May 15, 1951 W. F. FRIEDMAN 2,552,548

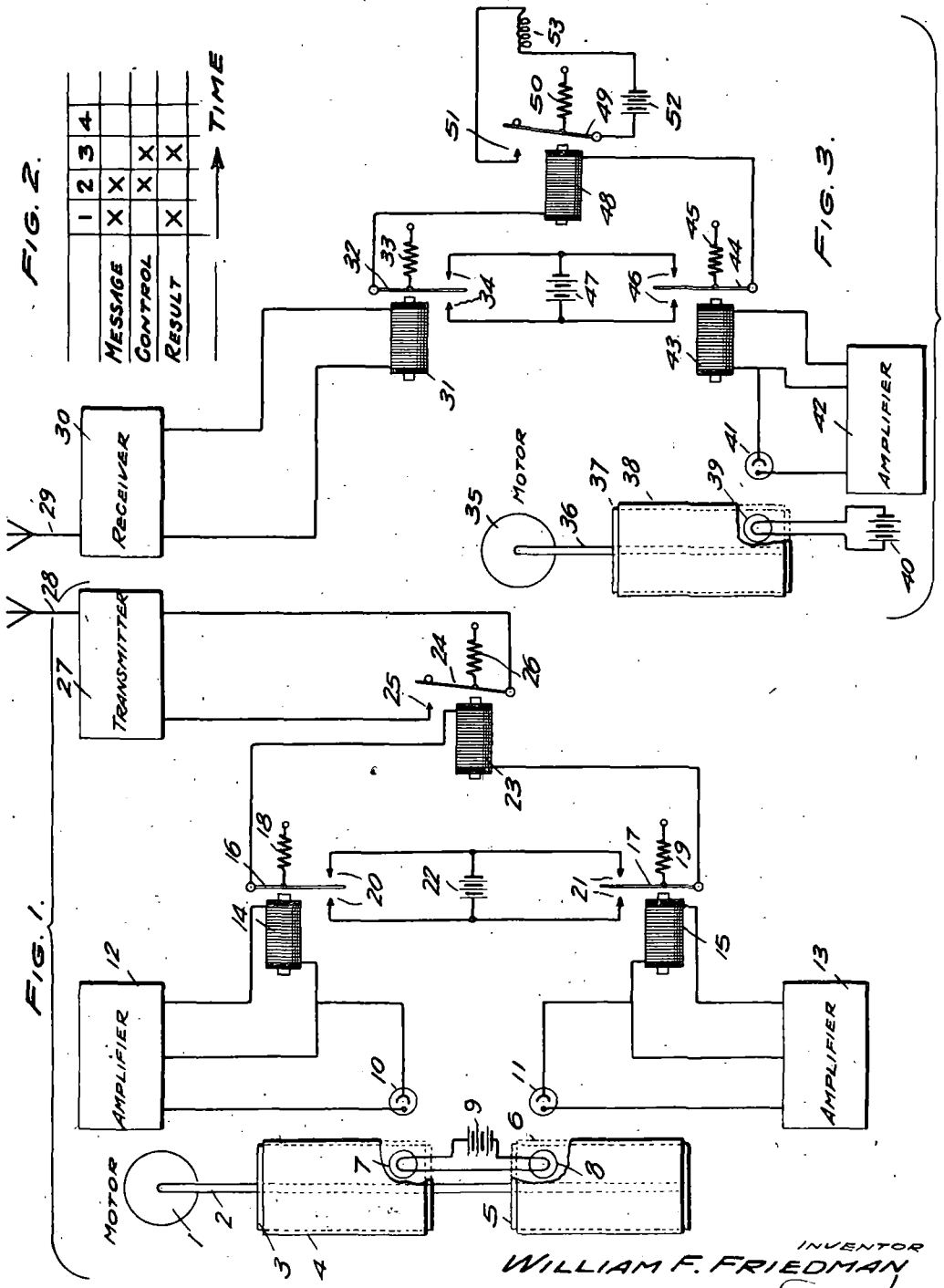
FACSIMILE ENCIPHERING SYSTEM

Filed March 6, 1943

FIG. 2.

	1	2	3	4
MESSAGE	X	X		
CONTROL		X	X	
RESULT	X		X	

TIME



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FACSIMILE ENCIPHERING SYSTEM

William F. Friedman, Washington, D. C.

Application March 6, 1943, Serial No. 478,193

5 Claims. (Cl. 178—5.1)

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

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

The subject matter of this invention is a system for enciphering facsimiles.

This invention relates to means for secretly communicating information by transmitting a facsimile of the message in a graphic form of any sort such as a writing, type-writing, picture, photograph or the like. Secrecy is obtained by transmitting a series of impulses caused in part by the message to be transmitted and in part by a control in graphic form such as any writing, picture or random arrangement of dots or lines. Such a control does not necessarily have any intelligibility in itself. It operates as a random key. At the receiving end, a duplicate of this control is employed. This duplicate control is moved in synchronism with the movements of the control at the transmitting end and causes a series of impulses which co-operate with the impulses received from the transmitter, the interaction between the two series of impulses serving to produce a facsimile of the original message.

It is an object, therefore, of my invention to provide apparatus comprising a transmission system including a transmitter section and a receiver section. Each of said sections has, as a part thereof, an electric circuit including the contacts of a plurality of relays interconnected in such a way as to cause a plurality of impulses to circulate in said circuit. In the transmitter section these impulses represent the combined effects due to the message to be transmitted and to a control element. An impulse can only occur in this circuit when both of the relays have not moved their contacts to the same position. In the receiver section these impulses represent those caused by the original message, since the impulses due to the control have been removed by the use of a duplicate of the control in the receiver section.

For a further exposition of my invention reference may be had to the annexed drawings and specification at the end whereof the novel features of my invention will be specifically pointed out and claimed.

In the drawings:

Figure 1 is a circuit diagram of the transmitter with parts designated by blocks bearing appropriate labels.

Figure 2 is a tabulation illustrating the impulses comprising the intelligence transmitted.

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Figure 3 is a circuit diagram of the receiver in block form.

In the one embodiment of my invention which has been selected from among others, my device is shown as comprising a transmitter section having a motor 1 driving shaft 2 carrying transparent drum 3 surrounded by message sheet 4 and also carrying transparent drum 5 surrounded by control sheet 6. Within drums 3 and 5 are located electric lamps 7 and 8 which serve as sources of light and which are energized from a source of electricity 9. Opposite lamps 7 and 8 so as to receive a beam of light therefrom and, respectively, under the control of message sheet 4 and control sheet 6, are located light-sensitive cells 10 and 11 which form parts of circuits including amplifiers 12 and 13 and relay coils 14 and 15. These relays also include movable contacts 16 and 17 biased in one direction by springs 18 and 19 and, in the other direction, by coils 14 and 16, respectively, when these coils are energized, and engaging one or the other of stationary contacts 20 and 21. Contacts 16, 17, 20 and 21 form parts of a circuit, including a source of current 22 and relay coil 23, which, when energized, attracts movable contact 24 into engagement with stationary contact 25, overcoming the pull of spring 26. Contacts 24 and 25 control a circuit including transmitter 27 having an output element 28, shown as an antenna.

At the place to which it is desired to transmit the intelligence, there is located a receiving system having a receiving element, indicated as an antenna 29, forming part of receiver 30 which is connected into circuit so as to control relay coil 31. This relay also includes movable contact 32 stressed away from coil 31 by spring 33 and co-operating with stationary contacts 34. Motor 35 drives shaft 36 carrying transparent drum 37 surrounded by second control sheet 38, which is a duplicate of control sheet 6. Within drum 37 is located electric lamp 39, energized by a source of electricity 40. Opposite lamp 39 so as to receive a beam of light therefrom under the control of second control sheet 38, is located light-sensitive cell 41 which forms a part of a circuit including amplifier 42 and relay coil 43. This relay also includes movable contact 44 biased in one direction by spring 45 and, in the other direction, by coil 43, when this coil is energized, so as to engage one or the other of stationary contacts 46. Contacts 34 and 46 form parts of a circuit including a source of electricity 47 and a relay coil 48. This re-

lay includes movable contact 49 stressed away from coil 48 by spring 50 and co-operating with stationary contact 51. Contacts 49 and 51 are parts of a circuit including a source of electricity 52 and coil 53, which is the operating element of a facsimile reproducer of any convenient type.

The operation of my device is as follows: The message and the control sheets are in any graphic form such as a writing, printing, drawing, photograph or the like. They may be said to consist of pluralities of spots or elemental parts each of which is either black or white depending upon the part of the message which it forms. Relative movement is provided between lamp 7 and message sheet 4, between lamp 8 and control sheet 6, and between lamp 39 and second control sheet 38 in any convenient manner heretofore used in the art of facsimile transmission. This causes the beam of light emitted by each lamp to scan every spot or element of the message or control associated with it. In the transmitter this scanning thus produces a series of impulses in the amplifying circuits through the action of the light sensitive cells 10 and 11. For convenience of description, these impulses can be said to be produced by black spots in the message or control. Thus coils 14 and 15 are energized every time an impulse occurs in the amplifying circuit associated therewith. The action of the relays controlled by these coils produces in the circuit associated with them a series of impulses distributed in time as shown in Figure 2 of the drawings in which the term "X" represents an impulse. This figure shows the four possible cases. Thus it will be seen in column 1 that energizing coil 14 by message sheet 4 without energizing coil 15 by control sheet 6 causes an impulse in the circuit containing coil 23 and labeled "Result" in Figure 2. This energizes coil 23 and causes transmitter 27 to emit an impulse. As seen in column 2, when both coils 14 and 15 are energized no impulse appears in the circuit containing coil 23. As seen in column 3, energizing coil 15 but not energizing coil 14 causes an impulse in the circuit containing coil 23. Column 4 shows that when no impulse is present in either amplifier 12 or 13 and, consequently, neither coil 14 nor 15 is energized, no impulse appears in the circuit containing coil 23. To put it another way, an impulse only appears in coil 23 and, therefore, an impulse is only sent out from transmitter 27, when coils 14 and 15 are not in the same condition, i. e., are not simultaneously energized or de-energized. This is due to the fact that simultaneous energization or de-energization of coils 14 and 15 causes movable contacts 16 and 17 to engage stationary contacts 20 and 21, respectively, which are connected to the same side or polarity of source 22.

The series of impulses emitted by the output element 28 of transmitter 27 is received by the input element 29 of receiver 30. Each impulse so received energizes coil 31. Motor 35 produces relative movement between second control sheet 38 and light 39 so that control sheet 38 is scanned in synchronism with control sheet 6. Since second control sheet 38 is a duplicate of control sheet 6, coil 43 is energized in synchronism with the energizations of coil 15. Referring again to Figure 2, the line labeled "Result" represents the impulses which pass through receiver 30 and energize coil 31, while the line labeled "Control" represents the simultaneous impulses caused by control sheet 38 and which energize coil 43. Figure 2, column 1, shows that when there is an impulse in coil 31 and none in coil 43, an impulse is produced in coil 48, which is represented in Figure 2 by the line labeled "Message." Following through the other columns of Figure 2 shows that when coils 31 and 43 are simultaneously energized or de-energized, no impulse appears in coil 48. Likewise, while either coil 31 or 43 is energized when the other is de-energized, coil 48 is energized. The energization of coil 48 causes coil 53 to be energized and coil 53 operates a stylus or other marking mechanism and thus message sheet 4 is reproduced.

It will be understood that, whereas the foregoing description calls for the transmission of a signal when one only of the coils 14 and 15 is energized, the apparatus will function just as well and achieve just as great privacy if rearranged slightly, as by giving an opposite bias, a normal closed condition, to switch 24—25. In such case, of course, a signal will be transmitted whenever coils 14—15 are in the same condition instead of when they are in different conditions.

I claim:

1. Means for secretly transmitting graphic information, said means comprising, a message in graphic form which it is desired to transmit, a scanner arranged to scan and reproduce said message as a series of electric impulses of varying intensity, a screen having varying portions, a second scanner arranged to scan and reproduce the variations of said screen as a second series of electric impulses of varying intensity, a relay connected under the control of said scanner and arranged to be moved by each of said impulses to one of two positions, a second relay connected under the control of said second scanner and arranged to be moved by each of said second impulses to one of two positions, an electric circuit including parts of said relays and adapted to be closed only when there is instantaneously an impulse in either series but not in the other, a transmitter connected under the control of said electric circuit so as to emit impulses whenever said circuit is closed, a receiver arranged to receive the impulses emitted by said transmitter and having an output comprising a third series of electrical impulses of varying intensity, a second screen duplicating said first mentioned screen, a third scanner arranged to scan synchronously with the scanning of said second scanner and reproduce the variations of said second screen as a fourth series of electric impulses of varying intensity, an electromechanical interlock connected under the control of said third and of said fourth series of impulses and arranged to be energized whenever an impulse occurs in one of said third and fourth series and no impulse occurs simultaneously in the other of said third and fourth series, and a recorder connected under the control of said interlock and arranged to operate whenever said interlock is energized and to thereby reproduce said message.

2. Means for secretly transmitting graphic information, said means comprising, a message in graphic form which it is desired to transmit, a scanner arranged to scan and reproduce said message as a series of electric impulses of varying intensity, a screen having varying portions, a second scanner arranged to scan and reproduce the variations of said screen as a second series of electric impulses of varying intensity, an electromechanical interlock connected under the control of both of said series of impulses and arranged to be energized whenever an impulse occurs in one of said series and does not occur simultaneously in the other of said series, a transmitter

connected under the control of said interlock so as to emit impulses whenever said interlock is energized, a receiver arranged to receive the impulses emitted by said transmitter and having an output comprising a third series of electrical impulses of varying intensity, a second screen duplicating said first mentioned screen, a third scanner arranged to scan synchronously with the scanning of said second scanner and reproduce the variations of said second screen as a fourth series of electric impulses of varying intensity, a second electro-mechanical interlock connected under the control of said third and of said fourth series of impulses and arranged to be energized whenever an impulse occurs in one of said third and fourth series and no impulse occurs simultaneously in the other of said third and fourth series, and a recorder connected under the control of said second interlock and arranged to operate whenever said second interlock is energized and to thereby reproduce said message.

3. Means for secretly transmitting graphic information, said means comprising, a message in graphic form which it is desired to transmit, a scanner arranged to scan and reproduce said message as a series of electric impulses of varying intensity, a screen having varying portions, a second scanner arranged to scan and reproduce the variations of said screen as a second series of electric impulses of varying intensity, a relay connected under the control of said scanner and arranged to be moved by each of said impulses to one of two positions, a second relay connected under the control of said second scanner and arranged to be moved by each of said second impulses to one of two positions, an electric circuit including parts of said relays and adapted to be closed only when there is instantaneously an impulse in either series but not in the other, a transmitter connected under the control of said electric circuit so as to emit impulses whenever said circuit is closed, a receiver arranged to receive the impulses emitted by said transmitter and having an output comprising a third series of electrical impulses of varying intensity, a second screen duplicating said first mentioned screen, a third scanner arranged to scan synchronously with the scanning of said second scanner and reproduce the variations of said second screen as a fourth series of electric impulses of varying intensity, a third relay connected under the control of said third scranner and arranged to be moved by each of said impulses of said fourth series to one of two positions, a fourth relay connected under the control of said receiver and arranged to be moved by each of said impulses of said third series to one of two positions, an electric circuit including parts of said relays and adapted to be closed only when there is instantaneously an impulse in either said third or said fourth series but not in the other, and a recorder connected under the control of said circuit and arranged to be energized whenever said circuit is closed to record the original message.

4. In an apparatus of the nature described for transmitting graphic information, means for scanning a message to be transmitted to derive therefrom an electric signal irregularly assuming a succession of values responsive to the photographic density of the message at the point of scanning, means for substantially simultaneously scanning a camouflage message to derive a second electric signal irregularly assuming a succession of values depending upon the photographic density of the camouflage message at the point of scanning the second said electric signal being non-synchronous with the first with respect to the variations therein, a switch having two circuit-closing positions, means for causing said switch to assume one of its circuit-closing conditions when said first-mentioned electric signal assumes one value and the other of its circuit-closing conditions when the said first-mentioned signal assumes another of its values, a second switch having two circuit-closing conditions, and means for controlling said switch responsive to said second electric signal, a third switch, a control circuit for said third switch said circuit serving to close said switch when the first-mentioned two switches are in predetermined circuit-closing positions only, and means for transmitting a signal when said third switch is in closed condition.

5. Means for secretly transmitting graphic information comprising a device for scanning a message to be transmitted and reproducing said message as a series of electric impulses of varying intensity, a second device for scanning a camouflage message and reproducing the same as a series of electric impulses of varying intensity the impulses of said second series being non-synchronous with the impulses of the said first series, a relay connected under the control of said first device and arranged to be moved by each of said impulses to one of two positions, a second relay connected under the control of said second device and arranged to be moved by each of the impulses of said second series of said impulses to one of two positions, an electric circuit including said relays adapted to be closed only when predetermined combinations of closed positions in said relays occur simultaneously, and a transmitter connected under the control of said electric circuit so as to emit impulses only whenever said circuit is closed.

WILLIAM F. FRIEDMAN.

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1694874

Dec. 11, 1928 1,694,874

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METHOD OF ELECTRICAL SIGNALING

Filed July 10, 1922

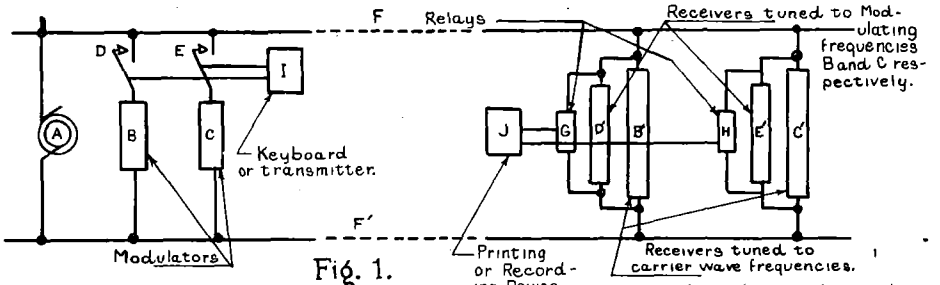

Fig. 1.

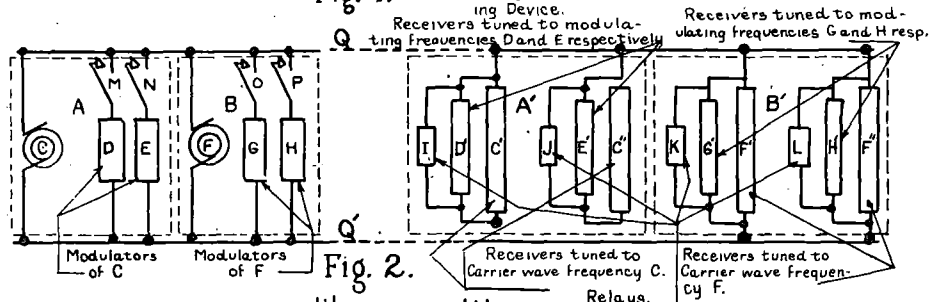

Fig. 2.

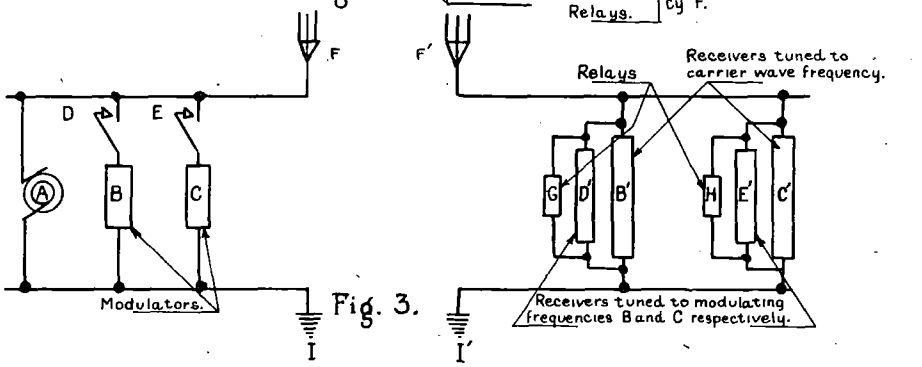

Fig. 3.

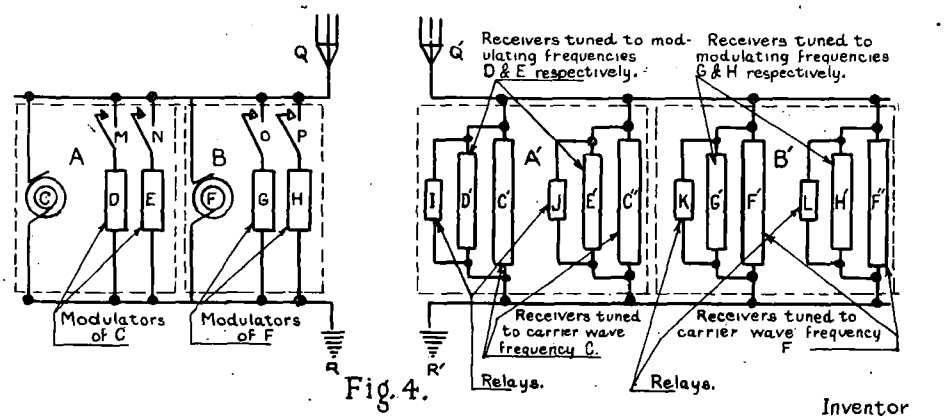

Fig. 4.

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Patented Dec. 11, 1928. 1,694,874

UNITED STATES PATENT OFFICE.

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METHOD OF ELECTRICAL SIGNALING.

Application filed July 10, 1922. Serial No. 573,981.

(GRANTED UNDER THE ACT OF MARCH 3, 1883, AS AMENDED APRIL 30, 1928; 370 O. G. 757.)

This invention relates in general to electrical signaling systems and more particularly to systems for the simultaneous transmission of a plurality of messages through one and the same channel, and has for its object the provision of a new and more simple system of circuits for achieving this end.

A further object of the invention is to effect a reduction of the length of time necessary to transmit and receive each of a plurality of messages by the heretofore prevalent systems of multiplex printing telegraphy, and thus increase the capacity of a single channel.

A further object is to effect an increase in the number of telegraph messages which can be transmitted over a single channel by the heretofore prevalent systems of multiplex telegraphy.

A further object is to achieve a system of multiplex radio telegraphy by the use of a single wave instead of a plurality of waves of different frequencies.

The fundamental principle of my invention is the differential modulation of a single carrier wave and the selective isolation of the several modulating frequencies at the receiving end, each so isolated modulating wave affecting a different independent circuit.

In order that the invention and its mode of application may be readily understood by persons skilled in the art, I have, in the accompanying illustrative drawings, and in the detailed following description based thereon, set forth an embodiment of the same.

Figure 1 is a diagrammatic sketch of one form of arrangement of circuits whereby a high frequency current carrier wave is modulated by several modulators of different character, the modulated carrier wave impressed upon a line and the several modulating frequencies selectively separated at the other end of the line.

Figure 2 is a diagrammatic sketch of one form of arrangement of circuits whereby a plurality of high frequency carrier waves are each modulated by several modulators of different characters, and at the other end of the line these modulated carrier waves are first separated by tuning to the frequencies of the carrier waves and then tuning again to the modulating frequencies.

Figures 3 and 4 are the same as Figures 1 and 2, respectively, except that the arrangements in Figures 3 and 4 are adapted for radio transmission instead of line transmission.

Having more particular reference to the drawings, and in connection with which like characters of reference designate similar parts throughout, in Figure 1, A is a source of high frequency oscillations of constant frequency, designated hereafter as the carrier wave; B and C are arrangements for modulating the carrier wave, each differently modulating the carrier wave A; D and E are keys which respectively control the modulation elements B and C. These keys may be operated manually by individual operators employing the Morse code signals but as shown in the figure they are here illustrated as operatively connected to I, which is a sending keyboard or an automatic tape-controlled transmitter, both of well known form. F and F′ constitute the line which the carrier wave traverses. B′ and C′ are selectively tuned circuits responsive to the carrier wave A; D′ and E′ represent circuits selectively tuned to respond individually to the respective modulating frequencies; G and H are relays which may be of well known forms, and are operable by the currents passed by D′ and E′ respectively, but they may be any other form of device suitable for making the currents of the isolated frequencies perceptible to the eye or ear, or for recording these currents in a suitable manner. The figure, however, shows G and H to be relays operatively connected to J, a printing or recording device of any of the well known forms.

Let us suppose that A impresses upon the line F—F′ a carrier wave of 50000 cycles per second, that B modulates the carrier wave by 1000 cycles per second and that C modulates the carrier wave by 2000 cycles per second. Therefore a carrier wave modulated in one instance to a 49000–51000 cycle wave, and in the other instance to a 48000–52000 cycle wave is impressed upon the line. At the receiving end of the line B′ and C′

are circuits tuned to the carrier frequency of 50,000 cycles, and the carrier wave current will divide, part, passing to one circuit, B′, and a part passing to the other circuit, C′. But D′ and E′ are arranged to respond to different modulating frequencies, that is, one will be acted upon only by the 1000 cycle modulating frequency, and the other will be acted upon only by the 2000 cycle modulating frequency. In that way the different modulating frequencies are separated. Hence relays G and H will respond selectively to the modulating frequencies of B and C.

The tuning of the receivers B′ and C′ to a modulated wave which covers a narrow band of frequencies as in the preceding example, 49000 to 51000 cycles or 48000 to 50000 cycles, may be accomplished by the well known methods in the art, which may be by the use of band filters, or any other suitable circuit arrangements.

In the same way a plurality of carrier waves of different frequencies may be employed, each carrier wave separately modulated by several modulations of different characters, and at the receiving end the different frequency carrier waves are first separated by suitable tuning and by further tuning the individual modulating frequencies on each carrier wave may be isolated. Thus a multiplex system of extremely wide range is made possible. This is shown diagrammatically in Figure 2, where A represents one unit of carrier wave current of one frequency from source C, with its associated modulating frequencies D and E, and B represents another unit of carrier wave current of another frequency from source F, with its associated modulating frequencies, G and H. A′ represents a system of circuits comprising circuits C′ and C″ selectively tuned to the frequency of the carrier wave C, and circuits D′ and E′, selectively tuned to the modulating frequencies D and E, which are produced at A, and I, J, are relays actuated by circuits D′, E′, respectively. B′ represents a system of circuits comprising circuits F′ and F″, selectively tuned to the frequency of the carrier wave, F, and circuits G′ and H′, selectively tuned to the modulating frequencies, G and H, which are produced at B, and K, L are relays actuated by circuits G′, H″, respectively. M, N, O, and P are the keys controlling the modulating circuits at A and B, and Q, Q′ is the line.

It is obvious also that transmitting sets can be placed at both ends of the line, and their corresponding receiving sets at both ends of the line, so that multiplex operation is possible. For such operation a plurality of single period generators or a single multiperiod generator can be employed. This arrangement is especially adapted for printing telegraph systems which employ code signals consisting of a plurality of elements or units affecting a plurality of relays associated with a printing or a recording mechanism. It may be desirable to discuss briefly this aspect of the invention.

In the heretofore prevalent forms of printing telegraph systems, the automatic operations concerned in causing a printing mechanism to function at a distance are controlled by groups of equal potential, direct current electrical impulses which pass over one and the same line, and actuate a set of relays, each impulse in the group effecting the operation of a particular relay, by a method described below. These relays actuate magnets which set up combinations of selecting discs in a printing mechanism, and each character of the message is determined by a different combination or arrangement of these selecting discs. Usually there are 32 such combinations, 26 for the ordinary letters and 6 others concerned in certain functions of the printer, such as carriage return, figure shift, and so on. The signals for message characters as commonly used in these systems constitute what is usually termed a five-unit code, that is, it consists of permutations of two elements taken five at a time. In one system of operation these two elements may be positive and negative potentials, in which case the code signal for a character consists of the distribution through time of five elements composed of positive and negative impulses. In another system of operation the two elements may consist of a time-interval when an impulse is sent, and a time-interval when no impulse is sent, this being the method of closed and open circuit operation. The code signal for the letter "A" for example, is "— — — — —," which in the positive and negative system of operation means that the first and second units of the signal are positive impulses, the third, fourth, and fifth, are negative impulses. In the open and closed circuit system of operation, this code signal means that only the first two time units are occupied by the passage of current, the last three, unoccupied. The permutations of transmitted impulses are governed by a set of make and break keys operated at the transmitting end manually, by means of a sending keyboard similar in form to the ordinary typewriter keyboard, or automatically by means of a transmitter controlled by a perforated tape.

In order that a plurality of relays shall be controlled by impulses of equal potential, and all coming over the same line, or through the same channel, and that the permutation of relays actuated at the distant end shall correspond to the permutation of depressed keys at the sending end, in the heretofore prevalent systems, connection is

established between each key at the sending end and its corresponding relay at the receiving end at a different instant, and the several connections necessary to transmit the code signal for each message character are made in a definite, fixed sequence. Thus, for example, in the case of five relays respectively controlled by five make and break keys, the time necessary to send the signals for one character is divided up into five equal intervals; during the first interval connection is established between key 1 at the sending end and its corresponding relay 1 at the receiving end; during the second interval, connection is established between key 2 at the sending end and its corresponding relay 2 at the receiving end, and so on. The method of effecting such a correspondence in action by transmitting similar impulses through one and the same channel involves the use of a distributor and various other apparatus included under the general term "synchronizing mechanism."

The principal of the synchronizing distributor is this: two similar rings, one, on the sending face of a distributor at the transmitting station, the other on the receiving face of an identical distributor at the receiving station, are each divided into five equal segments. A pair of rotating brushes on these distributors are connected to the line, and when these brushes revolve they sweep over and make contact with the segments of their respective rings. The brushes at the two ends of the line start from the same relative position and sweep over the contact segments with the same uniform angular velocity, thus connecting the first segment of the ring of the sending distributor with the first segment of the ring of the receiving distributor once per revolution of the brushes. Likewise the second, third, fourth, and fifth segments of the sending distributor are connected once per revolution of the brushes with the corresponding segments of the receiving distributor, the interval of each connection being the time of one-fifth of a revolution of the rotating brushes. Thus, each message character is transmitted as a combination of five separate or discrete impulses distributed equally and in a definite sequence through an interval of time, and for each revolution of the brushes, the code impulse combinations for one and only one character or letter are transmitted and received. The synchronization of the two distributors so that the respective brushes revolve with exactly the same angular velocity is a very complex feature of these printing telegraph systems, and acts as a limiting factor upon the speed of operation. In my system no such synchronization is necessary, for all of the signals comprising the combination of impulses for a single character are transmitted simultaneously, and at the receiving end are properly isolated by five selectively tuned circuits.

There is, of course, nothing novel in modulating a carrier wave either telephonically or telegraphically. The novelty of my invention consists in modulating a single carrier wave telegraphically by several distinct modulating frequencies, and isolating each modulating frequency individually. In telephonic modulation a relatively wide band of modulating frequencies is imposed upon the carrier wave, and this band of heterogeneous side frequencies is faithfully reproduced by the telephone receiver at the receiving end. The human ear hears all of these heterogeneous side frequencies simultaneously, but is able to distinguish them and hear them separately if an effort is made. For example, when orchestral music is being transmitted by radio telephone, the radio audience hears the ensemble effect but there is absolutely no difficulty in distinguishing the music produced by a violin from that produced by a cornet. Both sounds are being transmitted on one and the same vehicle or carrier wave, but the modulating frequency of the sound vibrations of the violin is different from that of the cornet. While in the illustration given above the separation of the modulating frequencies is effected by the ear, in the arrangement of this invention the separation of the modulating frequencies is accomplished by mechanical or electrical tuning devices.

In Figure 3 the arrangements of circuits is identical with that shown in Figure 1, but instead of having a line upon which the modulated carrier waves are impressed, a transmitting antenna, F, with its ground I, serves to radiate the modulated waves into space, and a receiving antenna F′, with its ground I′, serves to receive the waves radiated by F.

In Figure 4, the arrangement of circuits is identical with that shown in Figure 2, but instead of having a line upon which the modulated carrier waves are impressed, a transmitting antenna, Q, with its ground R, serves to radiate the modulated waves into space, and a receiving antenna, Q′, with its ground, R′, serves to receive the waves radiated by Q.

It is obvious that the arrangements shown in Figure 1 for controlling the operation of the keys governing the modulating circuits and for controlling the operation of the printing or recording mechanism, when a system of printing telegraph is employed, also apply to Figures 2, 3, and 4. But it is also obvious that the modulating keys may be operated manually by individual operators, as stated before, and at the receiving end, instead of having relays, several oper-

ators may receive the messages transmitted in ordinary Morse characters by using telephone receivers.

It is obvious that radio-frequency oscillations must be employed for radio communication by the systems illustrated in the last two figures.

While I have not indicated in the figures any particulars regarding the means to be employed in producing the carrier wave or the manner of modulating the carrier wave, or the manner in which the modulated carrier waves are impressed on the line or radiated into space, it is to be understood that any of the means and methods now well known in the art may be employed. Nor have I indicated any details with respect to the exact means to be used in receiving the modulated carrier waves, selectively separating the modulating frequencies, and causing them to affect selectively tuned relays or recording devices, for here also the means and methods now well known in the art apply to this invention.

What I claim as my invention is the following:

1. In a printing telegraph system, a source of high frequency electrical oscillations constituting a carrier wave, a set of modulators of different modulating frequencies which can be impressed upon said carrier wave, each of said modulators being associated with a make and break key which determines whether the modulating frequency controlled thereby will or will not be impressed upon the said carrier wave, said keys together comprising a single set of keys acting as a single unit associated with a keyboard mechanism, said keyboard mechanism being so constituted as to control said set of keys permutatively as a unit according to a plural-unit code suitable for the representation of message characters, means for transmitting the permutatively modulated carrier wave representing the message characters, a receiving station, means at said receiving station for detecting said transmitted permutatively modulated carrier wave, means for detecting the presence of and for isolating each modulating frequency of said permutatively modulated carrier wave, said latter means comprising a set of resonant circuits appropriate for the purpose, each of said resonant circuits being associated with and adapted to control a relay which is operative when the modulating frequency to which the respective resonant circuit is responsive is present, and is inoperative when the modulating frequency to which said resonant circuits is responsive is not present, a plurality of relays acting as a single unit associated with a printing mechanism, said printing mechanism being controlled as a unit by the joint and permutative action of said set of relays in such a manner as to print the message characters represented by the permutatively modulated transmitted and received carrier wave.

2. In a printing telegraph system comprising a source of high frequency electrical oscillations constituting a carrier wave, a set of modulators of different modulating frequencies which can be impressed in a permutative manner representing message characters in a plural-unit code upon the said carrier wave by means of a keyboard mechanism controlling a set of keys, governing the action of said set of modulators, a receiver capable of receiving the permutatively modulated carrier wave representing message characters, a set of resonant circuits, each of said resonant circuits being responsive to one individual and only one of said modulating frequencies, a set of relays controlled as a unit permutatively by the said set of resonant circuits, and a printing mechanism controlled by the said set of relays and suitable for printing the received message characters, the method of permutatively and simultaneously impressing the said modulating frequencies upon the said carrier wave, transmitting and subsequent receiving and detecting the said permutatively modulated carrier wave, detecting and isolating the said modulating frequencies, causing the said isolated modulating frequencies to control the operation of a set of relays permutatively according to the plural-unit code representing the message characters transmitted, the said set of relays acting as a unit to control the action of a printing mechanism suitable for printing the message characters.

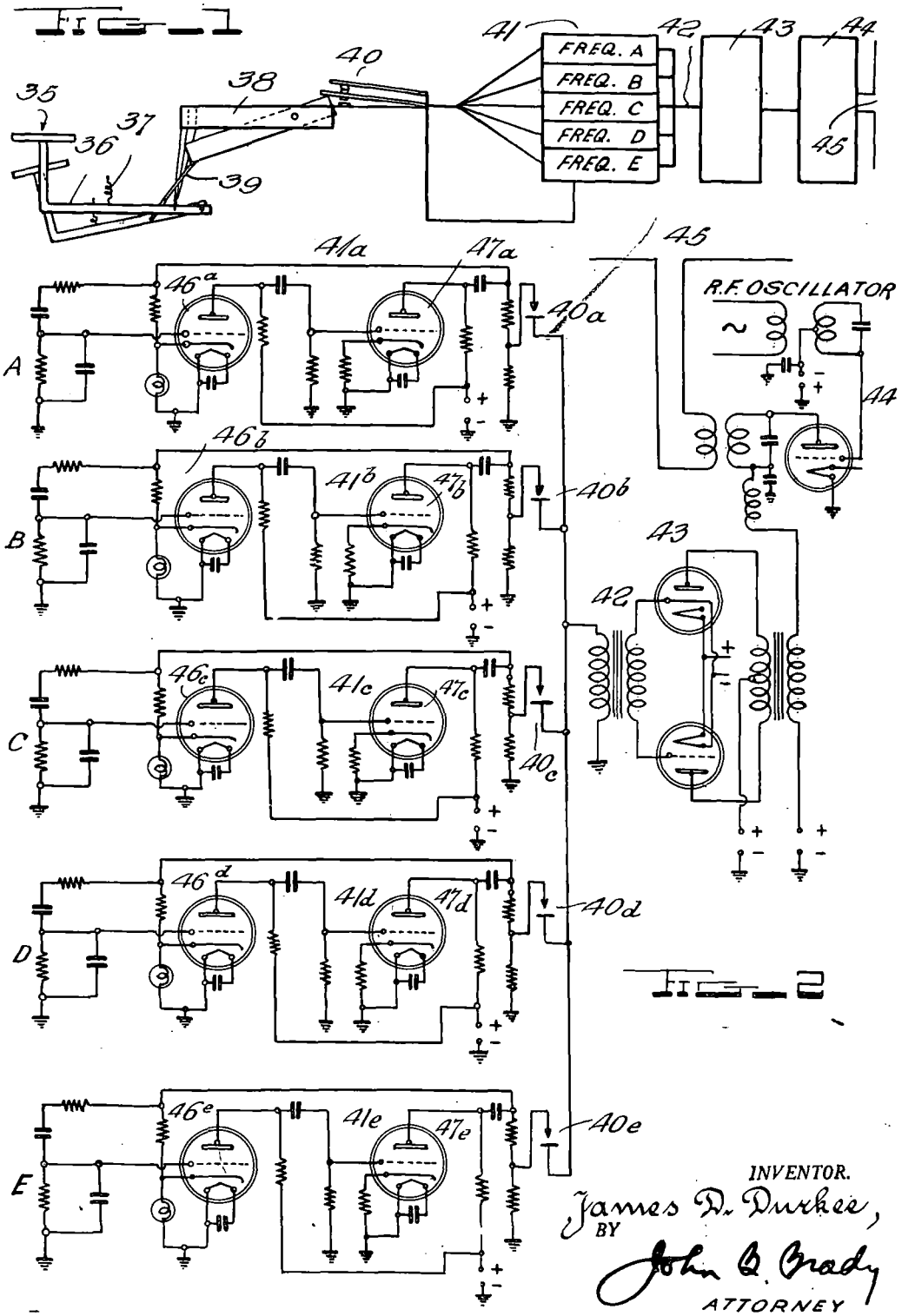
In testimony whereof I affix my signature.

WILLIAM F. FRIEDMAN.

Nov. 10, 1953 J. D. DURKEE 2,658,942

PRINTING TELEGRAPH SYSTEM

Filed Aug. 11, 1949 3 Sheets-Sheet 1



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Nov. 10, 1953 J. D. DURKEE 2,658,942

PRINTING TELEGRAPH SYSTEM

Filed Aug. 11, 1949 3 Sheets-Sheet 2

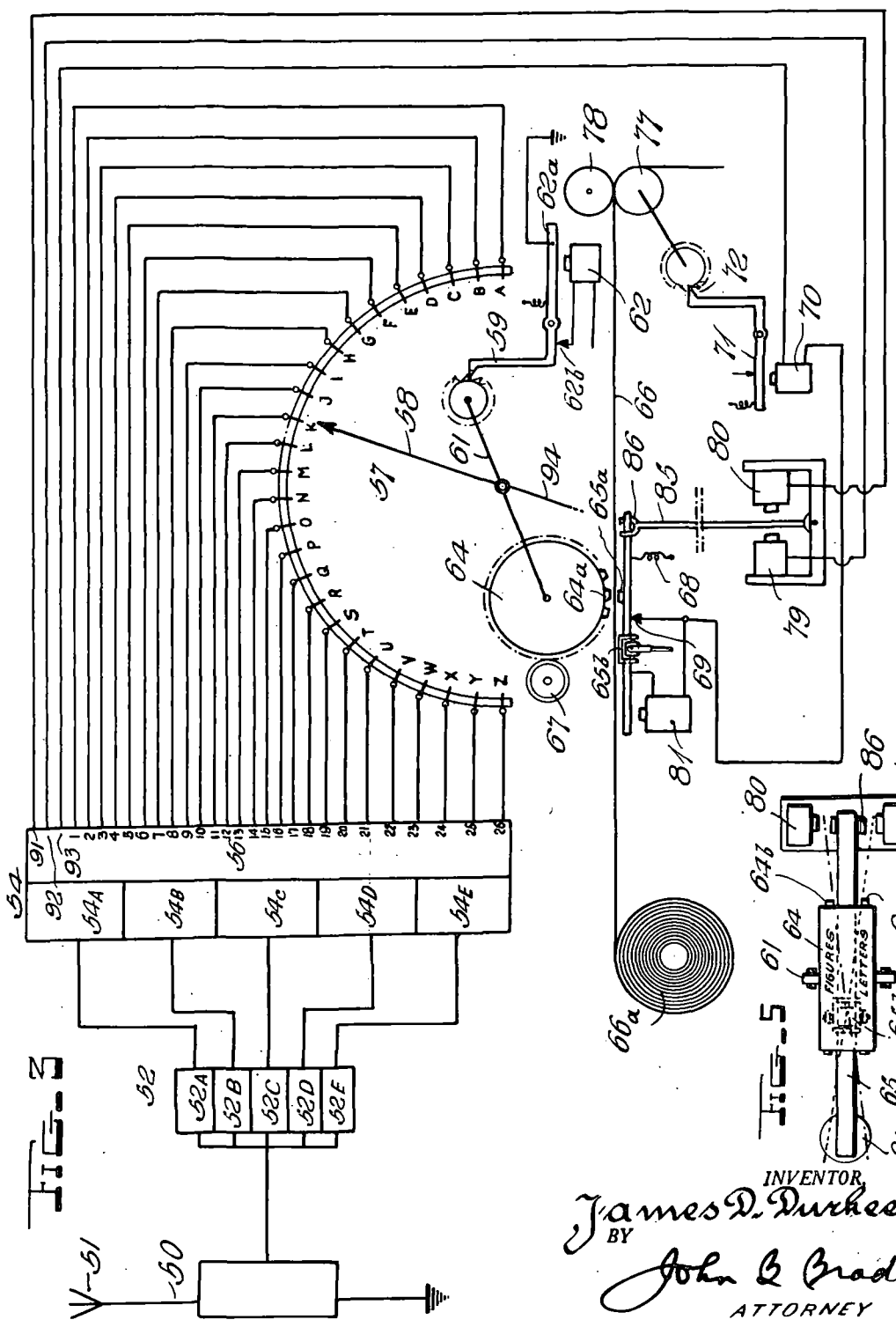

FIG. 3

FIG. 5

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PRINTING TELEGRAPH SYSTEM

Filed Aug. 11, 1949 3 Sheets-Sheet 3

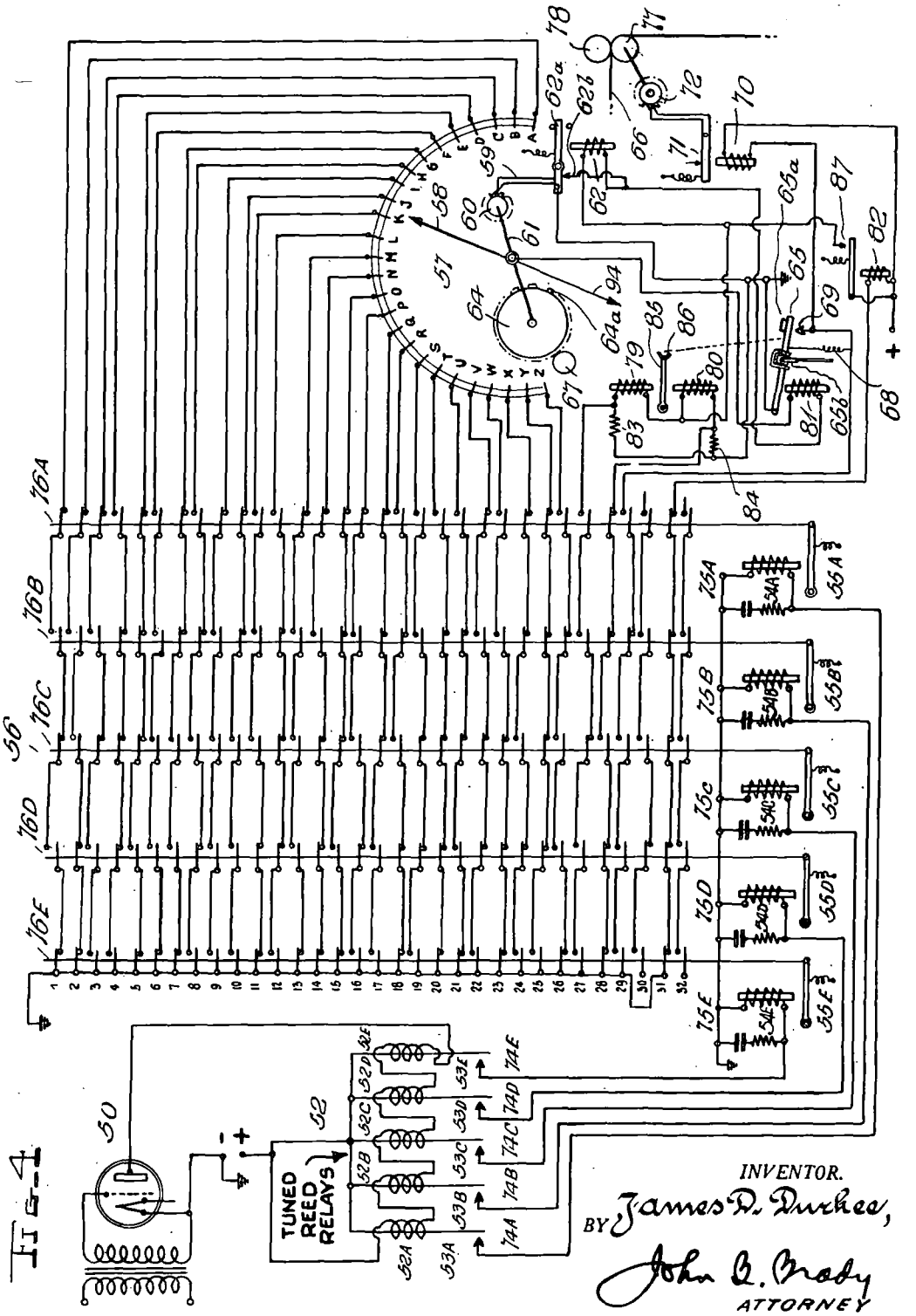

Fig. 4

Patented Nov. 10, 1953 2,658,942

UNITED STATES PATENT OFFICE

2,658,942

PRINTING TELEGRAPH SYSTEM

James D. Durkee, Fairlington, Va., assignor, by direct and mesne assignments, to Dualex Corporation, a corporation of Delaware

Application August 11, 1949, Serial No. 109,648

12 Claims. (Cl. 178—23)

1

My invention relates broadly to communication systems and more particularly to an improved system of printing telegraphy.

One of the objects of my invention is to provide an improved printing telegraph system particularly adapted for radio communication in which conditions of fading, interference, and static offer minimum detrimental effects upon the printing telegraph apparatus.

Another object of my invention is to provide a system of printing telegraphy operative at relatively high speed and with accuracy in the transmission of printed communications.

Another object of my invention is to provide a construction of improved printing telegraph system which involves a minimum of mechanical equipment, eliminating necessity for precise synchronism between transmitting and receiving stations.

A still further object of my invention is to provide a construction of printing telegraph transmitter and receiver embodying selective electrical circuits with a minimum of mechanical equipment for effecting high speed printing telegraph operations.

Still another object of my invention is to provide a printing telegraph system in which permutations and combinations of simultaneously applied coded signal impulses are established and impressed upon a vibrating reed converter including reeds resonant to the individual frequencies of the coded signal impulses with means for deriving from the converter system direct current pulses for controlling the selective operation of the printing telegraph apparatus.

Still another object of my invention is to provide a printing telegraph system including a prearranged matrix of electrical circuits individual to the characters to be printed and selectively operative under control of simultaneously applied coded signal impulses for controlling the printing telegraph mechanism.

Still another object of my invention is to provide a compact construction and arrangement of stepping relay, a printing telegraph mechanism controlled thereby, a matrix of electrical circuits for controlling the stepping relay, and a conversion system for operating the said matrix relative to simultaneously applied coded signal impulses for controlling the printing telegraph mechanism.

Still another object of my invention is to provide improved lightweight printing telegraph transmitting and receiving apparatus which may be used interchangeably in circuits now employing standard printing telegraph apparatus utilizing the international teletype code.

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Other and further objects of my invention reside in a construction and arrangement of step-by-step relay system for printing telegraph circuits as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 schematically shows the transmission system of my invention; Fig. 2 is a diagrammatic view of the transmission system illustrated in Fig. 1; Fig. 3 diagrammatically shows the receiving system of my invention; Fig. 4 is a diagrammatic illustration of the conversion system, the electrical matrix, the step-by-step relay, and the control mechanism, associated therewith for operating the printing telegraph equipment; and Fig. 5 is a schematic view illustrating the manner of shifting the printing telegraph apparatus from "Figures" to "Letters" position in the course of operation of the printing telegraph apparatus.

The application of automatic and mechanical signalling systems to radio communication has been, in the past, limited to circuits, on which there is relatively little or no interference, fading or static. These systems have also been limited in speed of operation and dependability. Since circuits possessing these characteristics are seldom encountered, particularly in the aviation, maritime and land mobile services, the use of manual radio operators for radio telephone and telegraph communications has been necessary in the past.

The requirement for increased speed of operations, particularly in the aviation services, has created communication demands, which can no longer be met by manual operations. Also, the large growth of communications activities in general has placed a load on the presently available frequencies which exceeds the capabilities of these frequencies where manual methods of operation must be depended upon.

My invention is directed to a signalling system which, due to its ability to operate rapidly and accurately, even in the presence of fading and interference, will satisfy the demands for a high speed automatic communication system for all types of radio and wire communications.

Basically, my method of transferring intelligence from the transmitting point to the receiving point is by permutations or combinations of one or more audio frequencies, in accordance with a pre-arranged code, and simultaneously applying these permutations or combinations to a wire circuit or as modulation to a radio frequency

transmitter. The radio frequency wave containing the coded audio frequency permutation or combination is received by a radio frequency receiver which demodulates it into its audio frequency components and delivers them to the field coils of a series of tuned reeds or resonant relays as audio frequency impulses. These resonant relays, which are individually resonant with one of the audio frequencies contained in the permutation or combination, begin vibrating at the frequency to which they are resonant. When the vibrations of the individual resonant relays reach full amplitude, an impulse of direct current is applied to a relay or gas triode which stores the impulse, electromagnetically, until a mechanism for translating the code permutation or combination into printed characters is actuated.

While I have referred to the use of tuned reeds in the mechanism of my invention, I desire that it be understood that I may replace the tuned reeds by electrical filters, particularly at the higher frequencies for accomplishing a similar purpose.

Since the vibration of the tuned reeds of the resonant relays are affected primarily by the resonance of the impulses with the natural period of the reeds rather than by the amount of power in each impulse, the action of the reeds is not greatly affected by fading signals and, since impulses which are not resonant with the reeds, regardless of power, will not cause the reeds to vibrate at full amplitude, no direct current is transferred to the latching relay or gas tube, and thus no code permutation or combination is presented to the translating mechanism. Therefore, the system is substantially unaffected by interfering signals or static.

Conversely, if the audio frequency oscillations are continuously applied and the reeds maintained at full amplitude of vibration and the coded permutation or combination is formed by the discontinuance of combinations of the audio frequency oscillations, the vibration of the affected reeds will drop below the amplitude which maintain continuous flow of current to the relays, thus presenting coded combinations as represented by the reeds remaining in contact.

Practically all modern printing telegraph systems and equipment utilize the principle of sequential application of some form of coded permutations or combinations. These methods require accurate synchronism between transmitting and receiving points, in addition, the speed of these methods is limited by the requirement for linear translation of code permutations or combinations in terms of time. Thus, if each coded permutation or combination is spaced ⅕ second apart, the limit is five characters per second.

By the simultaneous application of the coded permutations or combinations, as accomplished by my invention, no limitation in time of translation is involved and the speed is limited only by the ability of the translation mechanism to function.

In the presently available printing telegraph systems and equipment, the sequentially spaced electrical or audio frequency impulses are transformed into coded mechanical positions which are mechanically translated into printed characters.

In the method of my invention, the coded audio frequency impulses are translated into direct current impulses which are electrically translated into printed characters, thus greatly speeding up

all printing operations as well as providing complete flexibility of transference to any position.

Description of transmitting apparatus

The operation of the system of my invention as a printing telegraph device may be understood by reference to Fig. 1 in which a keyboard **35** is provided consisting of a group of letter, figure and functional depressible pivotally mounted keys **36**, each having a key-return spring **37**, and an associated set of five selector bars **38** connected to key **36** by wires **39**. Reference character **40** represents five sets of electrical contacts which are closed in permutations or combinations when a letter or other functional key **36** is depressed. Reference character **41** designates a multiple audio frequency oscillator-amplifier capable of generating five different audio frequency tones singly or in simultaneous permutations or combinations. Reference character **42** denotes a coupling transformer between the oscillator **41** and a modulator **43** which modulates the radio frequency carrier generated in the oscillator-amplifier equipment **44**, which in turn radiates a modulated radio frequency signal through antenna system **45**.

When key **36** is depressed the wires **39** pull down a combination of bars **38** which in turn close the electrical contacts **40**, associated with each bar. When the selected contacts **40** are closed the oscillators **41** associated with each set of contacts **40** which have been closed are caused to produce oscillations at the audio frequency to which they have been tuned. The output of the actuated oscillator **41** is then combined in coupling transformer **42** which drives modulator **43** causing the radio frequency output of amplifier **44** to be modulated at the selected audio frequencies and radiated into space through antenna **45**. In addition to the method described, the audio frequency tones may be impressed upon a pair of conductors or upon a carrier frequency which is transmitted by wire lines instead of radiated into space.

In Fig. 2 I have shown the schematic wiring diagram of the transmitter where the audio frequency oscillators are illustrated at **41***a*, **41***b*, **41***c*, **41***d* and **41***e*, including resistance capacity coupled oscillator circuits **46***a*, **46***b*, **46***c*, **46***d* and **46***e* associated with oscillator amplifiers **47***a*, **47***b*, **47***c*, **47***d* and **47***e* respectively. The contacts **40** are shown for each of the respective oscillator systems at **40***a*, **40***b*, **40***c*, **40***d* and **40***e* connected to the transformer system **42** through which the selected audio frequencies are impressed upon modulator **43** for keying oscillator system **44** and impressing the selected modulated frequencies on antenna system **45**.

Description of receiving system

Fig. 3 is a block diagram of the receiving system of my invention operating as a tape printing telegraph device. In operation the receiver **50** picks up the radio signal emitted by antenna system **45** of Figs. 1 and 2 on antenna system **51** and demodulates the signals and passes the rectified impulses through the field coils of tuned reed relays **52**A, B, C, D, and E. These impulses cause the selected tuned reed relay armatures **53**A, B, C, D, and E to vibrate in resonance with the audio frequency tones selected to produce the desired permutation or combination. When the vibrating relay armatures **53**A, B, C, D, or E reach their amplitude of vibration, direct current impulses are presented to the field coils of relays **54**A, B,

C, D, and E or a combination thereof, causing the associated armatures 55A, B, C, D, or E of these relays to close a series of contacts in the electrical matrix 56 which will close an electrical path to one position on the stepping relay 57, this position having been selected when the proper key 36 of Fig. 1 was depressed. When the position on stepping relay 57 is energized with electrical current, the arm 58 being impulsed by ratchet arm 59, ratchet relay 62, and ratchet wheel 60 connected to arm 58 through shaft 61 under control of the arm 58, starts stepping towards the energized position within a range of approximately 180°.

Upon arrival of arm 58 at position A, printing relay 81 is placed in short circuit across contacts 62*a*, 62*b* of ratchet relay 62, arresting the movement of arm 58. The drum 64, being directly coupled to the shaft 61 which carries arm 58 through its stepping cycle, has on its periphery the type characters of the alphabet in the lower case and the numerals and punctuation in the upper case as shown more clearly in Fig. 5. When arm 58 reaches the energized position A, drum 64 carries the type character 64*a* to a position immediately above printing arm 65 and tape 66. When relay 81 was energized by being placed in short circuit across contacts 62*a*, 62*b*, anvil 65*a* of arm 65 was caused to strike tape 66 which was in turn pressed against type character 64*a* causing that character to be printed on tape 66, the type having been previously inked by inking wheel 67.

Upon the release of key 36, Figs. 1 and 2, arm 65 is returned to a normally open position by spring 68, and contact 69 is closed, causing ratchet relay 70 to operate arm 71 moving ratchet 72 which in turn causes rollers 77 and 78 to turn, advancing tape 66 one step forward from supply reel 66*a*. The release of key 36 of Figs. 1 and 2 also removes the audio frequency tones thus returning all relays to their normal receiving position.

Fig. 4 is a schematic diagram of the electrical circuits used in the system described in Fig. 3, wherein 50 represents the output of a radio receiver or land-line amplifier, 52A, B, C, D, and E are the field coils of the five resonant relays, contacts 74A, B, C, D, and E are the contacts on the vibrating reeds 53A, B, C, D, and E of the resonant relay 52A, B, C, D, and E. Reference characters 75A, B, C, D, and E designate the field coils of the five relays 54A, 54B, 54C, 54D, and 54E which operate the moving armatures 55A, B, C, D, and E of the electrical matrix 56. This matrix consists of thirty-two channels made up by 160 mark and space contacts associated with the contacts on the five movable actuators 76A, B, C, D, and E. The "space" contacts are represented as being below the contact arms of the movable contact arm actuators 76A, B, C, D, and E, that are operated by armatures 55A, B, C, D, and E. The space contacts are normally closed when relay coils 75A, B, C, D, and E are not energized. The "mark" contacts are represented above the contact arms of the movable contact arm actuators 76A, B, C, D, and E and are normally open when relay coils 75A, B, C, D, and E are not energized. Energizing any one or a combination of relay coils 75A, B, C, D, or E will cause armatures 55A, B, C, D, or E and the contacts associated with the particular movable contact arm actuators 76A, B, C, D, and E to be moved and open all "space" contacts associated with the same arm.

The "make" and "space" contacts are arranged and permanently wired in such a manner that the movement of any one or a combination of moving actuators 76A, B, C, D, or E will provide an electrical path through one and only one of the thirty-two possible channels of the matrix 56. The provision of this electrical path through any one of the first twenty-six channels of the matrix 56, allows current from the negative side of the power source to be placed on one of the twenty-six positions of the stepping relay 57. Channels 27, 28 and 29 of the Fig. 4 are shown as being connected to the negative terminal or ground of the power source. They are used to actuate the "Letters" relay 79 or "Figures" relay 80 or the "space" relay 81. Channel 31 of the matrix 56 is likewise shown as connected to the negative source of battery or ground and is used to operate relay 82 for the control of a positive source of battery to the stepping relay coil 62.

Each position A–Z is arranged within an angular space of approximately 180° on the stepping relay 57 and is associated with a type character such as 64*a* on the drum 64, and when the arm 58 is in contact with a position A, the type character associated with that position or drum 64 is immediately above the printing arm 65 of relay 81.

"Letters" relay 79 and "Figures" relay 80 are normally energized through resistors 83 and 84 with only sufficient current to hold the armature 85 in position against the field magnet of the relay to which it was last attracted. When a combination of impulses are received which cause channels 27 or 28 of matrix 56 to be completed, the resistor 83 or 84 is shorted, causing the relay 79 or 80, whichever is associated with the shorted resistor, to attract armature 85 to the magnet of that relay.

Armature 85 is provided with a yoke 86 on the end associated with the armature 65 of relay 81, Figs. 3, 4 and 5, which moves the striking portion of armature 65 below the type character 64*b*, to the upper case or "Figure" position or in the lower case or "Letter" position 64*a* in accordance with the desired position as determined by the channel operated as represented in Fig. 5. The orientation of armature 65 to Figures or Letters position is represented in dash lines in one limiting position and dot dash lines in the opposite limiting position in Fig. 5. The orientation of the armature 65 is accomplished by yoke 86 which is moved under control of magnets 79 and 80 to swing armature 65 about the universal pivot 65*b* that allows the armature to pivot under control of relay magnet 81 and to orient under control of relay magnets 79 and 80. Relay magnets 79 and 80 are controlled by channels 91 and 92 responsive to code permutations and combinations for accomplishing Letters and Figures shift.

The armature 85 carrying yoke 86 that engages armature 65 is shown broken away in Fig. 3 to indicate that the yoke 86 has been oriented in position to explain the manner of engagement thereof with the end of armature 65. In practice it will be understood that magnets 79 and 80 would be viewed from the end thereof as will be clear by examining the plan view of Fig. 5.

Stepping relay contacts 1–26 disposed within an angular range of approximately 180° control the letters A–Z under control of contact arm 58. The arrangement of contacts on the stepping relay comprising contacts 1–26 control the figures and other symbols and punctuation and

other special characters such as weather symbols and the like under supervision of the second arm 94 extending in approximately diametrically opposite position with respect to arm 58 and also rotatable about shaft 61.

It may be observed that the stepping relay 57 is re-cycling and that the code wheel 64 has two complete alphabets, each occupying one-half the periphery of the wheel. The alphabets are associated with the respective arms 58 and 94. Since the device is re-cycling there is no need to reset the mechanism after the printing of each character since one of the rocking arms 58 and 94 steps forward to the next character from the position of the last printing. After one arm completes 180° travel the other arm picks up the rotation through 180°.

The mechanism of my invention is extremely compact in size because of the arrangement of the control system. The dimensional arrangement is such that the type wheel of drum 64 and the associated tape advancing mechanism and the ratchet mechanism for controlling the movement of arms 58 and 94 are all located substantially within the dimensional limits of the approximately 180° angular range of the stepping relay 57. Thus, the printer unit takes on the appearance of the substantially 180° contact system A–Z which is located closely adjacent the type wheel and the associated operating parts and substantially embraces the dimensional limits thereof.

Tape advance is accomplished by operating ratchet relay 20 which turns roller 77 by operating arm 71 to step ratchet 72 whenever contacts 69 are closed as a result of the release of armature 65 by the removal of energy from relay coil 81 or by the completion of channel 29 of matrix 56 as a result of the receipt of a "space" combination signal over channel 93.

Operation

The operation of the system of my invention is as follows: Assume it is desired to print the character Y which is represented by the simultaneous application of the tones produced by oscillators 41*a* and 41*d*.

The letter key "Y" of keyboard 35 of Fig. 1 is depressed causing contacts 40 associated with oscillators 41*b* and 41*d* to be closed. The output of these two oscillators causes modulator 43 to modulate amplifier 44 at the frequency tones produced by oscillator 41*b* and 41*d*. The amplifier in turn emits these tones on a radio frequency carrier.

Receiver and amplifier 50 pick up this emitted signal, demodulates and passes the rectified impulses as audio frequency tones to the coils of tuned reed relays 52B and 52D which begin vibrating at their resonant frequencies and when sufficient amplitude of vibration is attained, contacts are made at 74B and 74D which in turn causes field coils 75B and 75D of the relays 54B and 54D to move armatures 55B and 55D which moves extended actuators 76B and 76D to one limiting position thereof, closing the marking contacts and opening the spacing contacts of the arms associated with actuators 76B and 76D. With actuators 76B and 76D in the limiting position above described an electrical path is provided through channel 1 of matrix 56 from the negative side of the source of battery to relay coil 81 to contact 62*b* of stepping relay 62 on stepping switch 57.

When actuators 76B and 76D are moved from their original position, the path through matrix 56 provided by channel 31 was interrupted, causing current to be withdrawn from relay 82 allowing contact 87 to close. The closing of contact 87 supplies current to stepping relay 62 from the positive source of battery through the winding of relay 62 and contacts 62*b* to the negative source of battery and ground, causing ratchet 59 to start stepping arm 58. When arm 58 arrives at position A, the upward stroke of armature 62*a* does not break the source of current, since by the closing of electrical circuit through channel 1 of matrix 56, the coil of relay 81 was placed across contact 62*b*, keeping coil 62 energized which in turn stopped the movement of armature 62*a* and ratchet 59. When the movement of arm 58 was arrested the rotation of drum 64 was also stopped at a position where the letter "Y" was immediately above tape 66 and armature 65 striking surface 65*a*. The electrical energy which provided the holding current for relay 62 to arrest the movement of arm 58 also passed through relay coil 81 causing armature 65 to move upward which pressed tape 66 against the letter "Y," causing the letter "Y" to be printed on tape 66.

As previously described, the return of key "Y" to normal position on keyboard 35 of Fig. 1 removed the output of oscillators 41*b* and 41*c* from modulator 43 and amplifier 44, which in turn caused tuned reeds 52B and 52D to discontinue vibration, breaking contacts 74B and 74D allowing relays 54B and 54D to return to normal which moved actuators 76B and 76D to their original position. In this position channel 31 was closed which closed relay 81 removing the battery source from relay 81 and stepping relay 57. The removal of energy from relay 81 caused contacts 69 to close providing an electrical circuit from the positive side of the battery source through relay 70 to the negative battery supply which in turn caused relay armature 71 to operate ratchet 72 moving rollers 77 and 78 advancing tape 66 one step forward.

While my invention as hereinbefore described has been illustrated as applied to a tape type of printer, the operation may be applied to a page type printer by replacing the stepping relay 58 and associated apparatus with a conventional electric typewriter.

The thirty-two channels of matrix 56 are then used to provide an electrical circuit to a series of thirty two solenoids or relays which are used to operate the mechanism of the electric typewriter which performs the typing, carriage return, line feed, spacing and upper and lower case functions.

In applications where more or less than thirty two operations are required, the number of oscillators, tuned reeds and associated relays may be rearranged in a matrix which will perform the number of functions required.

One such application is in the use of drums to visually present pre-arranged or recorded information.

Where the number of displays to be presented are less than sixteen, four tones, four tuned reeds, a sixteen channel matrix and a sixteen position stepping relay with the messages printed on a cylindrical surface such as the drum 64 of Figs. 3 and 4, can be formed into a light weight system of visual telegraphy particularly adapted to aviation traffic control communications.

Another application of my invention is an arrangement of the matrix 56 where one channel is permanently wired in a fixed position in such

a manner that only when a signal consisting of the proper combination of tones is received will it pass through the matrix. Such an application being particularly adapted to selective calling systems illustrates the versatile character of the system of my invention.

The matrix **56** illustrated in Fig. 4 shows in diagrammatic form the graphic appearance of the code symbols used in the system of my invention. These are standard code characters of the international Teletype code with respect to the sequential arrangement of the mark and space signal impulses. The equipment of my invention is accordingly interchangeable with standard Teletype equipment and is operative over the same channels on which standard Teletype equipment is being operated.

I have found the equipment of my invention highly practical in construction and operation and while I have described my invention in certain preferred embodiments I realize that modifications may be made and I desire that it be understood that no limitations upon my invention are intended other than may be imposed by the scope of the appended claims.

As an example of one of the variations or modifications of my invention I may refer to any means for constantly activating the several reeds so that they are maintained in a state of vibration. Such constant rate of vibration is at an amplitude at which electrical contact is maintained by the reed contact. However, upon non-receipt of a tone the reed resonant to such tone may be dropped in amplitude of vibration sufficient to effect the release of the associated contact. Thus a slight infinitesimal time lag incidental to building up the vibration of the reed is eliminated in such an arrangement by having the reeds operate at full amplitude of vibration which is interrupted by the displacement of a frequency or combination thereof.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a printing telegraph receiving system, means for receiving permutations and combinations of simultaneously applied multiple coded signal impulses, a ratchet controlled step-by-step selector system operative over a range of approximately 180°, a printing device including a type wheel wherein a complete alphabet appears on each 180° of the type wheel operatively controlled by said selector system, and electric circuit means for simultaneously applying said permutations and combinations of simultaneously applied coded signal impulses to said ratchet controlled step-by-step selector system for controlling said printing device by the conjoint action of simultaneously applied impulses.

2. In a printing telegraph receiving system, means for receiving permutations and combinations of simultaneously applied multiple coded audio frequency signal impulses, electric circuit means for translating said simultaneously applied multiple audio frequency signal impulses into simultaneous direct current impulses and means including a type wheel wherein a complete alphabet appears on each 180° of the type wheel and operative through a range of approximately 180° for electrically translating said simultaneous direct current impulses into printed characters.

3. In a printing telegraph receiving system, means for receiving permutations and combinations of simultaneously applied multiple coded signal impulses, a multiplicity of pre-arranged electric matrix circuits, including individual circuit connections establishing a signal combination representative of a predetermined character, a multiplicity of relays controlled by said simultaneous applied multiple coded signal impulses for rendering said electric matrix circuits individually and selectively effective, a printing control mechanism including a type wheel wherein a complete alphabet appears on each 180° of the type wheel, and a stepping relay associated with said printing control mechanism and operative through a range of approximately 180° under control of said simultaneously applied multiple coded signal impulses for selecting one of said electric matrix circuits and effecting thereby the printing of a selected character by said printing control mechanism.

4. A printing telegraph receiving system as set forth in claim 3 wherein the simultaneously applied multiple coded signal impulses are received at audio frequencies and effect the establishment of circuits through the electric matrix circuits for the passage of direct current pulses to said printing control mechanism.

5. A printing telegraph receiving system as set forth in claim 3 in which the simultaneously applied multiple coded signal impulses are received at audio frequencies and effect resonant vibration of a multiplicity of reeds and which in turn control direct current relay circuits for selectively conditioning an individual electric matrix circuit representative of the selected character in said multiplicity of electric matrix circuits.

6. A printing telegraph receiving system as set forth in claim 2 in which said translating means include a multiplicity of reeds individually resonant to the individual frequencies of said simultaneously applied multiple coded signal impulses and direct current actuated relay circuits controlled subsequent to the attainment of a predetermined amplitude by said reeds.

7. A printing telegraph receiving system as set forth in claim 1 including a tape feed mechanism for advancing a tape longitudinally of the path of both of the alphabets on said type wheel and a striker bar selectively orientatable to a position aligned with either of said alphabets for presenting the tape to either row of alphabets on said type wheel.

8. In a printing telegraph receiving system, means for receiving permutations and combinations of simultaneously applied multiple coded signal impulses, a selector switch controlled by said impulses, a printing device including a type wheel wherein a complete alphabet appears on each 180° of the type wheel, and means disposed within dimensional limits of approximately 180° and controlled by said selector switch for controlling said printing device said means also including a matrix of electrical circuits beyond the aforesaid dimensional limits containing prearranged circuits individual to the permutation and combination signal impulses representative of each of the characters being printed.

9. In a printing telegraph receiving system, means for receiving multiple permutations and combinations of simultaneously applied multiple coded signal impulses, a converter including a multiplicity of individually resonant reeds, responsive to the multiple coded signal impulses, individual relay contacts controlled by each of said reeds and operative to establish closed electrical circuits when said reeds are vibrated substantially at resonance, separate relays controlled by each of said relay contacts, an armature and actuator individual to each of said last mentioned

relays, a multiplicity of contact arms controlled by each of said actuators, an electric matrix including contacts associated with each of said contact arms and connected in circuits corresponding in number to the number of electrical pulses being transmitted, a stepping relay having a multiplicity of radially disposed contact positions disposed within an angular range of approximately 180° corresponding in number to the number of electrical circuits through said electric matrix and electrically connected to the contacts thereof, a stepping relay arm operative over said radially disposed contacts within an angular range of approximately 180° and a printing device including a type wheel wherein a complete alphabet appears on each 180° of the type wheel and selectively controlled by said stepping relay arm and responsive to selected signal permutations and combinations established through said matrix.

10. In a printing telegraph receiving system, a receiving circuit responsive to a predetermined range of audio frequency permutations and combinations of signal impulses, a multiplicity of tuned reed relays individually responsive to audio frequency signal impulses within said predetermined range of audio frequency, said tuned reed relays each including a vibratory armature and a contact member spacially related thereto whereby selected electrical circuits are closed through said armatures and their associated contacts when the vibration of said armatures reaches a predetermined amplitude, direct current relays each having relay windings electrically connected with the aforesaid contacts and a source of direct current, an armature associated with each of said direct current relays, a movable actuator connected with each of said last mentioned armatures, a multiplicity of contact arms controlled by each of said movable actuators, said contact arms corresponding in number to the number of signal permutations and combinations incident upon said receiving circuit, contact elements associated with each of said contact arms, electrical circuit connections extending from the contact elements associated with the contact arms controlled by one of said actuators with the contact arms controlled by the adjacent actuator and forming an electrical matrix having circuit paths therethrough individual to each of the signal permutations and combinations incident upon said receiving circuit, a stepping relay including individual contacts connected to the aforesaid circuit connections, contact arms movable over said individual contacts, a printing telegraph device including a type wheel wherein a complete alphabet appears on each 180° of the type wheel, and means for selectively connecting said printing

telegraph device with said last mentioned contacts and effecting the printing of a character corresponding to the signal permutation and combination established by individual paths through said electrical matrix.

11. A printing telegraph receiver comprising a step-by-step selector having a multiplicity of contacts forming circuit terminals for permutation and combination direct current pulses, corresponding to signals and arranged in a curved path extending through approximately 180°, a pair of rocking arms selectively movable over said contacts, a type-wheel having a double alphabet printing face thereon, one alphabet of which extends over 180° of the type wheel and the other alphabet of which extends over the other 180° of the type wheel, means for driving said type wheel in timed relation to the movement of said rocking arms, a tape movable adjacent the double alphabet printing face of said type wheel, and means for selectively moving said tape into register with either alphabet on said double alphabet type wheel, said double alphabet type wheel being mounted within the curved path of said multiplicity of contacts.

12. A printing telegraph receiver comprising a step-by-step selector having a multiplicity of contacts forming circuit terminals for permutation and combination direct current pulses corresponding to signals and arranged in a curved path extending through approximately 180°, a rocking arm movable unidirectionally step-by-step for selectively sweeping said contacts, a shaft extending from said arm, a ratchet mechanism connected with said shaft for imparting unidirectional step-by-step movement thereto, a type wheel connected with said shaft and carrying type designations constituting a complete alphabet appearing on each 180° of the periphery thereof, a tape movable tangentially to the designations on the periphery of said type wheel, and means for selectively moving a tape into register with the designations on the periphery of the type wheel.

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June 15, 1954 J. D. DURKEE 2,680,970

MECHANICAL MOVEMENT

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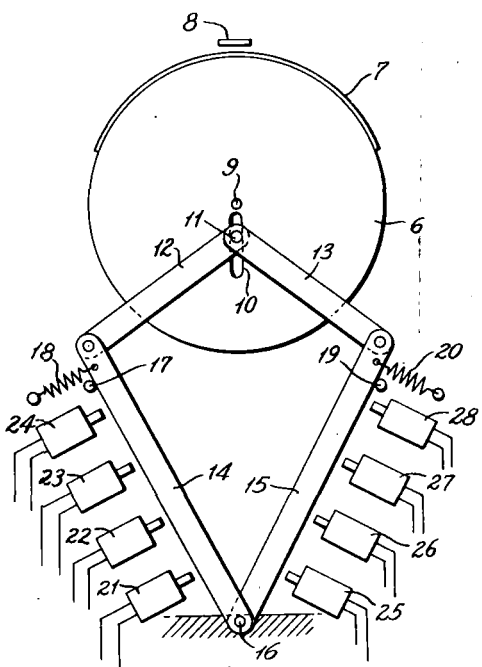

Fig. 1.

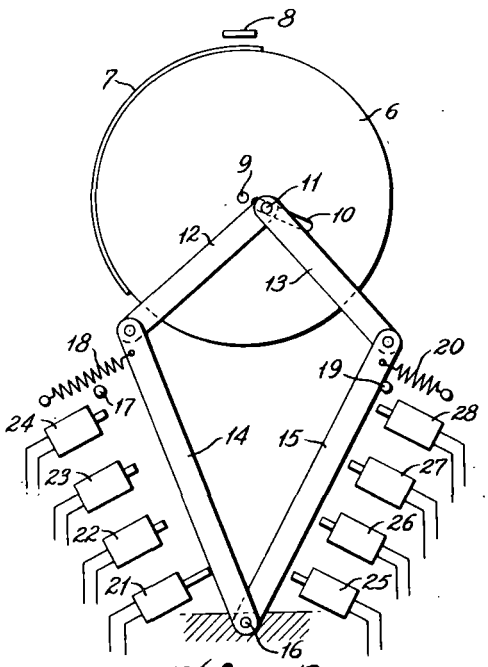

Fig. 2.

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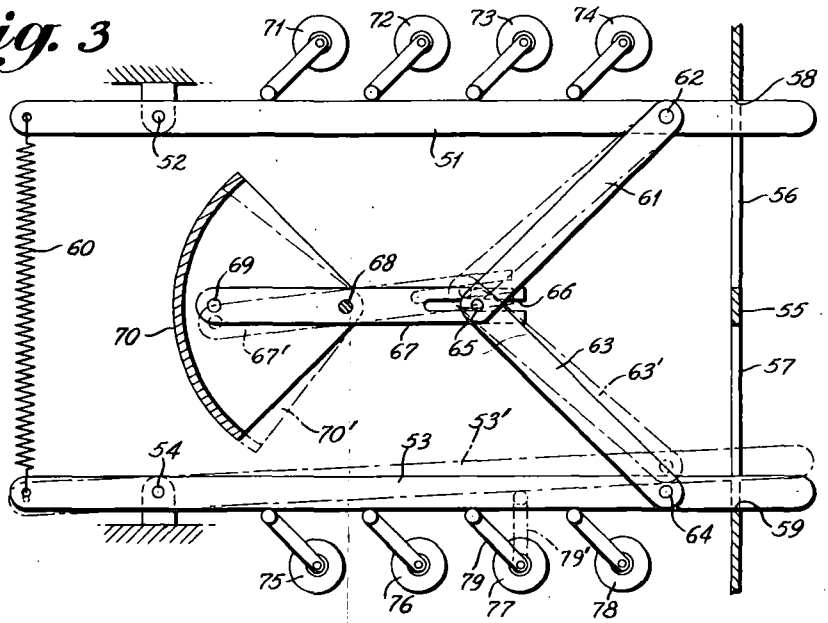
Fig. 3



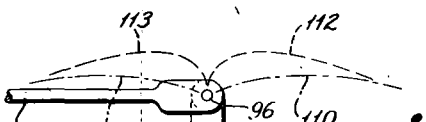
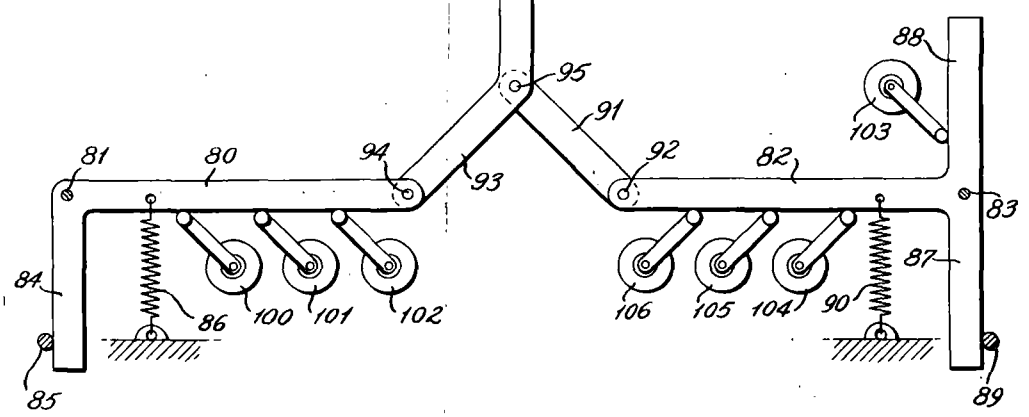


Fig. 4.



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MECHANICAL MOVEMENT

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Application July 28, 1952, Serial No. 301,402

8 Claims. (Cl. 74—96)

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The present invention relates to mechanism for rapidly moving and accurately positioning a mechanical element in any of a plurality of prescribed positions. The invention is of general utility, but by way of example of one field of use reference may be made to the positioning of a printer wheel of a telegraphic typewriter. A printer wheel for a telegraphic typewriter must be properly positioned to present the desired character to the inked ribbon and the paper. The positioning must be precise for neatness of the typewritten material. The movement of the printer wheel from one prescribed position to another must occur very rapidly in order for the typewriter to be capable of high speed. There are many other fields of utility for mechanisms capable of rapidly and precisely positioning a mechanical element in any of a plurality of desired positions.

One of the primary objects of my invention is to provide a mechanical linkage which is capable of rapidly and accurately positioning a mechanical element in any one of a number of desired positions. Another object of the invention is to provide such a mechanism which is extremely simple so that it can be produced economically and so that there is a minimum of expense for maintenance or repair. Still another object of the invention is to provide such a mechanism in combination with a plurality of motors or drive means, which motors or drive means are identical in order to reduce costs and to simplify repairs. Still another object of the invention is to provide mechanism of the type described in which the mechanical element to be positioned has an assigned neutral position which is intermediate its other positions. The mechanical element can be moved from its neutral position to any of its other positions by traveling through a shorter path than would be the case if the element's assigned neutral positions were otherwise placed. Still another object of the invention is to provide mechanism of the type described which provides for relatively slow acceleration and/or deceleration of the mechanical element.

The foregoing and other objects and advantages of the invention will be more fully understood by reference to the following description taken in connection with the accompanying drawing, wherein:

Figure 1 is a front elevational view of mechanism embodying my invention arranged to control the movement of a printer wheel, the mechanism and the printer wheel being shown in the neutral position;

Figure 2 is a front elevational view of the apparatus shown in Figure 1 but illustrating the printer wheel moved to its extreme position in one direction from the neutral position;

Figure 3 is a front elevational view of a modified form of apparatus embodying the invention; and

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Figure 4 is a front elevational view of still another embodiment of the invention.

The arrangement illustrated in Figures 1 and 2 includes a printer wheel 6 having a type bar 7 thereon. The type bar 7 carries a plurality of printing characters, not shown, which are circumferentially spaced and which are intended to be presented selectively to a printing zone which is diagrammatically indicated by the reference numeral 8. The printing wheel must be oscillated to present the desired printing characters to the printing zone and this oscillatory movement must occur rapidly in order that the machine may print at high speed. The positioning of the printer wheel must be precise for each of its angular positions in order that the printed characters will be neatly and accurately disposed on the paper.

The printer wheel is provided with a fixed axis of rotation 9. A radially extending slot 10 is provided in the printer wheel. This slot receives a pivot pin 11 which is free to slide therein. The pivot pin 11 pivotally connects the ends of a pair of actuator links 12 and 13. The opposite end of the actuator link 12 is pivotally connected to a base link 14 while the actuator link 13 is similarly connected to a base link 15. The base links 14 and 15 are independently oscillatable about a fixed axis 16. In this form of the invention the base links 14 and 15 are independently oscillatable about the same fixed axis, although in forms of the invention hereinafter described these links are oscillatable about axes which are not coincident.

The base link 14 is provided with a stop member 17 which limits its outward movement. A tension spring member 18 resiliently biases the base link 14 into position against the stop member 17. The base link 15 is provided with a similar stop member 19 and a tension spring member 20. The stop members 17 and 19 and the spring members 18 and 20 determine definite normal positions for the base links 14 and 15, to which those links will turn when permitted to do so.

Figure 1 illustrates the base links 14 and 15 in their normal positions. Under such circumstances the printer wheel 6 occupies a definite position which may be termed its neutral position. In this neutral position one printing character may be presented to the printing zone 8, and it is unnecessary to oscillate the printing wheel 6 to print such character. Figure 2 of the drawing illustrates the condition of the mechanism when it has been actuated to move the printer wheel to its extreme position in a counterclockwise direction. The base link 15 still occupies its normal position against the stop

member 19, but the base link 14 has been oscillated to the position shown in the drawing. The pivot pin 11, engaging as it does the walls of the slot 19, has caused the printer wheel 6 to oscillate to the position shown in Figure 2. It will be apparent from an inspection of Figures 1 and 2 that a lesser movement of the base link 14 would result in a lesser extent of oscillation of the printer wheel 6 in the counterclockwise direction. It will also be apparent from an inspection of these figures that movement of the base link 15 away from its stop member 19 will cause oscillation of the printer wheel 6 in a clockwise direction, the extent of such oscillatory movement of the printer wheel being dependent on the extent of movement of the base link 15.

Means for effecting oscillatory movement of the base links 14 and 15 are illustrated as identical solenoids 21 to 28, inclusive. The solenoids 21 to 24, inclusive, are positioned along the base link 14 at different distances from the fixed axis 16. The solenoids 25 to 28, inclusive, are positioned along the base link 15 at different distances from the fixed axis 16. Figure 2 illustrates the solenoid 21 as being energized. Its plunger has engaged the base link 14 and, since the solenoid 21 is positioned near the axis 16, the extent of movement of the base link 14 has been greater than would be the case with energization of the solenoids 22, 23 or 24. It will be readily understood that energization of the solenoid 22 would cause somewhat lesser counterclockwise movement of the printer wheel than that shown in Figure 2, whereas energization of solenoids 23 or 24 would cause progressively lesser such movement of the printer wheel. Energization of the solenoid 25 will cause maximum movement of the printer wheel in a clockwise direction, whereas energization of solenoids 26, 27 or 28 will cause progressively lesser movement of the printer wheel in that direction. All movements of the base links 14 and 15 occur in opposition to the resilient action of the springs 18 or 20, and those springs serve to immediately return the base links to their normal positions upon deenergization of the solenoids.

By energizing the proper one of the solenoids 21 to 28, the printer wheel may be moved to a position to present any desired printing character to the printing zone 8. Preferably only one of the solenoids should be energized at any one time, although there may be some slight overlapping of the intervals during which the various solenoids are energized. The movement of the printer wheel 6 will occur very rapidly and its position will be very precisely determined by the mechanism. The printer wheel will return to its neutral position as shown in Figure 1 immediately upon deenergization of the solenoids. Since the neutral position of the printer wheel is a position intermediate its other positions, it will be seen that the wheel can move from the neutral position to any other desired position by traveling through a relatively small angle.

The embodiment of the invention illustrated in Figure 3 differs considerably in appearance from the arrangement described above but it embodies the fundamental concepts of the invention. A base link 51 is oscillatable about a fixed axis 52. A similar base link 53 is oscillatable about a fixed axis 54. A fixed plate 55 is provided with slots 56 and 57 which form guideways for the free ends of the base links 51 and 53. The end 58 of the slot 56 forms a stop member which defines a normal position for the base link 51.

The end 59 of the slot 57 forms a stop member which determines the normal position for the base link 53. The base links 51 and 53 are resiliently biased toward their normal positions by means of the tension spring member 60.

An actuator link 61 is pivotally connected to the base link 51 at 62 and an actuator link 63 is pivotally connected to the base link 53 at 64. A pivot pin 65 pivotally connects the inner ends of the actuator links 61 and 63. The pivot pin 65 is slidably received in a slot 66 of a lever 67. The lever 67 is pivotally mounted on a fixed axis 68 and the end of the lever opposite the slot 66 is fixedly secured by means of a suitable fastening means 69 to a suitable mechanical element such as a printing wheel 70. The printing wheel 70 is oscillatable about the fixed axis 68.

A plurality of oscillatory motors 71, 72, 73 and 74 are positioned adjacent the base link 51 at different distances from the fixed axis 52. A plurality of similar oscillatory motors 75, 76, 77 and 78 are positioned adjacent the base link 53 at different distances from the fixed axis 54. The oscillatory motors are preferably electrically actuated and are identical in construction. The operation of the oscillatory motor 77 will be described, it being understood that the other oscillatory motors operate in the same manner. The oscillatory motor 77 has an arm 79 which occupies the position shown in full lines when the motor is deenergized. Upon energization of the motor 77 the arm 79 moves to the dotted line position 79'. In so moving, the arm 79 causes the base link 53 to move to the dotted line position 53', the actuator link 63 to move to the dotted line position 63', and the lever 67 to move to the dotted line position 67'. Movement of the lever 67 causes the printer wheel 70 to move to the dotted line position 70'. It will be understood that energization of any other oscillatory motor will cause its associated base link to move away from its respective stop member, and that the extent of movement of a base link will be dependent on the distance of the energized oscillatory motor from the fixed axis about which the base link operates. By energizing the proper motors 71 to 78, the printer wheel 70 will be moved quickly and accurately to any of its prescribed positions. Four oscillatory motors have been shown associated with each base link, but this number can be increased or decreased as required.

Attention should be called to the arrangement of the arms of the oscillatory motors 71 to 78 relative to the associated base links 51 and 53. By reference to the arm 79 of the motor 77 it can be seen that initial clockwise movement of that arm will cause rapid initial movement of the base link 53. However, as the arm 79 approaches the dotted line position 79', the rate of movement of the base link 53 will be substantially lower. Thus the printer wheel 70 will be given a rapid rate of initial movement and this rate will gradually decelerate as the printer wheel approaches its prescribed position. This is a distinct advantage in that it eliminates the shock which would result from sudden deceleration or sudden stopping of the printer wheel.

The form of the invention illustrated in Figure 4 embodies the fundamental concepts of the invention and additionally possesses certain advantages over the arrangements described above. A base link 80 is oscillatable abount a fixed axis 81 and a base link 82 is oscillatable about a fixed axis 83. The base link 80 is provided with an

angularly extending arm 84 which is arranged to engage a fixed stop member 85 which determines the normal position of the base link 80. The base link 80 is biased to its normal position by means of the tension spring member 86. The base link 82 is provided with angularly extending portions 87 and 88. The angularly extending portion 87 is arranged to engage a fixed stop member 89 which determines the normal position for the base link 82. The base link 82 is biased toward its normal position by means of a tension spring member 90.

An actuator link 91 is pivotally connected to the base link 82 by means of a pin 92. An actuator link 93 is pivotally connected by a pin 94 to the base link 80. The actuator link 91 is pivotally connected to the actuator link 93 by means of the pivot pin 95. The actuator link 93 is shown as extending beyond the pivot pin 95 and as being connected by means of a pin 96 to a connector 97 which may lead to any mechanical element the position of which it is desired to control.

A plurality of oscillatory motors 100, 101, and 102 are positioned adjacent the base link 80 at different distances from the fixed axis 81. Oscillatory motors 103, 104, 105 and 106 are positioned adjacent the base link 82 at different distances from the fixed axis 83. The motors 101 to 106, inclusive, may be the same as those described above in connection with the embodiment of the invention illustrated in Figure 3. It will be seen that energization of any of these motors will alter the position of the base link with which it is associated and that the position of the pivot pin 96 is controlled by the positions of the base links 80 and 82.

As indicated above, the embodiment of the invention illustrated in Figure 4 possesses advantageous characteristics which are not present in the forms of the invention described above. In the forms of the invention of Figures 1 to 3, movement of one of the base links of the mechanism creates no forces tending to move the other base link away from its stop member. For that reason, in the arrangements of Figures 1 to 3, either base link of the mechanism may be moved and there is no movement of the other base link of the mechanism. However, in the arrangement of Figure 4, movement of the base link 80 or the base link 82 sets up forces which tend to move the other base link from its normal position. This phenomenon has definite advantages in a rapidly operating mechanism such as is required in a printing machine operating at high speed. The tendency of the opposite base link to move in response to positive actuation of one of the base links is opposed by the inertia of such opposite base link and by the tension spring member tending to bias such opposite link toward its normal position. However, when one of the links is moved very quickly, the opposite link will overcome its own inertia and the effect of its biasing, and will momentarily move from its normal position, to be quickly returned, however, to such normal position by its biasing spring member.

The foregoing phenomenon may be understood by referring to the paths of movement of the pin 96 under various conditions of operation. If the base link 80 is moved relatively slowly from its normal position shown in the drawing, the forces tending to move base link 82 will be insufficient to overcome the inertia of base link 82 and the action of spring member 90. Under such conditions, the base link 82 will not move and the pin 96 will follow the path designated by the dot-dash line 110. Similarly, when the base link 82 is moved slowly there will be no movement of the base link 80 and the pin 96 will follow the dot-dash line 111. When the base link 80 is moved very suddenly from its normal position, there will be a momentary movement of the base link 82 from its normal position and the pin 96 will follow a path such as that illustrated by the dotted line 112. Similarly, the imparting of very rapid and sudden motion to the base link 82 will cause momentary departure of the base link 80 from its normal position and the pin 96 will follow a path such as that illustrated by the dotted line 113.

The fact that rapid operation of the form of the invention illustrated in Figure 4 causes the pin 96 to follow the dotted line paths 112 or 113 results in more gradual acceleration from rest of the mechanical element to which the connector 97 is attached. For the reasons pointed out above in the description of Figure 3, the oscillatory motors 100 to 106, inclusive, impart rather rapid initial movement to the base links 80 and 82 followed by gradual deceleration of such movement. The more gradual acceleration resulting from the pin 96 following the paths 112 and 113 in combination with the gradual deceleration resulting from the particular arrangement of the oscillatory motors relative to the base links gives a very smooth operation which is free from excessively sudden accelerations or decelerations of the controlled element.

It will be seen from the foregoing detailed description that I have provided a variety of mechanisms capable of accomplishing the enumerated objects of the invention. The illustrated embodiments are to be considered as exemplary only and the broader scope of the invention is defined by the following claims.

Having thus described my invention, I claim:

1. Mechanism for selectively moving a pivot pin to any of a plurality of prescribed positions on either side of an intermediate neutral position, comprising a pair of base links which are independently oscillatable about fixed axes, stop means which determine definite normal positions for said base links, means for biasing said base links to engage said stop means, a pair of actuator links pivotally connected to said base links at points spaced from the said axes thereof, said actuator links being pivotally connected together by a pivot pin which occupies a definite neutral position when both of said base links are in their normal positions and which moves in one direction from said neutral position upon oscillation of one of said base links and in the opposite direction from said neutral position upon oscillation of the other of said base links, and means for independently oscillating said base links by controlled amounts from their normal positions whereby said pivot pin may be selectively moved to prescribed positions on either side of its said neutral position.

2. Mechanism for selectively moving a pivot pin to any of a plurality of prescribed positions on either side of an intermediate neutral position, comprising a pair of base links which are independently oscillatable about fixed axes, stop means which determine definite normal positions for said base links, means for biasing said base links to engage said stop means, a pair of actuator links pivotally connected to said base links at points spaced from the said axes thereof, said actuator links being pivotally connected together by a pivot pin which occupies a definite neutral

position when both of said base links are in their normal positions and which moves in one direction from said neutral position upon oscillation of one of said base links and in the opposite direction from said neutral position upon oscillation of the other of said base links, and a plurality of solenoids positioned along said base links at different distances from said fixed axes, each of said solenoids being arranged, upon energization, to oscillate its associated base link from its normal position by an amount dependent on the distance of such solenoid from the fixed axis of said associated base link, whereby upon selective energization of such solenoids said pivot pin may be selectively moved to prescribed positions on either side of its said neutral position.

3. Mechanism as described in claim 2 in which the said fixed axes of said base links are coincident.

4. Mechanism for selectively moving a pivot pin to any of a plurality of prescribed positions on either side of an intermediate neutral position, comprising a pair of base links which are independently oscillatable about fixed axes, stop means which determine definite normal positions for said base links, means for biasing said base links toward said stop means, a pair of actuator links pivotally connected to said base links at points spaced from the said axes thereof, said actuator links being pivotally connected together by a pivot pin which occupies a definite neutral position when both of said base links are in their normal positions and which moves in one direction from said neutral position upon oscillation of one of said base links and in the opposite direction from said neutral position upon oscillation of the other of said base links, and a plurality of motors positioned along said base links at different distances from said fixed axes, each of said motors being arranged, upon energization, to oscillate its associated base link from its normal position by an amount dependent on the distance of such motor from the fixed axis of said associated base link, whereby upon selective energization of such motors said pivot pin may be selectively moved to prescribed positions on either side of its said neutral position.

5. Mechanism for selectively moving a pivot pin to any of a plurality of prescribed positions on either side of an intermediate neutral position, comprising a pair of base links which are independently oscillatable about fixed axes, stop means which determine definite normal positions for said base links, which normal positions are generally parallel, means for biasing said base links toward said stop means, a pair of actuator links pivotally connected to said base links at points spaced from the said axes thereof, said actuator links being angularly disposed relative to each other and being pivotally connected together by a pivot pin which occupies a definite neutral position when both of said base links are in their normal positions and which moves in one direction from said neutral position upon oscillation of one of said base links and in the opposite direction of said neutral position upon oscillation of the other of said base links, and a plurality of oscillatory motors positioned along said base links at different distances from said fixed axes, each of said motors being arranged, upon energization, to oscillate its associated base link from its normal position by an amount dependent on the distance of such motor from the fixed axis of said associated base link, whereby upon selective energization of such motors said pivot pin may be selectively moved to prescribed positions on either side of its said neutral position.

6. Mechanism for selectively moving a pivot pin to any of a plurality of prescribed positions on either side of an intermediate neutral position, comprising a pair of base links which are independently oscillatable about fixed axes, means for biasing said base links against stop means which determine definite normal positions for said base links, a pair of actuator links pivotally connected to said base links at points spaced from the said fixed axes thereof, said actuator links being pivotally connected together by a pivot pin which occupies a definite neutral position when both of said base links are in their said normal positions, means for oscillating a first of said base links by a definite amount from its normal position to thereby move said pivot pin to a prescribed position on one side of its said neutral position, and means for oscillating the second of said base links by a definite amount from its normal position to thereby move said pivot pin to a prescribed position on the opposite side of its said neutral position.

7. Mechanism comprising a pair of base links which are independently oscillatable about fixed axes, said base links being biased toward definite normal positions, a pair of actuator links pivotally connected to said base links at points spaced from the said fixed axes thereof, said actuator links being pivotally connected together by a pivot pin which occupies a definite neutral position when both of said base links are in their said normal positions, means for oscillating a first of said base links through a prescribed angle from its normal position to thereby move said pivot pin to a definite first position in one direction from its said neutral position, and means for pivotally moving the second of said base links through a prescribed angle from its normal position to thereby move said pivot pin to a definite second position in the opposite direction from its neutral position.

8. Mechanism for selectively moving a pivot pin to any of a plurality of prescribed positions on either side of an intermediate neutral position comprising a pair of base links which are independently oscillatable about fixed axes, stop means against which said base links may abut to define definite normal positions for said base links, a pair of actuator links pivotally connected to said base links at points spaced from the said fixed axes thereof, said actuator links being pivotally connected together by a pivot pin which occupies a definite neutral position when both of said base links are in their said normal positions, means for pivotally moving a first of said base links from its normal position to thereby move said pivot pin in one direction from its said neutral position, means for returning said first base link to its normal position to thereby return said pivot pin to its neutral position, means for pivotally moving the second of said base links from its normal position to thereby move said pivot pin in the opposite direction from its said neutral position, and means for returning said second base link to its normal position to thereby again return said pivot pin to its neutral position.

No references cited.

Nov. 10, 1953 J. D. DURKEE 2,658,943

PRINTING TELEGRAPH SYSTEM

Original Filed Jan. 23, 1950 3 Sheets-Sheet 1

FIG. 1

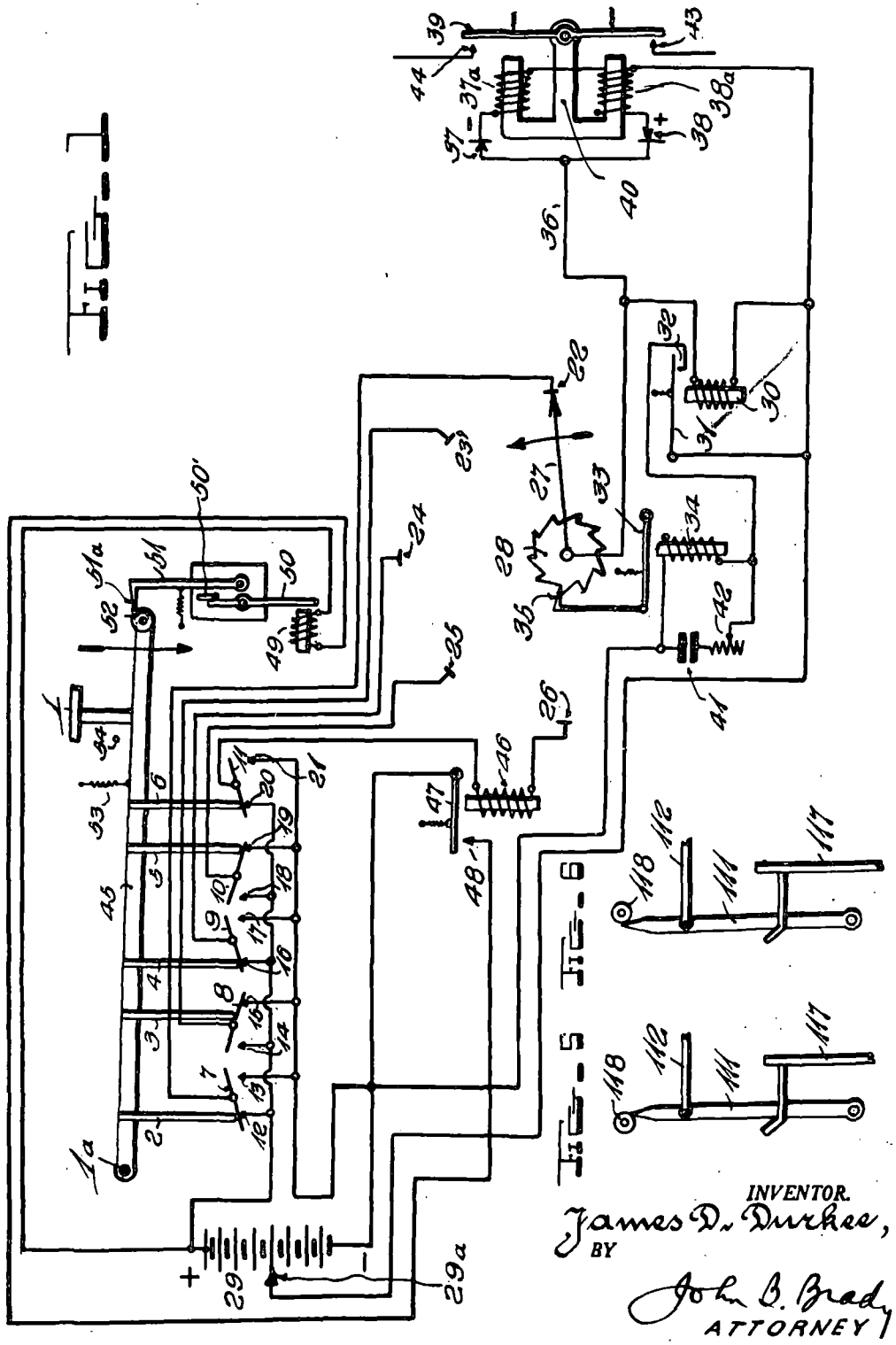

FIG. 6

FIG. 5

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PRINTING TELEGRAPH SYSTEM

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FIG. 3

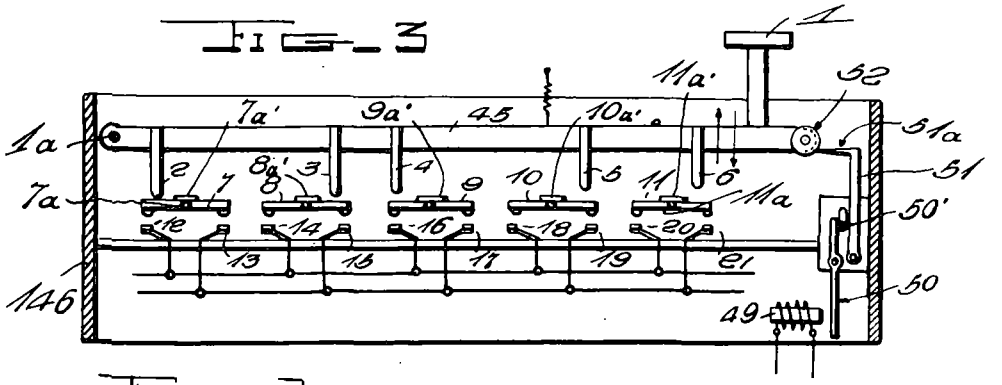
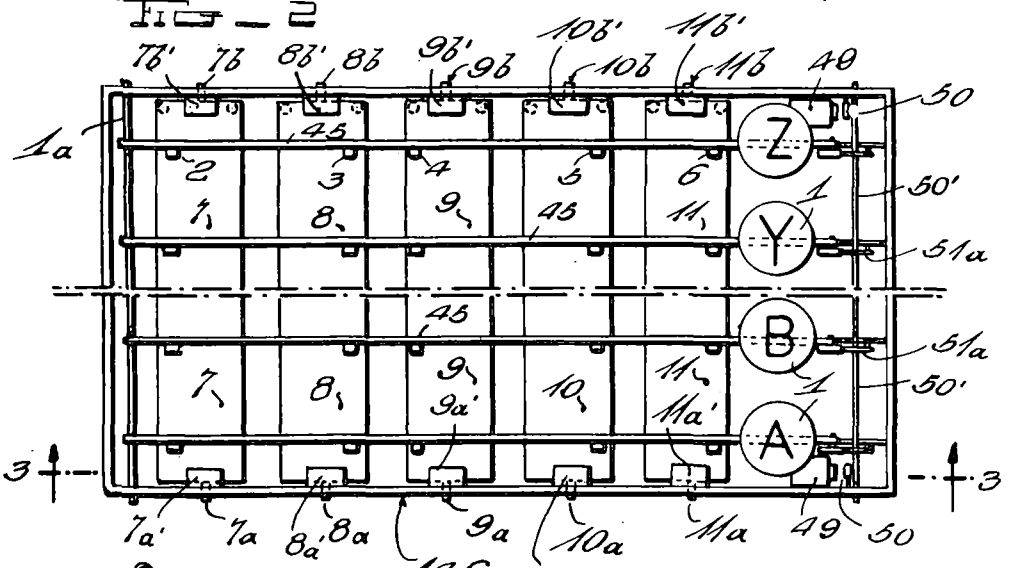


FIG. 2



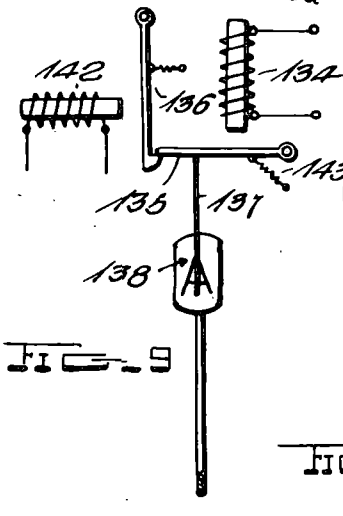


FIG. 9

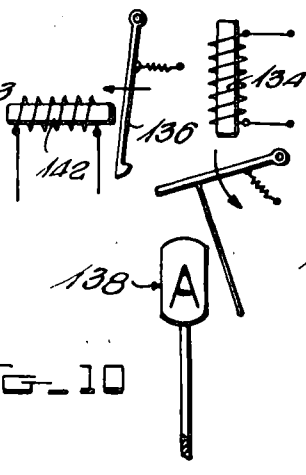


FIG. 10

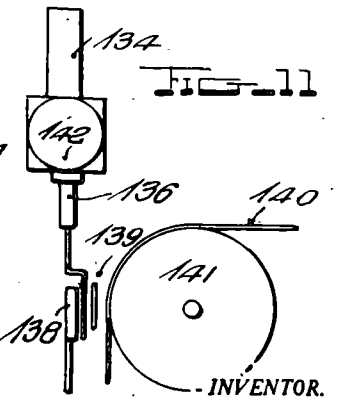


FIG. 11

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PRINTING TELEGRAPH SYSTEM

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Fig. 7

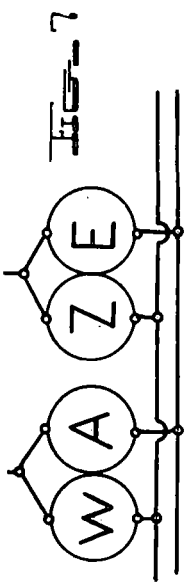

Fig. 8

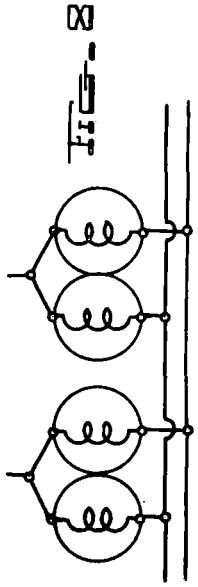

Fig. 4

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PRINTING TELEGRAPH SYSTEM

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14 Claims. (Cl. 178—23)

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My invention relates broadly to printing telegraph systems and more particularly to a high speed polarized system of printing telegraphy utilizing printing telegraph apparatus of compact size and light weight.

This application is a division of my application Serial Number 139,977, filed January 23, 1950, now U. S. Patent No. 2,613,267, dated October 7, 1952, for Printing Telegraph System.

One of the objects of my invention is to provide a printing telegraph system constituting an improvement upon conventional sequentially operated systems, overcoming inherent difficulties in these systems and to supplement the purpose for which the system described in my co-pending application No. 109,648, filed August 11, 1949, for Printing Telegraph System was developed.

My co-pending application is directed to a printing telegraph system, which when applied to space radio systems, overcomes conditions of fading, interference, and static, and is particularly adaptable to mobile radio printer operations where compactness and portability and a minimum of mechanical equipment with incidental maintenance are major requirements.

The system of my invention employs a polarized electrical matrix which requires the transmission of only five polarized pulses, without the necessity of transmitting start-stop or synchronizing pulses, to accomplish the thirty-two different permutations and combinations of signal impulses presently used in printing telegraph systems.

Since in my application a smaller number of permutations and combinations of signal pulses are required to produce the same number of permutations and combinations as used in currently existing systems, a greater number of permutations and combinations can be sent in less time with fewer impulses thereby requiring a smaller number of transmission bands and less frequency band-width.

In addition, since the system of my invention requires only a reversal of current direction or polarity, the transition from one polarity or phase to the opposite polarity or phase may be accomplished by sinusoidal wave form; thus, the impact excitation resulting from a rapid make or break keying operation or from a rapid frequency shift is eliminated, thereby further decreasing the keying band-width required at any speed of transcission.

A further object of my invention is to provide a self-synchronizing receiving system which may be made operable over a fairly wide range of transmission speeds and which requires a minimum of equipment or adjustment.

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Another object of my invention is to provide means for supplying a pulse or pulses which may have been lost in transmission or obliterated by interference and means for indicating on the receiving copy a mark or symbol which visually indicates that the character received is incorrect.

The apparatus described in this application is intended for use with the printing mechanism of my co-pending application No. 109,648 supra but may be used with an electric typewriter or with slight modification of the present printing telegraph systems may be used interchangeably with conventional equipment.

My invention will be more fully understood from the specifications hereinafter following by reference to the accompanying drawings in which Figure 1 diagrammatically shows the transmission system of my invention; Fig. 2 is a schematic plan view of a fragmentary portion of the transmission keyboard; Fig. 3 is a schematic end elevational view of the transmission keyboard, the view being taken on sectional line 3—3 of Fig. 2 and showing the frame structure in vertical section; Fig. 4 shows the receiving circuit of the printing telegraph system of my invention; Figs. 5 and 6 are detail views illustrating the operation of the control mechanism in the receiving apparatus; Figs. 7 and 8 are detailed views of the operating solenoids controlled by the printing telegraph receiving system; Figs. 9 and 10 are enlarged schematic views showing the operation of the error indicating means employed in the receiving system of my invention, the views being shown in front elevation and wherein Fig. 9 shows the error indicating means in printing position whereas Fig. 10 shows the error indicating means released and free of printing position; and Fig. 11 is an end view of the error indicating means shown in Fig. 9.

Almost from the beginning of the art of printing telegraph systems efforts have been made to accomplish the selection of characters by electrical resolution of the units of the Baudot code. Each solution required the use of a large number of electrical contacts and electro-magnetic relays in simultaneous operation with the resulting presence of a multiplicity of potential error producing elements. Practical experience indicated that greater reliability could be placed on mechanical resolution and the present state of the art reflects this experience. Mechanical operations, however, have the inherent characteristic of requiring a longer time to perform the same functions than does electrical energy.

However, operational communication requirements for increased speeds of operation have

now exceeded the capabilities of the mechanical equipment except under strained and abnormal conditions which require excessive maintenance and mechanical tolerances and precision of apparatus which are difficult to achieve.

The application of printing telegraph systems to radio communication also introduced additional difficulties which do not readily lend themselves to solution by mechanical methods due to the speed limitations of mechanical operations.

Two of the major difficulties introduced by radio communication are various forms of fading and interference in addition to the basic limitation in the number of cycles available in the total radio frequency spectrum.

Heretofore, various approaches to the radio applications of printer systems have been by increasing power of transmission and improving receiving conditions in an effort to duplicate the operating reliability of a land line to overcome fading and increasing the dot cycles of operation by additional fail safe impulses or increasing the units of the basic five unit code to provide error detection resulting from interference and certain forms of fading.

The approach of my invention to the solution of the requirement for increased speeds has been to eliminate the basic mechanical limitation of the mechanism used to resolve the units of the five unit code into characters by use of a polarized electrical matrix; to decrease the electrical contacts required to a minimum by use of rectifying apparatus and the application of new and novel electrical circuits and to decrease the operational functions to a minimum by simplification of equipment and electrical circuits.

The fading and interference problems introduced by radio communication have been accepted as natural characteristics of the medium. Circuits and operations are provided by my invention which take these natural characteristics into account and provide substitute characteristics in the form of locally produced impulses to replace those lost in transmission due to fading or to counter balance impulses introduced in transmission as a result of interference and to indicate on the receiving equipment when these functions have been required to complete the formation of a character.

In endeavoring to achieve greater economy of bandwidth, the start-stop or synchronizing impulses heretofore used in both radio and wire methods have been eliminated in my invention by self-synchronizing apparatus resulting in an approximate saving of twenty per cent of bandwith required to perform the functions necessary to the formation of a character as compared to systems which transmit start-stop impulses or synchronizing impulses.

My invention employs apparatus and methods which are compatible with existing methods and apparatus, allowing in almost every instance, the use, with slight modification, of existing equipment and methods to accomplish its purpose.

Transmitting apparatus

Figs. 1, 2 and 3 show the transmission system of my invention, the transmitting keyboard being shown in plan view in Fig. 2 and in end view in Fig. 3.

When the key 1, pivotally mounted at 1*a*, is depressed, bars 2, 3, 4, 5 and 6 which extend therefrom depress levers 7, 8, 9, 10 and 11 in a downward direction to form contact with the contacts 12 to 21. The levers 7—11 are supported

at opposite ends in frame 146 of the transmitting keyboard as shown at 7*a* and 7*b*; 8*a* and 8*b*; 9*a* and 9*b*; 10*a* and 10*b*; and 11*a* and 11*b* through resilient self restoring flexing strip members 7*a*'—7*b*'; 8*a*'—8*b*'; 9*a*'—9*b*'; 10*a*'—10*b*'; and 11*a*'—11*b*'. Contacts 12—21 are insulatingly supported in relation to frame 146 in alignment with the pivoted levers 7—11 as shown. The levers 7—11 are normally biased by the resilient self restoring flexing strip members 7*a*'—7*b*'; 8*a*'—8*b*'; 9*a*'—9*b*'; 10*a*'—10*b*'; and 11*a*'—11*b*', to a position in horizontal planes and flex under the pressure of the bars 2—6 in either a clockwise or a counterclockwise direction depending on the relative positions of the bars 2—6 with respect to the centers of levers 7—11, for effecting momentary contact at 12—21. When pressure of bars 2—6 on the levers 7—11 is removed the levers 7—11 are restored to horizontal position breaking the contacts 12—21 by the self restoring action of the flexing supports at each end of the levers 7—11. The contacts which are formed depend upon which side of the center of levers 7 to 11, the bars 2 to 6 are positioned. In the position illustrated in Fig. 1 lever 7 will contact 12, lever 8 will contact 15, lever 9 will contact 16, lever 10 will contact 19, and lever 11 will contact 20, placing alternatively positive and negative currents from source of battery 29 on stepping relay contacts 22, 23, 24, 25 and 26 arranged in the path of switch arm 27 of continuously cycling driven stepping relay 28.

When this contact was made a positive current flow took place from battery 29 (Fig. 1) contact through 12, and the contact carried by lever 7 to stepping relay contact 22 through arm 27 through relay coil 30 to the center tap 29*a* of battery 29. The current in coil 30 caused armature 31 to move down, making contact with contact 32 which in turn caused the armature 33 of stepping relay 28 to be moved down because of the current in relay coil 34 produced by closing of contact 32. The movement of armature 33 caused ratchet arm 35 to pull arm 27 away from contact 22 counterclockwise towards stepping relay contact 23. During the time the arm 27 was in contact with contact 22, a positive voltage was applied to line 36 with respect to ground or center tap 29*a* of battery 29, or was caused to flow through rectifier 38 through relay coil 38*a* in a positive direction resulting in movement of arm 39 of relay 40 to make contact at 43 which in turn keyed the marking frequency of a frequency shift radio printer keying circuit.

As soon as arm 27 left contact 22 the current in relay coil 30 was released and contacts 31 and 32 were opened de-energizing coil 34 of the continuously cycling spring driven stepping relay 28 which in turn repositioned ratchet arm 35 preparatory for another ratcheting operation.

The capacity 41 and adjustable resistor 42 across coil 34 acts to retard the arm 27, sufficiently long at each contact 22 to 26 to permit the full cycle of operation previously described to be completed.

When arm 27 arrived at contact 23 the same cycle of operation was set in motion as when the arm 27 was at contact 22, except that the charge of voltage on contact 23 is now derived from the negative source of battery 29, thru the contact on lever 8 and contact 15 and a negative charge was placed, thru rectifier 37 and relay coil 37*a* to ground or center tap 29*a* of battery 29, causing armature 39 to close contacts

44 keying the spacing frequency of the frequency shift keying system or causing a negative charge to be placed on line 36.

The same cycle of operation is repeated at stepping relay contacts 24, 25 and 26 resulting in moving arm 27 back to the original position in contact with contact 22 having thus completed a transmission cycle of four self-cycling operations from contact 22 to contact 26 which resulted in sending four equally spaced pulses and one starting pulse of alternate positive and negative charges to a line or causing the two frequencies of a frequency shift keying system to be alternatively operated causing five pulses divided between two different alternating currents to be transmitted.

Since the pulse caused to be transmitted when arm 27 is in contact with contact 22, is the starting pulse, it does not have to be especially spaced in relation to any previous pulse. The pulse created by contact of arm 27 with contact 26 is the end of the character forming combination.

Figs. 2 and 3 show the arrangement of the transmission keyboard more clearly from which the coaction of the pivoted keylevers 45 with the contact control means will be understood. The key-levers are arranged above the angularly shiftable levers 7, 8, 9, 10 and 11 and through bars 2, 3, 4, 5 and 6 selectively control the angular movement of the levers about their pivots 7a, 7b—11a, 11b, that in turn control the contacts 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21, for controlling the circuits heretofore described.

When arm 27 arrives at contact 26, current from negative battery 29 flows through coil 46, arm 27 and coil 30 to the center tap 29a of battery 29. This causes armature 47 to be attracted by the electro-magnetic core of coil 46 making contact at 48, permitting current to flow through coil 49 from positive battery 29 to negative battery 29. When coil 49 shown more clearly in Fig. 3 was energized armature 50 was drawn towards the electro-magnetic core of the coil 49 pushing oscillating bar 50' against armature 51 releasing pressure of point 51a of pivoted member 51 on roller 52 carried by the end of keylever 45 permitting spring 53 to pull keylever 45 up against stop 54 which action lifted key bars 2, 3, 4, 5 and 6 from bars 7, 8, 9, 10 and 11, allowing the latter to resume normal position. Thus permutations and combinations of signal pulses can be formed and transmitted by contacts 43 and 44 under selective control of the keyboard as described.

Had it been desired to utilize the keying mechanism in the manner described in my co-pending application No. 109,648 supra for simultaneous transmission of a coded character, the oscillators 40a, 40b, 40c, 40d and 40e of the circuit of Fig. 1 of that application would be connected to contacts 13, 15, 17, 19 and 21, and levers 7, 8, 9, 10 and 11 would be connected together and returned to contact with 40f. Contacts 13, 15, 17, 19 and 21 would have been disconnected and levers 7, 8, 9, 10 and 11, when in normal position, would have been making contact with contacts 12, 14, 16, 18 and 20 causing oscillators 40a, 40b, 40c, 40d and 40e to continuously generate alternating current tones into the line 36 or an amplifier as described in my aforesaid co-pending application. When key 1 is depressed contact is broken at contacts 7, 12, at 9, 14 and at 11,20, causing oscillators 40a, 40c and 40e to be removed from the line and the character which is made up of signals from oscillators 40b and 40d in simultaneous combination would be formed.

Receiving apparatus

Fig. 4 shows the receiving circuit for the receiving printer of my invention. I provide a "pyramid" or "Christmas tree" arrangement of relays 63, 97, 103, and 110, in series with a rectifier circuit, and having associated armatures 78, 98, 104, and 111, respectively, arranged to control permutations and combinations of signal pulses through associated contacts and circuits connected therewith. An unlatching or fifth relay 116 is used for controlling an armature 117 for unlatching armatures 78, 98, 104 and 111 for enabling the system to receive the next succeeding signal impulse group. The permutation and combination incoming signal pulses, whether received by line or as a result of rectification of a radio or audio frequency current, appears on line 147 of Fig. 4 as a positive or negative voltage with respect to ground 55 in accordance with the manner in which it was transmitted by the apparatus described in Figs. 1–3. The current flows through the stepping arm 61 of cycling switch 62 to contact 56 and the winding of relay 63 and, if the voltage is of positive polarity with respect to 55, which is the center tap 29a of battery 29 from which the voltage on line 147 is derived, through rectifier 64 to line 55. The current also flows through coil 65 from line 147 to line 55.

When current passed through coil 65, armature 66 made connection with contact 67 completing the circuit between positive battery 29 and coil 68 and ground 55. This moved armature 69 to the left causing ratchet arm 70 to turn ratchet wheel 71, which caused arm 61 to move from contact 56 to contact 57, and through shaft 145 caused arm 72 to move from open contact 73 to contact 74.

When armature 66 moves to the left under control of coil 65, armature 66 makes connection with contact 67. An extension rod 66a interconnects armature 66 with the operating spring 66b and draws operating spring 66b to the left whereby the continuity of the circuit 147 to arm 61 is broken between spring 66b and spring 66c, insuring against the possibility of a prolonged pulse causing a false operation prior to the completion of the pulse duty cycle. This also permits the carrier or signal current to be maintained in an on condition during the interim between the formation of signal characters.

When current is passed through relay 63, armature 78 causes extension bar 79 to pull contacts 80 to 87 into connection with contacts 89, 90, 91, 92, 93, 94, 95 and 96.

Upon arrival of arm 61 at contact 57 the circuit from line 147 through rectifier 64 to line 55 is completed. If the voltage on line 147 is now negative, rectifier 64 will not pass current through relay coil 97 to ground 55 and thus armature 98 remains in position shown and contacts to 102 are not broken.

The current through coil 65 again causes the arm 61, as a result of the action similar to that previously described, to move to contact 58. If the voltage in line 147 is now positive with respect to ground or center tap 29a of battery 29 and the circuit is completed from line 147 through arm 61, contact 58, coil 103, to rectifier 64, and line 55, the current flow through coil 103, causes armature 104 to move bar 105 causing leaf spring

contacts 106 and 107 to connect with contacts 108 and 109.

When arm 61 arrives at contact 58 the action resulting from current action in coil 65 is again repeated causing arm 61 to move to contact 59 and arm 32 of the stepping switch 62 to move to contact 76.

The arrival of arm 61 at contact 59 completes the circuit from line 147 through coil 110, arm 61 contact 59, to rectifier 64. If the voltage is now negative, rectifier 64 will not pass current through coil 110 to ground 55 and armature 111 and bar 112 remain in the position shown.

The current in coil 65 present when contact 62 of arm 61 is in contact with contact 59 causes arm 61 to move to contact 60 and arm 72 to move to contact 77.

Line 147 is now connected thru arm 61, contact 60 and contacts 113, 107, 109, 101, 85 and 94, to the printer magnets N and SP, to rectifiers 114 and 115 to line 55 through lead 55a.

If the voltage in line 147 was positive when contact was made by arm 61 at contact 60, a positive current will now pass through the printer magnets N (Fig. 4) and rectifier 115 to and by the process described above. This will cause the letter N of the printer to print.

When the letter N function was activated by the action of arm 61 contacting contact 60, current also passed through relay coil 116 in the lead 55a which caused armature 117 to unlatch armatures 78, 94, 104 and 111 of relays 63, 97, 103 and 110 preparing the system to receive a new cycle of character forming impulses.

Examination of Fig. 4 will show that, predicated upon the polarity of currents in line 147 with respect to line 55 as presented to the "pyramid" or "Christmas tree" shown in the lower right hand portion of Fig. 4 in sequential combination and with the use of pressure roller springs 118, 119, 120 and 121 to latch armature 78, 98, 104 and 111 in a fixed position for a period covering the cycle of operation, it is possible to individually select any one of the multiplicity of magnets in various permutations and combinations represented by reference "Let" designating "letters" to "Blk" designating "blank" of Fig. 4. In Figs. 5 and 6 I have shown the two limiting positions of armature 111 on an enlarged scale to illustrate the two extreme latched positions thereof under control of pressure roller spring 118. All of the armatures 78, 98, 104 are arranged in a manner similar to armature 111, that is the armature 78, 98 and 104 are controlled in their limiting positions by pressure roller springs 121, 120 and 119 respectively.

Figs. 7 and 8 are enlarged views of the solenoids in the polarized "pyramid" or "Christmas tree" circuit wherein Fig. 7 represents the juxtapositions of the differentially polarized operating solenoids for letters W and A and letters Z and E while Fig. 8 shows the electrical equivalent of the same juxtapositioned solenoids.

The capacitor-resistor combination 122 and 123, are used to control the dissipation of current in condenser 122 through coil 68 after opening of the circuit to battery 29 (+) by the operation of relay 65 and which in turn controls the length of time in which arm 61 moves from one contact to the other of the group of contacts 56 to 60.

Under certain conditions of operation particularly in radio circuits the possibility of loss of one or more impulses due to fading or obliteration of signals by interference is always present. To overcome this condition, provision has been made in the selector system for the supplying of lost impulses and recording this circumstance on the printed copy. The effect of interference is made to appear as a lost impulse in this system.

Each time that the armature 66 is in contact with contact 124 in addition to holding armature 125 in contact with contact 126, battery 29 (+) charges the condenser resistor delay network 127 and 128 across coil 129. Each time the armature 66 is opened by removal of energy from coil 65, contacts 66 and 124 are broken which opens the circuit from positive battery 29 to negative battery 29 through coil 129. When this occurs the energy stored in capacitor 127 starts discharging through resistors 128 and 128a into coil 129 holding armature 125 that is in circuit with condenser 130 through contact 126 to battery 29.

If no voltage appears on line 147 for a fixed period of time after contact has been established by arm 61 with any one of the contacts 57, 58, 59 and 60 before the dissipation of energy in condenser 127 is complete, armature 125 will be released from contact 126 and contact will be established with contact 131 allowing condenser 130 to discharge through resistor 130a, coil 132, arm 72 and contact 74, 75, 76 or 77 of a duplicate bank of contacts on the same shaft as contact arm 61 to line 147 through whichever circuit arm 61 provides through its contact with contacts 56 to 60, thus producing the same action which would have resulted from an incoming signal on line 147.

When this current passed through coil 132 the armature 133 was moved and closed the circuit through contact 133a connecting battery 29 to a relay 134 associated with the printing mechanism.

When the relay 134 was energized, the armature 135 was attracted to the pole of coil 134, latching itself to latching armature 136 and bringing the extension wire 137 of armature 135 across the surface of the character A for example on the type pallet 138 which may strike the ink ribbon 139 of Fig. 11 and be printed on the paper web 140 being advanced on platen 141 of the printer as shown more clearly in Figs. 9 and 10, and 11. Fig. 9 shows the condition for indicating error while Fig. 10 shows an all clear condition with the error indicator removed.

When relay 116 was energized contact was made between 144 and 117, placing battery on coil 142 which caused armature 136 to release armature 135 allowing spring 143 to draw armature 135 to its normal position with the extension 137 clear of the printing surface of the next character placed in a printing position.

When the letter key is operated to print the character formed, partly by the self-imposed impulses of condenser 130, the character which is printed will be marked by a vertical bar stroke by the extension bar 137 of armature 135 plainly indicating to the operator that the character was not properly received.

The rotary selecting printing mechanism described in my co-pending application No. 109,648 supra may be used in connection with the apparatus described in this application to select and print the characters and perform the other operations required of a printing mechanism. This may be accomplished by connecting the contacts of the rotary switch and the "letters," "figures" and "space" relays to the contacts represented by the solenoids for letters K, W, etc. of Fig. 4.

It will be fully understood that these same contacts of Fig. 4 can be connected to a series of solenoids or magnets and be used to operate an electric typewriter or initiate the printing mechanism of other types of presently used printing telegraph equipment.

Conventional printer mechanism is operated by the solenoids "letters" through "blank" shown in the polarized "pyramid" or "Christmas tree" in the lower left corner of Fig. 4.

Due to the fact that the necessity for a mechanical selector is eliminated in the printer system of my invention and yet very accurate and quick movement of the selection system of my invention obtained by use of positive and negative electrical impulses; I am able to reduce the size and weight of the equipment, as compared to conventional equipment, very materially.

While I have described my invention in certain of its preferred embodiments I realize that modifications may be made and I desire that it be understood that no limitations upon my invention are intended other than may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a printing telegraph system, a plurality of pairs of printer operating solenoids each including differentially polarized individual solenoids, a polarized pyramid circuit, selective conditioning means for controlling said polarized pyramid circuit for selectively exciting the individual printer solenoids of said pairs of printer operating solenoids by positive or negative current pulses, a signal input circuit, a stepping switch including an arm operative over a multiplicity of contactors, control relays individual to the said contactors, and means in said signal input circuit for selectively operating said stepping switch relative to signal pulses for selectively exciting certain of said relays, and means operated by said relays for controlling said polarized pyramid circuit.

2. In a printing telegraph system, a circuit for receiving positive and negative signal current pulses, a step-by-step switch controlled by said pulses, contactors individual to the step-by-step positions of said switch, relays selectively excited by currents from circuits extending from said contactors, a polarized pyramid circuit including sets of make and break movable contactors with associated contacts, means operated by said relays for controlling the displacement of said make and break movable contactors with respect to the associated contacts, and differentially polarized printer solenoids arranged in pairs and connected with the contacts in said polarized pyramid circuit and selectively operative by positive and negative current pulses for selectively operating printer mechanism.

3. A printing telegraph system as set forth in claim 2 including means for latching said movable contactors in selectively displaced positions.

4. A printing telegraph system as set forth in claim 2, including means for simultaneously restoring said movable contactors in said polarized pyramid circuit to the original positions thereof from their displaced positions.

5. A printing telegraph system as set forth in claim 2 in which said differentially polarized printer solenoids are selectively connected through unidirectional current feed circuits whereby the individual solenoids of each pair are selectively excitable by current pulses according to the polarity thereof.

6. A printing telegraph system as set forth in claim 2 which also includes an auxiliary circuit selectively excitable under conditions of failure of receipt of all of the current pulses constituting a signal permutation or combination.

7. A printing telegraph system as set forth in claim 2 which also includes an auxiliary circuit operative upon failure of any one of the signal permutations or combinations and means for restoring said auxiliary circuit to normal condition after correction of the failed permutation or combination.

8. A printing telegraph system as set forth in claim 2 which includes a circuit containing an electrostatic capacity wherein said electrostatic capacity accumulates an electrical charge upon the incomplete receipt of a code signal permutation or combination, an electrical circuit controlled by said electrostatic capacity, a relay controlled by said electrical circuit, and means for restoring said relay to normal condition after dissipation of the electrostatic charge in said electrostatic capacity.

9. A printing telegraph system as set forth in claim 2 in which said differentially polarized printer solenoids are arranged in pairs by a connection bonding adjacent ends of the windings of said solenoids and wherein the opposite ends of each winding are connected in series with separate rectifiers which are polarized to pass current through one of said solenoids in one direction and to pass current through the other solenoid in the opposite direction.

10. A printing telegraph system as set forth in claim 1 in which unidirectionally current conducting devices are electrically connected in series with the individual solenoids of each of said pairs of printer operating solenoids for selectively supplying operating current to said printer operating solenoids unilaterally according to the operation of said polarized pyramid circuit.

11. A printing telegraph system as set forth in claim 1 in which there are at least four of said control relays each having an operating armature for controlling the operation of said polarized pyramid circuit and wherein a fifth relay is connected in series with said polarized pyramid circuit and is provided with an armature operative after each printing operation to restore the armatures of the aforesaid control relays to positions preparatory for receiving signal impulses representing a succeeding character.

12. A printing telegraph system as set forth in claim 1 in which there are at least four of said control relays each having an operating armature for controlling the operation of said polarized pyramid circuit, the windings of said control relays all being connected with said signal input circuit through a rectifier for supplying unidirectional operating pulses to said windings and wherein a fifth relay is connected in series with said polarized pyramid circuit and is provided with an armature aligned with respect to all of the armatures of said control relays and operative after each printing operation to restore all of the aforesaid armatures to positions preparatory for receiving signal impulses representing a succeeding character.

13. A printing telegraph system as set forth in claim 1 in which the means in said signal input circuit for selectively operating said stepping

switch comprise a pair of relays, one of said relays having its winding connected in said signal input circuit and operating an armature for controlling a multiplicity of leaf springs and associated contacts, the other of said relays having its winding connected in series with one of the aforesaid leaf springs and associated contacts and having an armature ratcheting the arm of said stepping switch, certain of the leaf springs and contacts of said aforementioned relay forming a circuit path for signal impulses through said stepping switch and one of the leaf springs and associated contacts of the aforementioned relay forming a circuit path through said last mentioned relay for effecting a stepping operation of said stepping switch according to the reception of the signal pulses and a rectifier disposed in circuit with said arm for restricting the current flow therethrough to unidirectional pulses.

14. A printing telegraph system as set forth in claim 1 in which three independent rectifiers are

disposed in the circuits of said telegraph system one of said rectifiers being connected in series between said signal input circuit and said control relays and the other of said rectifiers being connected in series with said solenoids in said pyramid circuit, said last mentioned rectifiers being electrically reversed with respect to each other whereby current flows unidirectionally in said pyramid circuit in opposite directions according to the permutations and combinations of the signal pulses.

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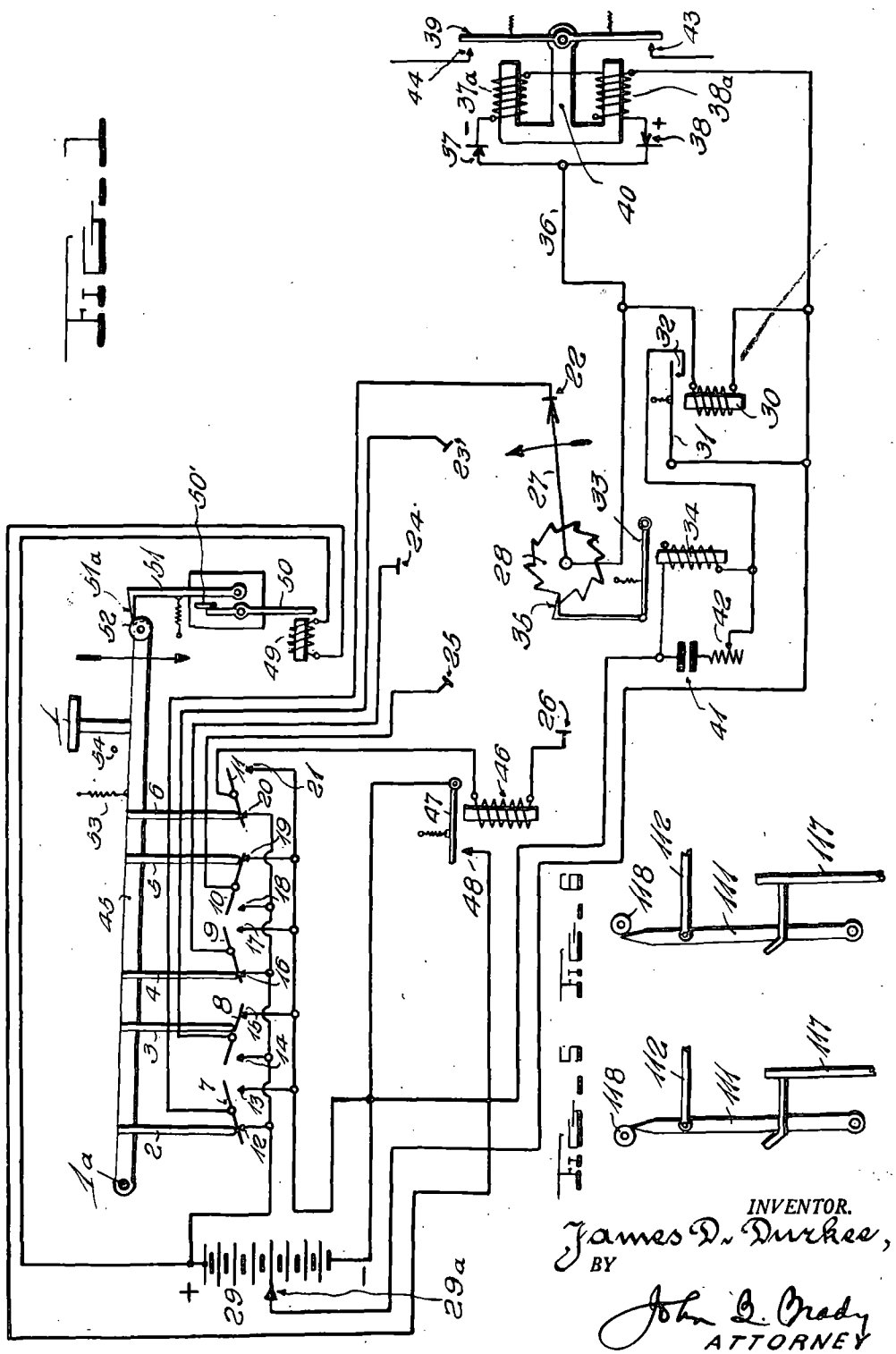
FIG. 1



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PRINTING TELEGRAPH SYSTEM

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FIG. 3

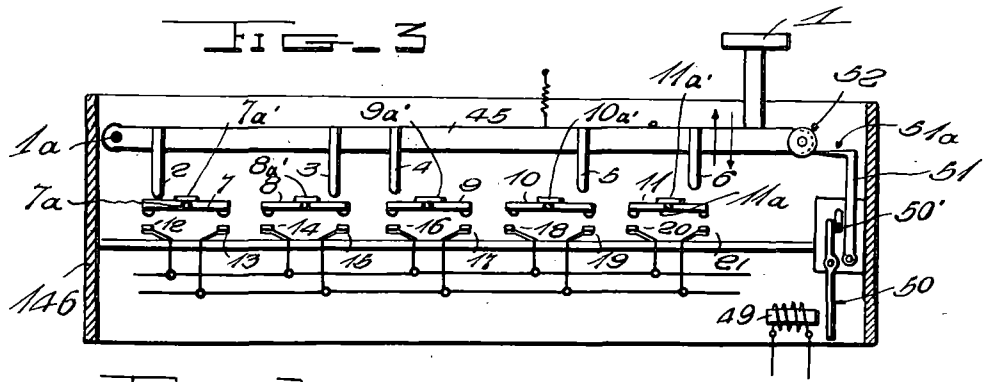
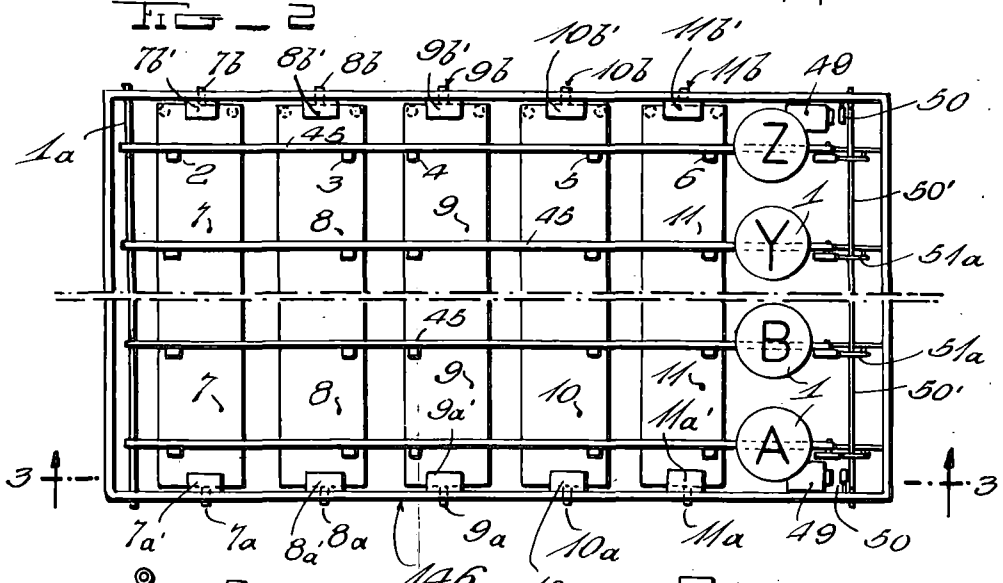


FIG. 2



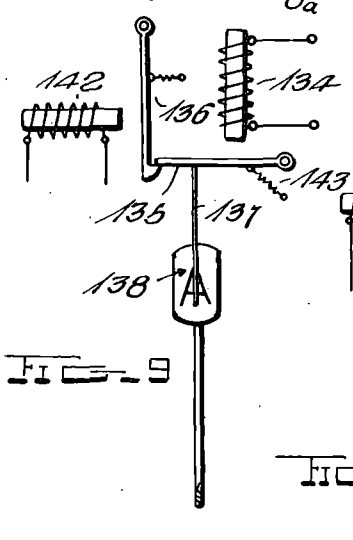


FIG. 9

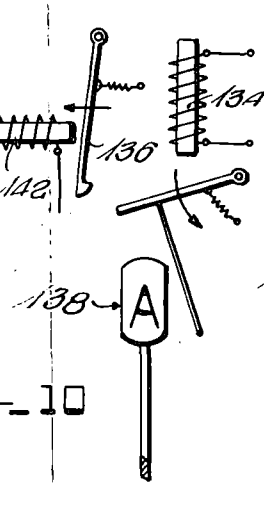


FIG. 10

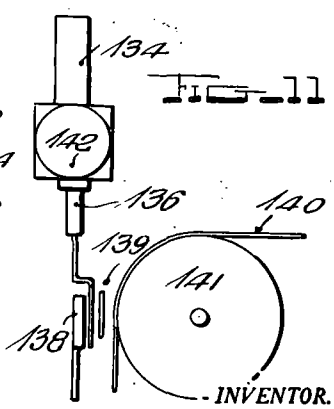


FIG. 11

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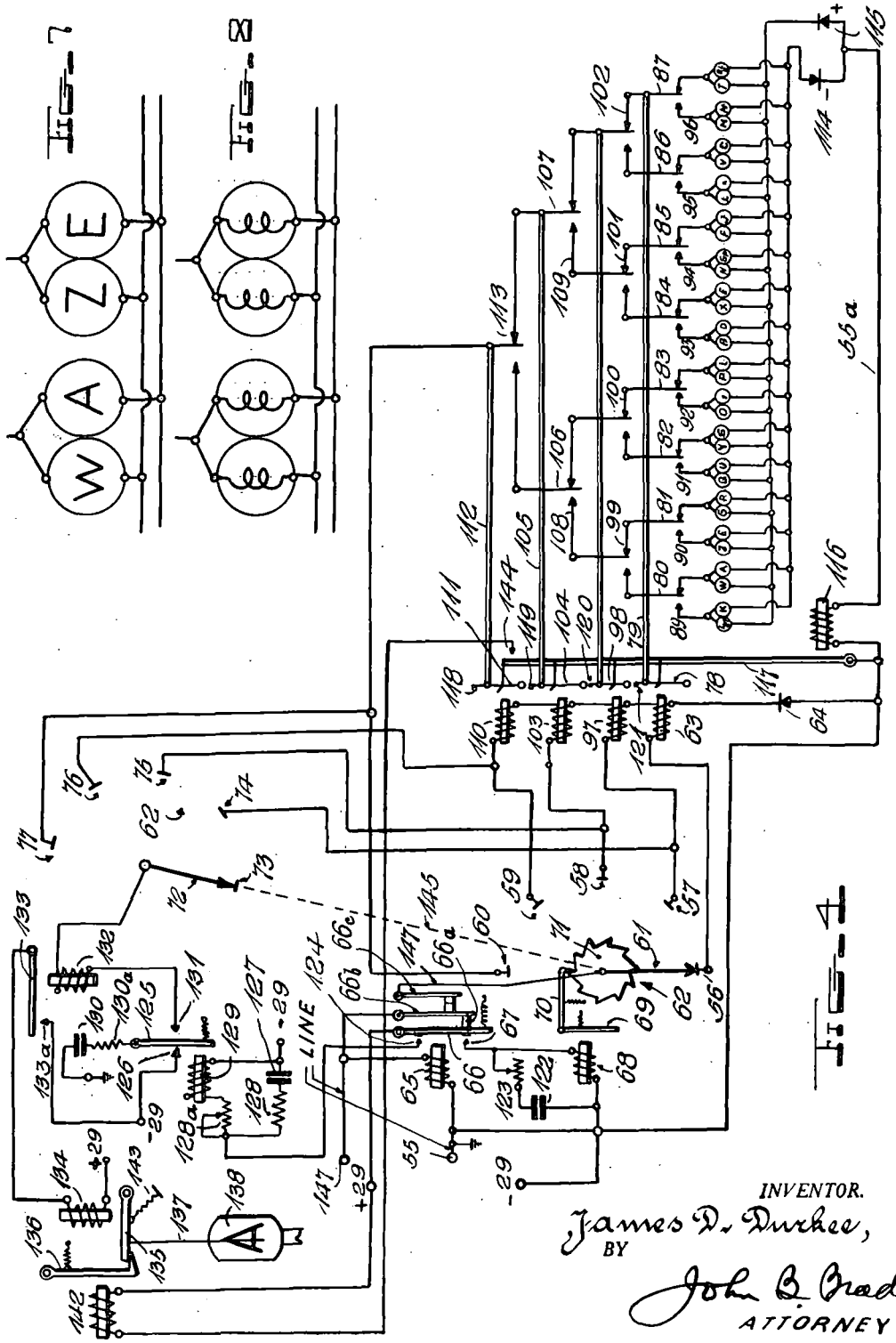

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PRINTING TELEGRAPH SYSTEM

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5 Claims. (Cl. 178—23)

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My invention relates broadly to printing telegraph systems and more particularly to a high speed polarized system of printing telegraphy utilizing printing telegraph apparatus of compact size and light weight.

One of the objects of my invention is to provide a printing telegraph system constituting an improvement upon conventional sequentially operated systems, overcoming inherent difficulties in these systems.

This invention covers a printing telegraph apparatus and system which is self-synchronizing, requires less channel band-width than existing methods, provides means for indicating when impulses are lost or obliterated by fading or interference and is capable of increased transmission speeds and yet employs less equipment even when adapted to equipment and systems presently in use.

This achievement is made possible by the invention of a polarized electrical matrix which requires the transmission of only five polarized pulses, without the necessity of transmitting start-stop or synchronizing pulses, to accomplish the thirty-two different permutations and combinations of signal impulses presently used in printing telegraph systems.

Since in my application a smaller number of permutations and combinations of signal pulses are required to produce the same number of permutations and combinations as used in currently existing systems, a greater number of permutations and combinations can be sent in less time with fewer impulses thereby requiring a smaller number of transmission bauds and less frequency band-width.

In addition, since the system of my invention requires only a reversal of current direction or polarity, the transition from one polarity or phase to the opposite polarity or phase may be accomplished by sinusoidal wave form; thus, the impact excitation resulting from a rapid make or break keying operation or from a rapid frequency shift is eliminated, thereby further decreasing the keying band-width required at any speed of transmission.

A further object of my invention is to provide a self-synchronizing receiving system which may be made operable over a fairly wide range of transmission speeds and which requires a minimum of equipment or adjustment.

Another object of my invention is to provide means for supplying a pulse or pulses which may have been lost in transmission or obliterated by interference and means for indicating on the

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receiving copy a mark or symbol which visually indicates that the character received is incorrect.

The apparatus described in this application is intended for use with an electric typewriter or with slight modification of the present printing telegraph systems may be used interchangeably with conventional equipment.

My invention will be more fully understood from the specifications hereinafter following by reference to the accompanying drawings in which Figure 1 diagrammatically shows the transmission system of my invention; Fig. 2 is a schematic plan view of a fragmentary portion of the transmission keyboard; Fig. 3 is a schematic and elevational view of the transmission keyboard, the view being taken on sectional line 3—3 of Fig. 2 and showing the frame structure in vertical section; Fig. 4 shows the receiving circuit of the printing telegraph system of my invention; Figs. 5 and 6 are detail views illustrating the operation of the control mechanism in the receiving apparatus; Figs. 7 and 8 are detailed views of the operating solenoids controlled by the printing telegraph receiving system; Figs. 9 and 10 are enlarged schematic views showing the operation of the error indicating means employed in the receiving system of my invention, the views being shown in front elevation and wherein Fig. 9 shows the error indicating means in printing position whereas Fig. 10 shows the error indicating means released and free of printing position; and Fig. 11 is an end view of the error indicating means shown in Fig. 9.

Almost from the beginning of the art of printing telegraph systems efforts have been made to accomplish the selection of characters by electrical resolution of the units of the Baudot code. Each solution required the use of a large number of electrical contacts and electro-magnetic relays in simultaneous operation with the resulting presence of a multiplicity of potential error producing elements. Practical experience indicated that greater reliability could be placed on mechanical resolution and the present state of the art reflects this experience. Mechanical operations, however, have the inherent characteristic of requiring a longer time to perform the same functions than does electrical energy.

However, operational communication requirements for increased speeds of operation have now exceeded the capabilities of the mechanical equipment except under strained and abnormal conditions which require excessive maintenance and mechanical tolerances and precision of apparatus which are difficult to achieve.

The application of printing telegraph systems to radio communication also introduced additional difficulties which do not readily lend themselves to solution by mechanical methods due to the speed limitations of mechanical operations.

Two of the major difficulties introduced by radio communication are various forms of fading and interference in addition to the basic limitation in the number of cycles available in the total radio frequency spectrum.

Heretofore, various approaches to the radio applications of printer systems have been by increasing power of transmission and improving receiving conditions in an effort to duplicate the operating reliability of a land line to overcome fading and increasing the dot cycles of operation by additional fail safe impulses or increasing the units of the basic five unit code to provide error detection resulting from interference and certain forms of fading.

The approach of my invention to the solution of the requirement for increased speeds has been to eliminate the basic mechanical limitation of the mechanism used to resolve the units of the five unit code into characters by use of a polarized electrical matrix; to decrease the electrical contacts required to a minimum by use of rectifying apparatus and the application of new and novel electrical circuits and to decrease the operational functions to a minimum by simplification of equipment and electrical circuits.

The fading and interference problems introduced by radio communication have been accepted as natural characteristics of the medium. Circuits and operations are provided by my invention which take these natural characteristics into account and provide substitute characteristics in the form of locally produced impulses to replace those lost in transmission due to fading or to counterbalance impulses introduced in transmission as a result of interference and to indicate on the receiving equipment when these functions have been required to complete the formation of a character.

In endeavoring to achieve greater economy of bandwidth, the start-stop or synchronizing impulses heretofore used in both radio and wire methods have been eliminated in my invention by self-synchronizing apparatus resulting in an approximate saving of twenty per cent of bandwidth required to perform the functions necessary to the formation of a character as compared to systems which transmit start-stop impulses or synchronizing impulses.

My invention employs apparatus and methods which are compatible with existing methods and apparatus, allowing in almost every instance, the use, with slight modification, or existing equipment and methods to accomplish its purpose.

Transmitting apparatus

Figs. 1, 2 and 3 show the transmission system of my invention, the transmitting keyboard being shown in plan view in Fig. 2 and in end view in Fig. 3.

When the key 1, pivotally mounted at 1*a*, is depressed, bars 2, 3, 4, 5 and 6 which extend therefrom depress levers 7, 8, 9, 10 and 11 in a downward direction to form contact with the contacts 12 to 21. The levers 7–11 are supported at opposite ends in frame 146 of the transmitting keyboard as shown at 7*a* and 7*b*; 8*a* and 8*b*; 9*a* and 9*b*; 10*a* and 10*b*; and 11*a* and 11*b* through resilient self restoring flexing strip members 7*a*'—7*b*'; 8*a*'—8*b*'; 9*a*'—9*b*'; 10*a*'—10*b*'; and 11*a*'—11*b*'. Contacts 12–21 are insulatingly supported in relation to frame 146 in alignment with the pivoted levers 7–11 as shown. The levers 7–11 are normally biased by the resilient self restoring flexing strip members 7*a*'—7*b*'; 8*a*'—8*b*'; 9*a*'—9*b*'; 10*a*'—10*b*'; and 11*a*'—11*b*', to a position in horizontal planes and flex under the pressure of the bars 2–6 in either a clockwise or a counter-clockwise direction depending on the relative positions of the bars 2–6 with respect to the centers of levers 7–11, for effecting momentary contact at 12–21. When pressure of bars 2–6 on the levers 7–11 is removed the levers 7–11 are restored to horizontal position breaking the contacts 12–21 by the self restoring action of the flexing supports at each end of the levers 7–11. The contacts which are formed depend upon which side of the center of levers 7 to 11, the bars 2 to 6 are positioned. In the position illustrated in Fig. 1 lever 7 will contact 12, lever 8 will contact 15, lever 9 will contact 16, lever 10 will contact 19, and lever 11 will contact 20, placing alternatively positive and negative currents from source of battery 29 on stepping relay contacts 22, 23, 24, 25 and 26 arranged in the path of switch arm 27 of continuously cycling driven stepping relay 28.

When this contact was made a positive current flow took place from battery 29 (Fig. 1) contact through 12, and the contact carried by lever 7 to stepping relay contact 22 through arm 27 through relay coil 30 to the center tap 29*a* of battery 29. The current in coil 30 caused armature 31 to move down, making contact with contact 32 which in turn caused the armature 33 of stepping relay 28 to be moved down because of the current in relay coil 34 produced by closing of contact 32. The movement of armature 33 caused ratchet arm 35 to pull arm 27 away from contact 22 counterclockwise towards stepping relay contact 23. During the time the arm 27 was in contact with contact 22, a positive voltage was applied to line 36 with respect to ground or center tap 29*a* of battery 29, or was caused to flow through rectifier 38 through relay coil 38*a* in a positive direction resulting in movement of arm 39 of relay 40 to make contact at 43 which in turn keyed the marking frequency of a frequency shift radio printer keying circuit.

As soon as arm 27 left contact 22 the current in relay coil 30 was released and contacts 31 and 32 were opened de-energizing coil 34 of the continuously cycling spring driven stepping relay 28 which in turn repositioned ratchet arm 35 preparatory for another ratcheting operation.

The capacity 41 and adjustable resistor 42 across coil 34 acts to retard the arm 27, sufficiently long at each contact 22 to 26 to permit the full cycle of operation previously described to be completed.

When arm 27 arrived at contact 23 the same cycle of operation was set in motion as when the arm 27 was at contact 22, except that the charge of voltage on contact 23 is now derived from the negative source of battery 29, thru the contact on lever 8 and contact 15 and a negative charge was placed, thru rectifier 37 and relay coil 37*a* to ground or center tap 29*a* of battery 29, causing armature 39 to close contacts 44 keying the spacing frequency of the frequency shift keying system or causing a negative charge to be placed on line 36.

The same cycle of operation is repeated at stepping relay contacts 24, 25 and 26 resulting in moving arm 27 back to the original position

in contact with contact 22 having thus completed a transmission cycle of four self-cycling operations from contact 22 to contact 26 which resulted in sending four equally spaced pulses and one starting pulse of alternate positive and negative charges to a line or causing the two frequencies of a frequency shift keying system to be alternatively operated causing five pulses divided between two different alternating currents to be transmitted.

Since the pulse caused to be transmitted when arm 27 is in contact with contact 22, is the starting pulse, it does not have to be especially spaced in relation to any previous pulse. The pulse created by contact of arm 27 with contact 26 is the end of the character forming combination.

Figs. 2 and 3 show the arrangement of the transmission keyboard more clearly from which the coaction of the pivoted keylevers 45 with the contact control means will be understood. The key-levers are arranged above the angularly shiftable levers 7, 8, 9, 10 and 11 and through bars 2, 3, 4, 5 and 6 selectively control the angular movement of the levers about their pivots 7a, 7b—11a, 11b, that in turn control the contact 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21 for controlling the circuits heretofore described.

When arm 27 arrives at contact 26, current from negative battery 29 flows through coil 46, arm 27 and coil 30 to the center tap 29a of battery 29. This causes armature 47 to be attracted by the electro-magnetic core of coil 46 making contact at 48, permitting current to flow through coil 49 from positive battery 29 to negative battery 29. When coil 49 shown more clearly in Fig. 3 was energized armature 50 was drawn towards the electro-magnetic core of the coil 49 pushing oscillating bar 50' against armature 51 releasing pressure of point 51a of pivoted member 51 on roller 52 carried by the end of keylever 45 permitting spring 53 to pull keylever 45 up against stop 54 which action lifted key bars 2, 3, 4, 5 and 6 from bars 7, 8, 9, 10 and 11, allowing the latter to resume normal position. Thus permutations and combinations of signal pulses can be formed and transmitted by contacts 43 and 44 under selective control of the keyboard as described.

Receiving apparatus

Fig. 4 shows the receiving circuit for the receiving printer of my invention. The permutation and combination incoming signal pulses, whether received by line or as a result of rectification of a radio or audio frequency current, appears on line 147 of Fig. 4 as a positive or negative voltage with respect to ground 55 in accordance with the manner in which it was transmitted by the apparatus described in Figs. 1–3. The current flows through the stepping arm 61 of cycling switch 62 to contact 56 and the winding of relay 63 and, if the voltage is of positive polarity with respect to 55, which is the center tap 29a of battery 29 from which the voltage on line 147 is derived, through a rectifier 64 to line 55. The current also flows through coil 65 from line 147 to line 55.

When current passed through coil 65, armature 66 made connection with contact 67 completing the circuit between positive battery 29 and coil 68 and ground 55. This moved armature 69 to the left causing ratchet arm 70 to turn ratchet wheel 71, which caused arm 61 to move from contact 56 to contact 57, and through shaft 145 caused arm 72 to move from open contact 73 to contact 74.

When armature 66 made connection with contact 67, extension rod 66a connected with operating spring 66b the continuity of the circuit 147 to arm 61 was broken between spring 66b and contact 66c, insuring against the possibility of a prolonged pulse causing a false operation prior to the completion of the pulse duty cycle. This also permits the carrier or signal current to be maintained in an "on" condition during the interim between the formation of signal characters.

When current was passed through relay 63, armature 78 caused extension bar 79 to pull contacts 80 to 87 into connection with contacts 89, 90, 91, 92, 93, 94, 95 and 96.

Upon arrival of arm 61 at contact 57 the circuit from line 147 through rectifier 64 to line 55 is completed. If the voltage on line 147 is now negative, rectifier 64 will not pass current through relay coil 97 to ground 55 and thus armature 98 remains in position shown and contacts to 102 are not broken.

The current through coil 65 again caused the arm 61, as a result of the action similar to that previously described, to move to contact 58. If the voltage in line 147 is now positive with respect to ground or center tap 29a of battery 29 and the circuit is completed from line 147 through arm 61, contact 58, coil 103, to rectifier 64, and line 55, the current flow through coil 103, caused armature 104 to move bar 105 causing leaf spring contacts 106 and 107 to connect with contacts 108 and 109.

When arm 61 arrived at contact 58 the action resulting from current action in coil 65 was again repeated causing 61 to move to contact 59 and arm 32 of the stepping switch 62 to move to contact 76.

The arrival of arm 61 at contact 59 completed the circuit from line 147 through coil 110, arm 61 contact 59, to rectifiers 64. If the voltage is now negative, rectifier 64 will not pass current through coil 110 to ground 55 and armature 111 and bar 112 remain in the position shown.

The current in coil 65 present when contact 62 of arm 61 is in contact with contact 59 caused arm 61 to move to contact 60 and arm 72 to move to contact 77.

Line 147 is now connected thru arm 61, contact 60 and contacts 113, 107, 109, 101, 85 and 94, to the printer magnets N and SP, to rectifiers 114 and 115 to line 55 through lead 55a.

If the voltage in line 147 was positive when contact was made by arm 61 at contact 60, a positive current will now pass through the printer magnets N (Fig. 4) and rectifier 115 to and by the process described above. This will cause the letter N of the printer to print.

When the letter N function was activated by the action of arm 61 contacting contact 60, current also passed through relay coil 116 in the lead 55a which caused armature 117 to unlatch armatures 78, 94, 104 and 111 of relays 63, 97, 103 and 110 preparing the system to receive a new cycle of character forming impulses.

Examination of Fig. 4 will show that, predicated upon the polarity of the currents in line 147 with respect to line 55 as presented to the matrix shown in the lower right hand portion of Fig. 4 in sequential combination and with the use of pressure roller springs 118, 119, 120 and 121 to latch armature 78, 98, 104 and 111 in a fixed position for a period covering the cycle of operation, it is possible to individually select any one of the multiplicity of magnets in various permutations and combinations represented by reference

"Let" designating "Letters" to "Blk" designating "Blank" of Fig. 4. In Figs. 5 and 6 I have shown the two limiting positions of armature 111 on an enlarged scale to illustrate the two extreme latched positions thereof under control of pressure roller spring 118. All of the armatures 78, 98, 104 are arranged in a manner similar to armature 111, that is the armatures 78, 98 and 104 are controlled in their limiting positions by pressure roller springs 121, 120 and 119 respectively.

Figs. 7 and 8 are enlarged views of the solenoids in the polarized matrix circuit wherein Fig. 7 represents the juxtapositions of the operating solenoids for letters W and A and letters Z and E while Fig. 8 shows the electrical equivalent of the same juxtapositioned solenoids.

The capacitor-resistor combination 122 and 123, are used to control the dissipation of current in condenser 122 through coil 68 after opening of the circuit to battery 29 (+) by the operation of relay 65 and which in turn controls the length of time in which arm 61 moves from one contact to the other of the group of contacts 56 to 60.

Under certain conditions of operation particularly in radio circuits the possibility of loss of one or more impulses due to fading or obliteration of signals by interference is always present.

To overcome this condition, provision has been made in the selector system for the supplying of lost impulses and recording this circumstance on the printed copy. The effect of interference is made to appear as a lost impulse in this system.

Each time that the armature 66 is in contact with contact 124 in addition to holding armature 125 in contact with contact 126, battery 29 (+) charges the condenser resistor delay network 127 and 128 across coil 129. Each time the armature 66 is opened by removal of energy from coil 65, contacts 66 and 124 are broken which opens the circuit from positive battery 29 to negative battery 29 through coil 129. When this occurs the energy stored in capacitor 127 starts discharging through resistors 128 and 128*a* into coil 129 holding armature 125 that is in circuit with condenser 130 through contact 126 to battery 29.

If no voltage appears on line 147 for a fixed period of time after contact has been established by arm 61 with any one of the contacts 57, 58, 59 and 60 before the dissipation of energy in condenser 127 is complete, armature 125 will be released from contact 126 and contact will be established with contact 131 allowing condenser 130 to discharge through resistor 130*a*, coil 132, arm 72 and contact 74, 75, 76 or 77 of a duplicate bank of contacts on the same shaft as contact arm 61 to line 147 through which ever circuit arm 61 provides through its contact with contacts 56 to 60, thus producing the same action which would have resulted from an incoming signal on line 147.

When this current passed through coil 132 the armature 133 was moved and closed the circuit through contact 133*a* connecting battery 29 to a relay 134 associated with the printing mechanism.

When the relay 134 was energized, the armature 135 was attracted to the pole of coil 134, latching itself to latching armature 136 and bringing the extension wire 137 of armature 135 across the surface of the character A for example on the type pallet 138 which may strike the ink ribbon 139 of Fig. 11 and be printed on the paper web 140 being advanced on platen 141 of the printer as shown more clearly in Figs. 9 and 10, and 11. Fig. 9 shows the condition for indicating error while Fig. 10 shows an all clear condition with the error indicator removed.

When relay 116 was energized contact was made between 144 and 117, placing battery on coil 142 which caused armature 136 to release armature 135 allowing spring 143 to draw armature 135 to its normal position with the extension 137 clear of the printing surface of the next character placed in a printing position.

When the latter key is operated to print the character formed, partly by the self-imposed impulses of condenser 130, the character which is printed will be marked by a vertical bar stroke by the extension bar 137 of armature 135 plainly indicating to the operator that the character was not properly received.

Rotary selecting printing mechanism may be used in connection with the apparatus described in this application to select and print the characters and perform the other operations required of a printing mechanism. This may be accomplished by connecting the contacts of the rotary switch and the "Letters," "Figures" and "Space" relays to the contacts represented by the solenoids for letters K, W, etc. of Fig. 4.

It will be fully understood that these same contacts of Fig. 4 can be connected to a series of solenoids or magnets and be used to operate an electric typewriter or initiate the printing mechanism of other types of presently used printing telegraph equipment.

Conventional printer mechanism is operated by the solenoids letters through blank shown in the polarized matrix in the lower left corner of Fig. 2.

Due to the fact that the necessity for a mechanical selector is eliminated in the printer system of my invention and yet very accurate and quick movement of the selection system of my invention obtained by use of positive and negative electrical impulses, I am able to reduce the size and weight of the equipment, as compared to conventional equipment, very materially.

The receiver and transmitter with which the system of the instant invention operates are set forth in my copending applications for Letters Patent Serial Numbers 228,657 and 228,658, both filed May 28, 1951.

While I have described my invention in certain of its preferred embodiments I realize that modifications may be made and I desire that it be understood that no limitations upon my invention are intended other than may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a printing telegraph system, a type bar printer including at the printing position thereof a platen for supporting and advancing the printer copy, a printing ribbon aligned with said platen at the instance of striking of the printer copy by a type bar, an error indicator device movable into the path of impact of the type bar with the printing ribbon and the printer copy for indicating failure of receipt of the required signal code impulse permutations and combinations for effecting the selection and printing of the intended character.

2. A printing telegraph system as set forth in claim 1 in which the error indicator device is electromagnetically actuated by failure of receipt of the required signal code impulse permutations and combinations.

3. A printing telegraph system as set forth in claim 1 in which the error indicator device is electromagnetically positioned in the path of impact

of the type bar upon failure of receipt of the required signal code impulse permutations and combinations and in which an additional electromagnetic device is located adjacent the error indicator device for restoring said indicator device to non-alignment with the impact path of the type bar when the required signal code permutation and combination for the particular character in error is corrected.

4. A printing telegraph system comprising in combination with a type bar printer including at the printing position thereof a platen for supporting and advancing the printer copy, inking means aligned with the platen at the instance of striking of the printer copy by the type bar and means for interposing an error indicator in the path of an actuated type bar, said inking means and said printer copy so long as incomplete signal code impulse permutations and combinations are received.

5. A printing telegraph system as set forth in

claim 4 in which means are provided for removing the error indicator from the path of an actuated type bar, said platen and the printer copy concurrently with the restoration of the complete signal code impulse permutation and combination for the character intended.

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CRYPTOGRAPHIC DEVICE

William F. Friedman, Washington, D. C.

Application October 19, 1939, Serial No. 300,212

19 Claims. (Cl. 35—2)

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

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

This invention relates to cryptographic devices and has for its object the provision of a hand-operated device capable of affording a relatively high degree of security without involving the use of complicated mechanisms.

Another object is to provide a device useful in cryptographic and cryptanalytic investigations requiring the use of sliding alphabets.

The invention is described with reference to the accompanying drawings, in which:

Fig. 1 is a perspective showing one form or embodiment of the invention;

Fig. 2 is a top plan view of another embodiment of the invention;

Fig. 3 is a cross-section taken on the line 3—3 of Fig. 2;

Fig. 3*a* is a fragment of the same section on an enlarged scale showing the T-grip for the guide rule in operative position;

Fig. 4 is a top view of the form of invention of Fig. 1 showing the guide rule in shifted position;

Fig. 5 is a top plan view showing another embodiment of the invention in which the base is composed of separate detachable grooved sections;

Fig. 6 is a perspective showing one of the grooved sections; and

Fig. 7 is a perspective showing a frame structure and sub-base on which said grooved sections may be assembled.

Referring to Fig. 1, in this embodiment the device comprises a base 1, on which are horizontally fastened a series of cylindrical rods 2, forming a set of channel ways 3, into which character bearing strips 4, may be inserted and slid from left to right or vice versa. In the specific embodiment disclosed herein the device comprises twenty-five such channel ways, but the device is by no means limited to this number. The number chosen in this embodiment is merely a convenient number, and it may be increased or decreased within certain limits in other embodiments without materially departing from the spirit of the invention. A rule, or reading guide 5, attached to a reading guide slide 6, can be slid to the left or right on a reading guide slide rail 7. End bars 8 and 9, serve as stops against which the reading guide 5 may be brought at the end of its travel to the left or right. To the back of the base 1 is fastened a hinged support 10, which can be pulled out to support the device in a slanting position as it rests upon a table, desk, or other plane surface. Or, if the operator prefers to lay the device flat upon the table, the rubber feet 11, at the four corners of the bottom of base 1 will support the device and keep it from sliding about on the table.

As stated above, into the channel ways 3 there are inserted character strips 4 of paper or other suitable material, hereinafter called alphabet strips, upon which appear sequences of letters of the alphabet, each sequence being repeated on the strip, and the letters being equidistant from one another throughout. The purpose of the duplication of sequence will appear presently. The letters on the alphabet strips may be in normal order or in disarranged order; if the latter, the various alphabets may or may not be different. Assuming, however, different alphabets are being used, each strip bears an identifying mark such as a number 14, so that the alphabet strips may be inserted into the channel ways 3 according to some preagreed key. For example, in Fig. 1 is shown a set of twenty-five channel ways into which twenty-five different alphabet strips 4 have been inserted according to the following key, reading from the top downward:

14—16—9—6—22—25—23—5—12—24—13—21—
18—1—7—17—20—19—15—8—11—2—3—10—4

If another embodiment of the device should include more than twenty-five channel ways, additional alphabet strips may be inserted, according to a longer key.

Having inserted the alphabet strips into the channel ways in key order, the device is now ready for use either to encipher a plain language message or to decipher a cryptogram which has been enciphered by means of the device, alphabets, and key shown in Fig. 1. Suppose this plain-text message is to be enciphered:

ACCORDING TO AN OFFICIAL REPORT
FROM MILITARY AUTHORITIES . . .

Moving the reading guide 5 to the left, and bringing it against the left end bar 8, the operator proceeds to align, in a column immediately to the right of the reading guide, the first twenty-five letters of the message. This is most conveniently done by placing the eraser end of a pencil upon the successive desired letters as found on the successive alphabet strips 4 from the top downwards, and pulling or pushing the alphabet strips in their channel ways toward the reading guide so that each strip stops with the proper letter just to the right of the right-hand edge of

the reading guide 5. When the alphabet strips are being aligned on the left-hand side of the device, as in the above procedure, the operator confines his search for letters to the left-hand half of the duplicated sequence on each alphabet strip.

When all twenty-five alphabet strips have been aligned as indicated, there is disclosed a multiplicity of columns of letters to the right of the plain-text column of letters thus aligned. All these columns of letters, except one, are columns of cipher letters, each column representing a cipher equivalent of the plain-text column. The single exception is the column which is the twenty-fifth removed from the plain-text column set up by the operator, and is merely a repetition of that plain-text column. One of these cipher columns is selected at random and is recorded in five-letter groups. The reading guide 5 is useful in this operation, since by placing it alongside the column selected, reading of the cipher column is facilitated. Suppose that the reading guide 5 be moved so that its left-hand edge aligns a column of cipher text. As shown in Fig. 4, such a column would read as follows:

SNAFJ LXRJG GVWVA ATVWW PVNUT

These letters are recorded and constitute the cipher letters for the twenty-five plain-text letters.

The reading guide 5 is now moved to the extreme right of the device, up against the right end bar 9; the next twenty-five letters of the plain text are aligned against the left edge of the reading guide 5. Again a set of columns of cipher letters are disclosed to the left of the reading guide.. One of these columns is selected at random and again a set of twenty-five cipher letters representing the second set of twenty-five plain-text letters is recorded. If the message contains more than fifty letters, the foregoing procedure is repeated until the entire message has been enciphered. There is no need to indicate to the recipient of the message which column is selected for the cipher equivalent of each set of twenty-five plain-text letters, as will be noted presently.

To decipher the message, having the alphabets and the key according to which they have been arranged, the operator merely proceeds as in encipherment, aligning the alphabet strips in their channel ways so that the first twenty-five cipher letters of the cryptogram are in one column. He then examines all the other twenty-five columns of letters, looking for one which contains intelligible text throughout its extent from top to bottom. There will be one and only one such column, and this will be the plain-text equivalent of the column of cipher text set up on the device. The reading guide 5 is useful in this search for the plain-text column, as it can readly be moved to scan the successive columns from left to right, or from right to left. The plain-text column thus found is recorded in word lengths and the operator proceeds to set up the next twenty-five cipher letters on the right-hand side of the device. Again he looks for a plain-text column and records it when found. He continues this process until the message has been completely deciphered.

In the form of invention shown in Fig. 2, the device comprises a pair of hinged components F—F' of metal, Bakelite or other suitable material and foldable on one another in the manner of a book. As here shown, the grooved slideways 3 are formed on the inner faces of the said components by milling, or in the case where a condensation product such as Bakelite is used, may be molded in the material. In the embodiment disclosed, there are a total of thirty such slideways, fifteen in each component, though it will be understood that the invention is not limited to any particular number. It will be noted that the slideways are open at their opposite ends so that the alphabet strips may be readily inserted and freely extended outwardly therefrom as they are slid into different positions in the operations of enciphering and deciphering. As in other forms of the invention, a T-grip 6 is attached to the guide rule 5 at its end for the purpose of manipulating the rule, and is slidable in a channel 20 having therein undercut grooves 21 and 22 formed laterally along its inside edges. The grip 6 is provided with a spring-pressed element 23 engaging in bottom groove 21, and having an oppositely disposed bead 24 engaging in the opposite groove 22 whereby the grip 6 is maintained under suitable sliding tension in the channel 20, and whereby the guide rule 5 is manipulated transversely in relation to the alphabet strips 4; and the opposite end of the rule is adapted to slide freely in a lateral undercut groove 25 formed in component F'. The grip 6 is rigidly secured to the guide rule 5 in the manner of a T-square and may be so manipulated that the rule affords a positive means of obtaining an accurate alignment in column formation of the characters on said alphabet strips and in varying relations for cryptographic purposes. This foldable form of device presents a number of practical advantages, among which may be mentioned its compactness and portability; also the foldable feature permits exclusion of dust and dirt.

While in one form of device here disclosed, cylindrical rods are secured to a base at regular intervals from one another to form the channel ways into which the alphabet strips are inserted, it should be understood that any other means may be employed to form the channel ways. For example, a series of elongated metal strips known in the trade as "card holders," used ordinarily to hold narrow strips of paper bearing names of mail-box owners in apartment houses, etc., may be used to form the channel ways; these card holders may be riveted to the base, or spot welded to it, or attached in any other suitable manner. Or as disclosed in connection with Fig. 2, the channel ways may be formed by milling grooves in the base 1 itself, which may be made of molded Bakelite, for example. In such case the grooves are made by a rotating cutter which undercuts at the two edges, forming a channel way such as is commonly found in slide-rules. Figure 6 shows such a section in the form of a piece of Bakelite or similar material 13, in which five such channel ways 3 have been cut. Sections with equal or unequal numbers of channel ways may be easily provided and given identifying symbols such as letters, A, B, C, . . .

In Fig. 7 there is shown a sub-base suitable for use with such sections of channel ways. Thus, instead of having all the channel ways on a single base, as is the case in Fig. 1, the sub-base is merely made in the form of a flat surface onto which sections of channel ways may be positioned and temporarily fixed, so that rearrangements of sections can be made according to subsidiary keys. Referring to Fig. 7, the sub-base 1a is a plane

surface which is provided with an undercut slot 14, for carrying a sliding clamp 15, provided with a knurled thumb screw 16, for fastening the clamp into position. End bars 8 and 9 elevated above the base by supports 17 and back stop 18, serve the same purpose as similarly designated end bars of Fig. 1.

Using a sub-base such as that shown in Fig. 7, with several sections such as that shown in Fig. 6, one method of operation of this embodiment of the invention is shown in Fig. 5. In that figure there are five sections of 3, 4, 5, 7 and 8 channel ways, giving a total of twenty-seven channel ways. First, the sections are temporarily fastened to the base in the alphabetical order of their identifying symbols. Then the twenty-seven alphabet strips would be inserted in the twenty-seven consecutive channel ways according to the predetermined numerical key already referred to above in connection with Fig. 1. To encipher a given message, there would then be a subsidiary or specific key, also arranged for in advance by means of an indicator in the message, which would direct that the sections be now placed onto the base in a mixed order, say E—D—A—B—C, as shown in Fig. 5. The encipherment of a message would then proceed exactly as before. In another message, the indicator for the sectional arrangement might be different, say one calling for the sequence of sections D—A—C—E—B. Thus, with five sections there could be 120 different arrangements of sections on the base, even though only one set of alphabet strips is employed. The purpose of this is, of course, to increase the keying possibilities of the device, and to impart uniqueness to successive messages, without going to the trouble of making a complete rearrangement of all alphabet strips in the set of twenty-five channel ways.

The many uses of this device, with variable alphabets, in crytographic or cryptanalytic studies will be apparent to all skilled in the art and nothing further need be said on this score except that there has existed for many years a hitherto unfulfilled need for a simple device of this type, suitable for the insertion of sliding alphabets.

Changes, modifications and equivalent arrangements are contemplated within the scope of the invention as defined by the appended claims.

I claim:

1. A cryptographic device comprising a base provided with a plurality of horizontal channel ways; strips provided with discrete sequences of equally spaced alphabetic characters adapted for insertion therein and adjustable independently of one another and means for facilitating the reading of said characters in selected columns.

2. A cryptographic device comprising a base, said base being provided with a plurality of vertical channel ways, and individually adjustable strips bearing discrete sequences of equally spaced alphabetic characters adapted to be slidably inserted therein; and means for facilitating the reading of said characters in selected columns and in different relations for cryptographic purposes.

3. A cryptographic device comprising a base formed with horizontally grooved slide-ways therein; individually adjustable alphabetic strips slidable in said ways; and means to facilitate the reading of selected alphabetic columns in varying relations for cryptographic purposes.

4. A cryptographic device comprising a base formed with grooved slide-ways therein; strips bearing thereon alphabetic character sequences and individually movable in said ways; and means adjustable transversely of said strips to facilitate the reading of said characters in varying relations for enciphering and deciphering messages.

5. A cryptographic device comprising a base having vertically grooved slide-ways formed therein; strips bearing thereon alphabetic character sequences and individually slidable in said ways; and means adjustable transversely of said strips for facilitating the reading of said characters in varying relations for enciphering and deciphering messages.

6. A cryptographic device comprising a base provided with a plurality of channel ways; alphabet bearing strips adapted to be individually inserted and aligned in varying relations in said ways for cryptographic purposes; and a slidable guide rule for making excursions transversely along the channel ways and in relation to said strips for enciphering and deciphering messages.

7. A cryptographic device comprising a base having a supporting foot hingedly attached to the under surface of said base; a plurality of members fixed to the obverse surface of the base at equidistant intervals to form a plurality of channel ways; strips bearing alphabetic sequences of characters individually slidable in said ways; a guide rule adapted to be moved transversely of said strips to facilitate the reading of selected sequences of characters in varying relations for cryptographic purposes; and stop members for the guide rule disposed at opposite ends of said channel ways.

8. A cryptographic device comprising a sub-base; interchangeable base-sections having grooves formed therein to provide a plurality of channel ways; means for removably attaching said sections in position on said sub-base to permit different arrangements of said sections in juxtaposed relationship for cryptographic purposes; character bearing strips adapted for slidable insertion in said channel ways; and a slidable guide rule movable transversely across said channel ways and in varying relations to said strips for enciphering and deciphering messages.

9. A combination according to claim 8 in which said grooved sections are of the same size and contain equal numbers of channel ways.

10. A combination according to claim 8, in which said grooved sections are of different sizes and contain unequal numbers of channel ways.

11. A combination according to claim 8 in which stops are provided at the opposite ends of the channel ways to limit the movement of the slide rule at the end of its travel.

12. A cryptographic device comprising a frame structure and including a sub-base formed therein; a series of base-sections having grooves therein to provide a plurality of channel ways; means for removably attaching said sections on said sub-base to permit different juxtaposed arrangements thereof for cryptographic purposes; strips bearing alphabetic sequences of characters slidable in said ways; and a slidable guide rule movable transversely of said strips and alignable in varying relations with respect to said characters for enciphering and deciphering messages.

13. A cryptographic device comprising a frame structure and including a sub-base therein; base-sections grooved to provide a plurality of channel ways, said sections having different numbers of said channel ways and being differentiated from one another by distinguishing symbols; means for detachably securing said sections

on the sub-base to permit different juxtaposed arrangements thereof for cryptographic purposes; strips bearing alphabetic sequences of characters movable in said channel ways; a guide rule slidable transversely of said strips and alignable in varying relations with said characters for enciphering and deciphering messages; and stop members at opposite ends of the channel ways to limit the movement of the slide rule at the end of its travel.

14. A cryptographic device comprising a multiple base formed of separate sections, said sections being interchangeable with one another to permit different juxtaposed arrangements for cryptographic purposes; a plurality of channel ways in said sections; strips bearing sequences of characters and individually slidable in said ways; and a guide rule movable transversely of said strips and alignable with said characters in varying relations for enciphering and deciphering messages.

15. A cryptographic device including a multiform base composed of separate sections, said sections having grooved slide-ways therein and being interchangeable with one another to permit different juxtaposed arrangements for cryptographic purposes; strips slidable in said ways and bearing thereon sequences of alphabetic characters; and guide means disposed transversely of said strips and movable to facilitate alignment of the characters in varying relations for enciphering and deciphering messages.

16. A cryptographic device composed of hinged sections foldable upon one another, said sections having grooved slide-ways formed on their inner faces; strips slidable in said ways and bearing thereon sequences of alphabetic characters; and guide means disposed transversely of said strips and movable to facilitate alignment of the characters in varying relations for enciphering and deciphering messages.

17. A cryptographic device composed of hinged sections foldable upon one another, said sections being provided on their inner faces with open-ended slide ways; strips slidable in said ways and bearing thereon sequences of alphabetic characters; and a guide rule hinged to fold with said sections, said rule being disposed transversely of said strips and movable to facilitate reading of the characters in varying relations for enciphering and deciphering messages.

18. A cryptographic device comprising a pair of hinged components foldable upon one another, said components being provided on their inner faces with open-ended slide ways; a guide rule hinged to fold with said components; means operative with one of said components to maintain said rule in a position transversely of said strips and movable to facilitate reading of the characters in column formation and in varying relations for enciphering and deciphering messages; and terminal stops to limit the movements of said rule at either end of its travel.

19. A cryptographic device comprising hinged components foldable upon one another, said components being provided on their inner faces with a plurality of slide ways; a guide rule hinged to fold with said components; a grooved channel formed along the edge of one of said components in parallelism with the slide ways; means including a spring-tensioned element slidable in said channel for operating the said rule while maintaining the same in a position transversely of said strips, said rule being movable to facilitate reading of the characters in varying relations and in column formation for enciphering and deciphering messages.

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March 5, 1946. W. F. FRIEDMAN 2,395,863

CRYPTOGRAPHIC DEVICE

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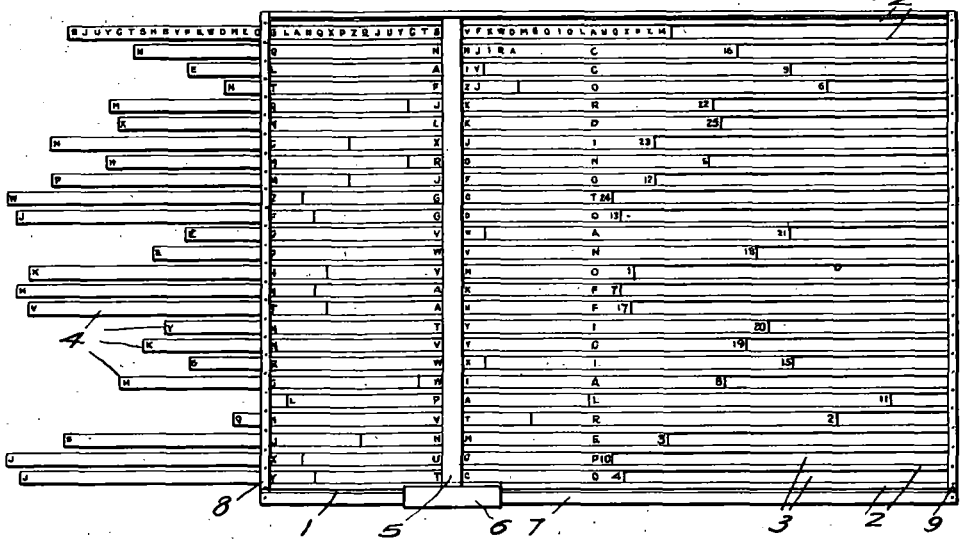
FIG. 4.



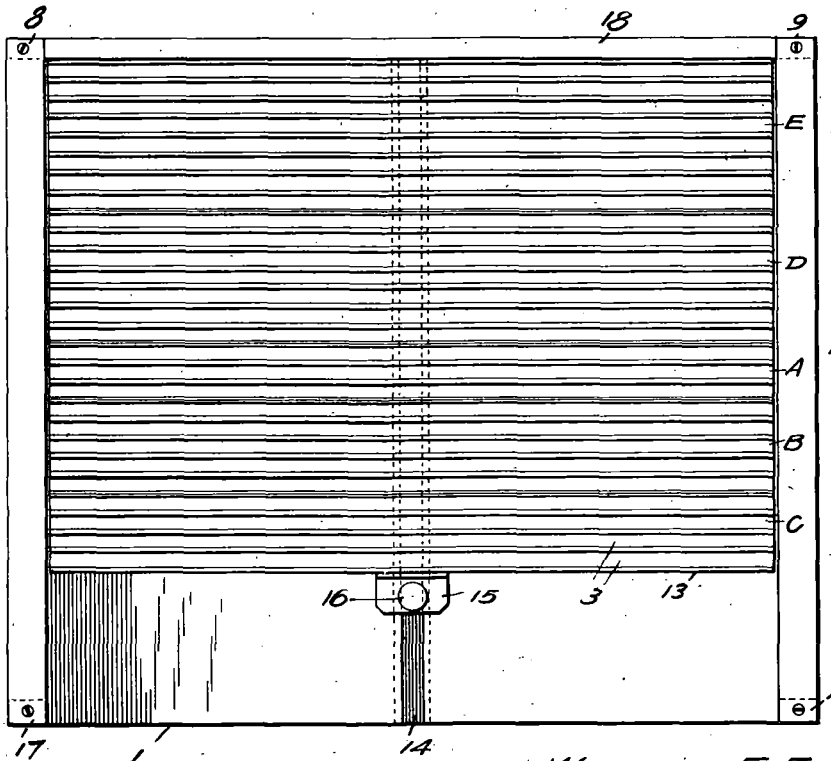


FIG. 5.

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CRYPTOGRAPHIC DEVICE

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FIG. 1.

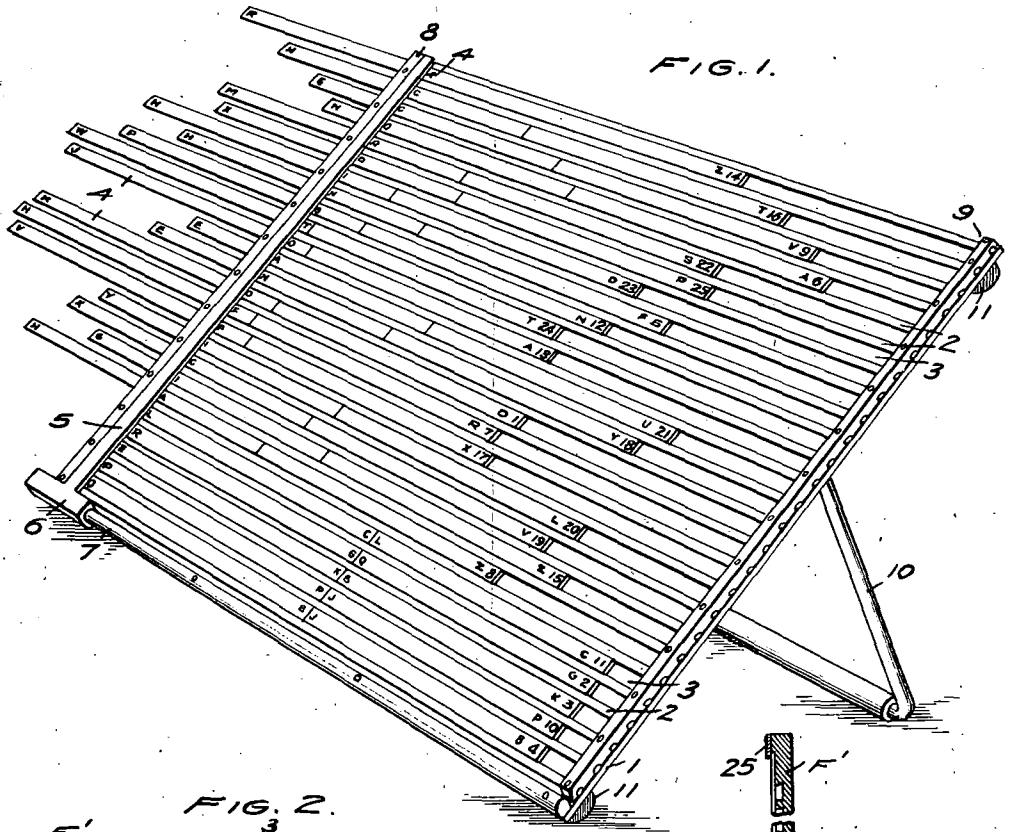
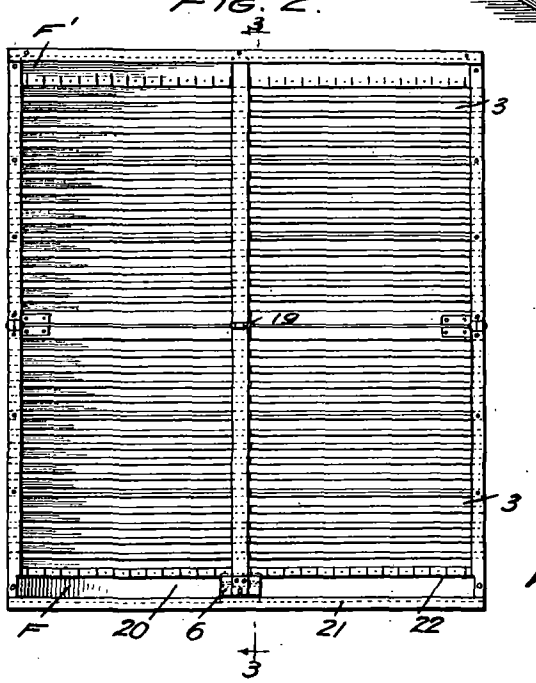


FIG. 2.



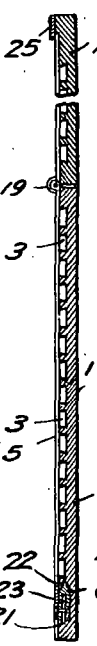
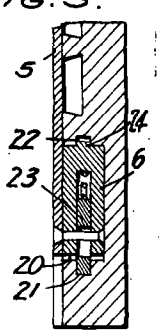


FIG. 3.

FIG. 3a



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CRYPTOGRAPHIC DEVICE

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FIG. 6.

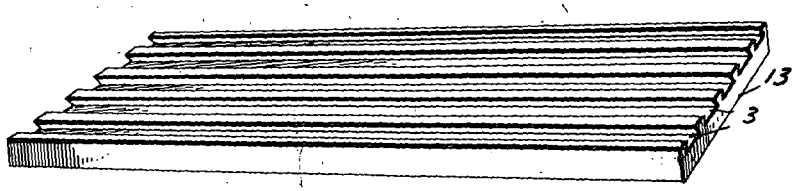
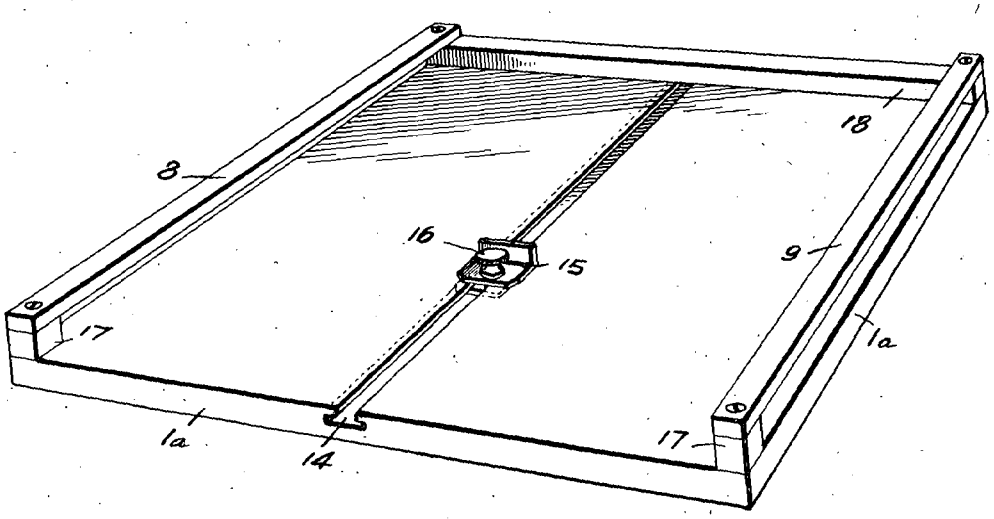


FIG. 7.



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Patented Mar. 5, 1946

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UNITED STATES PATENT OFFICE

2,395,863

CRYPTOGRAPHIC DEVICE

William F. Friedman, Washington, D. C.

Application October 19, 1939, Serial No. 300,212

19 Claims. (Cl. 35—2)

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

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

This invention relates to cryptographic devices and has for its object the provision of a hand-operated device capable of affording a relatively high degree of security without involving the use of complicated mechanisms.

Another object is to provide a device useful in cryptographic and cryptanalytic investigations requiring the use of sliding alphabets.

The invention is described with reference to the accompanying drawings, in which:

Fig. 1 is a perspective showing one form or embodiment of the invention;

Fig. 2 is a top plan view of another embodiment of the invention;

Fig. 3 is a cross-section taken on the line 3—3 of Fig. 2;

Fig. 3a is a fragment of the same section on an enlarged scale showing the T-grip for the guide rule in operative position;

Fig. 4 is a top view of the form of invention of Fig. 1 showing the guide rule in shifted position;

Fig. 5 is a top plan view showing another embodiment of the invention in which the base is composed of separate detachable grooved sections;

Fig. 6 is a perspective showing one of the grooved sections; and

Fig. 7 is a perspective showing a frame structure and sub-base on which said grooved sections may be assembled.

Referring to Fig. 1, in this embodiment the device comprises a base 1, on which are horizontally fastened a series of cylindrical rods 2, forming a set of channel ways 3, into which character bearing strips 4, may be inserted and slid from left to right or vice versa. In the specific embodiment disclosed herein the device comprises twenty-five such channel ways, but the device is by no means limited to this number. The number chosen in this embodiment is merely a convenient number, and it may be increased or decreased within certain limits in other embodiments without materially departing from the spirit of the invention. A rule, or reading guide 5, attached to a reading guide slide 6, can be slid to the left or right on a reading guide slide rail 7. End bars 8 and 9, serve as stops against which the reading guide 5 may be brought at the end of its travel to the left or right. To the back of the base 1 is fastened a hinged support 10, which can be pulled out to support the device in a slanting position as it rests upon a table, desk, or other plane surface. Or, if the operator prefers to lay the device flat upon the table, the rubber feet 11, at the four corners of the bottom of base 1 will support the device and keep it from sliding about on the table.

As stated above, into the channel ways 3 there are inserted character strips 4 of paper or other suitable material, hereinafter called alphabet strips, upon which appear sequences of letters of the alphabet, each sequence being repeated on the strip, and the letters being equidistant from one another throughout. The purpose of the duplication of sequence will appear presently. The letters on the alphabet strips may be in normal order or in disarranged order; if the latter, the various alphabets may or may not be different. Assuming, however, different alphabets are being used, each strip bears an identifying mark such as a number 14, so that the alphabet strips may be inserted into the channel ways 3 according to some preagreed key. For example, in Fig. 1 is shown a set of twenty-five channel ways into which twenty-five different alphabet strips 4 have been inserted according to the following key, reading from the top downward:

14—16—9—6—22—25—23—5—12—24—13—21—
18—1—7—17—20—19—15—8—11—2—3—10—4

If another embodiment of the device should include more than twenty-five channel ways, additional alphabet strips may be inserted, according to a longer key.

Having inserted the alphabet strips into the channel ways in key order, the device is now ready for use either to encipher a plain language message or to decipher a cryptogram which has been enciphered by means of the device, alphabets, and key shown in Fig. 1. Suppose this plain-text message is to be enciphered:

ACCORDING TO AN OFFICIAL REPORT
FROM MILITARY AUTHORITIES . . .

Moving the reading guide 5 to the left, and bringing it against the left end bar 8, the operator proceeds to align, in a column immediately to the right of the reading guide, the first twenty-five letters of the message. This is most conveniently done by placing the eraser end of a pencil upon the successive desired letters as found on the successive alphabet strips 4 from the top downwards, and pulling or pushing the alphabet strips in their channel ways toward the reading guide so that each strip stops with the proper letter just to the right of the right-hand edge of

the reading guide 5. When the alphabet strips are being aligned on the left-hand side of the device, as in the above procedure, the operator confines his search for letters to the left-hand half of the duplicated sequence on each alphabet strip.

When all twenty-five alphabet strips have been aligned as indicated, there is disclosed a multiplicity of columns of letters to the right of the plain-text column of letters thus aligned. All these columns of letters, except one, are columns of cipher letters, each column representing a cipher equivalent of the plain-text column. The single exception is the column which is the twenty-fifth removed from the plain-text column set up by the operator, and is merely a repetition of that plain-text column. One of these cipher columns is selected at random and is recorded in five-letter groups. The reading guide 5 is useful in this operation, since by placing it alongside the column selected, reading of the cipher column is facilitated. Suppose that the reading guide 5 be moved so that its left-hand edge aligns a column of cipher text. As shown in Fig. 4, such a column would read as follows:

SNAFJ, LXRJG GVWVA ATVWW PVNUT

These letters are recorded and constitute the cipher letters for the twenty-five plain-text letters.

The reading guide 5 is now moved to the extreme right of the device, up against the right end bar 9; the next twenty-five letters of the plain text are aligned against the left edge of the reading guide 5. Again a set of columns of cipher letters are disclosed to the left of the reading guide. One of these columns is selected at random and again a set of twenty-five cipher letters representing the second set of twenty-five plain-text letters is recorded. If the message contains more than fifty letters, the foregoing procedure is repeated until the entire message has been enciphered. There is no need to indicate to the recipient of the message which column is selected for the cipher equivalent of each set of twenty-five plain-text letters, as will be noted presently.

To decipher the message, having the alphabets and the key according to which they have been arranged, the operator merely proceeds as in encipherment, aligning the alphabet strips in their channel ways so that the first twenty-five cipher letters of the cryptogram are in one column. He then examines all the other twenty-five columns of letters, looking for one which contains intelligible text throughout its extent from top to bottom. There will be one and only one such column, and this will be the plain-text equivalent of the column of cipher text set up on the device. The reading guide 5 is useful in this search for the plain-text column, as it can readily be moved to scan the successive columns from left to right, or from right to left. The plain-text column thus found is recorded in word lengths and the operator proceeds to set up the next twenty-five cipher letters on the right-hand side of the device. Again he looks for a plain-text column and records it when found. He continues this process until the message has been completely deciphered.

In the form of invention shown in Fig. 2, the device comprises a pair of hinged components F—F' of metal, Bakelite or other suitable material and foldable on one another in the manner of a book. As here shown, the grooved slideways 3 are formed on the inner faces of the said components by milling, or in the case where a condensation product such as Bakelite is used, may be molded in the material. In the embodiment disclosed, there are a total of thirty such slideways, fifteen in each component, though it will be understood that the invention is not limited to any particular number. It will be noted that the slideways are open at their opposite ends so that the alphabet strips may be readily inserted and freely extended outwardly therefrom as they are slid into different positions in the operations of enciphering and deciphering. As in other forms of the invention, a T-grip 6 is attached to the guide rule 5 at its end for the purpose of manipulating the rule, and is slidable in a channel 20 having therein undercut grooves 21 and 22 formed laterally along its inside edges. The grip 6 is provided with a spring-pressed element 23 engaging in bottom groove 21, and having an oppositely disposed bead 24 engaging in the opposite groove 22 whereby the grip 6 is maintained under suitable sliding tension in the channel 20, and whereby the guide rule 5 is manipulated transversely in relation to the alphabet strips 4; and the opposite end of the rule is adapted to slide freely in a lateral undercut groove 25 formed in component F'. The grip 6 is rigidly secured to the guide rule 5 in the manner of a T-square and may be so manipulated that the rule affords a positive means of obtaining an accurate alignment in column formation of the characters on said alphabet strips and in varying relations for cryptographic purposes. This foldable form of device presents a number of practical advantages, among which may be mentioned its compactness and portability; also the foldable feature permits exclusion of dust and dirt.

While in one form of device here disclosed, cylindrical rods are secured to a base at regular intervals from one another to form the channel ways into which the alphabet strips are inserted, it should be understood that any other means may be employed to form the channel ways. For example, a series of elongated metal strips known in the trade as "card holders," used ordinarily to hold narrow strips of paper bearing names of mail-box owners in apartment houses, etc., may be used to form the channel ways; these card holders may be riveted to the base, or spot welded to it, or attached in any other suitable manner. Or as disclosed in connection with Fig. 2, the channel ways may be formed by milling grooves in the base 1 itself, which may be made of molded Bakelite, for example. In such case the grooves are made by a rotating cutter which undercuts at the two edges, forming a channel way such as is commonly found in slide-rules. Figure 6 shows such a section in the form of a piece of Bakelite or similar material 13, in which five such channel ways 3 have been cut. Sections with equal or unequal numbers of channel ways may be easily provided and given identifying symbols such as letters, A, B, C, . . .

In Fig. 7 there is shown a sub-base suitable for use with such sections of channel ways. Thus, instead of having all the channel ways on a single base, as is the case in Fig. 1, the sub-base is merely made in the form of a flat surface onto which sections of channel ways may be positioned and temporarily fixed, so that rearrangements of sections can be made according to subsidiary keys. Referring to Fig. 7, the sub-base 1a is a plane

surface which is provided with an undercut slot 14, for carrying a sliding clamp 15, provided with a knurled thumb screw 16, for fastening the clamp into position. End bars 8 and 9 elevated above the base by supports 17 and back stop 18, serve the same purpose as similarly designated end bars of Fig. 1.

Using a sub-base such as that shown in Fig. 7, with several sections such as that shown in Fig. 6, one method of operation of this embodiment of the invention is shown in Fig. 5. In that figure there are five sections of 3, 4, 5, 7 and 8 channel ways, giving a total of twenty-seven channel ways. First, the sections are temporarily fastened to the base in the alphabetical order of their identifying symbols. Then the twenty-seven alphabet strips would be inserted in the twenty-seven consecutive channel ways according to the predetermined numerical key already referred to above in connection with Fig. 1. To encipher a given message, there would then be a subsidiary or specific key, also arranged for in advance by means of an indicator in the message, which would direct that the sections be now placed onto the base in a mixed order, say E—D—A—B—C, as shown in Fig. 5. The encipherment of a message would then proceed exactly as before. In another message, the indicator for the sectional arrangement might be different, say one calling for the sequence of sections D—A—C—E—B. Thus, with five sections there could be 120 different arrangements of sections on the base, even though only one set of alphabet strips is employed. The purpose of this is, of course, to increase the keying possibilities of the device, and to impart uniqueness to successive messages, without going to the trouble of making a complete rearrangement of all alphabet strips in the set of twenty-five channel ways.

The many uses of this device, with variable alphabets, in crytographic or cryptanalytic studies will be apparent to all skilled in the art and nothing further need be said on this score except that there has existed for many years a hitherto unfulfilled need for a simple device of this type, suitable for the insertion of sliding alphabets.

Changes, modifications and equivalent arrangements are contemplated within the scope of the invention as defined by the appended claims.

I claim:

1. A cryptographic device comprising a base provided with a plurality of horizontal channel ways; strips provided with discrete sequences of equally spaced alphabetic characters adapted for insertion therein and adjustable independently of one another and means for facilitating the reading of said characters in selected columns.

2. A cryptographic device comprising a base, said base being provided with a plurality of vertical channel ways, and individually adjustable strips bearing discrete sequences of equally spaced alphabetic characters adapted to be slidably inserted therein; and means for facilitating the reading of said characters in selected columns and in different relations for cryptographic purposes.

3. A cryptographic device comprising a base formed with horizontally grooved slide-ways therein; individually adjustable alphabetic strips slidable in said ways; and means to facilitate the reading of selected alphabetic columns in varying relations for cryptographic purposes.

4. A cryptographic device comprising a base formed with grooved slide-ways therein; strips bearing thereon alphabetic character sequences and individually movable in said ways; and means adjustable transversely of said strips to facilitate the reading of said characters in varying relations for enciphering and deciphering messages.

5. A cryptographic device comprising a base having vertically grooved slide-ways formed therein; strips bearing thereon alphabetic character sequences and individually slidable in said ways; and means adjustable transversely of said strips for facilitating the reading of said characters in varying relations for enciphering and deciphering messages.

6. A cryptographic device comprising a base provided with a plurality of channel ways; alphabet bearing strips adapted to be individually inserted and aligned in varying relations in said ways for cryptographic purposes; and a slidable guide rule for making excursions transversely along the channel ways and in relation to said strips for enciphering and deciphering messages.

7. A cryptographic device comprising a base having a supporting foot hingedly attached to the under surface of said base; a plurality of members fixed to the obverse surface of the base at equidistant intervals to form a plurality of channel ways; strips bearing alphabetic sequences of characters individually slidable in said ways; a guide rule adapted to be moved transversely of said strips to facilitate the reading of selected sequences of characters in varying relations for cryptographic purposes; and stop members for the guide rule disposed at opposite ends of said channel ways.

8. A cryptographic device comprising a sub-base; interchangeable base-sections having grooves formed therein to provide a plurality of channel ways; means for removably attaching said sections in position on said sub-base to permit different arrangements of said sections in juxtaposed relationship for cryptographic purposes; character bearing strips adapted for slidable insertion in said channel ways; and a slidable guide rule movable transversely across said channel ways and in varying relations to said strips for enciphering and deciphering messages.

9. A combination according to claim 8 in which said grooved sections are of the same size and contain equal numbers of channel ways.

10. A combination according to claim 8, in which said grooved sections are of different sizes and contain unequal numbers of channel ways.

11. A combination according to claim 8 in which stops are provided at the opposite ends of the channel ways to limit the movement of the slide rule at the end of its travel.

12. A cryptographic device comprising a frame structure and including a sub-base formed therein; a series of base-sections having grooves therein to provide a plurality of channel ways; means for removably attaching said sections on said sub-base to permit different juxtaposed arrangements thereof for cryptographic purposes; strips bearing alphabetic sequences of characters slidable in said ways; and a slidable guide rule movable transversely of said strips and alignable in varying relations with respect to said characters for enciphering and deciphering messages.

13. A cryptographic device comprising a frame structure and including a sub-base therein; base-sections grooved to provide a plurality of channel ways, said sections having different numbers of said channel ways and being differentiated from one another by distinguishing symbols; means for detachably securing said sections

on the sub-base to permit different juxtaposed arrangements thereof for cryptographic purposes; strips bearing alphabetic sequences of characters movable in said channel ways; a guide rule slidable transversely of said strips and alignable in varying relations with said characters for enciphering and deciphering messages; and stop members at opposite ends of the channel ways to limit the movement of the slide rule at the end of its travel.

14. A cryptographic device comprising a multiple base formed of separate sections, said sections being interchangeable with one another to permit different juxtaposed arrangements for cryptographic purposes; a plurality of channel ways in said sections; strips bearing sequences of characters and individually slidable in said ways; and a guide rule movable transversely of said strips and alignable with said characters in varying relations for enciphering and deciphering messages.

15. A cryptographic device including a multiform base composed of separate sections, said sections having grooved slide-ways therein and being interchangeable with one another to permit different juxtaposed arrangements for cryptographic purposes; strips slidable in said ways and bearing thereon sequences of alphabetic characters; and guide means disposed transversely of said strips and movable to facilitate alignment of the characters in varying relations for enciphering and deciphering messages.

16. A cryptographic device composed of hinged sections foldable upon one another, said sections having grooved slide-ways formed on their inner faces; strips slidable in said ways and bearing thereon sequences of alphabetic characters; and guide means disposed transversely of said strips and movable to facilitate alignment of the characters in varying relations for enciphering and deciphering messages.

17. A cryptographic device composed of hinged sections foldable upon one another, said sections being provided on their inner faces with open-ended slide ways; strips slidable in said ways and bearing thereon sequences of alphabetic characters; and a guide rule hinged to fold with said sections, said rule being disposed transversely of said strips and movable to facilitate reading of the characters in varying relations for enciphering and deciphering messages.

18. A cryptographic device comprising a pair of hinged components foldable upon one another, said components being provided on their inner faces with open-ended slide ways; a guide rule hinged to fold with said components; means operative with one of said components to maintain said rule in a position transversely of said strips and movable to facilitate reading of the characters in column formation and in varying relations for enciphering and deciphering messages; and terminal stops to limit the movements of said rule at either end of its travel.

19. A cryptographic device comprising hinged components foldable upon one another, said components being provided on their inner faces with a plurality of slide ways; a guide rule hinged to fold with said components; a grooved channel formed along the edge of one of said components in parallelism with the slide ways; means including a spring-tensioned element slidable in said channel for operating the said rule while maintaining the same in a position transversely of said strips, said rule being movable to facilitate reading of the characters in varying relations and in column formation for enciphering and deciphering messages.

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CRYPTOGRAPHIC DEVICE

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FIG. 1.

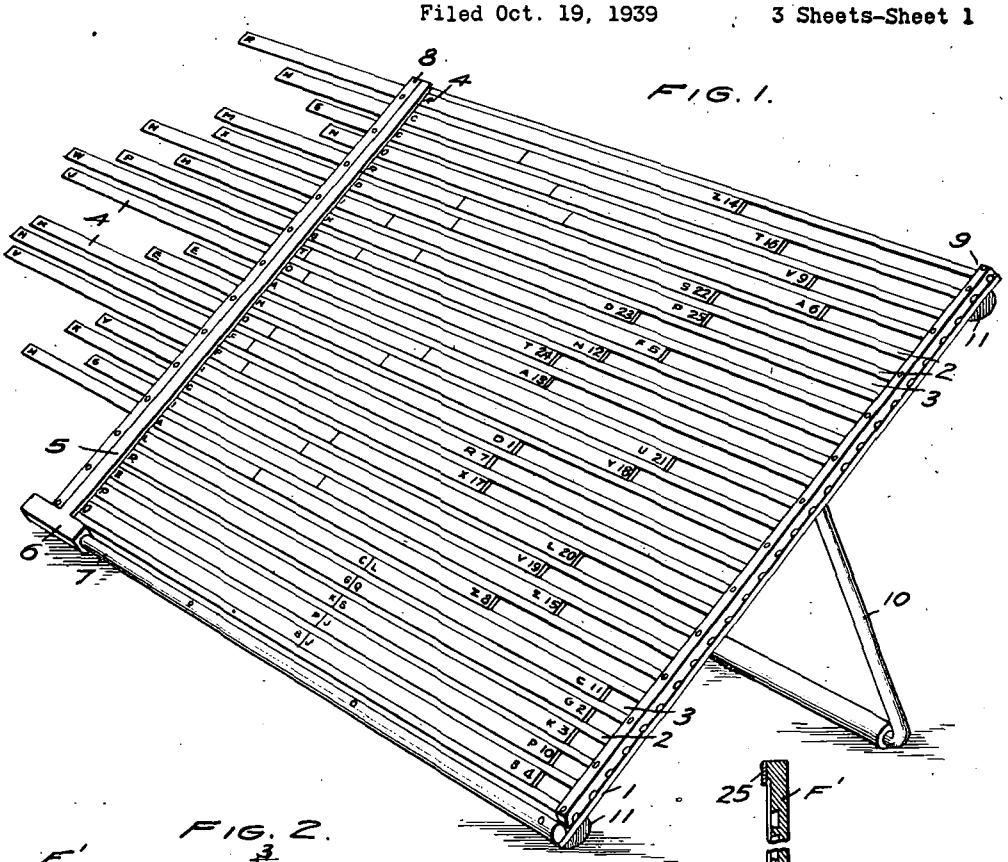


FIG. 2.

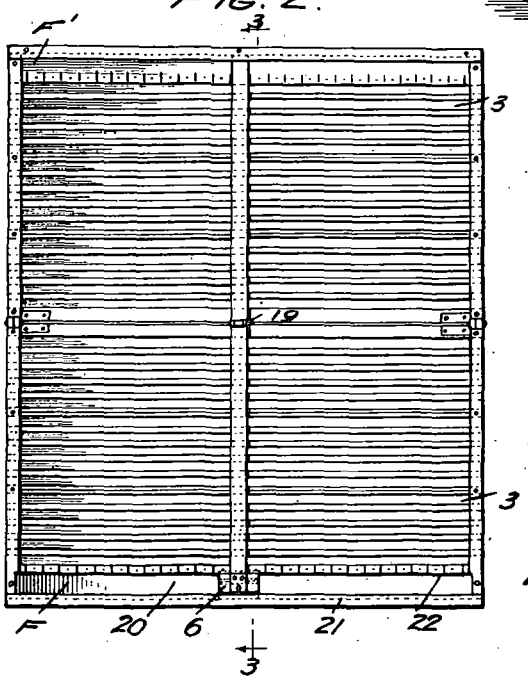


FIG. 3.

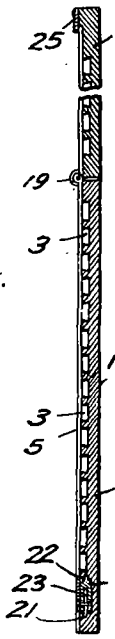
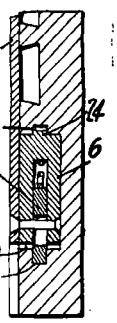


FIG. 3a.



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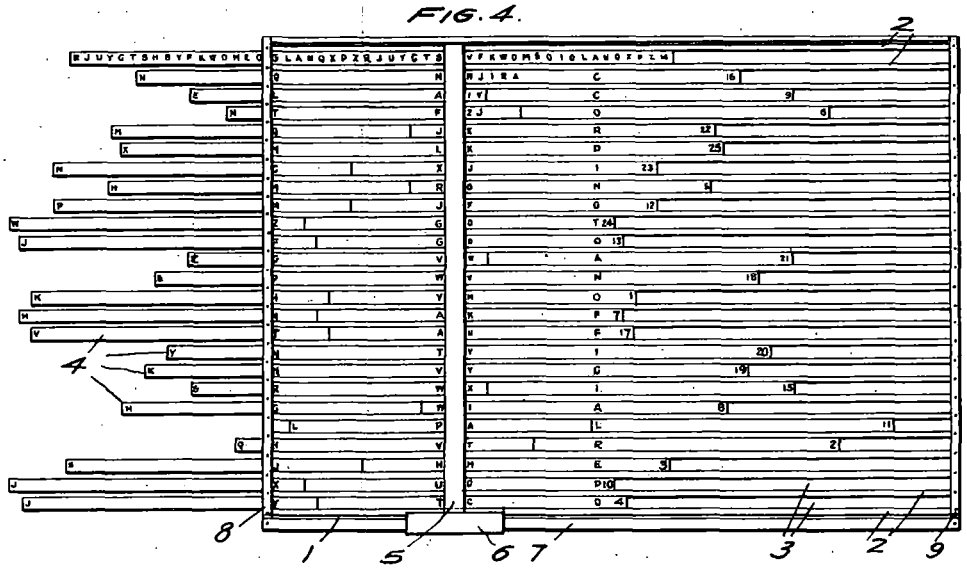
CRYPTOGRAPHIC DEVICE

Filed Oct. 19, 1939 3 Sheets-Sheet 2

FIG. 4.



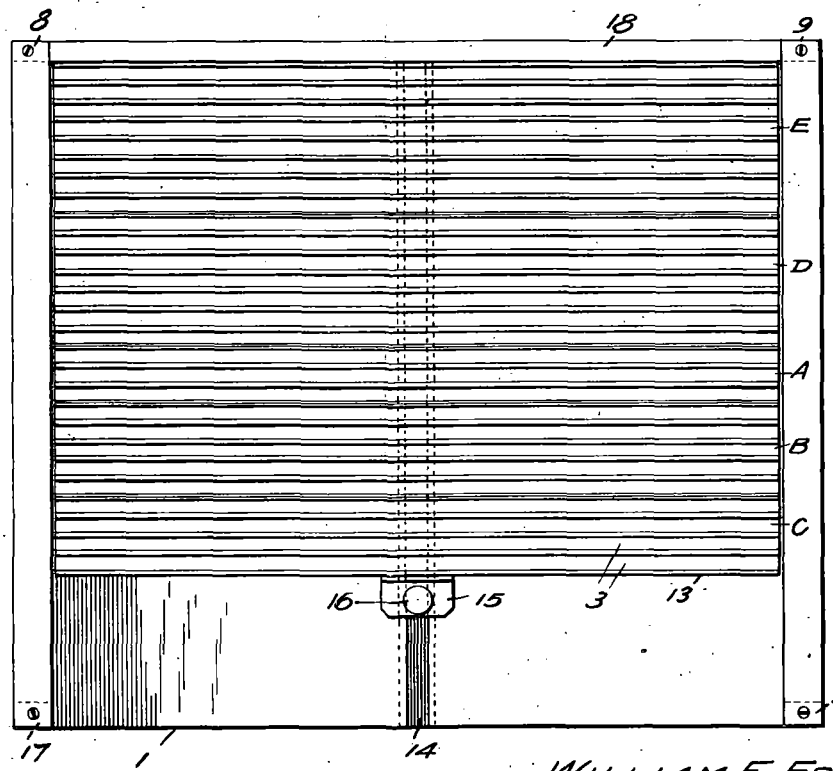


FIG. 5.

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CRYPTOGRAPHIC DEVICE

Filed Oct. 19, 1939 3 Sheets-Sheet 3

FIG. 6.

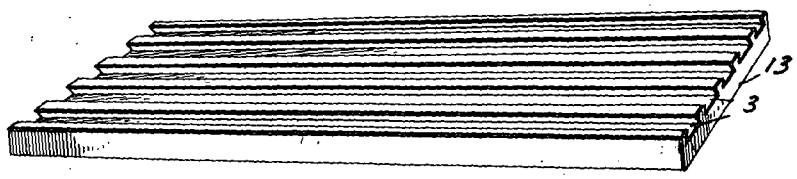
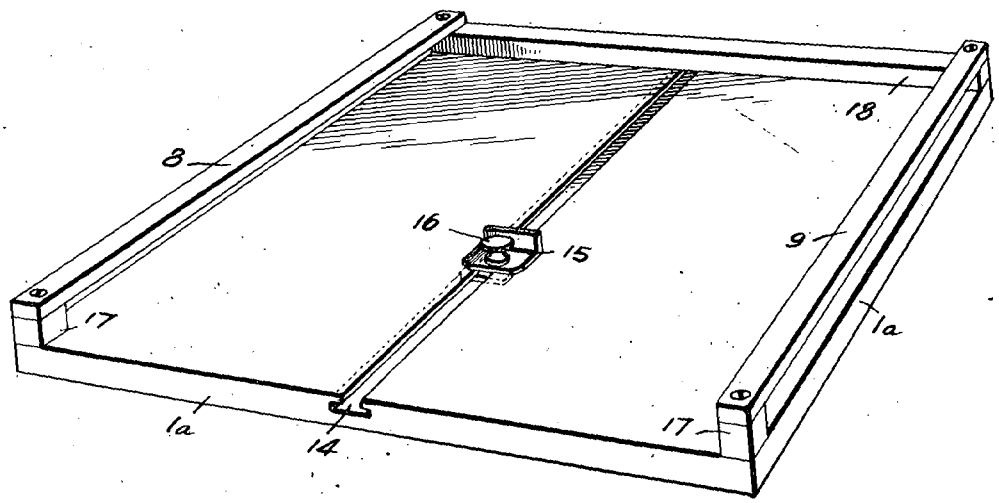


FIG. 7.



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PRINTING TELEGRAPH SYSTEM

Original Filed Jan. 23, 1950 3 Sheets-Sheet 1

FIG. 1

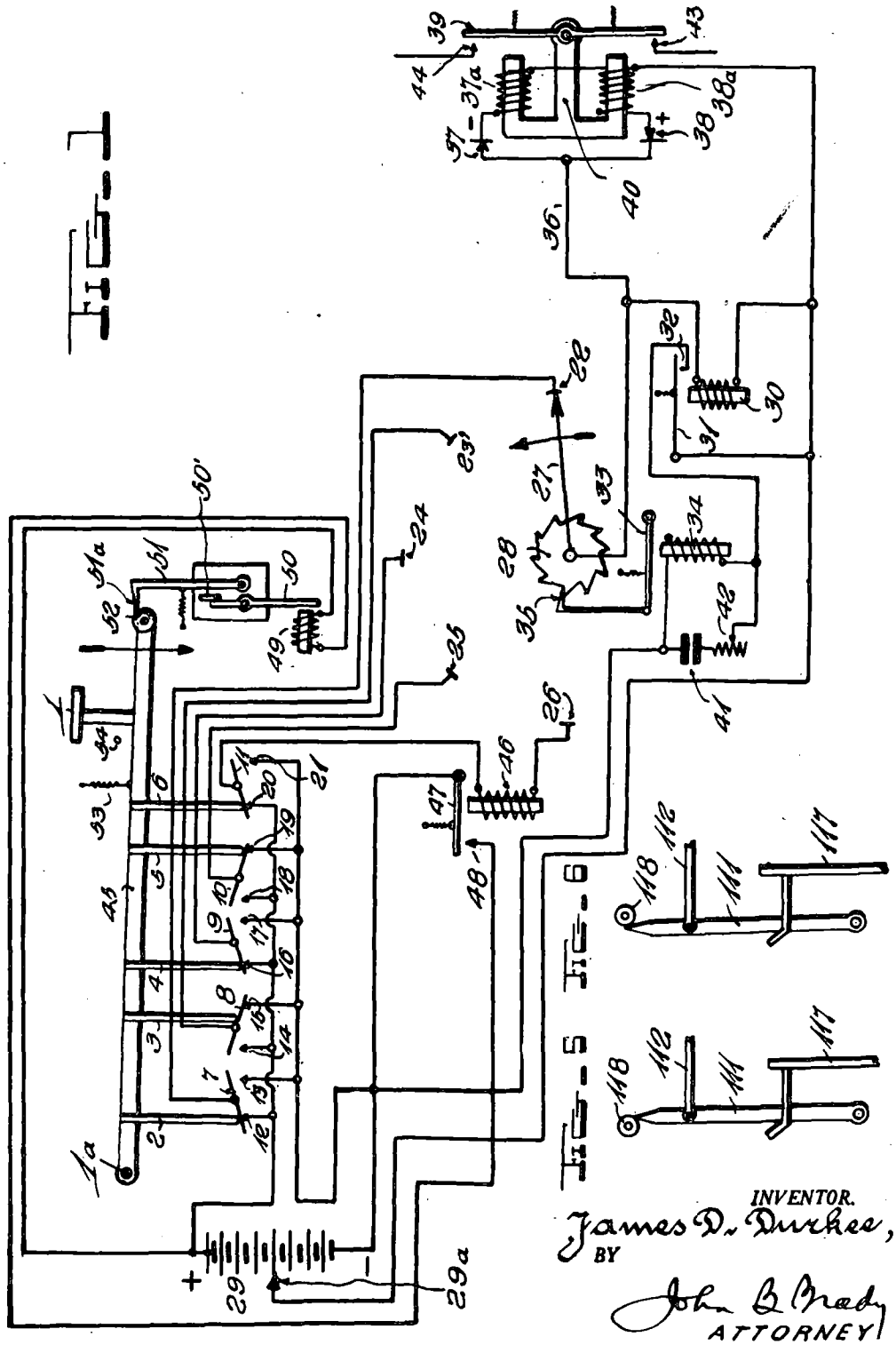

FIG. 6

FIG. 5

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PRINTING TELEGRAPH SYSTEM

Original Filed Jan. 23, 1950 3 Sheets-Sheet 2

FIG. 3

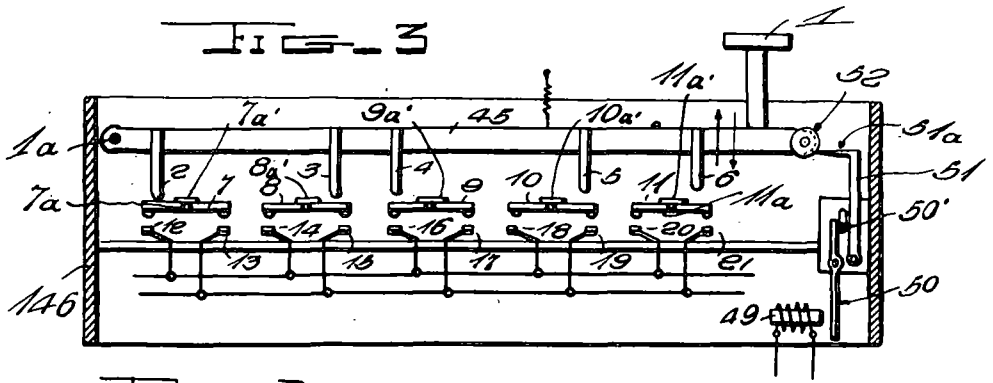
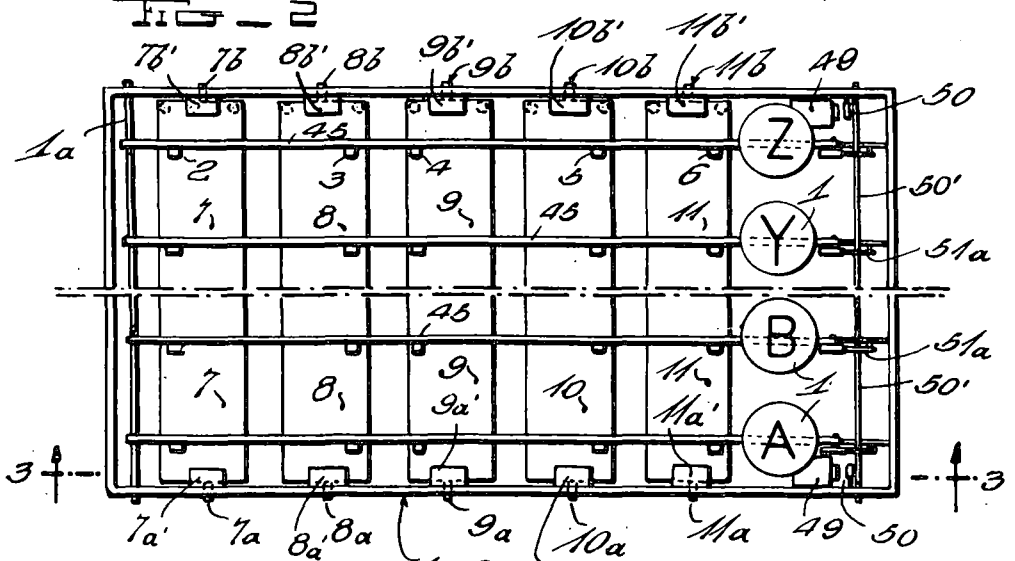


FIG. 2



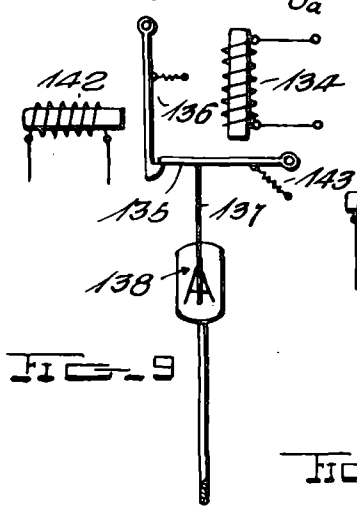


FIG. 9

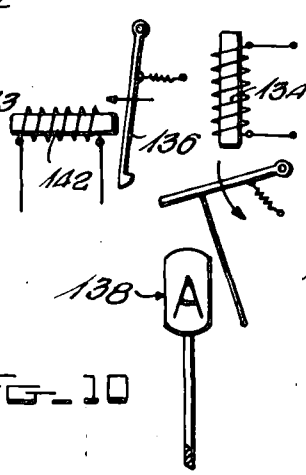


FIG. 10

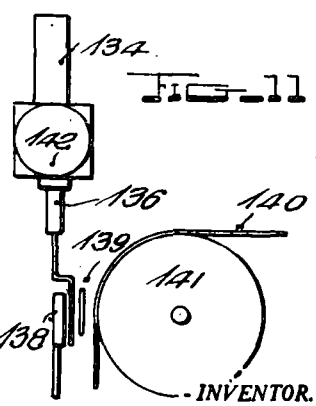


FIG. 11

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Original Filed Jan. 23, 1950 3 Sheets-Sheet 3

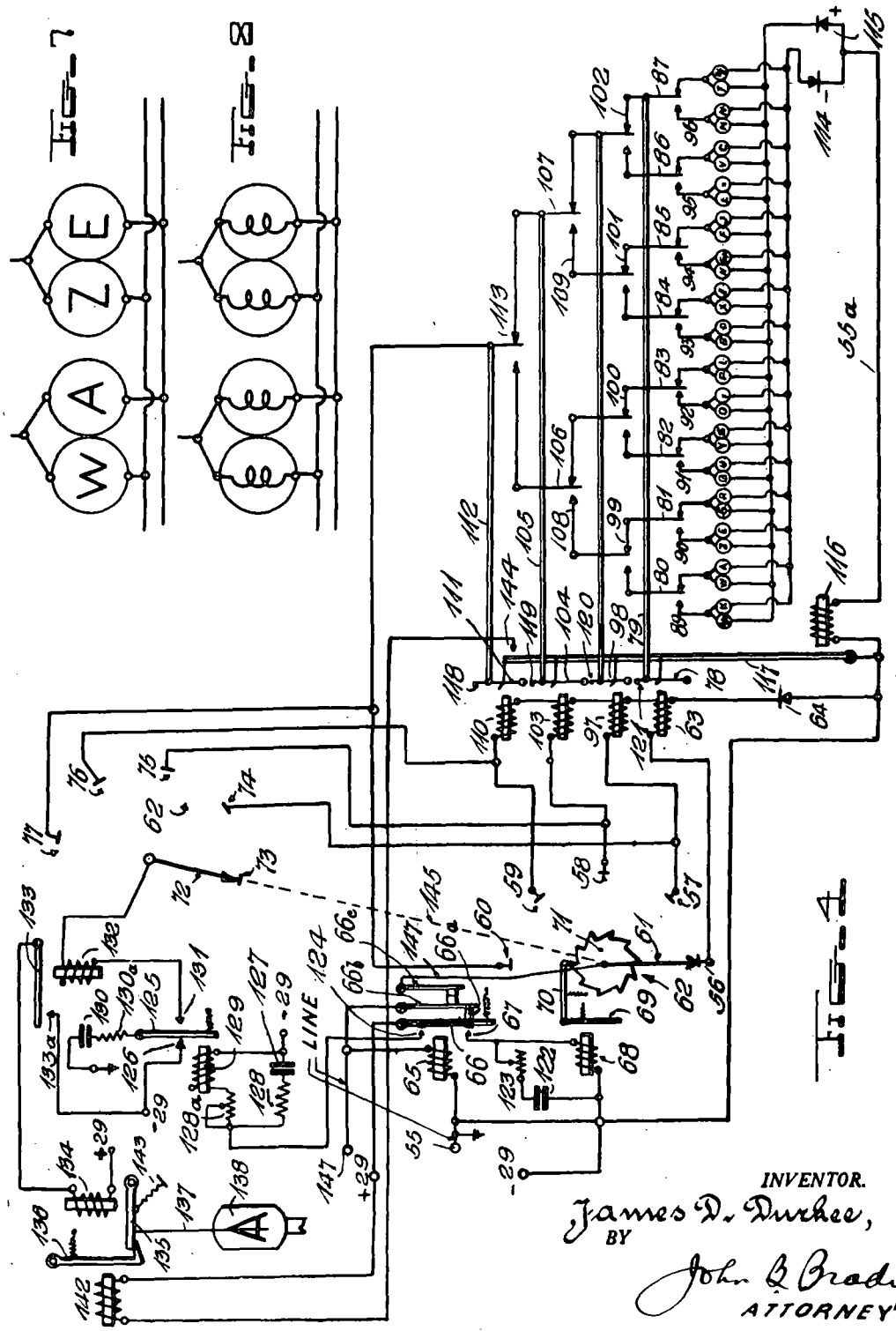

FIG. 4

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Patented Nov. 10, 1953 2,658,941

UNITED STATES PATENT OFFICE

2,658,941

PRINTING TELEGRAPH SYSTEM

James D. Durkee, Fairlington, Va., assignor, by direct and mesne assignments, to Dualex Corporation, a corporation of Delaware

Original application January 23, 1950, Serial No. 139,977, now Patent No. 2,613,267, dated October 7, 1952. Divided and this application May 28, 1951, Serial No. 228,658

9 Claims. (Cl. 178—17)

1

My invention relates broadly to printing telegraph systems and more particularly to a high speed polarized system of printing telegraphy utilizing printing telegraph apparatus of compact size and light weight.

This application is a division of my application Serial Number 139,977, filed January 23, 1950, now U. S. Patent No. 2,613,267, dated October 7, 1952, for Printing Telegraph System.

One of the objects of my invention is to provide a printing telegraph system constituting an improvement upon conventional sequentially operated systems, overcoming inherent difficulties in these systems and to supplement the purpose for which the system described in my co-pending application Ser. No. 109,648, filed August 11, 1949, for Printing Telegraph System was developed.

My co-pending application is directed to a printing telegraph system, which when applied to space radio systems, overcomes conditions of fading, interference, and static, and is particularly adaptable to mobile radio printer operations where compactness and portability and a minimum of mechanical equipment with incidental maintenance are major requirements.

The system of my invention employs a polarized electrical matrix which requires the transmission of only five polarized pulses, without the necessity of transmitting start-stop or synchronizing pulses, to accomplish the thirty-two different permutations and combinations of signal impulses presently used in printing telegraph systems.

Since in my application a smaller number of permutations and combinations of signal pulses are required to produce the same number of permutations and combinations as used in currently existing systems, a greater number of permutations and combinations can be sent in less time with fewer impulses thereby requiring a smaller number of transmission bands and less frequency band-width.

In addition, since the system of my invention requires only a reversal of current direction or polarity, the transition from one polarity or phase to the opposite polarity or phase may be accomplished by sinusoidal wave form; thus, the impact excitation resulting from a rapid make or break keying operation or from a rapid frequency shift is eliminated, thereby further decreasing the keying band-width required at any speed of transmission.

A further object of my invention is to provide a self-synchronizing receiving system which may be made operable over a fairly wide range of transmission speeds and which requires a minimum of equipment or adjustment.

The apparatus described in this application is intended for use with the printing mechanism of my co-pending application Ser. No. 109,648 supra but may be used with an electric typewriter or with slight modification of the present printing telegraph systems may be used interchangeably with conventional equipment.

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My invention will be more fully understood from the specifications hereinafter following by reference to the accompanying drawings in which Figure 1 diagrammatically shows the transmission system of my invention; Fig. 2 is a schematic plan view of a fragmentary portion of the transmission keyboard; Fig. 3 is a schematic end elevational view of the transmission keyboard, the view being taken on sectional line 3—3 of Fig. 2 and showing the frame structure in vertical section; Fig. 4 shows the receiving circuit of the printing telegraph system of my invention; Figs. 5 and 6 are detail views illustrating the operation of the control mechanism in the receiving apparatus; Figs. 7 and 8 are detailed views of the operating solenoids controlled by the printing telegraph receiving system; Figs. 9 and 10 are enlarged schematic views showing the operation of the error indicating means employed in the receiving system of my invention, the views being shown in front elevation and wherein Fig. 9 shows the error indicating means in printing position whereas Fig. 10 shows the error indicating means released and free of printing position; and Fig. 11 is an end view of the error indicating means shown in Fig. 9.

Almost from the beginning of the art of printing telegraph systems efforts have been made to accomplish the selection of characters by electrical resolution of the units of the Baudot code. Each solution required the use of a large number of electrical contacts and electro-magnetic relays in simultaneous operation with the resulting presence of a multiplicity of potential error producing elements. Practical experience indicated that greater reliability could be placed on mechanical resolution and the present state of the art reflects this experience. Mechanical operations, however, have the inherent characteristic of requiring a longer time to perform the same functions than does electrical energy.

However, operational communication requirements for increased speeds of operation have now exceeded the capabilities of the mechanical equipment except under strained and abnormal conditions which require excessive maintenance and mechanical tolerances and precision of apparatus which are difficult to achieve.

The application of printing telegraph systems to radio communication also introduced additional difficulties which do not readily lend themselves to solution by mechanical methods due to the speed limitations of mechanical operations.

Two of the major difficulties introduced by radio communication are various forms of fading and interference in addition to the basic lim-

itation in the number of cycles available in the total radio frequency spectrum.

Heretofore, various approaches to the radio applications of printer systems have been by increasing power of transmission and improving receiving conditions in an effort to duplicate the operating reliability of a land line to overcome fading and increasing the dot cycles of operation by additional fail safe impulses or increasing the units of the basic five unit code to provide error detection resulting from interference and certain forms of fading.

The approach of my invention to the solution of the requirement for increased speeds has been to eliminate the basic mechanical limitation of the mechanism used to resolve the units of the five unit code into characters by use of a polarized electrical matrix; to decrease the electrical contacts required to a minimum by use of rectifying apparatus and the application of new and novel electrical circuits and to decrease the operational functions to a minimum by simplification of equipment and electrical circuits.

The fading and interference problems introduced by radio communication have been accepted as natural characteristics of the medium. Circuits and operations are provided by my invention which take these natural characteristics into account and provide substitute characteristics in the form of locally produced impulses to replace those lost in transmission due to fading or to counter balance impulses introduced in transmission as a result of interference and to indicate on the receiving equipment when these functions have been required to complete the formation of a character.

In endeavoring to achieve greater economy of bandwidth, the start-stop or synchronizing impulses heretofore used in both radio and wire methods have been eliminated in my invention by self-synchronizing apparatus resulting in an approximate saving of twenty per cent of bandwidth required to perform the functions necessary to the formation of a character as compared to systems which transmit start-stop impulses or synchronizing impulses.

My invention employs apparatus and methods which are compatible with existing methods and apparatus, allowing in almost every instance, the use, with slight modification, or existing equipment and methods to accomplish its purpose.

Transmitting apparatus

Figs. 1, 2 and 3 show the transmission system of my invention; the transmitting keyboard being shown in plan view in Fig. 2 and in end view in Fig. 3.

When the key, 1, pivotally mounted at 1*a*, is depressed; bars 2, 3, 4, 5 and 6, which extend therefrom depress levers 7, 8, 9, 10 and 11 in a downward direction to form contact with the contacts 12 to 21. The levers 7—11 are supported at opposite ends in frame 146 of the transmitting keyboard, as shown at 7*a* and 7*b*; 8*a* and 8*b*; 9*a* and 9*b*; 10*a* and 10*b*; and 11*a* and 11*b* through resilient, self-restoring flexing, strip members, 7*a*′—7*b*′; 8*a*′—8*b*′; 9*a*′—9*b*′; 10*a*′—10*b*′; and 11*a*′—11*b*′. Contacts 12—21 are insulatingly supported in relation to frame 146 in alignment with the pivoted levers. 7—11 as shown. The levers 7—11 are normally biased by the resilient self restoring, flexing strip members 7*a*′—7*b*′; 8*a*′—8*b*′; 9*a*′—9*b*′; 10*a*′—10*b*′; and 11*a*′—11*b*′, to a position in horizontal planes and flex under the pressure of the bars 2—6 in either a clockwise or a counter-clockwise direction depending on the relative positions of the bars 2—6 with respect to the centers of levers 7—11, for effecting momentary contact at 12—21. When pressure of bars 2—6 on the levers 7—11 is removed the levers 7—11 are restored to horizontal position breaking the contacts 12—21 by the self restoring action of the flexing supports at each end of the levers 7—11. The contacts which are formed depend upon which side of the center of levers 7 to 11, the bars 2 to 6 are positioned. In the position illustrated in Fig. 1 lever 7 will contact 12; lever 8 will contact 15, lever 9 will contact 16, lever 10 will contact 19, and lever 11 will contact 20, placing alternatively positive and negative currents from source of battery 29, on stepping relay contacts 22, 23, 24, 25 and 26, arranged in the path of switch arm 27 of continuously cycling driven stepping relay 28.

When this contact was made a positive current flow took place from battery 29 (Fig. 1) contact through 12, and the contact carried by lever 7 to stepping relay contact 22 through arm 27 through relay coil 30 to the center tap 29*a* of battery 29. The current in coil 30 caused armature 31 to move down, making contact with contact 32, which in turn caused the armature 33 of stepping relay 28 to be moved down because of the current in relay coil 34 produced by closing of contact 32. The movement of armature 33 caused ratchet arm 35 to pull arm 27 away from contact 22 counterclockwise towards stepping relay contact 23. During the time the arm 27 was in contact with contact 22, a positive voltage was applied to line 36 with respect to ground or center tap 29*a* of battery 29, or was caused to flow through rectifier 38 through relay coil 38*a* in a positive direction resulting in movement of arm 39 of relay 40 to make contact at 43 which in turn keyed the marking frequency of a frequency shift radio printer keying circuit.

As soon as arm 27 left contact 22 the current in relay coil 30 was released and contacts 31 and 32 were opened de-energizing coil 34 of the continuously cycling spring driven stepping relay 28 which in turn repositioned ratchet arm 35 preparatory for another ratcheting operation.

The capacity 41 and adjustable resistor 42 across coil 34 acts to retard the arm 27, sufficiently long at each contact 22 to 26 to permit the full cycle of operation previously described to be completed.

When arm 27 arrived at contact 23 the same cycle of operation was set in motion as when the arm 27 was at contact 22, except that the charge of voltage on contact 23 is now derived from the negative source of battery 29, thru the contact on lever 8 and contact 15 and a negative charge was placed, thru rectifier 37 and relay coil 37*a* to ground or center tap 29*a* of battery 29, causing armature 39 to close contacts 44, keying the spacing frequency of the frequency shift keying system or causing a negative charge to be placed on line 36.

The same cycle of operation is repeated at stepping relay contacts 24, 25 and 26 resulting in moving arm 27 back to the original position in contact with contact 22 having thus completed a transmission cycle of four self-cycling operations from contact 22 to contact 26 which resulted in sending four equally spaced pulses and one starting pulse of alternate positive and negative charges to a line or causing the two frequencies of a frequency shift keying system to be alternatively operated causing five pulses divided be-

tween two different alternating currents to be transmitted.

Since the pulse caused to be transmitted when arm 27 is in contact with contact 22, is the starting pulse, it does not have to be especially spaced in relation to any previous pulse. The pulse created by contact arm 27 with contact 26 is the end of the character forming combination.

Figs. 2 and 3 show the arrangement of the transmission keyboard more clearly from which the coaction of the pivoted keylevers 45 with the contact control means will be understood. The key-levers are arranged above the angularly shiftable levers 7, 8, 9, 10 and 11 and through bars 2, 3, 4, 5 and 6 selectively control the angular movement of the levers about their pivots 7a, 7b—11a, 11b, that in turn control the contact 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21, for controlling the circuits heretofore described.

When arm 27 arrives at contact 26, current from negative battery 29 flows through coil 46, arm 27 and coil 30 to the center tap 29a of battery 29. This causes armature 47 to be attracted by the electro-magnetic core of coil 46 making contact at 48, permitting current to flow through coil 49 from positive battery 29 to negative battery 29. When coil 49 shown more clearly in Fig. 3 was energized armature 50 was drawn towards the electro-magnetic core of the coil 49 pushing oscillating bar 50' against armature 51 releasing pressure of point 51a of pivoted member 51 on roller 52 carried by the end of keylever 45 permitting spring 53 to pull keylever 45 up against stop 54 which action lifted key bars 2, 3, 4, 5 and 6 from bars 7, 8, 9, 10 and 11, allowing the latter to resume normal position. Thus permutations and combinations of signal pulses can be formed and transmitted by contacts 43 and 44 under selective control of the keyboard as described.

Had it been desired to utilize the keying mechanism in the manner described in my co-pending application Ser. No. 109,648 supra for simultaneous transmission of a coded character, the oscillators 40a, 40b, 40c, 40d and 40e of the circuit of Fig. 1 of that application would be connected to contacts 13, 15, 17, 19 and 21, and levers 7, 8, 9, 10 and 11 would be connected together and returned to contact with 40f. Contacts 13, 15, 17, 19 and 21 would have been disconnected and levers 7, 8, 9, 10 and 11, when in normal position, would have been making contact with contacts 12, 14, 16, 18 and 20 causing oscillators 40a, 40b, 40c, 40d and 40e to continuously generate alternating current tones into the line 36 or an amplifier as described in my aforesaid co-pending application. When key 1 is depressed contact is broken at contacts 7, 12, at 9, 14 and at 11, 20, causing oscillators 40a, 40c and 40e to be removed from the line and the character which is made up of signals from oscillators 40b and 40d in simultaneous combination would be formed.

Receiving apparatus

Fig. 4 shows the receiving circuit for the receiving printer of my invention. The permutation and combination incoming signal pulses, whether received by line or as a result of rectification of a radio or audio frequency current, appears on line 147 of Fig. 4 as a positive or negative voltage with respect to ground 55 in accordance with the manner in which it was transmitted by the apparatus described in Figs. 1–3. The current flows through the stepping arm 61 of cycling switch 62 to contact 56 and the winding of relay 63 and, if the voltage is of positive polarity with respect to 55, which is the center tap 29a of battery 29 from which the voltage on line 147 is derived, through rectifier 64 to line 55. The current also flows through coil 65 from line 147 to line 55.

When current passed through coil 65, armature 66 made connection with contact 67 completing the circuit between positive battery 29 and coil 68 and ground 55. This moved armature 69 to the left causing ratchet arm 70 to turn ratchet wheel 71, which caused arm 61 to move from contact 56 to contact 57, and through shaft 145 caused arm 72 to move from open contact 73 to contact 74.

When armature 66 made connection with contact 67, extension rod 66a connected with operating spring 66b the continuity of the circuit 147 to arm 61 was broken between spring 66b and contact 66c, insuring against the possibility of a prolonged pulse causing a false operation prior to the completion of the pulse duty cycle. This also permits the carrier or signal current to be maintained in an on condition during the interim between the formation of signal characters.

When current was passed through relay 63, armature 78 caused extension bar 79 to pull contacts 80 to 87 into connection with contacts 89, 90, 91, 92, 93, 94, 95 and 96.

Upon arrival of arm 61 at contact 57 the circuit from line 147 through rectifier 64 to line 55 is completed. If the voltage on line 147 is now negative, rectifier 64 will not pass current through relay coil 97 to ground 55 and thus armature 99 remains in position shown and contacts to 102 are not broken.

The current through coil 65 again caused the arm 61, as a result of the action similar to that previously described, to move to contact 58. If the voltage in line 147 is now positive with respect to ground or center tap 29a of battery 29 and the circuit is completed from line 147 through arm 61, contact 58, coil 103, to rectifier 64, and line 55, the current flow through coil 103, caused armature 104 to move bar 105 causing leaf spring contacts 106 and 107 to connect with contacts 108 and 109.

When arm 61 arrived at contact 58 the action resulting from current action in coil 65 was again repeated causing 61 to move to contact 59 and arm 32 of the stepping switch 62 to move to contact 76.

The arrival of arm 61 at contact 59 completed the circuit from line 147 through coil 110, arm 61 contact 59, to rectifiers 64. If the voltage is now negative, rectifier 64 will not pass current through coil 110 to ground 55 and armature 111 and bar 112 remain in the position shown.

The current in coil 65 present when contact 62 of arm 61 is in contact with contact 59 caused arm 61 to move to contact 60 and arm 72 to move to contact 77.

Line 147 is now connected thru arm 61, contact 60 and contacts 113, 107, 109, 101, 85 and 94, to the printer magnets N and SP, to rectifiers 114 and 115 to line 55 through lead 55a.

If the voltage in line 147 was positive when contact was made by arm 61 at contact 60, a positive current will now pass through the printer magnets N (Fig. 4) and rectifier 115 to and by the process described above. This will cause the letter N of the printer to print.

When the letter N function was activated by the action of arm 61 contacting contact 60, current also passed through relay coil 116 in the lead 55a which caused armature 117 to unlatch

armatures 78, 94, 104 and 111 of relays 63, 97, 103 and 119, preparing the system to receive a new cycle of character forming impulses.

Examination of Fig. 4 will show that, predicated upon the polarity of the currents in line 147 with respect to line 55 as presented to the matrix shown in the lower right hand portion of Fig. 4 in sequential combination and with the use of pressure roller springs 118, 119, 120 and 121 to latch armatures 78, 98, 104 and 111 in a fixed position for a period covering the cycle of operation, it is possible to individually select any one of the multiplicity of magnets in various permutations and combinations represented by reference "Let" designating "Letters" to "Blk" designating "Blank" of Fig. 4. In Figs. 5 and 6 I have shown the two limiting positions of armature 111 on an enlarged scale to illustrate the two extreme latched positions thereof under control of pressure roller spring 118. All of the armatures 78, 98, 104 are arranged in a manner similar to armature 111, that is the armatures 78, 98 and 104 are controlled in their limiting positions by pressure roller springs 121, 120 and 119 respectively.

Figs. 7 and 8 are enlarged views of the solenoids in the polarized matrix circuit wherein Fig. 7 represents the juxtapositions of the operating solenoids for letters W and A and letters Z and E while Fig. 8 shows the electrical equivalent of the same juxtapositioned solenoids.

The capacitor-resistor combination 122 and 123 are used to control the dissipation of current in condenser 122 through coil 68 after opening of the circuit to battery 29 (+) by the operation of relay 65 and which in turn controls the length of time in which arm 61 moves from one contact to the other of the group of contacts 56 to 60.

Under certain conditions of operation particularly in radio circuits the possibility of loss of one or more impulses due to fading or obliteration of signals by interference is always present.

To overcome this condition, provision has been made in the selector system for the supplying of lost impulses and recording this circumstance on the printed copy. The effect of interference is made to appear as a lost impulse in this system.

Each time that the armature 66 is in contact with contact 124 in addition to holding armature 125 in contact with contact 126, battery 29 (+) charges the condenser resistor delay network 127 and 128 across coil 129. Each time the armature 66 is opened by removal of energy from coil 65, contacts 66 and 124 are broken which opens the circuit from positive battery 29 to negative battery 29 through coil 129. When this occurs the energy stored in capacitor 127 starts discharging through resistors 128 and 128a into coil 129 holding armature 125 that is in circuit with condenser 130 through contact 126 to battery 29.

If no voltage appears on line 147 for a fixed period of time after contact has been established by arm 61 with any one of the contacts 57, 58, 59 and 60 before the dissipation of energy in condenser 127 is complete, armature 125 will be released from contact 126 and contact will be established with contact 131 allowing condenser 130 to discharge through resistor 130a, coil 132, arm 72 and contact 74, 75, 76 or 77 of a duplicate bank of contacts on the same shaft as contact arm 61 to line 147 through which ever

circuit arm 61 provides through its contact with contacts 56 to 60, thus producing the same action which would have resulted from an incoming signal on line 147.

When this current passed through coil 132 the armature 133 was moved and closed the circuit through contact 133a connecting battery 29 to a relay 134 associated with the printing mechanism.

When the relay 134 was energized, the armature 135 was attracted to the pole of coil 134, latching itself to latching armature 136 and bringing the extension wire 137 of armature 135 across the surface of the character A for example on the type pallet 138 which may strike the ink ribbon 139 of Fig. 11 and be printed on the paper web 140 being advanced on platen 141 of the printer as shown more clearly in Figs. 9 and 10 and 11. Fig. 9 shows the condition for indicating error while Fig. 10 shows an all clear condition with the error indicator removed.

When relay 116 was energized contact was made between 144 and 117, placing battery on coil 142 which caused armature 136 to release armature 135 allowing spring 143 to draw armature 135 to its normal position with the extension 137 clear of the printing surface of the next character placed in a printing position.

When the letter key is operated to print the character formed, partly by the self-imposed impulses of condenser 130, the character which is printed will be marked by a vertical bar stroke by the extension bar 137 of armature 135 plainly indicating to the operator that the character was not properly received.

The rotary selecting printing mechanism described in my co-pending application Ser. No. 109,648 supra may be used in connection with the apparatus described in this application to select and print the characters and perform the other operations required of a printing mechanism. This may be accomplished by connecting the contacts of the rotary switch and the "Letters," "Figures" and "Space" relays to the contacts represented by the solenoids for Letters K, W, etc. of Fig. 4.

It will be fully understood that these same contacts of Fig. 4 can be connected to a series of solenoids or magnets and be used to operate an electric typewriter or initiate the printing mechanism of other types of presently used printing telegraph equipment.

Conventional printer mechanism is operated by the solenoids Letters through Blank shown in the polarized matrix in the lower left corner of Fig. 2.

Due to the fact that the necessity for a mechanical selector is eliminated in the printer system of my invention and yet very accurate and quick movements of the selection system of my invention obtained by use of positive and negative electrical impulses, I am able to reduce the size and weight of the equipment, as compared to conventional equipment, very materially.

While I have described my invention in certain of its preferred embodiments I realize that modifications may be made and I desire that it be understood that no limitations upon my invention are intended other than may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. A printing telegraph system comprising a transmission system for selectively establishing permutations and combinations of positive and

negative current pulses, a keyboard selectively operative to establish permutations and combinations of positive and negative current pulses representative of different signal characters, a stepping relay including an actuating winding, a switch arm and a multiplicity of contactors controlled by said switch arm, an armature controlled by said winding, said switch arm being angularly shiftable step-by-step under control of said armature over said multiplicity of contactors associated therewith, and a polarized relay circuit responsive to said positive and negative current pulses selectively controllable through the circuits established by the movement of said angularly shiftable arm for controlling the selective transmission of signal impulses.

2. A printing telegraph system as set forth in claim 1 in which said keyboard for controlling the establishment of permutations and combinations of positive and negative pulses which are applied to said polarized relay includes finger actuable levers extending over a plurality of lever members disposed in directions normal to the direction of said finger actuable levers said lever members each being centrally pivoted and biased to open circuit position, contacts carried by the peripheries of said members and coacting with aligned fixed contacts and selector means carried by said finger actuable levers and movable into the path of said lever members for selectively moving said lever members either in clockwise or counterclockwise directions for selectively closing predetermined combinations and permutations of said contacts.

3. A printing telegraph system as set forth in claim 1 in which said keyboard includes key levers pivoted at one end and having a finger actuating means at the other end and selectively movable to an actuated position from an unactuated position for establishing permutations and combinations of positive and negative current impulses for application to said polarized relay, and means engageable with the end of the lever that carries said finger actuating means for selectively maintaining said key levers in actuated position.

4. A printing telegraph system as set forth in claim 1 in which said keyboard includes key levers pivotally mounted adjacent the rear ends thereof in a frame and selectively operative in either an actuated or unactuated position, a plurality of lever members extending in directions normal to the direction of said key levers and pivoted at their opposite ends in said frame in a plane beneath said key levers, depending members carried by said key levers selectively engageable with the peripheral edges of said lever members, said lever members carrying contacts adjacent their peripheral edges and coacting with aligned fixed contacts, said lever members being biased to positions normally maintaining said contacts and fixed contacts in open circuit position and said depending members operating upon actuation of selected key levers to move said lever members selectively clockwise or counterclockwise for closing said contacts for effecting the transmission of positive and negative current pulses to said polarized relay, and means located adjacent the front of said key levers for selectively maintaining said key levers in either actuated or unactuated positions.

5. A printing telegraph system as set forth in claim 1 in which said actuating winding has an adjustable retarding circuit associated therewith for adjustably prolonging the cycle of operation of the circuits established by the movement of the angularly shiftable arm step-by-step over said contactors.

6. A printing telegraph system as set forth in claim 1 in which said actuating winding has a condenser and an adjustable resistor connected in shunt therewith and controllable to electrically retard the cycle of operation of said angularly shiftable arm with respect to the associated contactors for completing a full cycle of operation for each position of the angularly shiftable arm with respect to an associated contactor.

7. A printing telegraph system as set forth in claim 1, in which said keyboard includes a frame, depressible levers pivoted at one side of said frame, bars associated with each of said levers, horizontally extending lever members disposed substantially normal to the direction of said depressible levers and pivotally mounted at their opposite ends in said frame, contacts positioned on said pivotally mounted lever members on opposite sides of the paths of movement thereof whereby said lever members are selectively moved in either clockwise or counterclockwise directions for closing electrical circuits for the establishment of said positive and negative current pulses, by contacting abutment of said bars with the upper surfaces of said lever members.

8. A printing telegraph transmitter comprising a frame, a set of fixed contacts mounted in prearranged positions adjacent the base of said frame, a plurality of lever members extending substantially the length of said frame in a plane above said fixed contacts, means for mounting said lever members in opposite ends of said frame in positions wherein said lever members may flex sideways about longitudinal centers from a horizontal position and be restored to the normally horizontal position thereof, contacts carried by the peripheral edges of said lever members in alignment with the aforesaid fixed contacts, key levers pivotally mounted at one side of said frame and extending in directions normal to the longitudinal centers of said lever members to a position adjacent the other side of said frame and selector bars depending from said key levers in prearranged positions for engaging the tops of said lever members in positions displaced from the longitudinal centers thereof and applying pressure thereto for flexing said lever members about said longitudinal centers through a sufficient displacement for moving the contacts carried thereby into contacting relation with said aligned fixed contacts for establishing permutations and combinations of signal pulses in a transmission circuit connected with said contacts.

9. A printing telegraph transmitter as set forth in claim 8 in which the bars depending from said key levers are variably spaced along the length of said key levers in positions for striking said lever members on opposite sides of the longitudinal centers thereof whereby to selectively orient the respective lever members clockwise or counterclockwise about the longitudinal centers thereof for moving the contacts carried by said lever members into contacting relation with said fixed contacts for establishing the permutations and combinations of pulses comprising the telegraph signals.

JAMES D. DURKEE.

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Number	Name	Date
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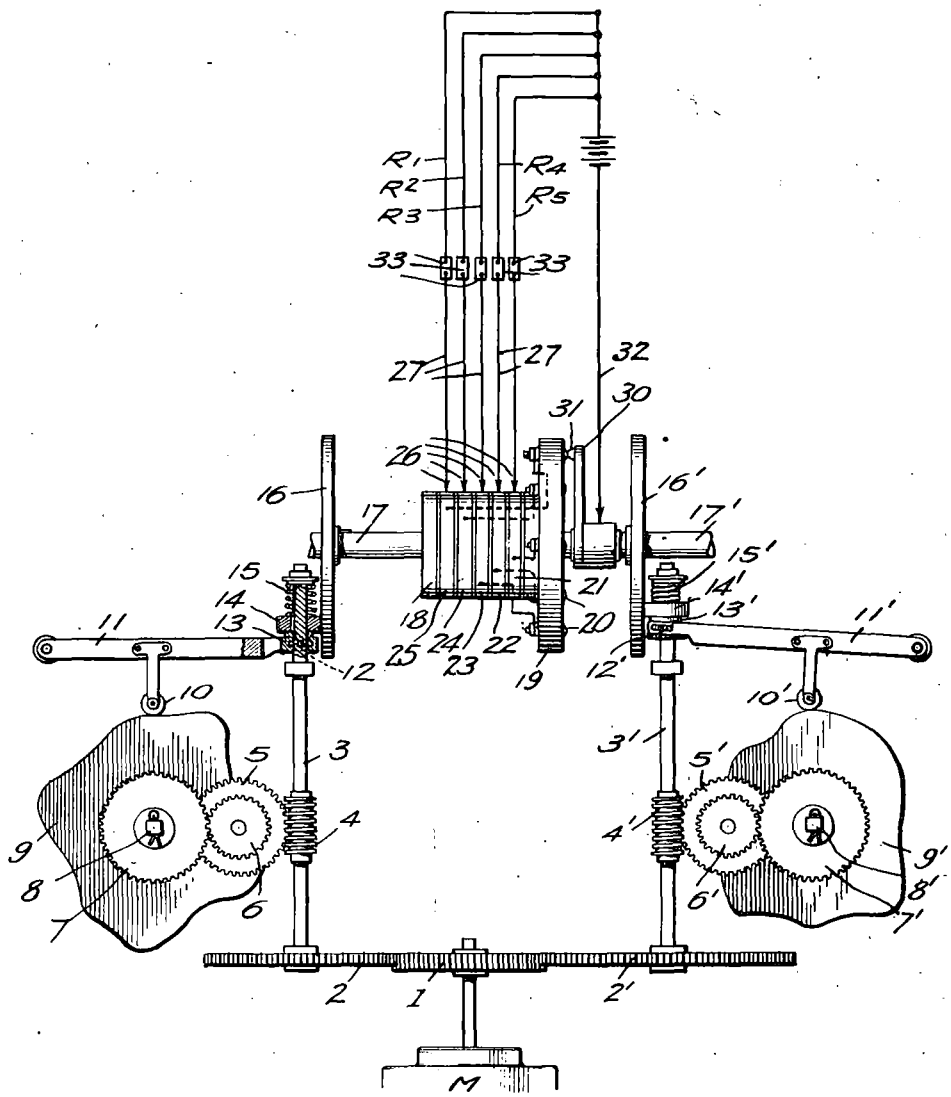
July 18, 1939. W. F. FRIEDMAN ET AL 2,166,137

ELECTRICAL SWITCHING MECHANISM

Filed Aug. 19, 1935



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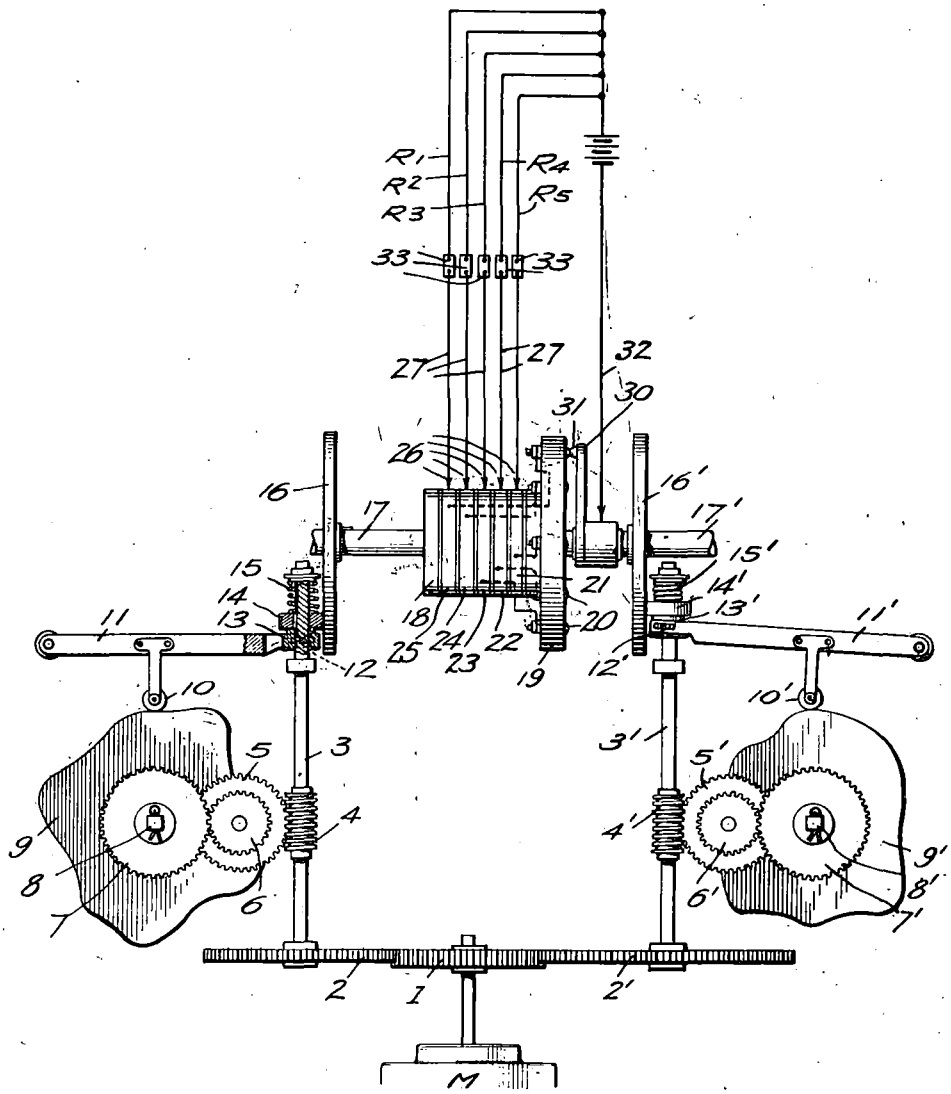

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Patented July 18, 1939 2,166,137

UNITED STATES PATENT OFFICE

2,166,137

ELECTRICAL SWITCHING MECHANISM

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Application August 19, 1935, Serial No. 36,868

10 Claims. (Cl. 200—17)

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

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

This invention relates to a switching mechanism and proposes a mechanism of this character for automatically establishing and/or varying circuit connections in a random order.

As distinguished from the idea of performing switching operations in an orderly sequence, the present invention contemplates an opposite function and provides means to vary the circuit connections in an irregular, aperiodic or fortuitous manner. The invention contemplates an operation which affords opportunity for the laws of probability to function in establishing the variation in circuit connections, rather than an operation controlled by the usual laws of direct cause and effect. An object of this invention is to provide a means of selecting from a plurality of available electrical circuits a single circuit at random, which electrical circuit will be operative for a period of time, the length of which depends upon one or several variable factors.

Another object of this invention is to provide apparatus for varying the speed of rotating bodies by means of a friction drive mechanism working in conjunction with cam wheels of irregular outline and operatively coordinated with a differential gearing system for the purpose of opening and closing electrical circuits for varying periods of time.

A further object of the invention is to provide a device in the nature of a fortuitously-operated device for selecting from a large assortment of punched cards, a random sample.

A further object of the invention is to provide a device in the nature of a scrambling device for arranging in a purely random sequence, a large number of punched cards originally arranged according to a definite sequence, such as an alphabetical or numerical sequence. For example, in the well-known card-sorting machines employed in accounting or statistical work, the function of the machine is to arrange a large number of punched cards in a sequential order, such as alphabetical or numerical. In certain types of operations with punched cards it is often necessary to disarrange the cards so as to destroy the original sequential order and bring the cards into a purely random order. However, once a large number of cards has been sequentially arranged, any attempts to destroy the arrangement by shuffling the cards would be extremely tedious and many cards would be damaged. In the present invention, the device if operated in connection with an ordinary card-sorting machine, would permit of placing a sequentially-ordered batch of cards in the machine and taking out of it a purely fortuitously-ordered batch of cards.

In order that the invention and its mode of application may be readily understood, there is disclosed in the accompanying drawing and in the detailed following description thereof, one form or embodiment of the invention.

In the drawing, the single figure shows in schematic form an apparatus for carrying out the invention.

Referring to the drawing, 1 is a gear, driven by any prime mover such as a motor M; gear 1 meshes with the two gears 2 and 2', having different numbers of teeth. Gear 2 is fixed to shaft 3 and drives the worm gear 4, which in turn, through the train of gears 5, 6, 7, drives shaft 8, on which is mounted cam 9 of irregular outline. Roller 10 rides on the periphery of cam 9 and serves to move lever 11, through a succession of angles which are determined by the depressions and elevations of cam 9. The free end of lever 11 is connected by a pin 12 to a collar 13 which is free to slide up and down on shaft 3 but is independent of the latter in its rotation. The upper end of collar 13 presses against disk 14, which is also mounted on shaft 3 but, by a slot and bar arrangement, is driven by shaft 3. Spring 15 serves to keep the assembly 12, 13, and 14 in place on the shaft 3 and also to cause the roller 10 to follow the outline of cam 9. Disk 14, by frictional effect, drives wheel 16, keyed to shaft 17 so that as shaft 3 turns disk 14 turns and slides up and down against the face of wheel 16, causing shaft 17 to rotate at continuously varying speeds as the roller 10 rides on the periphery of cam 9. Inherent in the mechanism here disclosed and as the result of such a friction drive a slipping action is produced, which action is aided by the sliding movement of disks 13 and 13' on the face of wheels 16 and 16', respectively. The cams 9 and 9' as well as the system of gearing previously described, contribute an important part to this slipping action and consequent lost motion whereby the switching operation is performed in an irregular, aperiodic or fortuitous manner. This constitutes an important object of the invention all as fully set forth in the specification and shown in the drawing. On the shaft 17 is mounted the commutator generally designated as 18 and a contact wheel 19, provided with a plurality of contacts 20, connected in a random manner to the commutator rings 21, 22,

23, 24, 25. Resting against the commutator rings are collectors 26, which are connected to conductors 27 leading to individual circuits, which circuits may include any conventional means or instrumentalities suggested, schematically as at 33 for utilizing the randomizing function of the present invention.

The action of the members 2 to 17 inclusive is the same as that of the members 2' to 17'. Shaft 17' rotates switch arm 30, carrying brush 31 which sweeps over the contacts 20 as it rotates. The commutator assembly which essentially comprises commutator 18 and its associated parts, including contact wheel 19, may be regarded as one component of a switching device, while switch arm 30 carrying brush 31 may be regarded as the other component of said switching device. Brush 31 is connected to the common return conductor 32 for the circuits R_1, R_2, R_3, R_4, R_5 to which conductors 27 lead. Since wheel 19 and brush arm 30 rotate in different directions and at constantly varying speeds, the circuits R_1, R_2, R_3, R_4 and R_5 are selected in the order of the contacts 20 on wheel 19, but each circuit is operative for a different interval of time.

In the drawing, specific mechanical principles are shown for effecting the movements of the various parts of the apparatus. However, these are shown only for the purpose of demonstration of the principles incorporated in this invention, and it is pointed out that any other mechanical means for varying the angular velocity of the commutator 18 rotating with contact disk 19 and the contact arm 30, either separately or conjointly, will effect the result desired. It is also pointed out that, while five commutator rings are depicted in the drawing, any number may be used, and that the number of contacts on the face of the disk 19 may be equal to the number of contact rings or greater by any practicable number. It will also be noted that cams 9 and 9' are intended to be detachable and interchangeable, means being shown in the drawing to facilitate removal for that purpose, or to permit substitution of other cams of different shape.

Changes, modifications and equivalent arrangements are contemplated within the scope of the invention as defined by the appended claims.

We claim:

1. In a mechanism of the character described, a pair of rotating bodies associated for operative movement relative to one another; friction drives having a slipping action and arranged to actuate said bodies in a discrete time relation; and means including a system of differential gearing and cams of irregular contours operatively coordinated with said gearing and with each of said drives individually to aid the slipping action and to effect aperiodic movement of said bodies relative to one another.

2. A mechanism of the character described for controlling the operation of an electrical system, comprising a rotatable commutator provided with contact elements and a rotatable switching device operable with said elements for establishing a plurality of circuit connections; and means to effect a random operation of said system comprising variable driving units for operating said commutator and said switching device asynchronously, and means for differentially controlling the operation of the units.

3. A combination according to claim 2, in which the last named means includes cams of irregular contours individually operable with said units.

4. A combination according to claim 2, in which the last named means includes cams of different irregular contours.

5. A switching mechanism comprising in combination, a rotatable commutator provided with contact elements and a rotatable conductor operable with said elements for establishing a plurality of circuit connections; independently variable friction drives for operating said commutator and said conductor respectively; and means including differential gearing, and cams of irregular contours operatively coordinated with said gearing and individually with each of said drives to vary the circuit connections aperiodically.

6. A randomizing switching mechanism of the character described, comprising a rotatable commutator provided with a plurality of contact elements and a rotatable conductor operable with said elements for establishing a plurality of circuit connections; and means for continuously and irregularly changing the relative speed of said commutator and said conductor to vary the circuit connections aperiodically, said means including a friction drive operative with the commutator and conductor individually, cams of irregular contours operatively coordinated with each drive, and gearing for actuating the cams differentially.

7. A mechanism for controlling the operation of an electrical system, comprising relatively rotatable switching devices provided with cooperating contact elements for establishing a plurality of circuit connections; and means for continuously and aperiodically varying the relative speed of rotation of said switching devices, said means comprising change speed drives individually operative with said switching devices, interchangeable cams of different irregular contours operative with said drives, and a differential gearing system for operating the cams and drives in opposing relation.

8. A mechanism of the character described, comprising switching components movable relative to each other and provided with contacts for establishing a plurality of circuit connections; and means including continuously slipping drive elements and cams of irregular contours operative with each component for continuously and irregularly varying the timing of the contacts in a random manner.

9. A switching device comprising components provided with electrical contacts, said components being rotatable with respect to each other for establishing a plurality of circuit connections; a friction drive mechanism for each of said components, and including means for separately and differentially operating said mechanisms to vary the timing of the circuit connections in a random manner.

10. A switching mechanism, comprising relatively movable components provided with contacts for establishing a plurality of different circuit connections; means for varying the circuit connections, comprising frictional drive mechanisms operable variably with said components; and means for changing the rate of movement of said mechanisms to assist in randomizing the circuit controlling operation of the contacts.

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Patented July 18, 1939 2,166,137

UNITED STATES PATENT OFFICE

2,166,137

ELECTRICAL SWITCHING MECHANISM

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Frank B. Rowlett, East Falls Church, Va.

Application August 19, 1935, Serial No. 36,868

10 Claims. (Cl. 200—17)

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

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As distinguished from the idea of performing switching operations in an orderly sequence, the present invention contemplates an opposite function and provides means to vary the circuit connections in an irregular, aperiodic or fortuitous manner. The invention contemplates an operation which affords opportunity for the laws of probability to function in establishing the variation in circuit connections, rather than an operation controlled by the usual laws of direct cause and effect. An object of this invention is to provide a means of selecting from a plurality of available electrical circuits a single circuit at random, which electrical circuit will be operative for a period of time, the length of which depends upon one or several variable factors.

Another object of this invention is to provide apparatus for varying the speed of rotating bodies by means of a friction drive mechanism working in conjunction with cam wheels of irregular outline and operatively coordinated with a differential gearing system for the purpose of opening and closing electrical circuits for varying periods of time.

A further object of the invention is to provide a device in the nature of a fortuitously-operated device for selecting from a large assortment of punched cards, a random sample.

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23, 24, 25. Resting against the commutator rings are collectors 26, which are connected to conductors 27 leading to individual circuits, which circuits may include any conventional means or instrumentalities suggested, schematically as at 33 for utilizing the randomizing function of the present invention.

The action of the members 2 to 17 inclusive is the same as that of the members 2' to 17'. Shaft 17' rotates switch arm 30, carrying brush 31 which sweeps over the contacts 20 as it rotates. The commutator assembly which essentially comprises commutator 18 and its associated parts, including contact wheel 19, may be regarded as one component of a switching device, while switch arm 30 carrying brush 31 may be regarded as the other component of said switching device. Brush 31 is connected to the common return conductor 32 for the circuits R_1, R_2, R_3, R_4, R_5 to which conductors 27 lead. Since wheel 19 and brush arm 30 rotate in different directions and at constantly varying speeds, the circuits R_1, R_2, R_3, R_4 and R_5 are selected in the order of the contacts 20 on wheel 19, but each circuit is operative for a different interval of time.

In the drawing, specific mechanical principles are shown for effecting the movements of the various parts of the apparatus. However, these are shown only for the purpose of demonstration of the principles incorporated in this invention, and it is pointed out that any other mechanical means for varying the angular velocity of the commutator 18 rotating with contact disk 19 and the contact arm 30, either separately or conjointly, will effect the result desired. It is also pointed out that, while five commutator rings are depicted in the drawing, any number may be used, and that the number of contacts on the face of the disk 19 may be equal to the number of contact rings or greater by any practicable number. It will also be noted that cams 9 and 9' are intended to be detachable and interchangeable, means being shown in the drawing to facilitate removal for that purpose, or to permit substitution of other cams of different shape.

Changes, modifications and equivalent arrangements are contemplated within the scope of the invention as defined by the appended claims.

We claim:

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2. A mechanism of the character described for controlling the operation of an electrical system, comprising a rotatable commutator provided with contact elements and a rotatable switching device operable with said elements for establishing a plurality of circuit connections; and means to effect a random operation of said system comprising variable driving units for operating said commutator and said switching device asynchronously, and means for differentially controlling the operation of the units.

3. A combination according to claim 2, in which the last named means includes cams of irregular contours individually operable with said units.

4. A combination according to claim 2, in which the last named means includes cams of different irregular contours.

5. A switching mechanism comprising in combination, a rotatable commutator provided with contact elements and a rotatable conductor operable with said elements for establishing a plurality of circuit connections; independently variable friction drives for operating said commutator and said conductor respectively; and means including differential gearing, and cams of irregular contours operatively coordinated with said gearing and individually with each of said drives to vary the circuit connections aperiodically.

6. A randomizing switching mechanism of the character described, comprising a rotatable commutator provided with a plurality of contact elements and a rotatable conductor operable with said elements for establishing a plurality of circuit connections; and means for continuously and irregularly changing the relative speed of said commutator and said conductor to vary the circuit connections aperiodically, said means including a friction drive operative with the commutator and conductor individually, cams of irregular contours operatively coordinated with each drive, and gearing for actuating the cams differentially.

7. A mechanism for controlling the operation of an electrical system, comprising relatively rotatable switching devices provided with cooperating contact elements for establishing a plurality of circuit connections; and means for continuously and aperiodically varying the relative speed of rotation of said switching devices, said means comprising change speed drives individually operative with said switching devices, interchangeable cams of different irregular contours operative with said drives, and a differential gearing system for operating the cams and drives in opposing relation.

8. A mechanism of the character described, comprising switching components movable relative to each other and provided with contacts for establishing a plurality of circuit connections; and means including continuously slipping drive elements and cams of irregular contours operative with each component for continuously and irregularly varying the timing of the contacts in a random manner.

9. A switching device comprising components provided with electrical contacts, said components being rotatable with respect to each other for establishing a plurality of circuit connections; a friction drive mechanism for each of said components, and including means for separately and differentially operating said mechanisms to vary the timing of the circuit connections in a random manner.

10. A switching mechanism, comprising relatively movable components provided with contacts for establishing a plurality of different circuit connections; means for varying the circuit connections, comprising frictional drive mechanisms operable variably with said components; and means for changing the rate of movement of said mechanisms to assist in randomizing the circuit controlling operation of the contacts.

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