

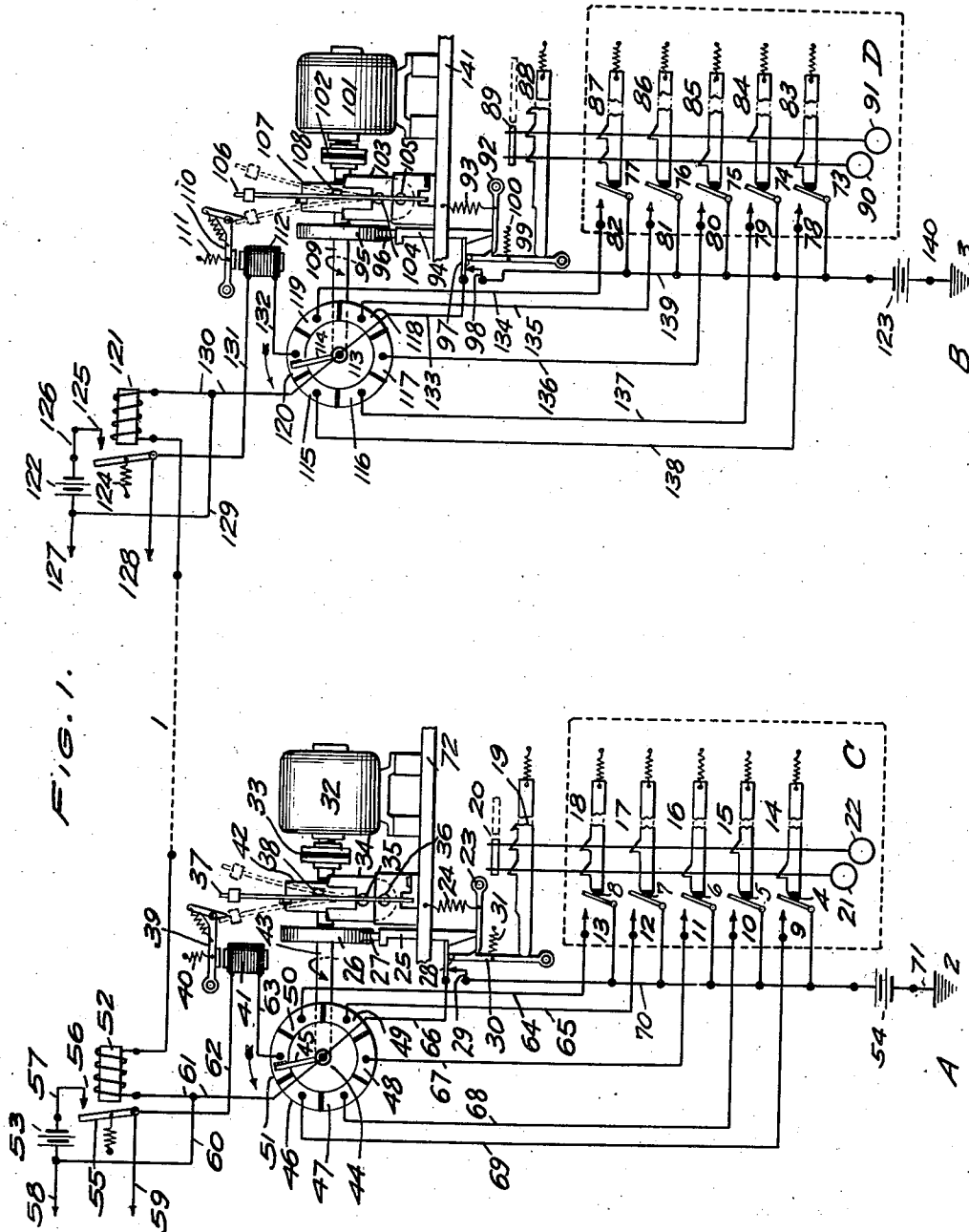
Aug. 30, 1938.

G. A. GRAHAM ET AL
PRINTING TELEGRAPH SYSTEM

2,128,242

Filed May 16, 1934

5 Sheets-Sheet 1



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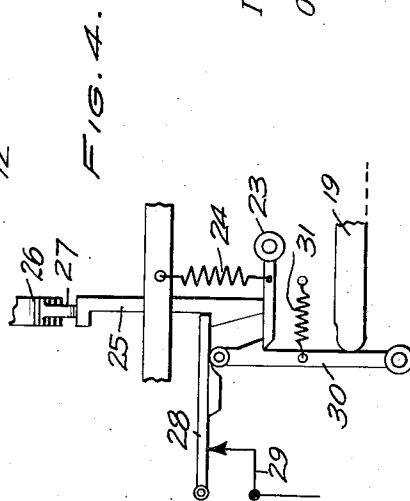
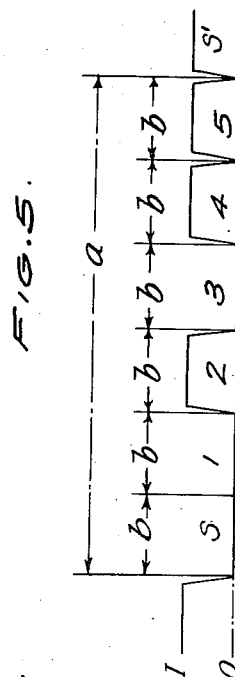
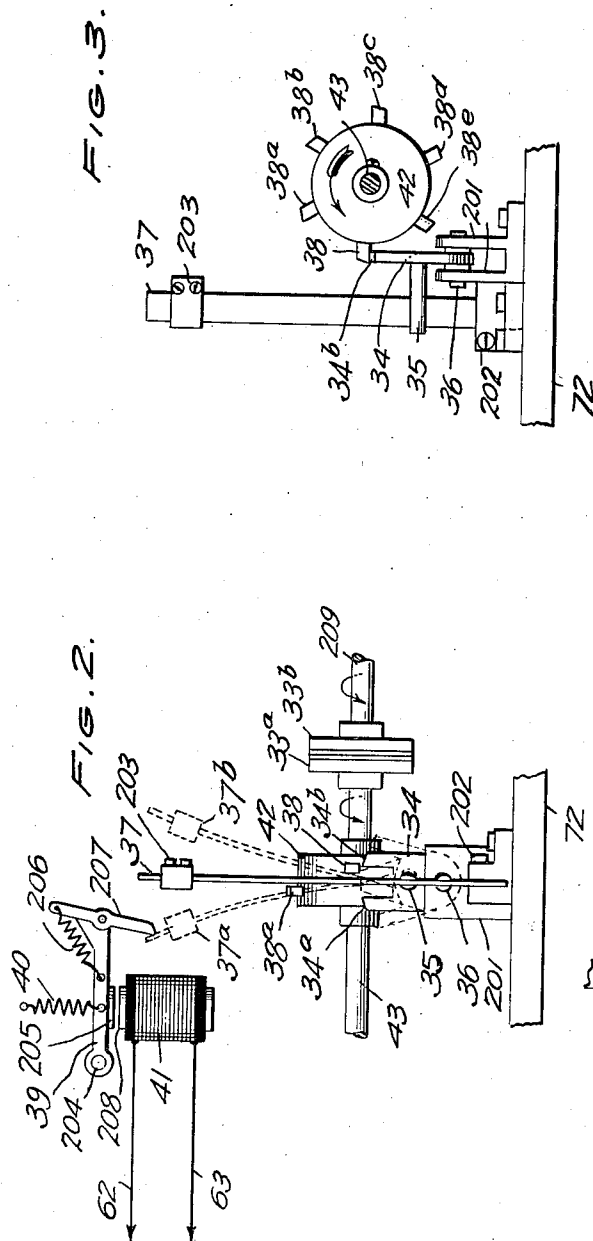
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G. A. GRAHAM ET AL
PRINTING TELEGRAPH SYSTEM

2,128,242

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5 Sheets-Sheet 2



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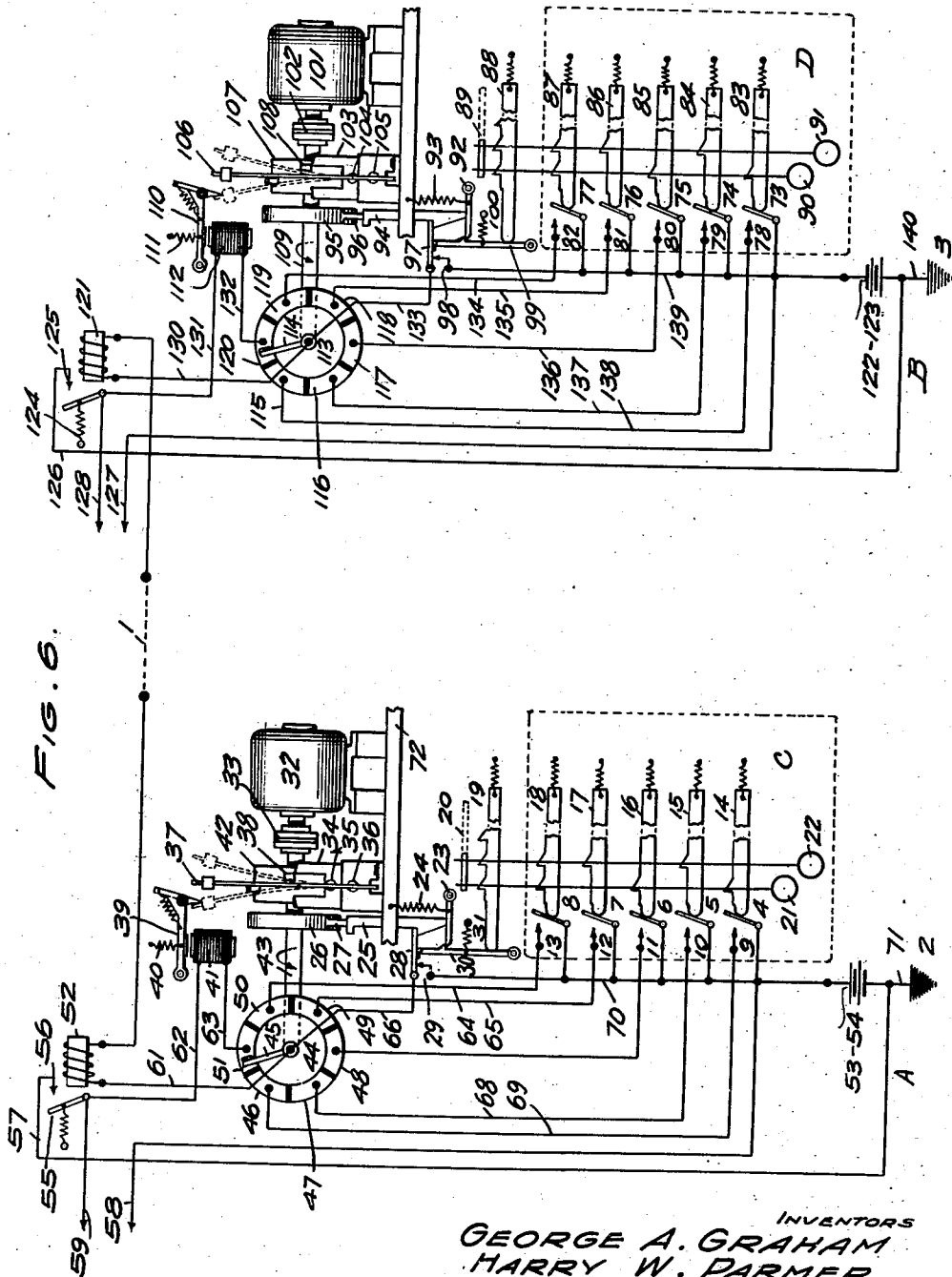
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2,128,242

PRINTING TELEGRAPH SYSTEM

Filed May 16, 1934

5 Sheets-Sheet 3



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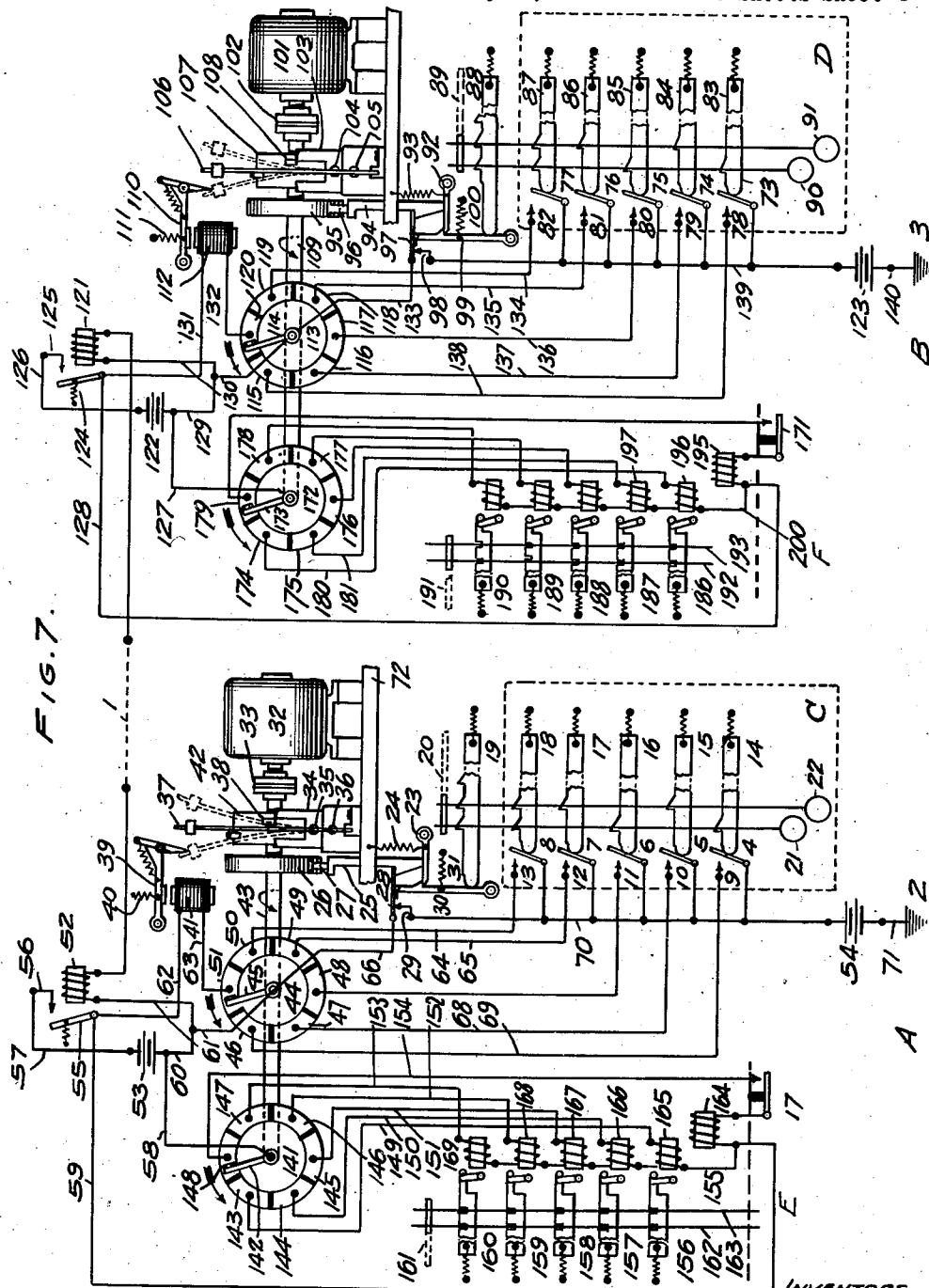
G. A. GRAHAM ET AL

2,128,242

PRINTING TELEGRAPH SYSTEM

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5 Sheets-Sheet 4



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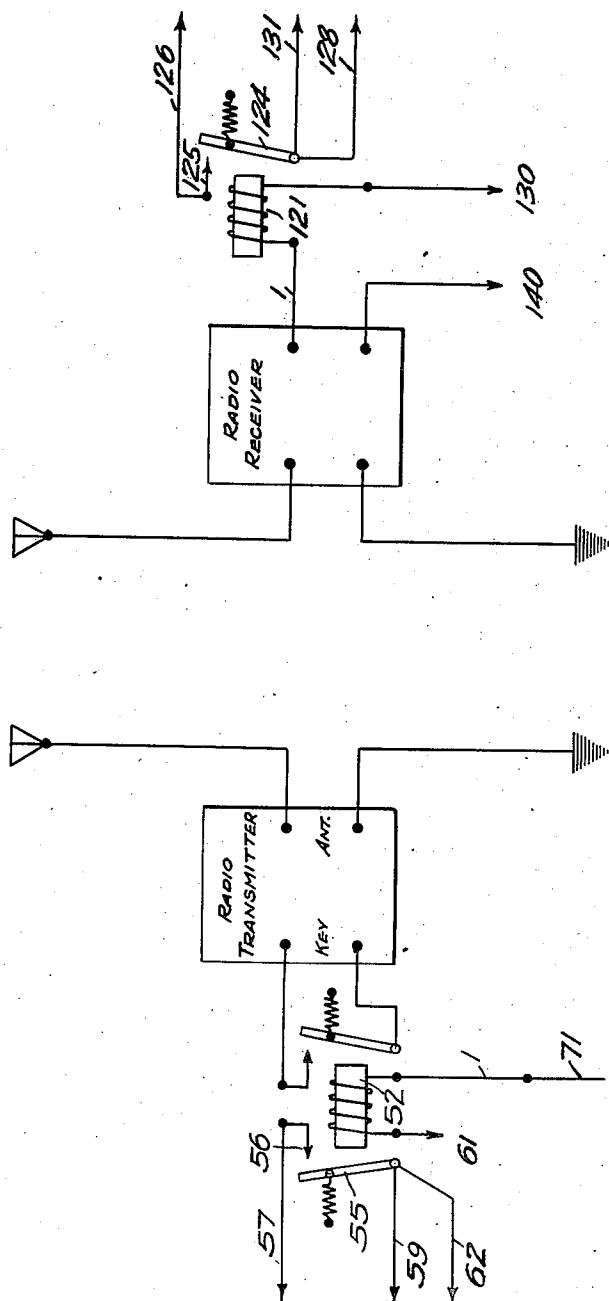
G. A. GRAHAM ET AL
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5 Sheets-Sheet 5

FIG. 8.



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UNITED STATES PATENT OFFICE

2,128,242

PRINTING TELEGRAPH SYSTEM

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Application May 16, 1934, Serial No. 725,968

25 Claims. (Cl. 178—53.1)

(Granted under the act of March 3, 1883, as
amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manu-
factured and used by or for the Government for
governmental purposes, without the payment to
us of any royalty thereon.

This invention relates primarily to printing
telegraphy and printing telegraph equipment, and
constitutes in effect a printing telegraph system
wherein exact synchronization is effected for
each and every signalling impulse in a new and
novel manner. However, application of the
methods and devices described herein to electro-
mechanical systems and appliances outside the
field of printing telegraphy are within the scope
of the invention.

One of the main objects of this invention is to
synchronize each and every interval, be it spac-
ing or marking, of the receiving mechanism with
that of the transmitting mechanism, and hence
to eliminate sources of error peculiar to previous
printing telegraph practice.

In the art of printing telegraphy it is a well
known fact that the basis of any system is the
maintenance of satisfactory synchronism. The
usual method is to make one station the control-
ling or time keeping station and run the controlled
station's distributor slightly faster. Controlling
currents are then sent once per revolution from
the correcting station to correct for the phase
difference which has occurred, and so accumula-
tion of error is prevented. It is to be understood
that the motors driving the distributors require
more or less precise governing and the method of
correction for the prevention of accumulative error
takes various forms which may be summarized
as follows:

1. Positively stopping the rotating brush arms
or cam devices once per revolution (so-called
"start-stop" method).
2. Uncoupling momentarily the shaft and the
brush arm (Baudot epicyclic coupling).
3. Modifying the speed of the motor (speed cor-
rection).

However, attention is invited to the fact that the
known methods herein cited do not prevent the
occurrence of errors within one revolution of the
distributor shaft, or if solely of the governed type
do not prevent error within the governing inter-
vals because obviously an error must occur in
order that the governor respond to correct that
error. Motor governing by electrically driven
tuning forks or reeds is not decisive, and motors
driven by tuning forks lack power for varying
loads. In the case of the "start-stop" systems
mis-printing occurs dependent upon the magni-
tude of the error within the one revolution. Nor-

mally the governing means of the motors are re-
lied upon to restrict such errors within certain
limits but in practice frequent failure and con-
stant maintenance are experienced due to causes
such as a difference in voltage at the respective
stations, or the pitting of governor contacts and
collector rings, etc.

Certain inventors have recognized the desir-
ability of exact synchronization for each and
every impulse and have attempted to obtain the
desired results by means of reeds or tuning forks
which were made to operate a multiplicity of con-
tacts. The contacts were then wired into various
circuits to perform stepping or timing functions.
Examples of this are found in Potts, 1,151,216,
and Kleinschmidt, 1,758,194, but tuning fork or
reed contact arrangements are neither satisfac-
tory nor dependable because of slow speed and
low power when used to step a shaft forward
under magnet action; or to energize relays and
magnets for functional operation because of the
fleeting nature of the reed or tuning fork impulse.
Also such contact operation is accompanied by
contact oscillations affecting the current value in
the incident circuit. The outstanding limitations
of the reed or tuning fork contact arrangement
may be summarized as follows:

1. Operational speed limited by numerous mag-
net operations in the formation of one character.
2. Limited to controlling the power derived
from the tractive effort of the magnets which
is also a function of time. In magnets of any
appreciable power, time is a very vital factor,
the relationship being:

$$i = \frac{E}{R} \left(1 - e^{-\frac{Rt}{L}} \right)$$

i = instantaneous current

E = voltage

R = resistance

L = inductance

t = time

On opening the magnet circuit time is again in-
troduced by the relationship—

$$i = I_0 e^{-\frac{Rt}{L}}$$

It therefore has become increasingly apparent in
the fields of printing telegraphy that magnets of
any appreciable required power should be restrict-
ed to functional operations and not high speed
operation such as the fleeting impulse of tuning
fork or reed contacts, as for example in Potts or
Kleinschmidt. Also see the many contact appli-

cations in Printing Telegraph Practice by H. H. Harrison. In other words the fork or reed contact does not give any margin or safety factor for building up of current in the magnet. This is particularly true for reeds or forks vibrating above 40 vibrations per second. In our invention we employ a reed, but the reed definitely times rotational processes deriving their power from other sources than the reed, and hence power is not only constantly applied but may be of a high value. The reed then valves or escapes appreciable power constantly applied. In contradistinction to the circumstances related above this invention is predicated upon a proper solution of the inherent disadvantages mentioned and provides a printing telegraph system wherein the receiving processes are held in step with the transmitting processes throughout all intervals.

Accordingly another main object of this invention is to provide critical synchronizing methods for all time intervals, but at the same time permit of high speed operation, in such a manner that differences in local voltages at the various stations do not affect the accuracy of synchronization during legitimate operation; and hence to provide synchronizing means which are inherently independent of voltage differences or variation.

Another main object of this invention is to control the progressive movement of a rotating body driven by appreciable power by a constant frequency device and hence any number of other rotating bodies, similarly controlled by duplicate constant frequency devices, may be maintained in exact unison with each other and the aforementioned rotating body.

Another main object of this invention is to apply the principles and inherent precision of a vibrating reed to control the incremental progression of a rotating shaft, tending to rotate under the urge of appreciable power constantly applied.

Other objects will become apparent to those skilled in the art as the description proceeds.

The accompanying drawings serve to illustrate the principles involved in which:

Fig. 1 is a schematic drawing showing the basic principles of the invention as applied to the operation of two printing telegraph stations, local battery and line battery being shown at each station;

Fig. 2 is a view of the timing agent, or reed mechanism utilized to control or escape the progression of a rotating shaft;

Fig. 3 is a projected view of Fig. 2;

Fig. 4 is a view showing certain keyboard controlled start-stop features;

Fig. 5 is a graphical representation of the signalling time intervals established definitely by our system;

Fig. 6 is a schematic drawing similar to Fig. 1, except that one battery only is used at each station for the dual purpose of local and line batteries;

Fig. 7 is a schematic drawing showing an application of the methods of signalling, synchronization, and distribution, to one particular form of selecting and printing mechanism; and

Fig. 8 is a schematic drawing showing the application of our invention to radio communication.

Reference is now made to Fig. 1, in which A and B represent two stations, some distance apart, connected together electrically by the line wire 1, and the earth return 2 and 3. The details

within the areas C and D represent conventional keyboard transmitters of the Baudot saw-toothed five-unit code type. This type is shown for convenience only, inasmuch as our invention is not restricted to the five-unit code or to any particular type of transmitter, be it keyboard, tape, etc. However, the operational characteristics of such a keyboard transmitter are generally known and require no detailed description herein. Suffice it to say that at C, depression of any key of the keyboard, of which two are shown as 21 and 22 acts to move certain particular combinations of the sawtoothed bars, 14, 15, 16, 17, or 18, to the left, thus setting up a permutative arrangement of the transmitting levers 4, 5, 6, 7, and 8, in relationship with the transmitting contacts 9, 10, 11, 12, and 13. In this case 32 combinations are possible which may be made to correspond to the 26 letters of the alphabet with 6 additional combinations for functional features. In addition to the five code bars a sixth or universal bar, which moves to the left upon the depression of any key of the keyboard, is often provided for certain purposes. Also a keyboard lock is usually provided which may be cleared as the result of the completion of the printing process or may be cleared as a function of such a cam wheel as shown at 26. It is not desired to introduce this feature in our drawings for reasons of simplicity. We will therefore assume that keyboard locking features are provided which act to lock up the permutative combinations of bars 14, 15, 16, 17 and 18, and also the universal bar 19; and that upon the completion of one revolution of cam wheel 26 this keyboard lock is removed and all bars returned to normal for a succeeding operation. These considerations also apply to keyboard D.

In our device a universal bar is provided as at 19, to perform the function of releasing a latch upon the depression of any key, and hence breaking the line circuit. The latch is designated as 23, and the latch trigger is detail 30. Retractable tensions are provided by springs 24 and 31. So much for the latch releasing features. The latch restoring features consist of a cam 27 on cam wheel 26 acting on cam push rod 25. It will then be seen that, given that the cam wheel 26 is rotating, the cam 27 will thrust the push rod 25 once every revolution of the cam wheel and act to restore the latch should the latch have been released during the revolution. In the event that the latch had not been released during the revolution, the cam action would be passive. Now as shown in the drawings, this latch and restoring action on the push rod 25 serves to operate upon contact lever 28 and hence upon contact 29, which may be summarized as with latch locked in position during the rotation of cam wheel 26 or otherwise, the contact lever 28 is in electrical continuity with contact 29, but on the other hand should the latch have been released by keyboard action, the contact lever 28 would be withdrawn from contact 29 throughout that revolution of the cam wheel. An enlarged view of these same details is shown in Fig. 4.

Now let us consider the shaft 43 upon which the cam wheel 26 at station A is mounted. This shaft 43 extends from the driven side of a friction clutch as at 33 to the distributor arm 45 of the distributor 44. The actual plane of the distributor is parallel to the plane of the cam wheel 26 and at right angles to the axis of the shaft 43, but has been shown in plan view for descriptive purposes. The direction of rotation of

the shaft 43 and of the distributor arm 45 is as shown by the arrows. The distributor arm 45 is provided with a proper brush which sweeps the distributor segments 46, 47, 48, 49, and 50.

The distributor arm and the various segments are wired as shown in the figure. The friction clutch is connected on its driving side to an electrical motor 32, which we will assume to be running under power derived from the local station battery 53, even though the actual electrical connections are not shown, being of no interest in the description. Then motor 32 drives shaft 43 through the friction clutch 33. Now the characteristic of this clutch is to exert through frictional components a turning movement to shaft 43, irrespective of whether or not the shaft 43 is actually rotating. In other words, shaft 43 may be permitted to revolve under the driving action of the clutch, or may be restrained from revolution and the clutch allowed to slip, upon the restraining forces being greater than the forces of frictional turning movement. It remains to be shown how shaft 43 may be restrained or permitted to revolve upon occasion, and the relationship thereof with our invention. Briefly, the relationship is that the shaft 43 is permitted to progress under escapement action as controlled by an individual timing agent of definite predetermined and constant periodicity, i. e., a vibrating reed.

In the theory of vibrating bodies it is known that the fundamental frequency of vibration of a reed is determined by the following physical properties of the reed; the material; the length; and the thickness; in the relationship:

$$n = 84,590 \frac{a}{L^2} \text{ approximately,}$$

where n is the frequency of vibration, a the thickness in centimeters, and L the length in centimeters. The degree of clamping, the work the reed is required to do, and whether or not the end of the reed is weighted, introduce modifications of the above empirical formula. However, the point to be stressed here is that the physical properties determining the fundamental frequency of vibration of a reed are readily reproducible and any desired number of reeds may be made to vibrate at a predetermined frequency. Even though it is admitted that temperature effects alter this fundamental to a very minor degree, it is stated as a premise that any number of such reeds of equal physical properties that are released to vibrate for a limited number of cycles, let us say three complete cycles, are in absolute unison throughout those three cycles.

The above considerations are applied in our invention wherein with reference to Fig. 1, 37 designates such a reed at station A, and 106 a similar reed at station B, suitably clamped in position and mounted on the base 72 and 141 respectively. At rest or start position, the reeds 37 and 106 are held locked to the left (shown dotted) under the latches of the armatures 39 and 110 of start-stop magnets 41 and 112. In the stressed position shown potential energy is stored in these reeds and upon being released the reeds tend to vibrate with an initial amplitude as represented by the dotted views to the right. Obviously this process is repeated with a decrement dependent upon the work imposed on the reed and the mass of the counterweight. In each half cycle of vibration the reeds are made to move escapement yokes 34 and 103 thus alternately escaping the pins of hubs 42 and 107.

The reed, start-stop features, escapement, driven shaft, clutch, and drive shaft, are shown more clearly in Figs. 2 and 3. With reference to Fig. 2, the reed is 37, weight 203, escapement driving link 35, escapement pawl yoke 34, bearing shaft 36, bearing trunnion 201, reed clamp 202, base 72, escapement pawls 34a and 34b, escapement pins 38 and 38a, escapement hub 42, driven shaft 43, driven clutch member 33a, driving clutch member 33b, and drive shaft 209. The phantom positions 37a and 37b denote the limiting positions of the reed in vibration, wherein position 37a is also the starting and stopping position. The start-stop magnet is 41, magnet pole 208, armature 205, armature lever 39, pivot 204, retractile spring 40, start-stop latch 207, latch spring 206, and electrical conductors 62 and 63 connecting the windings of magnet 41 to a source of electrical power. The above details, with the exception of the magnet and clutch details, are shown in another view by Fig. 3, in which note escapement pins 38b, 38c, 38d, and 38e. Let us now consider the sequence of events which occur in a typical example of operation from the instant that the reed is released by the magnet. We will assume that the magnet 41 is energized; the armature latch is restraining the reed 37 in position 37a; the escapement pawl 34b is interposed under pin 38 and that shaft 43 and the driven clutch side 33a are motionless; and the drive shaft 209 is rotating in the direction indicated by the arrow hence the driving clutch side 33b is slipping with respect to the driven side 33a. Upon de-energizing magnet 41, the armature latch 207 is disengaged from the reed by retractile spring 40 action. The reed moves over to position 37b carrying the escapement yoke 34 along with it by virtue of the link coupling 35. Accordingly pawl 34b is removed from beneath pin 38 and shaft 43 is permitted to revolve as indicated under the compulsion of the friction clutch. However, the escapement yoke 34 has now interposed pawl 34a to interfere with the revolution of shaft 43 beyond pin 38a. The shaft has stepped forward one pin position and is again motionless. Due to natural vibratory phenomenon, the reed now returns to position 37a moving the escapement yoke 34 back to the initial position thereby removing pawl 34a from under pin 38a and interposing pawl 34b in the path of the oncoming pin 38b. The shaft once again progresses to the position of engagement of pin 38b and pawl 34b. Without undue repetition it should be apparent that in this wise the shaft is alternately permitted to progress under reed escapement any desired number of times. In our example we permit the shaft to escape six times and stop the reed in the initial position 37a upon the completion of the sixth half cycle (three complete cycles of reed vibration). The stopping of the reed is performed as a properly timed function of the energization of the start-stop magnet through the operation of the armature and attached latch. It will be observed that the latch is so constructed that the reed may pass under the latch and lock in position 37a after the armature has been energized. Also escapement pawl 34b is under pin 38 and shaft 43 is restrained from further progression. All elements have now been restored to the initial position in readiness for a repetition of the events described. It is to be understood that these events occur at relatively high speeds, in fact, in certain models constructed the reed was made to vibrate at 40 cycles per second, which in terms of

escaped pins (and hence as will be shown later in terms of transmitting distributor spacing-marking intervals) permits printing telegraph transmission or reception speeds of approximately 130 words per minute. Accordingly an ample margin is provided for such commercial speeds as 65 words per minute.

In summation of the above it has been shown how the rotary progression of a shaft operating under appreciable power may be accurately timed for predetermined intervals by means of such a constant frequency device as a reed, and that such timing is independent of the speed of shaft 209 (i. e. independent of the speed, and hence of any variation of the value of the impressed E. M. F. of the motor driving shaft 209), the only requirement in this respect being that shaft 209 rotate above a given rate. Obviously the presentation of pins to the escapement must be at some speed above that of the reed controlled escapement operation. This feature entirely eliminates the necessity for a governed motor, and any motor which operates above a given rate may be used.

In the design and development of the reed and escapement certain additional features were incorporated which require explanation as a basis for further understanding. Each escapement pin 38, 38a, 38b, 38c, 38d . . . , has that corner of disengagement with the escapement pawls 34a and 34b very slightly rounded to facilitate smooth disengagement. Care and some experience is required in this construction to obtain the desired results and to obviate any tendency of the escapement driving the reed, rather than the reed driving the escapement yoke. However, pin 38e is provided with a well rounded corner for the particular purpose of restoring the reed to the initial position under the latch. Consider that after the reed has been released and moved over the position 37b, upon return to position 37a will experience a decrement in amplitude. A corresponding decrement affects the amplitude of each successive vibration even although in our example we assumed that only six half cycles were performed, and hence the decrement is small but exists due to natural law and the fact that the reed assisted by the weight 203 has been required to perform the work of moving the escapement yoke. At the end of the sixth vibration the reed may not entirely seat behind latch 207. Pin 38e by virtue of the rounded corner, and of a certain out of line position, assists in this process and imparts sufficient energy to the reed in the last half cycle to fully pass the reed behind the latch. This feature should be borne in mind because it will be used later in our description as the method of moving the reed from inoperative position 37 to start position 37a behind the latch. In printing telegraph practice it may be desired to start a certain number of stations from inactive status in which case the reeds will be in position 37. It will be seen that certain devices may readily be incorporated to act to start the motors and hence shafts similar to 43 at all stations revolving. Pins 38, 38a, 38b, 38c, and 38d will pass through the then centrally located escapement yoke 34 and the pawls 34a and 34b, but pin 38e will present the rounded corner to the corner of pawl 34a and thrust pawl 34a, link 35, and the reed to the left sufficiently to cause the reed to pass beneath latch 207. We are now in start position at all stations and shaft 43 is held from further movement by pawl 34b and pin 38. These considerations have no effect upon the escapement signifi-

cance of pin 38e and pawl 34a because full engagement of pawl 34a with the under surface of pin 38e is provided in position 37b where the pawl is fully under the pin irrespective of the rounded corner. With regard to the clutch certain additional features not shown in the drawings are incorporated in the actual models. For example spring tension is provided through ball thrust bearings as required to maintain proper engagement of the clutch surfaces. A description of such features is not deemed necessary to clarify the intent of our invention but is rather incidental to manufacturing processes for lasting performance.

We may now resume our description of the remaining elements of Fig. 1. 52 and 121 are conventional line relays capable of operational speeds to printing telegraphy. These relays are equipped with the armatures and contacts 55-56 and 124-125 respectively. Armature retractile springs are shown but magnetic bias may be used if desired. Each station A and B is equipped with local or station battery at 53 and 122. The voltage and capacity of these batteries are determined by the characteristics of the local circuits and the load considerations. The wires 58-59 and 127-128 indicate connections to printing equipment. Now many forms or types of printers may be connected to these wires and operated with complete success. We will hereinafter show one specific type and discuss still another type as applied to our processes of synchronization but at this point suffice it to say that printing equipment is connected to wires 58-59 and 127-128. The batteries 54 and 123 are line batteries (furnish current to the line and equipment in series with the line), and are poled to aid each other. The voltage of these batteries depends upon the resistance of the line circuit and upon the value of current required for operation of the line relays.

Let us recapitulate: Fig. 1 shows two transmitting-receiving printing telegraph stations located some distance apart and generally designated as A and B, respectively. The equipment at one station is the counterpart of the equipment at the other station. C and D are keyboard transmitters, equipped with start-stop latches. 32 and 101 are distributor motors. Numerals 43 and 109 designate intermediate shafts the progression of which is dependent, for each and every interval, upon the performance of the reeds 37 and 106. The reeds are released or restored by elements previously described, i. e., magnets 41 and 112, and certain pins of the escapement hubs 42 and 107. Numerals 44 and 113 denote transmitting distributors, the receiving distributors being shown later in Fig. 7. Each station is provided with proper battery and with line relays. The relays function to operate printing equipment (not shown) through receiving distributors; electrical or cam (also not shown). The various elements comprising a station are wired as shown schematically in the figure. The two stations are connected together by a line wire and earth return. This circuit may be complete metallic, simplex, or other suitable arrangement so long as the stations are connected together electrically.

A typical example of the operation of the various elements shown in Fig. 1 may now be considered. We will assume that keyboard locking and clearing features are installed as described above in the discussion of the keyboard; motors 32 and 101 are running; reeds 37 and 106 are

held under the latches in the left dotted position, and hence shafts 43 and 109 are motionless because with reeds to the left the escapement yokes 34 and 103 prevent the pertinent pins from escaping; the distributor arms 45 and 114 are at rest in the position shown and in contact with distributor segments 51 and 120 respectively; and that relay armatures and contacts 55—56 and 124—125 are closed. Let us trace the circuits to verify these assumptions. Starting from battery 54 at station A, the line circuit is wire 70, contact 29, contact lever 28, wire 66, wire 61, relay 52, line wire 1; and at station B line wire 1, relay 121, wire 130, wire 133, contact lever 97, contact 98, wire 139, battery 123, wire 140 to ground 3 and by ground 2 and wire 71 return to battery 54 at station A. The line circuit is closed hence relays 52 and 121 are energized and their contact combinations 55—56 and 124—125 are closed. The contacts however concern the local circuits at each station. The local circuit at station A provides two branches; battery 53, wire 57, contact 56, armature 55, wire 62, magnet 41, wire 63, distributor segment 51, distributor arm 45, wire 61, wire 60, and return to battery 53, this circuit constitutes the reed holding and releasing means; battery 53, wire 57, contact 56, armature 55, wire 59 to printer equipment (either a distributor and associated printing devices, or a receiving magnet and associated printing devices), from printing equipment by wire 58 return to battery 53. The corresponding local circuits at station B are: battery 122, wire 126, contact 125, armature 124, wire 131, magnet 112, wire 132, distributor segment 120, distributor arm 114, wire 130, wire 129, and return to battery 122; battery 122, wire 126, contact 125, armature 124, wire 128 to printer equipment, return by wire 127 to battery 122.

The operator at either station may now manipulate his keyboard. Assume that the operator at station A depresses key 22. All keys are on the common pivot 20. The Baudot saw-toothed bars 15, 17, and 18 will then be thrust to the left and locked, closing levers 5, 7 and 8, against contacts 10, 12, and 13. The universal bar 19 has also been moved to the left at the same time thereby thrusting the trigger 30 to the left, and locked there by the keyboard lock. The trigger 30 is so constructed as to exercise cam action at its extremity on contact lever 28 and hence the contact lever is moved out of engagement with contact 29 opening the circuit at that point. Accordingly the line circuit has been opened at contact 29. The first result caused by the opening of the line circuit is the de-energization of relays 52 and 121 causing these relays to open their contact combinations 55—56 and 124—125. These contacts open the circuits to magnet 41 and magnet 112 respectively and the reeds 37 and 106 are released and swing toward the right dotted position. The reeds 37 and 106 move the escapement yokes 34 and 103 also to the right thereby permitting pins 38 and 108 to escape and shafts 43 and 109 to revolve. The initial movement of shafts 43 and 109 serves to remove cams 27 and 96 from thrust on push rods 25 and 94. However there is this notable difference. At station A keyboard actuation has tripped trigger 30 while at station B the trigger has not been tripped. The difference is in effect that the opening of contact 29 at station A by keyboard action is further to be held open until the cam 27 completes one revolution and acts to restore the latch 23 even although key 22 may

have been released meanwhile. On the other hand, at station B contact lever 97 and contact 98 remain closed because the latch 92 is held by trigger 99 and hence the push rod 94 remains in its initial position even although the cam 96 has moved out of engagement. Hence the keyboard transmitting contacts at station B will be shorted out during this revolution of cam wheel 95, which definitely allocates the signalling functions to station A and holds station B receptive to that signalling. The reed 37 has now moved over to the right dotted position and has moved the escapement yoke 34 to the right also by virtue of the connection of link 35, hence the left pawl of the escapement yoke is in position to stop the next pin behind pin 38. Accordingly the shaft 43 is only permitted to revolve to that pin position. The reed 106 at station B has performed in an identical manner with respect to shaft 109. In these processes the distributor arms 45 and 114 have moved from segments 51 and 120 respectively to segments 46 and 115 where they are held until the reeds 37 and 106 again clear the escapement. It is desired to emphasize the fact that the relative speed of shaft 43 with respect to shaft 109 has nothing to do with the signaling time interval that the distributor arms contact segments 46 and 115, this time interval being definitely a function of the two reeds. Now we have assumed that bar 14 was not moved and therefore lever 4 is open with respect to contact 9. This interval then is a spacing interval during which the line circuit is open at contact 9 and is so translated by the line relays 52 and 121 and hence contact combinations 55—56 and 124—125, and in turn by the printers' selecting mechanism connected to wires 58—59 and 127—128. The reeds 37 and 106 now return to the left dotted positions and in so doing permit by escapement action shafts 43 and 109 and distributor arms 45 and 114 to rotate to the next escapement pin position which coincides in angular displacement with the centers of segments 47 and 116. We have assumed that bar 15 was moved to the left closing lever 5 and contact 10 in marking position. Marking current now flows from battery 54, wire 70, lever 5, contact 10, wire 68, segment 47, distributor arm 45, wire 61, relay 52, wire 1, relay 121, wire 130, wire 133, contact lever 97, contact 98, wire 139, battery 123, wire 140, ground 3, ground 2, wire 71 return to battery 54. This interval then is a marking interval and is so translated by the line relays 52 and 121 by means of the contact combinations 55—56 and 124—125 to act accordingly upon the printers' selecting mechanism connected to wires 58—59 and 127—128. The reeds 37 and 106 now swing to the right dotted positions on the first half of the second cycle and in so doing permit shafts 43 and 109 to revolve to the next escapement pin position thus progressing the distributor arms 45 and 114 to the centers of segments 48 and 117. The assumption was that bar 16 was not moved and therefore lever 6 is open with respect to contact 11. This interval constitutes a spacing interval during which the line circuit is open at contact 11 and is so translated by relays 52 and 121 and in turn through the relay contacts by the printers' selecting mechanism connected to wires 58—59 and 127—128. The reeds 37 and 106 now return to the left dotted position on the second half of the second cycle and in so doing permit shafts 43 and 109 to revolve to the next escapement pin position and accordingly progress the distributor arms 45 and 114 to the centers of segments 49

and 118. We have assumed that bar 17 was moved to the left closing lever 7 and contact 12 in marking position. Marking current now flows from battery 54, wire 70, lever 7, contact 12, wire 65, segment 49, distributor arm 45, wire 61, relay 52, wire 1, relay 121, wire 130, wire 133, contact lever 97, contact 98, wire 139, battery 123, wire 140, ground 3, ground 2, wire 71 return to battery 54. This interval then is a marking interval and is so translated by the line relays 52 and 121 by means of the contact combinations 55—56 and 124—125 to act accordingly upon the printers' selecting mechanism connected to wires 58—59 and 127—128. The reeds 37 and 106 now swing to the right dotted position on the first half of the third and last cycle and in so doing permit shafts 43 and 109 to revolve to the next escapement pin position and accordingly progress the distributor arms 45 and 114 to the centers of segments 50 and 119. We have assumed that bar 18 was moved to the left closing lever 8 and contact 13 in marking position. Marking current again flows as described above for bar 17 and segment 49 except that now the path is by wire 70, lever 8, contact 13, wire 64, segment 50, and the distributor arm 45 to line by wire 51, relay 52, line wire 1. As before this interval is a marking interval and is so translated by the line relays 52 and 121 by means of the contact combinations 55—56 and 124—125 to act accordingly upon the printers' selecting mechanism connected to wires 58—59 and 127—128. The reeds 37 and 106 now return to the left dotted position on the second half of the third and last cycle and in so doing escape the sixth consecutive escapement pins on the escapement hubs 42 and 107. It will be recalled that the sixth escapement pin, detail 38e of Fig. 3, provided a rounded corner to facilitate the restoration of the reed beneath the start-stop latch. Consider this impulse to have been imparted to reeds 37 and 106 as the sixth pins of hubs 42 and 107 are escaped. Shafts 43 and 109 revolve to the initial pin positions 38 and 108 and the distributor arms 45 and 114 revolve to the center of the initial segments 51 and 120. Also cams 27 and 96 have completed one revolution and are again in engagement with push rods 25 and 94. As described above the cam 96 has no effect on push rod 94 because that push rod had not been triggered out of initial position but the push rod 25 having been triggered out of initial position is now restored to that position by cam 27 and at the same time, or slightly prior thereto, the keyboard lock is released and bar 19 and all other bars restored to initial position. (See description of keyboard lock above.) The restoration of push rod 25 and bar 19 to initial positions results in engaging latch 23 under trigger 30 and restoring contact lever 28 to contact 29. These occurrences are properly timed so that at the instant the distributor arms 45 and 114 make contact with segments 51 and 120 the initial circuits described at the start of this example are set up, or restored, to operate magnets 41 and 112 and hence restrain the reeds from further vibration. With respect to time, the armature latching of 39 and 110 are actually in position to catch the reeds slightly before the reeds pass under the latches. Hence the latch construction. Also it will be appreciated that coincident with this time period the actual printing processes of the selected character or function occurs with respect to the printing equipment connected to wires 58—59 and 127—128.

In the above example, and in fact in the dis-

closure shown by Fig. 1, it will have been noted that receiving distributors have not been shown or discussed at length. Fig. 1 shows distributors which are employed as transmitting distributors because whereas operation from station A was assumed, during the process the signalling segments of station B were automatically shorted out to maintain the required line continuity. Had operation from station B been assumed the same arrangements would have existed at station A. It has been the intention of the specification up to this point to build up a background sufficient to serve the investigator or reader as proper material for the required extension of our invention to receiving distributors as well as transmitting distributors. Even at this point those skilled in the art will doubtless have appreciated that proper continuation of shafts 13 and 109 would serve as agents upon which either receiving distributors or cam selectors could well be operated in harmony with the theory of the invention. These matters will be disclosed at length hereinafter.

Before continuing however let us examine the line current characteristics (or signalling characteristics) of our invention. Reference is made to Fig. 5. This figure represents graphically the time intervals established definitely by the reed, escapement action upon the transmitting distributor for each and every spacing and marking interval in contradistinction to previous systems. In our system the time elements *b* are predeterminable, equal, and for a 40-cycle reed represent 1/80 of a second. In certain previous systems the time element *a* is accurately established but the elements *b* vary greatly with respect to each other, contingent upon many independent variables. In other reed controlled systems the make and break of the current is apt to be oscillatory rather than clean.

As stated previously Fig. 1 showed the arrangements at two printing telegraph stations, some distance apart, in which battery was used for line signalling purposes as differentiated from local station battery for purely local performance. On the other hand, Fig. 6 shows the connections by means of which one battery only may be used at each station for the dual purpose of line and local battery. This figure then may be considered as supplementing Fig. 1 and the theory of operation is sufficiently parallel to that previously given for Fig. 1 as to not warrant a separate description.

We will now continue with the primary consideration of describing our methods of signalling, synchronization and distribution, as applied to one particular form of printer conceived by us, although many other types may be employed.

Reference is made to Fig. 7. In this figure A and B generally represent two stations, some distance apart, connected together electrically by the line wire 1, and the earth return 2 and 3. C and D are keyboard transmitters. 44 is the transmitting distributor face and 141 is the receiving distributor face, the distributor arms of which 45 and 142 are connected to the reed controlled shaft 43 at station A. 113 is the transmitting distributor face and 172 is the receiving distributor face, the distributor arms of which 114 and 173 are connected to the reed controlled shaft 109 at station B. The reed start-stop magnets are 41 and 112 and the line relays are 52 and 121 respectively. The line batteries are 54 and 123, and the local station batteries are 53 and 122. The elements directly above E and F 75

comprise the basic features of printing units. The printing function may be by motor driven cams or by magnet action. In our case we show a magnet printing type. It will be sufficient to describe the printer at station A. The selector or translator is of the well known Baudot five-slotted bar type, the selector bars being 156, 157, 158, 159, and 160 positioned properly under the pivoted 161, stunt bars 162 and 163. Obviously there are as many stunt bars as there are characters to be printed or functions to be performed. Each selector bar is held normally to the left, but under magnet action 165, 166, 167, 168, and 169 are moved to the right in accordance with the permutations of the Baudot code. In any of these permutative arrangements one and only one stunt bar may fall in the slots and hence one character or function be presented for printing or performance. The printing magnet is shown at 164. In our use of these elements a printing and clearing feature is incorporated at 170, the action being that the contacts are held open so long as none of the stunt bars have fallen in the slots but as soon as a stunt bar falls fully in the slots contact is made through the agency of a universal bar shown dotted and the magnet is receptive to the printing pulse. After the printing stroke and in the return motion of the armature of magnet 164, the selected stunt bar is returned to normal by action through the universal bar.

Let us consider an example of operation from station A. We will assume that motors 32 and 101 are running; the line is energized, battery current flowing from 54, wire 70, contact 29, contact lever 28, wire 66, wire 61, relay 52, wire 1, relay 121, wire 130, wire 133, contact lever 97, contact 98, wire 139, battery 123, wire 140, ground 3, ground 2, return by wire 71; hence relays 52 and 121 are energized and their contact combinations closed by virtue of which the reed magnets are also energized and the reeds 37 and 106 held in the left dotted position, the circuit in this respect at station A being battery 53, wire 57, contact 56, armature 55, wire 62, magnet 41, wire 63, distributor segments 51, distributor arm 45, wire 61, wire 60, return to battery 53, and a similar circuit at station B, and shafts 43 and 103 are motionless by virtue of the reed escapement position.

The operator at station A strikes, let us say, the key 21 which is in our representation of the five unit code, bar 14 marking position, bar 15 spacing position, bar 16 marking position, bar 17 spacing position, bar 18 marking position, and the universal bar 19 marking as for every key. The depression of the key has opened contact lever 28 and contact 29 at station A, and hence has opened the line circuit. The contact lever 97 and contact 98 at station B remain closed as shown. The opening of the line circuit at station A results in de-energizing relays 52 and 121 and by the contacts opening of these relays de-energizing magnets 41 and 112 which in turn release the reeds for the performance of the first half of the first cycle. The distributor arms 45 and 142 at station A and 114 and 173 at station B move forward to segments 46, 143, 115, and 174 respectively where all are held by reeds escapements for exactly the same period of time. Had either station's distributor arm combination arrived at this stop position ahead of the distributor arm combination at the other station the signalling time interval would not have been affected in the least degree because the reeds control the release of both distributor arm combina-

tions. During this interval marking current flows from battery 54, wire 70, keyboard lever 4, contact 9, wire 69, segment 46, arm 45, wire 61, relay 52, wire 1, relay 121, wire 130, wire 133, contact lever 97, contact 98, wire 139, battery 123, wire 140, ground 3, ground 2, wire 71, return to battery 54. So much for the line signalling circuit. At station A current flows from battery 53, wire 57, contact 56, armature 55, wire 59, common wire 155, selector magnet 165, wire 149, segment 143, arm 142, wire 58, return to battery 53. Selector bar 156 has been moved to the right and is mechanically locked in that position, the lock not to be released until after the printing stroke or functional operation has been completed. At station B the selector bar 186 has also been moved to the right in an identical manner, the circuit being from battery 122, wire 126, contact 125, armature 124, wire 128, common wire 200, magnet 195, wire 130, segment 174, arm 173, wire 127, return to battery 122. Without unduly prolonging the matter, it is believed that the succeeding spacing and marking processes have been made clear throughout the remaining five half cycles of reed vibration to the final stopping of the reed and the performance of the printing stroke at each station when the arms 142 and 173 have returned to segments 148 and 179, after which contacts 170 and 171 are automatically opened by universal bar action in conjunction with the return to normal of the printing magnet armature. The very vital point to be stressed is that all transmission and reception time intervals have been definitely established by the independent agency of the reeds, without recourse to any contacts on the reeds or to any contacts operated by the reeds.

It may readily be seen that the application of our principles to radio communication rather than to wire communication is but a question of transmission medium. However, in the event that such connections are not quite clear, the stations as shown in Fig. 7 are connected for radio transmission and reception as shown in Fig. 8 without going into any of the details of transmitter or receiver construction. The relays 52 and 121 have been given the same detail numbers for identification purposes. Additional contacts have been added to relay 52. Station A has been taken as the transmitting station and station B as the receiving station.

Changes and modifications are contemplated within the scope of the invention as defined by the appended claims:

We claim:

1. In a printing telegraph system, comprising a plurality of stations each of which is provided with transmitting and receiving means; means for maintaining the processes of reception in exact unison with the processes of transmission, comprising a mechanism for the simultaneous escapement of said transmitting and receiving means; and a constant frequency device including a vibrating reed for positively actuating and controlling the escapement action of said mechanism and independently of external timing devices.

2. In a transmitting-receiving printing telegraph system, comprising a plurality of stations, each station being provided with means for the transmission and reception of permutative code combinations of impulse conditions; means at each station for maintaining all processes of reception in synchronous relation with those of transmission, comprising a phase controlled escapement mechanism, said mechanism compris-

ing a rotatable escapement wheel, an escapement yoke adapted to effect step by step control of the motion of said wheel, and a vibrating reed for actuating and timing the escapement action of said yoke.

3. In a high speed signalling system, comprising means for sending and receiving code combinations of signalling conditions, means for equalizing the time intervals of an equal unit code, comprising an escapement mechanism; and a constant frequency device, including a vibrating reed of predetermined periodicity for controlling the action of said mechanism in accordance with the frequency of said reed and independently of external timing agencies.

4. In a system of printing telegraphy, comprising rotary members for controlling the processes of selection and distribution between local and distant stations of the system, and including power sources for driving said members; means for synchronizing the action of the members of one station with those of another station, comprising an escapement mechanism operative to regulate the transmission of motion to said members in equalized intervals and independently of the speed of said power sources; and matched vibrating reeds at said stations for positively actuating and timing said mechanisms.

5. In a system of electrical communication, means for controlling the processes of transmitting and receiving signalling impulses at one station from any one of a plurality of other stations, comprising duplicate escapements at each station; vibrating reeds having matched periodicity and functioning independently of other timing agencies for positively timing the action of the escapements; a prime mover, and differential means for transmitting motion therefrom to each escapement, comprising a slipping clutch to permit the escapements to operate in synchronism and independently of the speed of the prime mover.

6. In a system of printing telegraphy, comprising rotary elements for controlling the processes of selection and distribution between local and distant stations of the system; means for synchronizing the action of said elements of one station with those of another station, comprising an escapement; a vibrating reed of predetermined constant periodicity at each station for timing and actuating said escapement; power sources and differential means for coupling the same with each escapement whereby said escapements are driven in synchronism under the positive control of said reeds and independently of the speed of said sources.

7. In a printing telegraph system comprising transmitting means at a local station for establishing electrical sequences affecting receiving means at a distant station; and means to maintain the sequences in synchronism, comprising an escapement mechanism at each station and matched vibrating elements of predetermined constant periodicity for controlling said mechanism; and means for starting and stopping the vibration of said elements in predetermined operative cycles.

8. In a printing telegraph system, comprising a plurality of transmitting and receiving stations, each station being provided with means for the transmission and reception of electrical impulses; means for establishing the sequence of said impulses, and including a rotatable shaft at each station; and means carried by each shaft to maintain the sequences of a transmitting sta-

tion in phase with the sequences of a receiving station, comprising an escapement mechanism and a vibrating reed for controlling said mechanism independently of the speed of rotation of said shaft.

9. In a printing telegraph system, comprising a plurality of transmitting and receiving stations, each station being provided with means for the transmission and reception of signalling impulses; and means for the establishment of definite and equal periodicity of each signalling interval, comprising an escapement mechanism, said mechanism including a rotatable body provided with movement arresting means, an escapement yoke for operating the arresting means; and a vibrating element having a predetermined periodicity to actuate said yoke for positively controlling the escapement action of said mechanism.

10. In a printing telegraph system, comprising a plurality of sending-receiving stations, each station being provided with means for the transmission and reception of electrical impulses; and means at each station for maintaining all receiving processes in exact synchronism with the transmitting processes, comprising an escapement mechanism; and a constant frequency timing element including a vibrating reed for positively controlling the escapement action of said mechanism independently of voltage variations in the system.

11. In a printing telegraph system, comprising a plurality of stations, each station being provided with means for the transmission and reception of signalling impulses; an escapement mechanism at each station to effect the phase control of said impulses, comprising a rotating member; mechanical means for operating said member, including a driving shaft and a driven shaft carrying said member; and means comprising a vibrating reed operative with the escapement mechanism to maintain a synchronous relation between the rotating members of each station in predetermined incremental progression and independently of the speed of the driving shaft.

12. In a printing telegraph system, comprising a plurality of stations; means at each station for the transmission and reception of signalling impulses, including transmitting and receiving distributors; means for maintaining synchronous operation of said distributors comprising an escapement for controlling the predetermined incremental progression of each distributor; and a vibrating reed for positively actuating and controlling the escapement.

13. In signalling systems, comprising elements mounted for rotation on intermediate driven shafts differentially coupled to the driving shafts, said driving shafts being operated at predetermined speeds; means for controlling the rotation of said driven shafts at a definite rate of progression in relation to unit time and independently of the speed of the driving shafts, comprising an escapement mechanism; and a vibratory element of predetermined periodicity for positively controlling said escapement independently of external timing agencies.

14. In a system of printing telegraphy, comprising a plurality of stations, each station being provided with means for the transmission and reception of signalling impulses; means for synchronizing all time intervals of transmission and reception between said stations, said means in-

cluding elements mounted for rotation on intermediate driven shafts; driving means for said shafts; and means at each station for controlling the rotation of said driven shafts at a definite progression in relation to unit time and independently of the speed of said driving means, comprising an escapement mechanism; and a vibratory element of predetermined periodicity at each station for timing said escapement independently of external timing agencies.

15. In a mechanical transmission system, comprising rotating elements mounted on driving and driven shafts, said shafts being coupled for differential movement relative to one another; and means for controlling the progression of the driven shaft independently of the speed of the driving shaft, comprising an escapement mechanism; and a vibrating element of predetermined periodicity for positively actuating and timing said mechanism.

16. In a system of synchronizing the speed of rotating bodies, means for determining the progression of said bodies with respect to unit time, comprising an escapement operative with each body; and means for controlling each escapement, comprising matched vibrating reeds of predetermined periodicity for positively actuating and timing the escapements.

17. In a printing telegraph system, comprising rotating bodies driven from separate sources of varying power; means for synchronizing the speed of rotation of said bodies independently of the speed and power of said sources, comprising an escapement mechanism operative with each body; and a constant frequency timing device, including a vibrating reed for positively controlling the escapement action of each mechanism.

18. In a printing telegraph distribution system, comprising local and distant transmitting and receiving distributors, said distributors being driven from separate sources of power; means for maintaining synchronous progressive electrical and mechanically controlled operation of said distributors independently of the speed and power variation of said sources, comprising an escapement mechanism coordinated with each distributor; and means for positively actuating and timing each mechanism, including a vibrating reed having a predetermined periodicity.

19. In a printing telegraph system, comprising transmitting means at a local station for establishing electrical sequences affecting receiving means at a distant station; means for maintaining the sequences of each station in synchronism, comprising an escapement mechanism; a timing device comprising a vibrating reed of predetermined constant periodicity for positively controlling the escapement action of said mechanism; and means dependent upon the action of said device for starting and stopping the cycle of said sequences.

20. In a printing telegraph system, comprising means for the transmission of electrical impulses, said means including a rotating body; means for controlling the incremental progression of said body, comprising an escapement mechanism; a vibrating reed for timing said escapement mechanism through an operative cycle; a latch for retaining the reed against vibration; a magnet for operating the latch; an electrical circuit including said magnet; means responsive to a starting impulse to de-energize the magnet whereby the latch is released; and means in said circuit acting under the control of the escapement mechanism upon the completion of an operative cycle

to energize the magnet whereby the latch is operated to lock the reed against further vibration.

21. In a printing telegraph system, comprising distributors; means controlled by said distributors for transmitting and receiving code combinations of signalling conditions; a mechanism for controlling the incremental progression of said distributors, including a rotary member provided with escapement pins; a vibrating reed of predetermined periodicity for timing an operative cycle of said mechanism; means to control the escapement action, comprising escapement pawls actuated by the vibrating reed and alternately engaging said pins; a magnet having a spring retracted armature, and a latch carried by said armature for locking said reed against movement when the magnet is energized; an electrical circuit including said magnet; means responsive to a starting impulse to open said circuit whereby the magnet is de-energized and the latch is released to start the vibration of the reed; means in the aforesaid circuit acting under the control of the escapement mechanism upon the completion of an operative cycle to energize said magnet whereby the latch is brought into position to lock the reed, one of said pins being provided with means to impart an extra thrust to one of said pawls whereby the reed is swung into locking engagement at the end of said cycle.

22. A printing telegraph system, including rotating bodies driven from separate sources of varying power; means for synchronizing the speed of rotation of said bodies independently of the speed and power of said sources, said means including an escapement mechanism; means for controlling said mechanism including a vibratory reed; means including a magnet for normally holding said reed from vibration; a circuit system including said magnet; and means acting in response to electrical impulses transmitted through said circuit system to operate said magnet whereby said reed is released to escape said mechanism through an operative cycle.

23. A printing telegraph system comprising a plurality of stations, each station being provided with means for the transmission and reception of electrical impulses, and said means including rotating bodies; means for determining the progression of said bodies with respect to unit time comprising a step by step mechanism; means for controlling said mechanism including a vibratory reed; means including a magnet for normally holding said reed from vibration; an electrical circuit system including said magnet; and means for operating said magnet whereby said reed is released to escape said mechanism in code groups in response to impulses transmitted through said circuit system.

24. In a system of machine or automatic telegraphy, comprising members in rotary progression for distributing, transmitting and receiving processes between local and distant stations of the system, and including distributor segments and stop-start segments coordinated with said members at each station; power sources for driving said members; means for maintaining step by step unison for each and every distributor transmitting segment as well as stop-start segments of one station with each and every distributor receiving segment as well as stop-start segments of another station, comprising an escapement mechanism operative to regulate the progression of said members in equalized step by step intervals and independently of the speed of said power sources; and

matched vibrating reeds at said stations positively actuating and timing said mechanisms.

25. In a system of printing or machine telegraphy, comprising members in rotation for distributing sending and receiving processes between local and distant offices of the system, and including power sources for driving said members; means for maintaining step by step unison of the sending distributor at one office with the receiving distributor at another office for each and every signaling interval whether marking or spacing in

equalized steps with respect to time, comprising an escapement mechanism operative to control the progression of rotation of said members in equalized intervals and independently of the rate of rotation of said power sources; and matched vibrating reeds of predeterminable periodicity at said stations for positively actuating and timing said mechanisms.

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