TMr is initially established by timing marks on the respective elements. The ratchets have a tooth for each possible angular position at which they may be pulled into synchronous speed. Thus, if the engaging pawls of the clutches are tripped slightly ahead of the tooth in which they are to engage, a slight variance in the tripping time will not cause any detrimental effect in view of the fact that they are engaged at the same instant by the driving faces of the next ratchet teeth. Shaft 53 is thus kept in operation as long as the driving motor at the receiver is clutched thereto and the driving ratio is such that this shaft makes one revolution for each record feeding cycle at the transmitter. A clutch element 54, slidably mounted on shaft 53 but keyed for rotation therewith, is provided for each denominational order of the accumulator. The element 54 is provided with a groove in which fits the short arm of a lever 55 pivoted as shown and having a block 56 normally held as in Fig. 6 by armature latch 57 of an adding magnet 58. A leaf spring 59 bears against the extremity of the longer arm of lever 55 and moves the same in a counterclockwise direction upon release of block 56 by armature 57. This movement brings clutching member 54 into engagement with cooperating teeth 60 which are integral with a gear 61 loosely mounted on shaft 53. Gear 61, when thus coupled to shaft 53, causes the rotation of a gear 62 meshing therewith and consequently the displacement of accumulator index wheel 63. The rearward extremity of member 55 is adapted to be engaged by a finger 64 toward the end of the cycle for the purpose of disengaging the clutch element 54 from teeth 60 and relatching block 56 on armature 57.

Briefly summarizing the adding operation, it is noted that magnet 58 may be energized at various points in the cycle of the machine, depending upon the location of a data indication in a column of the record card being analyzed by the lower brushes LB. This energization may occur in response to a digit indication in any of the index point positions from 9 to 1 inclusive. Should a digit indication be in the "9" index point position, clutch element 54 is tripped nine steps before finger 64 is operated to declutch it. Similarly, a digit indication in the "1" index point position causes the clutch element 54 to be tripped one step before it is declutched by the finger 64. The digit indications are customarily in the form of holes in the card. Each step of clutching arrangement corresponds to a tenth of a revolution in the accumulator index wheel 63 so that a "9" hole moves the wheel $^9/_{10}$ of a revolution and a "1" hole moves it $^1/_{10}$ of a revolution. Energization of adding magnet 58 also causes the closing of a pair of so-called accumulator-list contacts 58*a* associated therewith to establish circuits to the print magnets on listing cycles which will be described later in connection with the circuit diagram.

Read-out mechanism

Also driven by gear 61 is a gear 65. Since the ratio of gears 65 and 62 is 2:1, the former will turn through a half revolution for each revolution of the latter. Carried by and insulated from gear 65 is a pair of electrically connected brushes 66, one of which cooperates successively with the conducting segments 67 while the other cooperates with an arcuate conducting strip 68.

The relationship of the parts is such that, when the index wheel 63 is in its zero position, one of the brushes 66 is in contact with the zero segment 67 and the other brush is in contact with the strip 68, thus forming an electrical connection between the two. If the wheel 63 is displaced to indicate, say, "8," then one of the brushes 66 will be in contact with the "8" segment 67 and the other brush will be in contact with the arcuate strip 68.

The positioning of the brushes 66 provides a convenient electrical read-out mechanism for controlling total printing operation and the electrical circuits involved in these functions will be more fully explained with reference to the circuit diagram.

Accumulator resetting mechanism

The shaft 69 (Fig. 6) upon which the index wheels 63 of an accumulator are loosely mounted is slotted for cooperation with spring-pressed pawls (not shown) pivoted upon and carried by the individual index-wheels in such manner that counterclockwise rotation of shaft 69 causes the index wheels 63 to become engaged and driven forwardly to the zero position during a single revolution of shaft 69.

Referring to Fig. 2, shaft 69 carries a gear 70 at its extremity which is in engagement with gear 71 mounted upon reset shaft 72. Gear 71, of which there is one for each accumulator, is coupled to the resetting shaft 72 in the well known manner more fully explained in the patent above referred to. At the extremity of shaft 72 is a gear 73 (see also Fig. 5) which is adapted to be driven by an intermediate gear 74 which is secured to shaft 75' which corresponds to shaft 75 shown in Fig. 1. Also fixed to shaft 75' is an arm 76' which carries a spring-pressed clutch dog 77' normally held in the position shown in Fig. 2 by a latching arm 78' supported by armature shaft 79' of magnet armature 80'.

Energization of magnet 81' causes dog 77' to be released for engagement with clutch driving element 82'. Element 82' is integral with a gear 83' which meshes with a gear 84', secured upon the shaft 19' which is running constantly as long as the main drive shaft is clutched to the driving pulley. With this arrangement, drive element 82' is in constant rotation and whenever it is desired to effect resetting of the accumulators, magnet 81 is energized to provide a connection between the element 82' and the resetting shaft 72. Resetting is usually an accompaniment of total taking and, by virtue of an intermittent gear connection, occurs during the latter part of a total taking cycle after the totals have been printed.

Although there are no accumulators at the transmitter, a reset clutch is provided as shown in Fig. 1 for operating the P cams which are mounted on shaft 75 and have circuit controlling contacts associated therewith. This clutch mechanism is similar to that just described for the accumulators at the receiver and corresponding parts at the transmitter are given the same reference characters without the primes. The clutch is engaged during a total taking cycle to cause the P cams to operate their associated contacts to control the machine during a print-

ing cycle at the receiver. If the printing is accompanied by a resetting operation at the receiver, then both reset clutches function in unison as will be better understood upon explanation of the wiring diagram. It should be mentioned that proper speed and phase relationship of shafts 75 and 75' are maintained, since the drive shafts 19 and 19' at the transmitter and receiver, respectively, are operated in exact speed and phase relationship. The reset magnets 81 and 81' are energized at the same time in the cycle, under control of the related cam contacts, to cause driving engagement of the related clutch mechanisms 77 and 82, and 77' and 82', respectively, at the same time.

Circuit controlling devices

In Fig. 4 is shown a so-called emitter which cooperates with the read-out devices of the accumulator for total printing operations. Carried by a stud 85 coaxially with the shaft 75' is a pair of electrically connected brushes 86, one of which contacts with conducting segments 87 while the other wipes over a common arcuate conducting strip 88. The brushes 86 are carried by a gear 89 driven through an idler 90 from a gear 91 carried by constantly running shaft 19'. The emitter used for controlling total printing operations is timed so that a brush 86 successively contacts with each of the segments 87 as the corresponding type elements 33 of Fig. 3 approach printing position opposite platen 34.

A plurality of cam-controlled contacts, operable only during printing and reset cycles, are provided at the receiver, these contacts being prefixed with the letter "P" but bearing the subscript *r* to distinguish them from the P cams already referred to at the transmitter. The P*r* cams are mounted on a shaft 92 driven from shaft 75'. Similar cam controlled devices prefixed with the letter "L" are carried by or may be driven from shaft 19 at the transmitter and shaft 19' at the receiver and these are in constant operation as long as the driving pulleys are clutched to the main drive shafts. It will be noted in the timing chart (Figs. 8 and 8*a*) that the P and P*r* cams are two-cycle cams. This is for the reason that the drive ratio between the cam shaft and the drive shaft is such that these cams make only one revolution for two revolutions of the drive shaft. It is understood that the purpose of such a gear ratio is to provide sufficient time for a total printing cycle to occur. The contacts associated with the constantly running cams at the receiver are provided with a subscript *r* to distinguish them from the L-cam contacts at the transmitter.

The usual circuit breakers 133 and 133' are provided at the transmitter and receiver respectively and are timed to make at the beginning of each index point in the machine cycle and break before the end thereof to control circuits to the accumulators and print magnets as will be explained later.

Contacts 150, 152 are operated by the conventional upper and lower card levers which, in turn, are actuated by cards passing the upper and lower sensing stations, respectively. Card lever contacts serve the purpose of preventing initial operation of the feeding mechanism except upon depression of the start key 129 (Fig. 7). These contacts are instrumental in causing the feeding mechanism to stop at the end of a cycle upon a card feeding failure or when the machine runs out of cards.

All cam contact devices are indicated in the timing diagrams (Figs. 8, 8*a*) where their relative timing may be observed.

General explanation of the circuit diagram

The wiring diagram of the electric circuits is shown in Figs. 7 and 7*a* wherein the various cam contact devices are diagrammatically shown and suitably labeled L, L*r* or P, P*r* as just explained. The exact timing of these contact devices is shown in Figs. 8, 8*a* to which reference may be made for the actual time in the cycle of operation during which they function. Due to the presence of numerous interlocking relays in the circuits both at the transmitter and receiver, it has not been advisable in all instances to show relay magnets and their associated contacts in close proximity to one another.

For purposes of clarity in the wiring arrangement the relay contact points are shown in the circuits which they control and their relay magnets are repeated adjacent thereto. Furthermore, the contacts are designated with the same reference numeral as their controlling magnet, followed by a lower case letter.

Synchronizing means.—The driving motors at the transmitter and receiver may be operated in synchronism by any well known means, a preferred method being that illustrated in the U. S. Patent #1,505,158, issued to De Loss K. Martin on August 19, 1924. This method will now be explained briefly in connection with Figs. 7 and 7*a* and if more detailed description is desired, reference may be made to the above Martin patent. The obvious purpose of maintaining the driving mechanism at each station in synchronism is to assimilate most nearly the condition of an accounting machine having the usual compact structure in which the various units are driven from a common, constantly running drive shaft.

At the transmitter (Fig. 7) a pair of alternators 95 and 96 are provided to supply electrical power at two different frequencies. The frequency set up by alternator 95 becomes the carrier frequency of the system whereas the frequency established by alternator 96 is utilized purely as a synchronizing frequency. Upon the closing of switch S1, a circuit is completed from ground G1, alternator 95, alternator 96, switch S1 now closed, either through filter 98 to ground G2 or via conductor 99 through transmitter 100 to ground G3. Filter 98 is comprised of suitable circuit elements which may be inductance, capacitance, or resistance. Filters are generally classed as high pass, low pass and band pass filters, filter 98 being of the low pass type and designed to permit the synchronizing frequency but not the carrier frequency to pass therethrough. The synchronizing frequency which appears at the output of the filter is fed to the input of an amplifier 97, then upon closing of switch S2, the output circuit of amplifier 97 affords a power supply through switch S2, motor TM, to ground G4. Motor TM is a synchronous motor and is thereby driven at synchronous speed in accordance with the controlling frequency of the alternator 96. It is noted that both the synchronizing frequency and the carrier frequency are impressed upon the transmitter and that the output of the transmitter is in turn impressed upon the aerial and transmitted therefrom as radiant energy in the well known manner.

It will be understood that wherever an amplifier such as 97 is shown hereinafter, the power supply

is included in the diagrammatic outline representation of the amplifier and its connected surface. Furthermore, it will be appreciated that the representative showing includes as many stages of amplification as are necessary to provide sufficient power to operate whatever load may be connected to its output.

When the receiving device 101 receives this radiant energy from the transmitter, it is demodulated and its output includes a signal having a frequency corresponding to the synchronizing frequency mentioned above. Receiver 101 is shown diagrammatically in box form but is understood to include the fundamental sections which comprise the radio frequency amplifier, a detector or demodulator, and an amplifier for the output of the detector, and that such amplification is provided as will be necessary to supply a current of sufficient strength to operate the various relays and magnets of the accumulators and print unit.

In the present system it will be noted that at the transmitter a current having a given frequency is provided for synchronizing purposes. This current is amplified at the transmitter to drive the motor TM at a fixed speed. The same current is also utilized to modulate the transmitter from which it is sent to the receiver as radiant energy in the well known manner. The radiant energy is demodulated by the receiver, the output of which includes a current having the synchronizing frequency. The latter current is separated from the total output of the receiver and is amplified to drive the motor TM*r* at the same fixed speed as TM. It will be appreciated in this method of synchronizing that, although the power employed for driving the motors at the transmitter and receiver respectively is supplied locally, a current of predetermined frequency is utilized commonly at both transmitter and receiver for controlling the respective local sources of power.

The feed mechanism is driven by motor TM through shaft 6 and accumulators and print mechanism by motor TM*r*, through the corresponding shaft of the receiver (not shown) and the shafts 53 and 19', as previously explained. Since motors TM and TM*r* are driven at identical speed by current of the same frequency, and since the main drive shafts are clutched to their driving pulleys at the same instant and thus started from the "D" position simultaneously, as previously described, the shafts at the transmitter and at the receiver are driven in a synchronous relationship closely approximating the condition normally attained by actual mechanical connection between these parts in the usual tabulating machine structure.

Phase transformers.—The source of energy which drives the motors TM and TM*r* in the manner just described is also sent to energize a phase transformer at the transmitter and receiver upon the closing of switches S4 and S5, respectively. The internal connections of these transformers are not shown but may be of the type explained in detail in the U. S. Patent 2,153,178, issued to Clyde J. Fitch and dated April 4, 1939. The action of the phase transformers is to take single phase synchronous alternating current and sub-divide the same into as many equally spaced phases as may be required by the system. The turns ratio of the windings are such that the voltages delivered across the free ends of the secondary circuits are equal. For purposes of illustration, sixteen such secondary circuits are provided and are designated PH1 to 16. Eight of these circuits, PH5 to 12, are used for adding into the accumulators, four (PH1 to 4) are reserved for automatic group control and group indication, and the remaining four (PH13 to 16) are employed in controlling the routine operations of the units at the receiver, all of which will be described hereinafter. Different phase sine wave currents are taken off the various phase connection outlets of the secondary of the transformer at the transmitter but it is obvious that a plurality of let us say 60 cycle sine waves cannot be transmitted simultaneously over the working channel of a single radio network to effect the different operations of system referred to above. In order to overcome this difficulty the wave shapes similar to that of a sine wave are changed to the forms illustrated in Fig. 10, one method of which will now be described.

Wave form modifying and impulse generating circuits.—Referring now to Fig. 9, a sinusoidal wave form of the alternating current is shown and is similar to the current wave forms developed by each of the plurality of secondary circuits previously explained. These sinusoidal current waves may then be impressed upon any type of full wave rectifier to change the current wave shape to conform to that shown in Fig. 9*a* which is representative of the pulsating current wave forms. In turn the rectified current wave forms may then be applied as follows: First of all, it will be understood that if the voltage applied to the grid of a thermionic tube is made sufficiently negative with respect to the cathode, current flow in the input or plate circuit is suspended. When such suspension occurs, the cut-off point of the tube is said to have been reached. The so-called cut-off point of a thermionic tube and the value of the negative potential which must be applied to the grid thereof to cause it to attain this cut-off point are dependent upon the operating characteristics of the particular tube employed. Now if the voltage rectified wave forms corresponding and similar to those of the current wave forms shown in Fig. 9*a* are impressed on the grid of the thermionic tube, for example, and the voltage is sufficient to drive the tube far below its plate-current cut-off point, the shape of the current waves in the plate circuit will be altered to conform to the shapes shown in Fig. 9*b*. The characteristics of the circuits may be selected and adjusted so that the length of the base of the short impulses shown in Fig. 9*b* is approximately one-sixteenth of the distance between the impulses. Of course it is obvious that the particular wave shapes may vary according to the characteristics of the circuits employed, and it is evident by the method just described or by conversions based upon the same principle, that many different wave shapes of the resultant current may be obtained. Accordingly, only a preferred method will be given.

In further explanation of the principle of wave conversion just described, this entire action may take place automatically in a single thermionic tube of a type well-known in the art comprising a combination of a full wave rectifier and triode in one envelope. The electrical connections for this type of tube may be as shown in Fig. 7 for tubes 111 to 128, the alternating voltage sinusoidal wave being applied across a center tapped resistor 181 in each of these tube circuits so that the wave shape of the current flowing through this resistor, or the voltage across it, is similar to that shown in Fig. 9. A resistor 182 is connected between the cathode of the tube and the center tap of resistor 181, the terminals of which are connected to the two rectifier plates of the said tube. Therefore, the wave shape of the rectified current through resistor 182 and the voltage across this resistor

is similar to that shown by the pulsating wave in Fig. 9a. The grid of the tube may be also connected to the center tap of the resistor 181, the grid being normally at zero bias due to the fact that no current is passing through resistor 182. Then voltage across resistor 182 may be applied between the grid and cathode of the said tube. If the said voltage is of sufficient value the tube may be driven far below its plate current cut-off point to obtain a plate current having a wave shape similar to that shown in Fig. 9b. This is impressed accordingly on the connected out-put circuit which includes the plug wire connection between jacks 132 and 134, lower brush LB, contact roll 143, normally insulated from brush LB by a record card being fed therebetween, relay contacts LCLf which are closed when a card is at the lower brushes, circuit breakers 133, now closed, transformer 137, conductor 109, transformer 135, to positive terminal B3+. The negative terminal B3— is connected directly to the cathode, and current flows through the triode plate circuit just described upon electrical connection between the brush LB and the contact roll 143 through a digit indication in the corresponding column of the record card. This current flow lasts for only a comparatively short time, however, because the bias on the grid is not a constant factor but varies in timed relationship with the frequency of the A. C. supply coming from the secondary of the phase transformer.

The said supply is impressed upon the full wave rectifier and therefore the rectified voltage impressed on resistor 182 immediately drives the grid bias negative with respect to the cathode to a sufficient value to prevent further flow of plate current in the triode output circuit. The plate current is thus reduced to a substantially zero value, and remains so until the grid bias is reduced nearly to zero again, whereupon a pulse is impressed upon the output circuit of the triode. This pulse is utilized as a signal and is sent from the transmitter to the receiver to control one of the various functions of the machine to be described later.

From the foregoing description, it will be understood that if sixteen separate phases spaced 11¼ electrical degrees apart are taken off of the secondary of the phase transformer and connected to sixteen electrical circuits embodying a tube of the type just described so that the terminals of the separate resistors 181 are joined with the terminals of the secondary windings of each phase, sixteen series of short impulses similar to those shown in Fig. 10 may be generated. It will be noted that no two impulses overlap or occur at the same time, and therefore any number of phases may be transmitted over the single carrier medium simultaneously.

Referring now to Fig. 7a, a plurality of receiving circuits are connected to the secondary of the phase transformer at the receiver. As these circuits are all alike, a description of one of them, for example the one leading from the transformer connections PHr12, will suffice. This circuit includes a diode triode tube 158 and an ordinary triode tube 158a having adding magnet 58 in the plate circuit thereof. The operation of the diode triode tube 158 in rectifying and changing the wave form of the A. C. current supply from PHr12 is the same as that already described for the tube circuits at the transmitter. The grid of tube 158a is connected in the cathode circuit of tube 158 and is arranged to be normally biased to cut-off. Negative potential of a supply source represented by terminal B1r— is applied to the cathode of a tube 185, the plate of which is connected by a conductor 186, 186a to one side of a resistance 183 and a condenser C1, each of which lead to the cathode circuit of tube 158 and, consequently, to the grid of tube 158a. Positive potential of the same supply source denoted by terminal B1r+ is applied to the anode of tube 158.

Another source of potential is employed and is represented by terminals B2r+ and B2r—. Terminal B2r+ is positive with respect to terminal B2r— and the latter may be considered slightly positive with respect to a common wire 186a. It will be noted that terminal B1r+ is also positive to wire 186a, whereas B1r— is negative with respect to wire 186a.

When a signal is received at the receiver, it is impressed on the high biased tube 185 and via conductor 186, 186a to the circuits embodying the tube 158. Condenser C1 becomes charged to actuate the grid of tube 158a in such a manner that, assuming the phase relationship of the signal is the same as PHr12, tube 158a is caused to pass a virtually steady current through its plate circuit to energize adding magnet 58 thereby effecting addition in that particular order of the accumulator. It will be noted that tube 158a, normally inoperative, becomes operative only upon reception of a signal of the phase corresponding to the phase PHr12. The signal phase and the tube circuit phase must agree in order that the tube 158a may be operated since the bias placed on the grid of tube 158a by each of these supply sources individually is insufficient to cause a flow of current through the windings of adding magnet 58.

At the transmitter (Fig. 7) the same arrangement of tube circuits is provided in connection with the control magnets 171 of the group control mechanism generally designated GC. The tube circuits, including tubes 161 to 164, are pluggable from jacks 169 to the phase connections PH1 to 4 of the phase transformer. The signal supply comes through transformer 137 and tube 188 to selectively operate the tubes 161a to 164a according to which of the phases PH1 to 4 the signal phase corresponds.

Initial reset cycle.—Slightly above the tube circuits just described in Fig. 7 is located the usual group control mechanism generally designated GC, and as is usual in tabulating machines, it is first necessary to set up the group control holding relay magnet R43 before the card feeding mechanism previously described can be set in operation. This is effected by depression of the reset key to close contacts 110, thereby completing a circuit from right side of line 105, contacts 110, relay coil R30, to left-hand side of line 106. The lines 105 and 106 are connected through a main switch MS to a suitable source of supply W which provides the electrical energy for energizing the transmitter circuits such as the one just described. Energization of magnet R30 closes its contacts R30a in the upper part of Fig. 7 which will thereupon complete a circuit from right side of line 105, stop key contacts 107, contacts R30a now closed, main drive clutch magnets 130, to line 106. Magnets 130, upon becoming energized, cause a coupling of the drive motor to the main drive shaft 6, mentioned above, and, incidentally, also causes the closing of contacts 130a which provide a holding circuit for magnets 130 through cam contacts L1 to line 105. Cam contacts L1 open toward the end of each

cycle, and at such time, the circuit is maintained through either contacts UCL*e* or LCL*e* which are in series with stop key contacts 107. Cam contacts P1 are provided to cooperate with contacts L1 by overlapping the break in the later contacts during a reset cycle, to maintain the magnet 130 energized for two machine cycles. The timing chart may be observed in Fig. 8. The manner in which one or more of these contacts in the holding circuit may be opened to interrupt the same will be explained hereinafter.

The relay magnet R30, energized by depression of the reset key, closes a second pair of contact points R30*b* to complete a circuit from line 105, cam contacts L2, contacts R30*b*, reset magnet 81, to line 106. As explained in the mechanical description, energization of magnet 81 causes a cycle of operation of the P cam contacts at the transmitter to control various circuits of the system. Contacts P7 (at the lower part of Fig. 7), for example, close to energize the group control relay magnet R43 from line 106, cam contacts P7, relay magnet R43, contacts LCL*c* or L23, to line 105. The manner in which the group control mechanism GC functions in the system will be described later.

Prior to the closing of cam contacts P7 to energize magnet R43 in the manner just described, however, relay magnet R49 is energized by a circuit from line 106, relay magnet R49, cam contacts L19, relay contacts R43*d*, cam contacts P9, to line 105. Magnet R49, upon energization, closes contacts R49*d* to complete the output circuit of tube 127 for causing transmission of a control signal of a characteristic phase (PH15) to the receiver, this output or plate circuit being traceable from negative terminal B3—, cathode and plate of tube 127, relay contacts R49*d* now closed, via conductor 109 through the primary winding of transformer 135 to positive terminal B3+. Pulses are thus set up in the secondary winding of transformer 135 by transformer action and are applied to the input of filter 136 which is of such a construction as to pass pulses of the control signal to transmitter 100. At the transmitter these pulses are superimposed on the carrier wave and transmitted to receiver 101 (Fig. 7*a*). Corresponding pulses are set up in the output circuit of the receiver on conductor 102. Filter 145 permits pulses representing the control signal to pass through it and along conductor 147 to the primary winding of transformer 146. The secondary winding of the transformer 146 is connected to the grid element of a highly biased tube 185 and, upon energization of the primary winding, transformer action occurs, which reduces the bias on the grid of tube 185 sufficiently to cause this tube to pass current. The output circuit of the tube includes negative terminal B1*r*—, cathode and anode elements of tube 185, conductors 186 and 186*a*, to and through resistance 183*a*, thereby creating a voltage drop which charges the condenser C1*a* in parallel therewith, then through cathode and plate of tube 148 to terminal B1*r*+. The resistance 183*a* and condenser C1*a* have connection with the grid element of tube 148*a* so as to reduce the bias on the grid and cause a flow of current through the plate circuit of this tube to energize magnet 154. A separate power source, denoted by terminals B2*r*+ and B2*r*—, is provided for tube 148*a* and similar tubes in the same row (Fig. 7*a*) and the arrangement is such that, when any of these tubes is conditioned to pass current, its connected magnet is energized from this power source. Contacts 154*a* close when magnet 154 is energized to complete a circuit for energizing the reset magnet 81' from line 141, reset magnet 81', contacts 154*a* now closed, cam contacts L2*r* to line 140. Lines 140 and 141 are connected to a suitable source of supply W*r* through the main switch MS*r*. The energization of magnet 81' causes the resetting of the accumulators, to clear out any old amounts which may be standing therein and prepare the accumulators for new entries. The main clutch 130', of course, must be energized to drive the adding wheels through the reset just described. Referring to the lower part of Fig. 7, contacts 130*b* close upon energization of the main clutch 130, so that tube 126 supplies power at a characteristic phase PH14 to the receiver over a circuit similar to that previously traced for a signal of phase PH15 except that the circuit from terminal B1*r*— (Fig. 7*a*) through conductors 186 and 186*a* now passes through circuits associated with tube 149 to bring about a change in the bias on the grid of tube 149*a* for causing the latter tube to pass current to energize its related magnet 153 in the same manner as described for tube 148*a*. Relay contacts 153*a* close to energize the main clutch 130'. Briefly, then, upon depression of the reset key both main clutches and both reset magnets are energized concurrently to cause the operation of the P cams at the transmitter and the operation of the P*r* cams and the reset of the accumulators at the receiver. Immediately following the reset cycle, the feeding of record cards may be initiated upon depression of the start key.

Starting circuit.—With relay magnet R43 energized and the accumulators cleared, depression of the start key to close contacts 129 completes a circuit from line 105, conductor 123, contacts 129, relay magnet R33, relay contacts R49*b*, relay magnet R32 to line 113. The contacts R49*b* will be in their normal deenergized position because when magnet R43 is energized, the circuit to magnet R49 is broken. Relay contacts R33*a* are in parallel with the previously mentioned contacts R30*a* and complete the following circuit through the main clutch magnet 130: from line 105, stop key contacts 107, relay contacts R33*a* now closed, main clutch magnet 130, to line 106. The energization of magnet 130 is again accompanied by the energization of the main clutch magnet 130' at the receiver by means of the previously described circuit energized from tube 126. Thus, the main drive shafts of the transmitter and the receiver start and continue to run at identical speed and phase relation.

Relay magnet R32 is provided with a pair of contacts R32*a* which are adapted upon closure to complete a circuit to the card feed control relay magnet R39. This circuit is traceable from line 106, relay magnet R39, contacts R32*a* now closed, stop key contacts 107*a* (operable concurrently with the contacts 107), contacts R43*c* of the group control relay magnet R43 which are now closed, cam contacts P9, to line 105. This circuit, it will be observed, can only be completed when the group control relay magnet 43 is energized. Magnet R39 closes its contact points R39*b* which are wired in series with card feed clutch magnet 18 to energize the latter so that records commence to feed. Contacts R39*a* also close to provide a holding circuit for magnet R39 through lower card lever relay contacts LCL*b* which close as the first record card reaches the lower brushes.

Card lever circuits.—As the record cards are

advanced past the upper set of analyzing brushes UB, the usual upper card lever contacts 150 are closed to complete a circuit from line 105, contacts 150, magnet UCL, to line 106. Magnet UCL controls a number of contacts which are disposed in various circuits for controlling purposes. One of these contacts, for example UCLe pointed out above as being in the holding circuit for the main clutch 130, helps interrupt this circuit if cards fail to feed past the upper brushes. Deenergization of main clutch 130 is always accompanied by deenergization of main clutch 130' at the receiver, because contacts 130b (Fig. 7) open to break the previously described control circuit to the receiver from tube 126, with the result that the main drive shafts are simultaneously latched up in the "D" position, in the well known manner. Since the card lever contacts 150 open between successive cards, a holding circuit is provided through contacts UCLa and cam contacts L5 which serve to maintain magnet UCL energized during the interval when contacts 150 are open. In a similar manner, the lower card lever relay contacts 152 cause energization of lower card lever relay LCL and the contact points LCLa cooperate with cam contacts L6 to provide a similar holding circuit.

Listing circuits.—The circuit for the listing magnet 29 (Fig. 7a) is completed from line 140, cam contacts L2r, cam contacts P10r, TAB-LIST switch set to the list position, upper and center straps of relay contacts GI'c, listing magnet 29, to line 141. Through this circuit magnet 29 is energized during each cycle of operation of the machine and the printing mechanism will function accordingly.

As the record cards advance past the lower brushes LB at the transmitter, circuits are provided for communicating the descriptive data analyzed by these brushes through accumulator list contacts 58a to the printing magnets 37 at the receiver which control the stopping of the type bars as already explained in operation of the printing mechanism given hereinbefore. The list contacts 58a are closed upon energization of the adding magnets as the latter receive impulses from the analyzing brushes LB at the transmitter. The adding circuit will be explained later. The closing of a pair of accumulator list contacts 58a completes a circuit to a print magnet 37 as follows: from line 140, circuit breaker contacts 133' now closed, the particular contacts 58a which are also now closed, the print magnet 37 in series therewith, LIST-TAB switch set to LIST, to line 141. Print magnet 37 upon energization stops the upward movement of the type bar it controls to effect the listing of the digit analyzed on the record card at the transmitter.

Adding circuits.—The circuits for adding into the accumulators are completed simultaneously with the listing circuits just described when all the list control switches are set for listing. When the switches are set to the other position, no listing occurs but adding into the accumulator takes place as data entries are read from each card passing the lower brushes LB. A representative adding circuit is traceable from terminal B3—, cathode and plate of tube 122, jack 132, plug wire to jack 134, brush LB through the hole in the card in the corresponding column, contact roll 143, relay contacts LCLf now closed, circuit breaker contacts 133, primary winding of transformer 137, conductor 169, primary winding of transformer 135 to terminal B3+. From transformer 135 over to transformer 146 at the receiving station (Fig. 7a) the transmission circuit is identical with that previously described. The circuit from terminal B1r— over conductors 186 and 186a is now completed, however, through the circuits embodying tube 158 to B1r+. Tube 158, it will be noted, has its rectifying portion operating under the influence of phase PHr12 which corresponds to the phase PH12 controlling tube 122 (Fig. 7). Upon operation of tube 158, the associated tube 158a is caused to pass current from the source denoted terminals B2r— and B2r+ through the related magnet 58. The circuit just traced energizes the adding magnet 58 for one order of the accumulator to turn its adding wheel in a manner previously described to effect addition.

Group control.—When the group control switch 160 (Fig. 7) is set to the ON position, cards are allowed to continue to feed as long as the control indicia on successive cards passing the upper and lower brushes remain the same. The principle is the same as that shown in Patent #1,976,617 previously referred to. A representative control circuit is from terminal B3—, cathode and anode of tube 111, jack 132, plug wire to jack 134, lower brush LB, through hole in the card in the corresponding column, contact roll 143, contacts LCLf now closed, circuit breaker contacts 133 also now closed, primary winding of transformer 137, conductor 169, primary winding of transformer 135 to B3+. Through the transformer action of transformer 137, the negative bias on the grid element of tube 188 is lowered to a sufficient extent to cause this tube to pass current. The output circuit of this tube is traceable from terminal B1—, cathode and anode of tube 188, through the circuits connected with tube 164 which are similar to those previously described at the receiver, through the cathode and anode of this tube, to terminal B1+. Operation of tube 164 causes 164a to be conditioned for passing current from terminal B2—, through cathode and anode of tube 164a, magnet 171 connected thereto, jack 165, plug wire to jack 166, upper brush UB in the corresponding column, hole in the card, contact roll 142, contacts L11 and L12 now closed to terminal B2+. It will be noted that the circuit just traced depends upon the fact that the hole in the record card at the upper and lower brushes is the same in the particular column on which the control is operating. Energization of the particular magnet 171 by the circuit just traced causes the closing of its 171a contact points which are in series with one of the control magnets 172 and provide a circuit to energize the latter from line 106, magnet 172, contacts 171a, common conductor 170 to line 105. Contacts 172a close when magnet 172 becomes energized to provide a holding circuit through cam contacts L28, and contacts 172b also close to complete a circuit for maintaining the group control relay magnet R43 energized. The latter circuit is traceable from line 106, relay contacts R43a, relay magnet R43, conductor 169, contacts 172b now closed, jack 175, plug wire to jack 176, through left and center strap of contacts UCLc now closed, to line 105. This circuit is not set up upon the occurrence of a group change and the relay magnet R43 is deenergized on the next cycle when L23 breaks, the card feed mechanism continuing under its momentum to the end of the cycle where it is latched up by the card feed clutch 18. The operations just described are well known in the tabulating art and are de-

scribed in detail in the previously mentioned Patent #1,976,617.

Total printing and reset cycle

After the opening of relay contacts R43c (Fig. 7) upon the occurrence of a group control change, relay contacts R43d close to complete a circuit from line 106, relay magnet R49, cam contacts L19, contacts R43d now closed, cam contacts P9, to line 105. Energization of relay magnet R49 closes its contact points R49a which are in series with the reset clutch magnet 81. The circuit which energizes magnet 81 is traceable from line 106, magnet 81, relay contacts R49a now closed, cam contacts L2, to line 105. Relay contacts 49d also close to render tube 127 effective to energize the circuit for operating reset clutch magnet 81' at the receiver concurrently with the energization of magnet 81 at the transmitter in a manner already described under the heading of "Initial reset cycle." Upon energization of the reset magnet 81 the P and Pr cams start to turn and the first operation to take place is the printing of the totals standing in the accumulators at the receiver. This is brought about as follows: at the start of the cycle a circuit is completed from line 106, relay contacts R43b, relay contacts R49c now closed, contacts LCLg now closed since there is a card at the lower brushes, relay magnet 200, cam contacts L18, to line 105. Energization of relay magnet 200 causes its contact points 200a to close, thereby to complete a circuit to the receiver from terminal B3—, cathode and anode of tube 128, cam contacts L24 now closed, contacts 200a, conductor 109, primary winding of transformer 135 to terminal B3+. The transmission circuit from transformer 135 to transformer 146 at the receiver (Fig. 7a) is as previously described herein. A circuit is completed from B1r—, cathode and anode of tube 185, conductors 186 and 186a, through the circuits connected with tube 138, cathode and anode of this tube to terminal B1r+. It will be understood from what has gone before that this results in the conditioning of tube 138a for the passage of current from the source denoted by terminals B2r— and B2r+ to energize magnet 155. Energization of magnet 155 by the circuit just traced completes an obvious circuit for energizing total print control magnets 191, 192 which are then maintained energized through contacts 192e and cam contacts L18r. Contacts 191a—d and 192a—d connect the readout mechanism of the accumulators with the print magnets 37, the latter becoming energized at differential times under the control of the total print emitter as its brushes 86 sweep the segments 87, in a manner already described, to stop the type bars in accordance with the totals standing in the accumulators and thus effect printing of these totals.

The total printing operation is followed by a resetting of the accumulators to clear the same in preparation for new entries to be made therein from the following group of record cards. This is so well known in the art that further description here is deemed unnecessary.

Automatic resumption of card feeding

Cam contacts L3 are provided to energize the start relay magnet R32 near the end of the resetting cycle of operations to pick up and energize the card feed clutch magnet 16. The circuits involved in the starting of the machine have been already traced in detail and the operations controlled thereby will proceed in the same manner as above.

Group indication cycle.—On the first tabulating cycle after a reset, if certain machine switches are properly thrown, a group indication is effected in the following manner: the GI magnet (Fig. 7) is energized by a circuit from line 106, relay magnet GI, contacts 201b, contacts L25, switch 180 in the position shown for group indication, lower card lever contacts 152, to line 105. Relay magnet GI is held energized through its contacts GIa and cam contacts L7. Shortly after the energization of magnet GI, cam contacts L26 make (see timing chart Fig. 8) to complete a circuit for energizing the control magnet 201. The circuit is traceable from line 106, magnet 201, contacts L26, now closed, switch 181 in the position shown for group indication, contacts GIc now closed, contacts GIa also now closed, cam contacts L7, to line 105. Magnet 201 is maintained energized through its contact points 201a which now close and cam contacts P11. Energization of magnet 201 causes normally closed contacts 201b to open in order to prevent the energization of magnet GI on subsequent tabulating cycles prior to the next group change.

Magnet GI, when energized, causes contacts GIb to close and a circuit is completed when contacts L27 close from terminal B3—, cathode and anode of tube 125, contacts L27, contacts GIb, conductor 109, primary winding of transformer 135, to terminal B3+. The transmission circuit is the same as previously traced down to and through the primary winding of transformer 146 (Fig. 7a). A circuit is then completed from terminal B1r—, conductors 186, 186a through the circuits embodying tube 139, cathode and anode of tube 139, to B1r+. Tube 139a is then conditioned to pass current to energize magnet 152 in the same manner as already described for similar tubes and magnets. Energization of magnet 152 closes its contacts 152a to complete an obvious circuit for energizing the group indication relay magnet GI' at the receiver. Contacts GI'a close to provide a holding circuit for magnet GI' through cam contacts L7r. Contacts GI'b also close and a circuit is completed, as was traced previously for the magnet 152 as far as conductor 186a, then through the circuits embodying tube 159, cathode and anode of this tube to terminal B1r+. Operation of tube 159 influences tube 159a in the now understood manner to bring about the energization of print magnet 37 connected thereto. Energization of print magnet 37 effects the usual group indication, this circuit being completed only on the first card cycle after a reset because of the fact that magnet GI at the transmitter is deenergized when L7 breaks and contacts GIb open to break the plate circuit of tube 125. It is understood that the list clutch magnet 29 is energized for this cycle to set the printing mechanism in operation to print the group indication just referred to. The specific circuit is traceable from line 141, list clutch magnet 29, center and lower strap of contacts GI'c now closed, cam contacts P10r, cam contacts L2r, to line 140.

Summary of operation

It is seen, then, from the above description how a plurality of displaced signals are generated at the transmitting station, by the use of a phase transformer and tube circuits leading from the secondary connections thereof.

Certain of these signals are effective to control the routine operations of an accounting machine at the receiving station. Others are initiated as the analyzing brushes contact digit indications in the data columns of the record card, the relative displacement of each of the latter signals being representative of the data column from which it originates. Where more than one column of the record card contains statistical data with like digit values, then a characteristic columnar signal for each is set up simultaneously, for all practical purposes. Strictly speaking the two signals are displaced from each other according to predetermined phase relationships assigned to them and do not interfere with each other.

Each signal passed to the transmitter has both primary and secondary differentiating characteristics, the former being a constant phase timing which is used to segregate the signal in the correct channel of the receiving station; the latter being a variable distinguishing characteristic, preferably a differential timing, which is translated by suitable manifesting means into a partcular character. The signals form a combined wave on a common carrier medium, and this wave is transmitted to the receiver where similar tube circuits and a phase transformer are provided to cause the incoming signals to select their various orders in the accumulating and printing mechanisms, or functional control devices in accordance with the phase of said signals.

The group control signals as it will be remembered, do not go to the receiver. There is however, at the transmitter a combined wave formed of these signals and a separation out by means of further tube circuits to provide for the normal operation of the group control mechanism.

It will be appreciated that the number of signals being sent is ever-changing and the columnar relationship of the data is destroyed in the combination of the signals with the carrier wave. At the receiver the signals are separated according to their phases and the columnar relationship of the data is thereby reformed, as is manifested by the operation of the corresponding orders of the accumulator or type bars.

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. In a system for concurrently manifesting a plurality of characters in definite relative positions, electrical transmitting means and receiving means interconnected by a single medium of transmission, alternating current means for generating a number of signals constantly differentiated by phase displacement to identify each with a particular one of said positions, control means adapted to impart to the individual signals secondary distinguishing characteristics representative of the significations of the characters in the positions to which they respectively appertain, said transmitting means being responsive to said signals to transmit to said receiving means signals reproducing the phase displacement and secondary distinguishing characteristics of the signals passed by said control means, means operatively connected to said receiving means for segregating the signals received thereby, according to their phases, and manifesting means comprising a plurality of units operatively associated with said segregating means so as to be individually controlled by the respective segregated signals, the units of said manifesting means being differentially responsive to the signals in dependence upon the secondary distinguishing characteristics, to manifest the characters in their proper relative positions.

2. In a system for concurrently manifesting a plurality of characters in definite relative positions, electrical transmitting means and receiving means interconnected by a single medium of transmission, alternating current means for generating a number of signals constantly differentiated by phase displacement to identify each with a particular one of said positions, control means adapted to pass the signals individually to said transmitting means at differential times representative of the significations of the characters in the positions to which they respectively appertain, said transmitting means being responsive to said signals to transmit to said receiving means signals reproducing the phases and differential timing of the signals passed by said control means, means operatively connected to said receiving means for segregating the signals received thereby, according to their phases, and manifesting means comprising a plurality of units operatively associated with said segregating means so as to be individually controlled by the respective segregated signals, the units of said manifesting means being differentially responsive to the signals in dependence upon the differential timing thereof, to manifest the characters in their proper relative positions.

3. In a system for manifesting data from a record sheet whereon indicia appear in a plurality of columns and identify characters individually by their locations in particular index point positions in the columns, means to feed the record sheet in the direction of its columns, analyzing means comprising sensing devices assigned to the respective columns to analyze the columns simultaneously as the record sheet is fed, alternating current means for generating a plurality of signals constantly differentiated by phase displacement and conducting said signals to the respective sensing devices of said analyzing means, transmitting means and receiving means interconnected by a single medium of transmission, means to convey signals passing through said analyzing means as indicia are sensed, to said transmitting means for transmission to said receiving means, the signals being differentially timed in accordance with the index point positions of the indicia, means operatively connected to said receiving means for segregating the signals received thereby, according to their phase displacement, and manifesting means comprising a plurality of units operatively associated with said segregating means so as to be individually controlled by the respective segregated signals, the units of said manifesting means being differentially responsive to the signals in dependence upon the differential timing thereof, to manifest the characters in their proper relative positions.

4. In a system for manifesting a plurality of multi-order items of data composed of charac-

ters which vary in the individual orders, electrical transmitting means and receiving means interconnected by a single medium of transmission, alternating current means for energizing said transmitting means for each item to transmit through said medium wave groups differentiated by phase displacement to identify the respective orders of the data, means controlling the operation of said energizing means so as to impart secondary distinguishing characteristics to the wave group of each phase representative of the signification of the character in the order to which it appertains, means connected to said receiving means for segregating the wave groups of different phases in different channels, and multi-order manifesting means comprising individual control means for its different orders operatively associated with the respective channels of said segregating means, said control means being adapted to respond to said wave groups differentially in each order in dependence upon the secondary distinguishing characteristics of the wave group, to manifest the characters in their proper relative positions.

5. In a system for manifesting multi-order data composed of characters which vary in the individual orders, electrical transmitting means and receiving means interconnected by a single medium of transmission, alternating current means for energizing said transmitting means to transmit through said medium wave groups differentiated by phase displacement to identify the respective orders of the data, cyclically operating means controlling the operation of said energizing means, adapted to determine independently for each order, the fraction of each cycle during which a wave group of the phase pertaining to the respective order is transmitted; means connected to said receiving means adapted to segregate the wave groups of different phases in different channels, multi-order manifesting means comprising individual control means for its different orders operatively associated with the respective channels of said segregating means, said control means being adapted to respond to said wave groups differentially in each order, according to the intra-cyclical timing of each wave group.

6. In a system for manifesting multi-order data represented by sensible indicia on a record sheet, the indicia representing different characters by their placement at different index point positions in the columns pertaining to their respective orders, electrical transmitting means and receiving means interconnected by a single medium of transmission, means associated with said transmitting means for feeding the record sheet in the direction of its columns at a constant rate, analyzing means connected with said transmission means, comprising devices for sensing the individual columns of the record sheet, a plurality of alternating current sources for generating signal waves differentiated by phase displacement, and means for connecting said sources individually to the respective sensing devices of said analyzing means, whereby said transmitting means is energized to transmit through said medium signal waves identified with the respective columns of the record sheet by their phase and distinguished by their differential timing to represent different characters; means connected to said receiving means for segregating said signal waves in different channels, according to their phases manifesting means comprising a plurality of manifesting elements representing different orders of the data to be manifested, driving means for said manifesting means operating in synchronism with said record sheet feeding means and having means for imparting differential movements to said manifesting elements, and control means operatively associated with the respective channels of said segregating means, adapted to determine the extents of the differential movements of the different manifesting elements, in dependence upon the differential times of the respective signal waves to determine the characters to be manifested.

7. In a system for manifesting multi-order data composed of characters which vary in the individual orders, transmitting means and receiving means interconnected by a single medium of transmission, a plurality of parallel channels, one for each order of the data, alternating current means for generating and delivering to the respective channels a number of signal waves differentiated from each other by phase displacement, said parallel channels being joined by a common channel to said transmitting means, means controlling said parallel channels individually to release therethrough signal waves of the respective phases, individually differentially timed to represent the significations of the characters in the respective orders of the data, whereby discrete or complex waves are set up in said common channel for transmission by said transmitting means; means connected to said receiving means for segregating the signal waves in different channels, according to their phases, and multi-order manifesting means comprising individual control means for its different orders operatively associated with the respective channels of said segregating means, said control means being adapted to respond to said signal waves differentially in each order in dependence upon the differential timing of the signal wave.

8. A system as described in claim 7, wherein the signal waves of different phases set up in said common channel are discrete or complex depending upon whether the characters they represent are different or identical.

9. A system as described in claim 3, wherein said record sheet feed means are adapted for cyclical operation to feed a record card during each cycle, means normally adapted to stop said feed means at the end of each cycle, means for restraining said stopping means for operation, a control circuit including control means for said restraining means, means normally conditioning said control circuit by impulses in phase with the signal transmitted by one of said sensing devices, means whereby a signal from said last mentioned sensing device can be impressed upon said control circuit to combine with the normal conditioning impulses thereof to energize said control circuit, and means comprising a second analyzing means adapted synchronously to sense another card than the one sensed by said first analyzing means, to interrupt the energization of said control circuit upon a disagreement of indicia on the two cards.

ARTHUR H. DICKINSON.

CERTIFICATE OF CORRECTION.

Patent No. 2,355,282. August 8, 1944.

ARTHUR H. DICKINSON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 10, second column, line 13, after the syllable "teristics" and before the comma insert --thereof--; page 11, second column, line 56, for "for" read --from--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 10th day of October, A. D. 1944.

Henry Van Arsdale

Acting Commissioner of Patents.

(Seal)

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