

July 23, 1946.

R. W. BUMSTEAD

2,404,565

TELEGRAPHY

Filed April 25, 1942

3 Sheets-Sheet 1

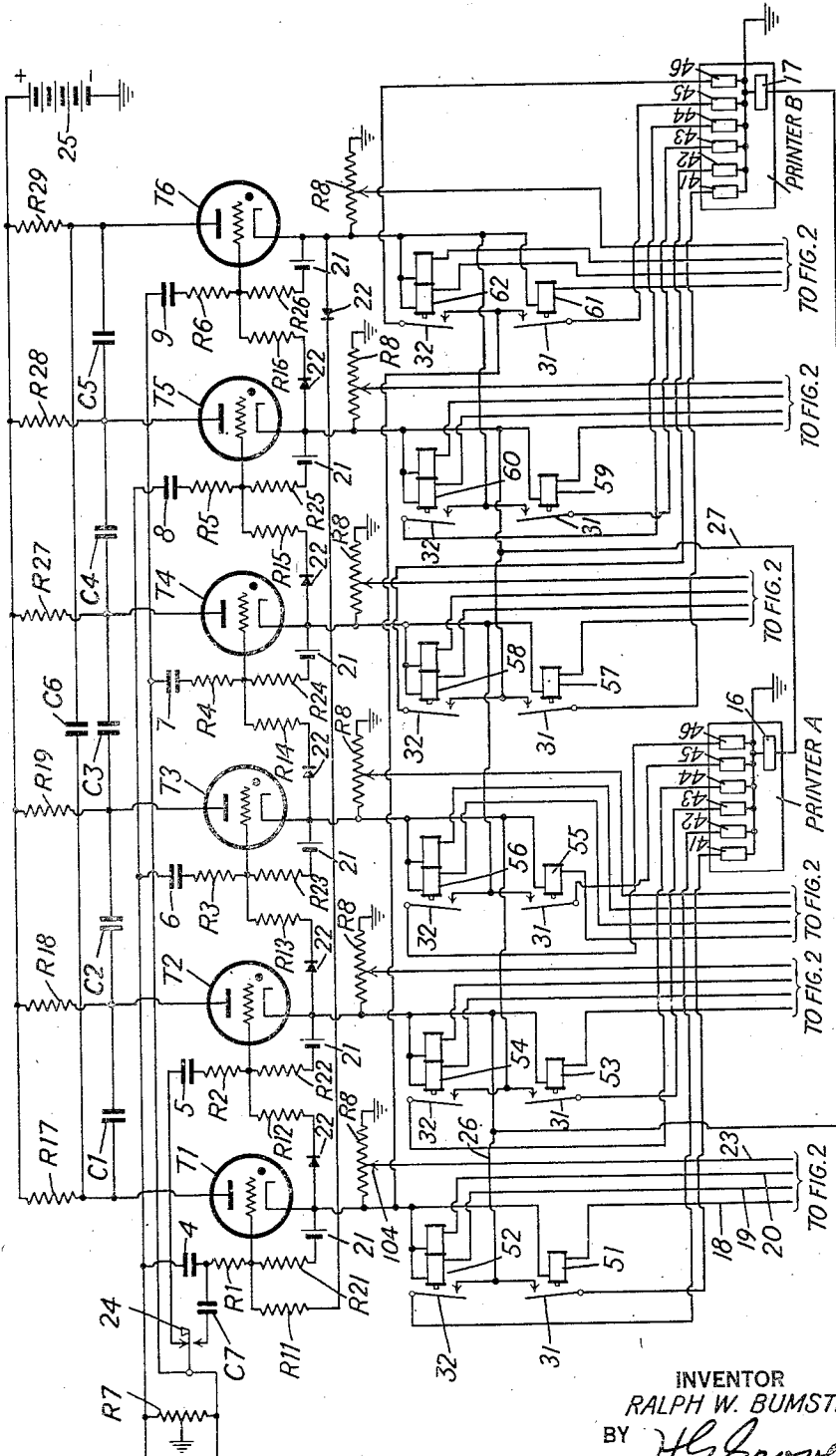


Fig. 1

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3 Sheets-Sheet 2

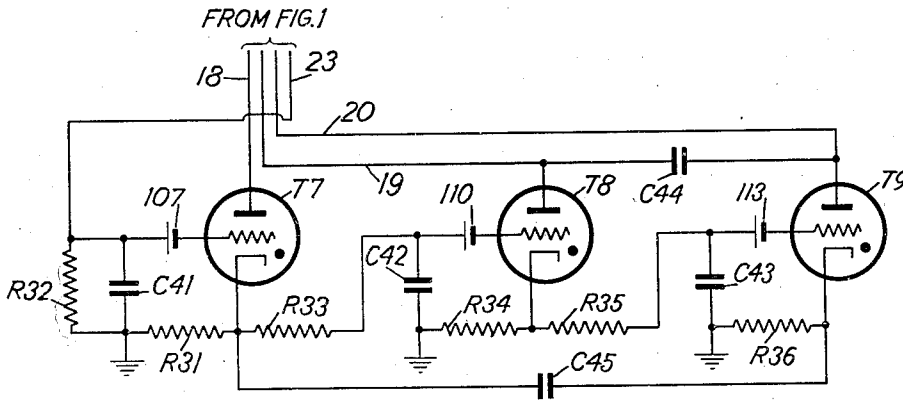


Fig. 2

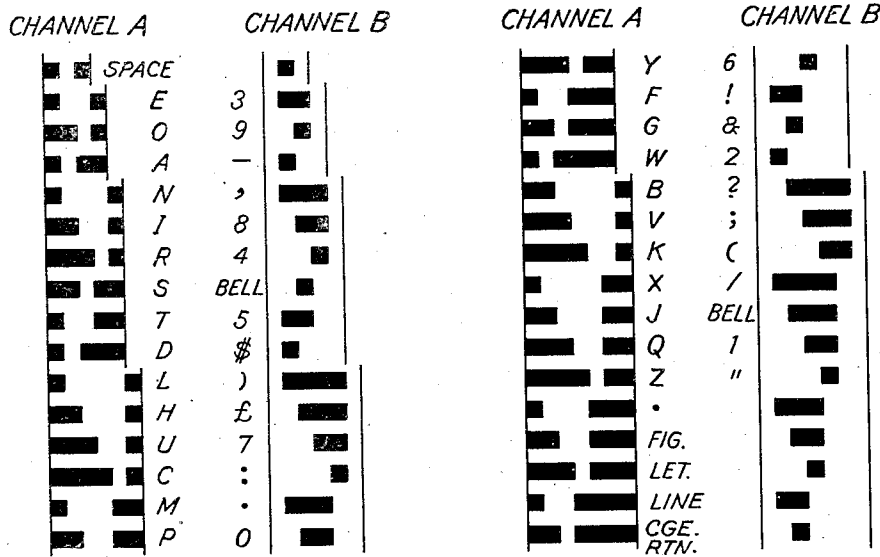


Fig. 4

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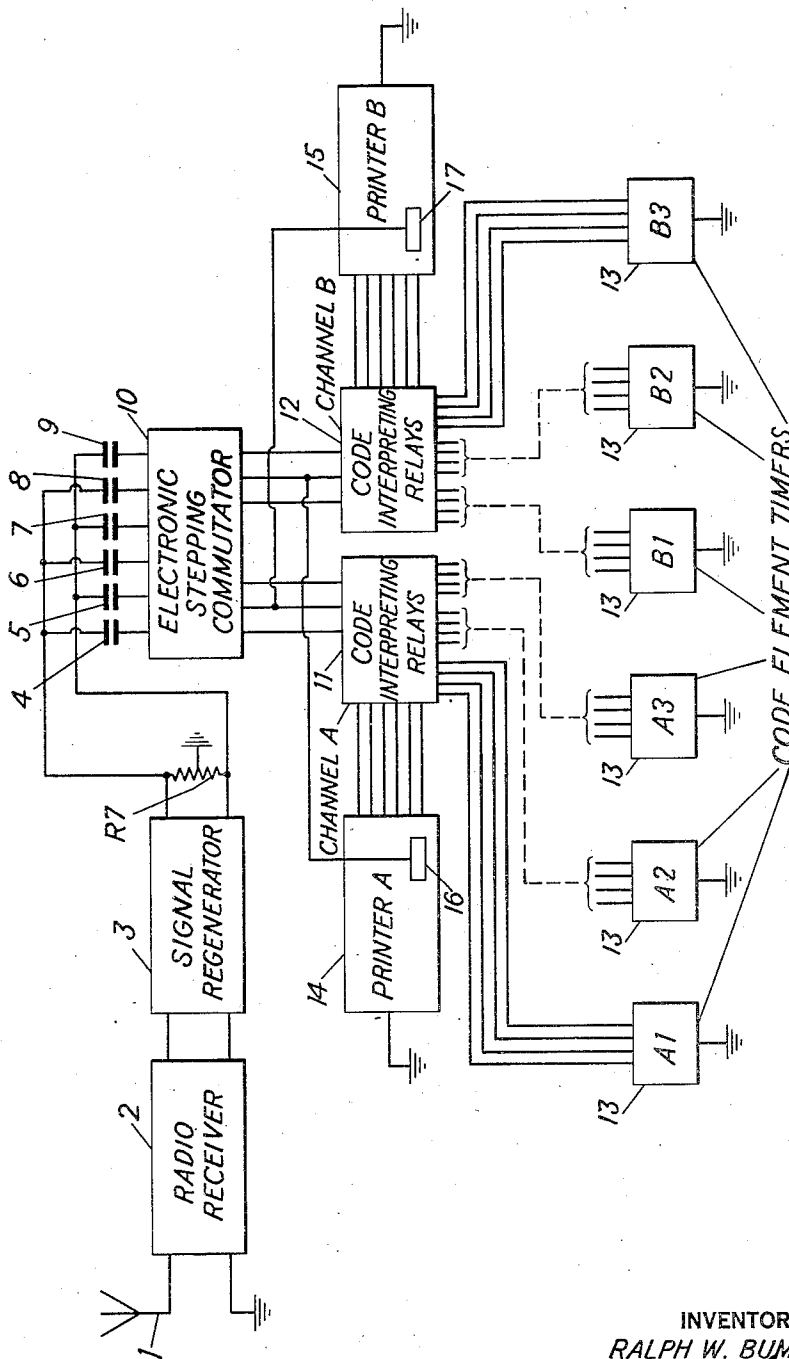


Fig. 3

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UNITED STATES PATENT OFFICE

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TELEGRAPHY

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Application April 25, 1942, Serial No. 440,455

24 Claims. (Cl. 178—61)

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This invention relates to a novel system of telegraphy which is especially useful on radio communications channels for controlling printing telegraph apparatus of more or less conventional design. The system is also suitable for the transmission of intelligence on wire lines and submarine cables.

It is an object of my invention to provide a system for use with a novel telegraph code having capabilities for dependable transmission of a relatively high number of words per minute.

A second object is to provide a printer control circuit operable in response to the reception of variable length code signals in which the code elements are also of variable length.

A third object is to provide a start-stop printer control system operable in response to continuously transmitted signals.

A fourth object is to provide an electronic device to be controlled by incoming code signals of variable length for actuating a type-selector mechanism in a printer.

A fifth object is to provide a signal code converter responsive to variable length signals and capable of controlling the code selector members of a printer, or re-transmitting unit.

A sixth object is to provide a telegraph system for use with a signal code having certain characteristics which are favorable to privacy of communication.

A seventh object is to provide a multiplex system such that character selection is accomplished by means of a three-element signal code.

An eighth object is to provide a multiplex system for the transmission of intelligence by means of code signals which are not easily decipherable by unauthorized recipients.

A ninth object is to provide a radio telegraph system possessing inherent capabilities for the detection of errors due to the reception of mutilated signals.

The foregoing objects and other objects of my invention will be made apparent in the following detailed description. This description is accompanied by drawings in which:

Fig. 1 shows diagrammatically a circuit arrangement including an electronic distributor for successively applying the elements of the code signals to different code interpreting relays, these relays and their circuit connections being also shown.

Fig. 2 shows an electronic timing means which complements the circuit arrangement of Fig. 1.

Fig. 3 shows a schematic diagram of the receiving apparatus assembly, and

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Fig. 4 shows a diagram of a novel signalling code which I preferably use in connection with the telegraph apparatus of this invention.

I refer first to Fig. 3 while supplying a brief description of the fundamental features of my invention and the mode of operation thereof. Assuming first that the intelligence is to be transmitted over a radio channel and that multiplex transmission provides for the intermeshing of code signals for two distinct messages, these signals may be received on an antenna 1 and sensed by a radio receiver 2. The output from the radio receiver may first be passed to a signal regenerator 3 where any deformations of the wave components may be re-shaped. The regenerator delivers substantially a square wave output. Accordingly, the output leads from the signal regenerator 3 may be caused to produce a reversible voltage on the load resistor R7 which has a grounded center-tap. Let it be assumed that when the upper output lead of the signal regenerator 3 is positive, that the square peak of the output wave then represents a marking impulse. On the other hand, when the lower one of the output leads from the signal regenerator 3 is positive, this condition represents a spacing impulse.

The marking impulses are applied to capacitors 4, 6, and 8 for controlling certain gaseous discharge tubes in the unit 10 which I term an electronic stepping commutator. The impulses representing spacing conditions will, however, be applied to the capacitors 5, 7, and 9 which control other gaseous discharge tubes of this commutator in the unit 10. Electronic commutators are well known in the art and may, as in the present embodiment, be of the gaseous discharge type. The commutator 10 differs from ordinary rotary distributors and other cyclically operated switching mechanisms by virtue of the irregularity with which successive steps may be taken. In other words, marking and spacing elements of variable duration must be capable of stepping the commutator from one to a successive point at irregular time intervals.

Six output leads are shown at the bottom margin of the electronic commutator 10. Three of these are associated with a code interpreting relay unit 11 which is appropriate to intelligence channel A. The three remaining output leads from the commutator 10 are connected to suitable relays in the unit 12 for interpreting the signals appropriate to intelligence channel B.

The code interpreting relays of units 11 and 12 depend for their operation upon the automatic

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control of certain code element timers 13. In the present embodiment, where two printers A and B are to be actuated in response to multiplex signals, six code element timer units are provided, three for each printer. They are respectively labelled, therefore, A1, A2, and A3 for printer A; and B1, B2, and B3 for printer B.

The unit 14 represents printer A and is shown having six input leads each of which controls a conventional code selector magnet in a printer of well-known type. These input leads carry impulses which derive from contacts on the code interpreting relays. Correspondingly, printer B has six input leads, each for the control of its code selector magnets, and impulses carried by these leads derive from the contacts of relays in the channel B unit 12.

Printer A possesses a printer control magnet 16 which is in circuit with a particular one of the output leads from the electronic stepping commutator 10. This particular lead initiates an impulse at the mid-point of interpreting a code signal for channel B. Hence, the operation of printer A following a code selection takes place while code selection is under way for channel B. Similarly, the printer control magnet 17 for printer B is in circuit with a particular output lead from the commutator 10 which is also used to decode the signals for channel A. Hence, the operation of printer B is timed to be coincident with the interpretation of a channel A code signal. This arrangement permits continuous reception of alternate code signals for the two channels and also permits each printer to operate after the code combinations have been set up in its code selecting magnets.

In carrying out my invention I propose to utilize existing facilities with obvious modifications for keying the signals automatically at the transmitter. As in most telegraph codes the signals are represented by a succession of two conditions, a mark and a space. The character code signals, however, are preferably composed in accordance with different combinations of signal elements all of which are of dot length or multiples of the time interval occupied by a dot. Fig. 4 shows an arbitrary chart of code element combinations. Each marking or spacing element is variable between one and four unit lengths or "bauds" as they are conventionally termed.

The term "baud" as employed in this specification and in the claims is in accordance with generally accepted terminology, as shown, for example, in an article by J. L. Callahan, R. E. Mathes and A. Kahn published in the January 1938 issue of "Proceedings of the I. R. E." Quoting from that article: "The baud (named after Baudot, the inventor of the five unit equal-length printer code that carries his name) is the shortest duration of a mark or space element in a given telegraphic code. All other marks or spaces comprising the code are integral multiples thereof."

It is essential to the carrying out of my invention that the code to be used shall be composed of marking and spacing elements each of which is commensurate with a "baud" or an integral number of "bauds." This is true because, irrespective of the signaling speed, the cadence of the signals must be maintained constant. For economy of line time it is preferable to arrange the code signals so that those of shortest length shall be assigned to the most frequently occurring characters.

An analysis of a large sample of telegraph text shows that the word-space character and the let-

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ters of the alphabet should be arranged in the order appearing in Fig. 4 for maximum economy of line time. The space between words is more frequently used than any letter character. The letters E, O, and A occur most frequently. The letters X, J, Q, and Z occur least frequently. Other letters of the alphabet occur with more or less frequency and may, therefore, be assigned to code element combinations of variable length depending upon their frequency of occurrence in ordinary text.

In the chart of Fig. 4, and as mentioned above, it will be observed that each complete character signal is composed of three variable length elements. The first and last of these elements possess the same characteristic and the middle element possesses a different characteristic. When the first and last elements are "marking," then the intervening element is "spacing." Alternately transmitted character signals are intended to be so characterized. The intervening character signals are inverted. That is to say, the first and last elements thereof are spacing signals and the middle element is a marking signal.

In a two-channel multiplex system switching from one channel to the other may take place after each character code combination has been transmitted. The character signals for message A may, if desired, be composed of code elements of which the first and last are marking. For message B, however, the first and last elements of each character code will then be spacing. Hence the line of separation between the end of a message A character code signal and the commencement of a message B character code signal will always be indicated by a polarity reversal. Two other polarity reversals also occur in the body of each character code signal and these are not distinguishable from the ones first mentioned. The receiving apparatus must, therefore, be brought in step with the transmitter in order to decode the intelligence. The mutilation of one code signal automatically throws the decoders out of step for further transmission, and reception then being completely garbled, an error cannot go unnoticed. Re-phasing of the decoders is a simple matter which will be hereinafter explained.

By alternating the code combinations as between marking and spacing elements in successive character code signals, it is possible to effect continuous transmission of significant code elements without any loss of time for meaningless spacing between the code signals. The present system, therefore, bears certain resemblances to that of United States Patent No. 1,187,035 which was granted June 13, 1916 jointly to Albert H. Bumstead and to myself. In that patent we disclosed a system wherein each code signal consisted of a marking element of variable duration followed by a spacing element of variable duration. In order to improve upon the efficiency of code signal transmission, the number of code elements in each signal is now increased from two to three and the length of each code element is reduced from six to four degrees of variability.

The more complete diagram of Fig. 1 will now be referred to in giving a full explanation of the circuit arrangement. This diagram should, however, be viewed by placing it over Fig. 2 in such manner that any one of the groups of four wires each leading to the bottom margin may be matched against a single group of four wires at the top margin of Fig. 2. In Fig. 2, the circuit arrangement shown may be applied as though

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5 duplicated, for each one of the groups of four output wires from Fig. 1.

In Fig. 1, I show six gaseous discharge tubes, T1, T2, T3, T4, T5, and T6. Each of these tubes is arranged to respond in succession to marking and spacing units of the received signals. It is well known in the art that such tubes may be interconnected in such manner that when a first tube is ignited, it will remain conductive until a succeeding signal ignites the second one. At that instant, the previously ignited tube becomes extinguished and the ignited second tube prepares a condition for the next succeeding signal to ignite the third tube. However, the steps of progress in the successive ignition of these tubes may be of variable duration, and in order to measure the time intervals between successive ignitions, I employ a further electronic system as shown in Fig. 2, consisting of three gaseous discharge tubes T7, T8, and T9.

I will now describe more completely the circuit arrangement which includes the gaseous tubes T1 to T6 inclusive.

The gaseous discharge tube T1 has an input circuit which includes a cathode, a biasing source 21, and a resistor R21 connected to its control grid. Also connected to this control grid is a resistor R1 through which a signal impulse may be passed across a capacitor 4 and in certain instances across capacitor C1. The latter is used at moments of depression of the key 24 for phasing purposes at the outset of reception.

The grid of tube T1 also has a connection through resistor R11 and uni-directional conductor 22 to the cathode of tube T6. The purpose of this connection is to neutralize the negative bias from the source 21 during the time of ignition of tube T6 and in anticipation of the firing of tube T1. The positive potential from the cathode of tube T6 does not in itself produce a sufficient potential drop across resistors R11 and R21 to fire the tube T1, but when this grid bias is further reduced by the signal, then, and then only, is the negative potential from source 21 sufficiently overcome to produce ionization in the tube T1.

Each of the tubes T1—T6 possesses an output circuit which includes the grounded source 25, one of the resistors R17, R18, R19, R27, R28, or R29 each appropriate to the anode of a respective tube, and a cathode resistor R3 to ground. The cathode of each of these tubes is also connected to other circuits which are parallel to resistor R8. In the case of tube T1, these parallel circuits are completed at different times through the windings of relays 51 and 52, the times of circuit closure being dependent upon the operation of the code element timers of Fig. 2. For the tube T1, the entire circuit arrangement of Fig. 2 is comprehended in the one unit 13 which in Fig. 3 is designated A1. Each of the alternative circuits through the windings of relays 51 and 52 returns to ground through a different one of the gaseous discharge tubes T7, T8, and T9 (Fig. 2).

The input and output circuits of tubes T2—T6 are exactly the same as described above in reference to the tube T1. In order that tube T1 may be extinguished at the moment of firing tube T2, a surge impulse is caused to be impressed across capacitor C1 which interconnects the two anodes of these tubes. This device for extinguishing one tube when another is fired is well known in the art. For example, it is shown in Patent No. 2,252,364, issued August 12, 1941, to G. R. Clark, that the anodes of two gaseous tubes

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V4 and V6 may be intercoupled by a capacitor C9 for the purpose of causing each tube when it fires to extinguish the other. The operation is described in the Clark patent on page 3, column 1, lines 64—67. Similarly capacitors C2, C3, C4, C5, and C6 interconnect different pairs of anodes in the tubes T1—T6 so that successive firing of these tubes will always result in extinguishing the glow of the previously fired tube.

Tube T2 is prepared for firing by the previously ignited tube T1, which produces a potential drop through the uni-directional conductor 22, resistors R12, and R22, the biasing source 21 (for tube T2), and thence to ground through resistor R8 appropriate to the cathode of tube T2.

In the same manner, preparatory conditioning circuits are shown for tubes T3—T6 which include the following elements: between the cathodes of tubes T2 and T3 there is a uni-directional conductor 22, resistors R13 and R23 and a separate biasing source 21. The grid of tube T3 is connected to the junction between R13 and R23 and is also connected to capacitor 6 through R3 for receiving a control signal.

Capacitor 7 and resistors R4, R14, and R24 are appropriate to the control grid of tube T4. Capacitor 8 and resistors R5, R15, and R25 are appropriate to the grid of tube T5. Capacitor 9 and resistors R6, R16, and R26 are appropriate to the grid of tube T6. The circuits are exactly similar for each tube and, therefore, need not be further described.

It will be clear from the above description that when marking impulses are impressed on capacitors 4, 6, and 8 simultaneously, only one of the tubes T1, T3, or T5 will be ignited, depending upon which of the tubes T6, T2, or T4 was previously ignited. Similarly, in response to the reception of a spacing impulse impressed simultaneously on capacitors 5, 7, and 9, a single one of the tubes T2, T4, and T6 will be ignited, depending upon which of the tubes T1, T3, or T5 was previously ignited. Hence, the succession of marking and spacing impulses produces a step-by-step firing of the tubes T1—T6 in the order in which they are numbered. Each of the relays 51—62 inclusive possesses one or two windings as shown. Each winding when energized is sufficient by itself to pull up the relay armature. The winding of relay 51 connects through conductor 18 to the anode of tube T7. The left hand winding of relay 52 is connected through conductor 19 to the anode of tube T8. The right hand winding of relay 52 is connected through conductor 20 to the anode of tube T9.

During the reception of a marking signal of two or more bauds, as measured by the ionization of tube T1, the code element timers as shown in Fig. 2 may be sequentially actuated so that relay 51 will operate first, and, while it holds, the left winding of relay 52 energizes. If the signal is of four bauds length, the maximum, then relay 51 and the left winding of relay 52 will de-energize, but relay 52 will still be held by the energization of its right winding.

Although the tubes T7, T8, and T9 may be ignited successively in response to the firing of tube T1, the code element timer devices are automatically extinguished by the extinction of tube T1 since they derive their anode potential through the space path of tube T1. I will now describe the code element timer circuit arrangement of Fig. 2, and, in so doing, I wish it to be understood that this circuit is duplicated in association of each one of the tubes T1—T6.

Tube T7 has an input circuit which includes resistors R31 and R32 and the biasing source 107, all between the cathode and the control grid. Resistor R32 is shunted by capacitor C41, thus forming a time constant circuit for controlling the firing of tube T7 after it receives a control impulse from tap 104 on resistor R3; this tap being connected to the conductor 23 and thence to the grid of tube T7 through source 107. The value of the time constant elements R32 and C41 provides a delay equal to substantially one and one half bauds. Tube T7 cannot, therefore, be ignited until after the termination of a marking signal of one baud length.

The tube T8 is fired after a delay equal to one baud subsequent to the moment of firing tube T7. This result is obtained by causing a potential drop through resistors R33 and capacitor C42 to ground. The input circuit for tube T8 includes a cathode resistor R34, capacitor C42, and biasing source 110. The time constant value of resistor R33 and capacitor C42 is suitably determined for producing a delay equal to one baud in the firing of tube T8.

Tube T9 likewise has an input circuit which includes a cathode resistor R36 connected to ground, capacitor C43, and the biasing source 113. Between the positive terminal of source 113 and cathode of tube T8 is connected a resistor R35 across which a suitable potential drop occurs when tube T8 is fired. This potential drop charges capacitor C43 to a point where it overcomes the negative bias of source 113 on the grid of tube T9, thus causing this tube to be fired after a delay of one baud following the ignition of tube T8.

Although all of the tubes T7, T8, and T9 are extinguished simultaneously with the extinction of tube T1, it is also necessary to extinguish tubes T7 and T8 when tube T9 is fired. T7 is extinguished by the capacitive connection through C45 between the cathodes of the tubes T7 and T9. Tube T8 is extinguished, however, by a capacitive connection through C44 between the anodes of these tubes. Extinction of tubes T7 and T8 by surge impulses across capacitors C45 and C44 is thus caused in the well-known manner.

I will now show how any one of four permutations in the energization of the relays 51 and 52 may result from the non-firing or the successive firing of tubes T7, T8, and T9.

It will be appreciated by those skilled in the art that my invention may be used in association with various forms of printing telegraph apparatus or with other selective devices which are capable of operation in response to code signals. Conventional printers are arranged to obtain type bar selections from the permutational setting of a series of code bars. While such code bars have not been herein shown nor described, it will be understood that they may be readily actuated by means of a series of individual selector magnets of the series 41-46 as shown in the blocks for printer A and printer B respectively. See Fig. 1. It will also be understood that my invention is not limited in its scope to selective mechanisms which would necessitate the use of printer code bars. On the contrary, any device which is to be remotely controlled by means of code signals could be usefully employed where the interpretation of code signals is required.

Certain permutations of the code selector magnets 41-46, inclusive, in printer A require that neither of the magnets 41 nor 42 shall be energized. This permutation is obtained by a marking signal of one baud length. The one baud be-

ing less than the time constant value of capacitor C41 in shunt with resistor R32, none of the tubes T7, T8, nor T9 will be ignited before tube T1 becomes extinguished.

In order to energize code selector magnet 41, it is necessary that relay 51 alone be energized. This is accomplished by a marking signal of two bauds duration. In this case tube T7 is ignited, but the time constant value of resistor R33 and capacitor C42 causes a delay in the ignition of tube T8 beyond the duration of the two baud signal. Hence relay 51 will be energized, but relay 52 will not be energized. The pulling up of the armature 31 prepares a circuit through selector magnet 41 alone.

Assume now that the length of the signal is three bauds. Both tubes T7 and T8 will be ignited and hence the two relays 51 and 52 will be energized. The closing of armatures 31 and 32 against their contacts prepares for the energization of selector magnets 41 and 42. This condition, therefore, corresponds to a third permutation of the two code selector magnets 41 and 42.

The fourth permutation requires code selector magnet 42 alone to be energized. This is accomplished by the firing of tube T9 and the resultant extinguishing of tubes T7 and T8. The space path through tube T9 is fed with potential from tube T1 through the right hand winding only of relay 52 and thence through conductor 20 to the anode of tube T9. As previously stated, the firing of tube T9 causes the extinction of tubes T7 and T8. Hence, the code selector magnet 42 alone becomes energized.

In considering the operation of relays 51 and 52 and their effects upon the code selector magnets 41 and 42, it should be understood that neither of these magnets is energized merely by closing armatures 31 and 32 against their front contacts, because these front contacts themselves are not energized until the firing of tube T2. The relays 51 and 52 are suitably designed to hold their armatures against the front contacts for a brief moment at the instant of firing tube T2 and before the tube T1 becomes completely deionized. The front contacts of armatures 31 and 32 are connected directly to the cathode of tube T2 through conductor 26.

When tube T2 becomes ignited in response to the reception of a spacing signal, the same operation of the code element timers of Fig. 2 is repeated for measuring the number of bauds in this spacing signal. As a result of such operation, a permutational selection and energization of code selector magnets 43 and 44 takes place. Any one of four permutations is obtained as a result of measuring the duration of a spacing element which varies between one and four bauds in length. The code selector magnets 43 and 44 are similarly controlled by relays 53 and 54 in the manner explained hereinabove with respect to code selector magnets 41 and 42.

The cooperation of tube T3, relays 55 and 56, and their armatures 31 and 32 respectively in controlling the permutational selection of magnets 45 and 46 will also be understood in view of the foregoing description. It will be clear from the above also that printer A receives a complete permutational set-up of its selector magnets as a result of successive firing of tubes T1, T2, and T3.

The operation of the printer magnet 16 for setting in motion the type printing mechanism depends, however, upon the moment of firing of tube T5, which is in the group appropriate to the selection of code permutations for printer B.

The control circuit for printer magnet 16 is, therefore, connected to the cathode of tube T5 through conductor 27.

It is not necessary to trace the circuits which include the relays 51—52 inclusive and the code selector magnets appropriate to printer B in view of the foregoing description of similar circuits appropriate to the printer A. It should be noted, however, that the printer control magnet 17 in printer B is connected through conductor 23 to the cathode of tube T2 so that its actuation may follow the successive steps of operation of the tubes T4, T5, and T6 and the permutational selection of the code selecting magnets 41—46 in printer B.

Operation

In order to better understand the sequence of operations which take place upon reception of a single character signal, the code signal for letter "K" has been chosen to illustrate successive activations of the different discharge tubes and the consequent selective functions which are performed thereby. In the following table different symbols are disposed in the several lines to represent a horizontal time scale which measures the bauds of the code signal.

(a) Time scale in bauds	1 2 3 4 5 6 7	
(b) Code signal "K"	M M M M S S M	
(c)	6 1 1 1 1 2 2 3 4	Relay
(d) Activation of	7 7 7 8 9	51 energized and released.
(e) "T" tubes		52 energized: magnet 42 selected.
(f)		53 energized: magnet 43 selected.

As shown in Fig. 4, the code signal for letter "K" when transmitted on channel A comprises a first marking element having the duration of four bauds followed by a spacing element having the duration of two bauds and ending with a one-baud marking element.

Line (a) gives the numbers of the bauds in the time scale.

Line (b) shows the code signal itself expressed by means of the letter M for marking bauds and the letter S for spacing bauds.

Line (c) shows the times when different tubes of Fig. 1 are activated, the letter "T" being omitted from the references. That is to say, up until the commencement of the code signal in question, tube T6 will be understood to be conductive. This tube is extinguished upon the initiation of the marking element at the commencement of the code signal assigned to channel A. At this instant tube T1 (abbreviated 1) is ignited. The ignition state lasts for four bauds. Tube T2 is ignited at the commencement of the spacing element and remains ignited for a period of two bauds. Tube T3 is ignited for a period of one baud and is extinguished upon reception of a spacing element appropriate to a code signal in channel B. This code signal pertains to responses in tubes T4, T5, and T6.

During the conductive period of tube T1, and up until the first baud is completed, the time constant device comprising resistor R32 and capacitor C41 in the input circuit of tube T7 delays the activation of tube T7 until the commencement of the second baud. Relay 51 is in series with the space path of tube T7 and is, therefore, energized during the lapse of bauds 2 and 3 as shown on line (d).

At the commencement of the third baud, tube

T8 becomes ignited, the necessary delay being obtained by means of the time constant circuit which includes resistor R33 and capacitor C42. Likewise tube T9 is activated during the fourth baud, this time constant circuit comprising resistor R35 and capacitor C43. The two windings of relay 52 are respectively in series with the anode circuits for tubes T8 and T3. Relay 52 is, therefore, energized during bauds 3 and 4. The activation of tube T9, however, causes tubes T7 and T8 to be extinguished, as has been previously explained, and, hence, relay 51 does not remain energized after the completion of the third baud.

Line (e) shows the activation of tubes T8 and T9 in bauds 3 and 4 respectively. Bearing in mind that the printer magnet selections are obtained by circuit closures through the armatures of relays such as 51 and 52 and that with respect to relays 51 and 52, such circuit closures are made at the instant of rendering tube T2 conductive, it will be seen that no printer magnet selection results from the actuation and release of relay 51. With respect to the operation of relay 52, however, its windings are successively energized and this relay holds its armature until tube T2 is activated. Hence, printer magnet 42 is selected. If the length of the marking element in question had been only three bauds instead of four, then relay 51 would not have been released and both printer magnets 41 and 42 would have been selected.

Referring to line (f) of the above table, it will be observed that relay 53 is energized at the initiation of the second spacing baud, which is baud 6. The time constant circuit for tube T7 in connection with the relay 53 does not permit tube T7 to ignite during the first spacing baud, which is baud 5. But this spacing element extends through two bauds and causes printer magnet 43 to be selected.

The marking element which terminates the code signal and is restricted to baud 7 is of insufficient duration to activate tube T7 when regarded as in series with relay 55. This relay, therefore, remains un-energized and no printer magnet selection takes place in respect thereto.

The overall effect of operation of the tubes and relays as above described in response to the reception of the code signal for letter "K" is to cause printer magnets 42 and 43 to be selected. This selection would represent a permutation suitable for printing the character "K."

Other operations in respect to the selection of printer magnets for the remaining letters of the alphabet and for other characters may be readily understood in view of the foregoing.

In describing my invention as above, I have incidentally brought out the functions of the various elements of receiving apparatus so that the operation of the system as a whole may be readily understood. Certain details of operating procedure have only been slightly touched upon, however, and while these may not in all cases be essential to the carrying out of the invention, it may be well to discuss them in more detail.

Manipulation of the phasing key 24 is to be understood as necessary only at the commencement of message reception, or in case the signals become mutilated so as to throw the distributor out of phase. This key 24 is used for bringing the electronic switching system comprising tubes T1—T6 in step with the received signals. It is obvious that if a character signal were to start by igniting tube T3, then a portion of the character signal would be allocated to printer A while an-

other portion thereof would be allocated to printer B. Furthermore, the first element of a character signal must not be caused to excite either of the tubes T3 or T5. By depressing the key 24 momentarily, it is possible to arrest the consecutive excitation of the tubes in the system T1—T6 after T1 has been ignited, since both marking and spacing impulses are then applied to the grid of tube T1, and no spacing impulses can reach the grid of tube T2. But, at the instant of key depression, one of the tubes T2 to T6 inclusive may have been ignited. The signals will, therefore, advance the electronic switching step by step as far as T1. Thereafter during depression of key 24, subsequent spacing and marking signals will have no effect. But upon release of key 24, the next succeeding space signal will traverse capacitor 5 for igniting tube T2. If such operation fails to start tube T2 in proper phase with a character signal for channel A, then the key should be depressed again. The chances are one in three that any attempt will be successful. During this trial period, suitable test signals should be sent. For example, the signal for "F" would be quite suitable since it has three elements which are distinguished by lengths of one, two, and three bauds respectively. If a succession of F's is transmitted on channels A and B, they will be transcribed as Y's under one condition of dephasing and as H's under the condition of dephasing of the distributor.

I have not disclosed nor discussed in the foregoing part of this specification any details of a transmitting apparatus which might be suitably arranged and send out character signals of the type shown in Fig. 4. Perforated tape transmitters of various designs are well known in the art and those which have a magnetic tape feed mechanism, as in start-stop transmitters, may readily be adapted to the present system. It should be understood, however, that where this system is used for two-channel multiplexing, the terminating baud of a character signal in one tape may be rendered effective to start transmission of one character signal in the alternate tape and vice-versa. If the tape perforations for each character are arranged transversely of the tape, as is usual, then the duration of each marking or spacing impulse may be denoted by the distance of a perforation from a longitudinal reference line, say the row of sprocket holes for the feeding of the tape. Both marking and spacing elements of the code signal may be perforated in any of four positions in the tape according to the length of the signalling element. Hence, with the three-element code signal, twelve parallel rows of perforations will be made, but only three perforations will exist in each sending position. The tape itself is to be driven step by step from one scanning position to another and the stepwise motion will be at irregular intervals depending upon the number of bauds in each character signal. The technique of tape transmission as conventionally practiced requires only slight modifications in order to adapt it for the transmission of unequal length code signals in the manner above suggested.

Recapitulation

In the foregoing description, I have shown how the received signals may be applied first to the operation of an electronic switching system, each tube of which is ignited in succession. The ignition of one tube extinguishes the previously ignited tube. During the ignition of any single tube, the number of bauds of a marking or spac-

ing element is counted by means of a system of three gaseous discharge tubes the space paths of which are in circuit with a pair of selecting relays. The closure of selecting circuits under control of these relays is timed at the moment of transition from one to the next conductive state of the gaseous discharge tubes in the electronic distributor. Three of the latter tubes are used in making character selections by means of the control of six code selector magnets in printer A. After a particular code combination has been set up in these six selector magnets, printer A is caused to operate for printing the character. The printing operation takes place while the selection of code combinations is being made with respect to printer B. Likewise the printing operation in printer B takes place during the next succeeding selecting operation appropriate to printer A.

The decoding of messages which are transmitted by means of the signal code herein shown would be quite difficult if attempted by unauthorized persons. Assuming that it is not known how these code signals are composed, they might, of course, be received on an ordinary tape recorder. If separated into combinations of uniform length they would convey no intelligence whatsoever. The fact that the same character is represented part of the time by a transposed code combination would also be confusing. There is no space separation between character signals. There is no uniformity of marking elements for the characters. One signal consists of two marking elements separated by a spacing element, and the next succeeding signal is represented by a single marking flanked by two spacing elements.

If, however, it is desired to increase the cryptographic nature of the transmission, certain further transposing methods may be adopted. These are well known in the art and need not be discussed in detail. It is a well established practice to provide either a periodic reversal of the signal polarities or else the reversals can be made in a random manner by means of a cypher tape which is produced in duplicate, and only the transmitter and the authorized receiver possess the two copies. Without one of these duplicate tapes, it is impossible to decode a transmitted signal.

I have stated in the objects of the invention that the system lends itself to the detection of errors when the signals are transmitted over a radio channel and may become mutilated. It is apparent that such mutilation of the signals as in the splitting of a single marking element into two marking elements would throw the electronic distributor out of step. Thereafter, until the distributor is again phase-corrected, each character would straddle the two multiplex channels at the receiver. This condition would immediately be noticed by the receiving attendant who would then call for re-transmission of as much of the transcription as may have been mutilated and such transcription would naturally commence with test signals during which the electronic distributor would be newly phased.

Various modifications of this invention may suggest themselves to those skilled in the art. The scope of the invention is, therefore, limited only in accordance with the scope of the claims.

I claim:

1. In a telegraph system, the method of utilizing alternate marking and spacing elements to formulate the code combinations for each letter of the alphabet and every other character, which comprises starting and ending each such code combination with like elements, interposing a

single element of opposite sense between said like elements, and instantly following one code combination by another, the sense of corresponding elements in two successive code combinations being always reversed.

2. The method of selecting the code bars of a telegraph printer which comprises applying a first selection simultaneously and permutationally to two of said code bars, applying succeeding selections in the same manner to different pairs of code bars, and causing each pair-selection to result from timing the duration of a single element of a signal code combination.

3. Telegraph signal decoding and type printing apparatus operable in response to signals of unequal length, said apparatus comprising a set of magnetically actuated character selectors, relay means for producing a permutational setting of said character selectors by their magnets such that a character corresponding to a received code signal is caused to be printed, means for timing each of three successive elements of said signal, and an electronic distributor responsive to alternate marking and spacing elements of said code signal, and arranged for stepwise advancement through successive stages with each shift in the sense of said signal elements, said timing means and said distributor being jointly operative to control said relay means.

4. Apparatus according to claim 3 wherein two printers are provided, and said distributor comprises means for allocating successive complete code signals alternately to each printer.

5. In a telegraph system, the combination of a distributor for receiving code signals of unequal length, means in said distributor for subjecting the same to stepwise advancement through successive stages with each shift in the sense of the signal elements of which said code signals are composed, means for individually timing said signal elements, and type printing apparatus operable in accordance with the character significance of said signals as translated by said timing means in cooperation with said distributor.

6. The combination according to claim 5 and including a plurality of gaseous discharge tubes in said distributor, and means including circuit elements and a source of operating potentials connected to the electrodes of said tubes in such manner that said stepwise advancement is characterized by the successive firing of individual tubes in different stages, and the extinction of the discharge in the tube previously fired.

7. The combination according to claim 5 and including a plurality of gaseous discharge tubes in said timing means, and means including time-constant circuit elements and a source of operating potentials connected to the electrodes of said tubes in such manner that one of said tubes is fired after a predetermined time interval following a stepwise advancement of said distributor, and others of said tubes are fired in periodic succession during the lapse of time between successive stepwise advancements of said distributor, the number of tubes so fired corresponding with the number of bauds, less one, which are comprehended in a given signal element.

8. In a telegraph system, a distributor comprising a plurality of gaseous discharge tubes, an operating potential source and circuit parameters for said tubes arranged to ignite the same in a predetermined sequence under control of alternate marking and spacing impulses of received code signals, and timing means oper-

able in response to the ignition of each of said tubes for counting the number of bauds in each of the elements of said code signals.

9. In a telegraph system, a distributor comprising a plurality of gaseous discharge tubes, an operating potential source and circuit parameters for said tubes arranged to ignite the same in a predetermined sequence under control of alternate marking and spacing impulses of received code signals, a plurality of parallel-arranged circuits connected between an output electrode of each said tube and said operating potential source, and inertialess switching means for closing certain of said circuits successively in dependence upon the duration of the discharge in a given one of said discharge tubes.

10. In a device of the class described, a plurality of gaseous discharge tubes each controllably coupled to a source of marking and spacing telegraph signals which are transmitted at a definite baud frequency, a direct current operating potential source for said tubes, a cathode resistor connected between each of said tubes and the negative terminal of said direct current source, means including circuit parameters for said tubes whereby the tubes are ignited one at a time in a predetermined sequence in step with each shift in the sense of the signal elements, a plurality of relays, inertialess circuit closing means individual to each relay winding circuit, a plurality of said winding circuits being in shunt with each said cathode resistor, and time constant control means effective to successively operate said circuit closing means at a rate corresponding to the baud frequency of said signals.

11. The combination according to claim 10 and including telegraph signal translating means operable by the contacts of said relays.

12. In a device of the class described, an inertialess distributor comprising a plurality of parallel circuits each including the space path of an individual gaseous discharge tube, input circuits for the several tubes arranged to receive signal impulses, means for pre-conditioning each said input circuit in succession for causing its respective tube to strike upon the arrival of a given signal impulse, means for extinguishing each tube upon the striking of the succeeding tube, and signal translating and decoding means in series with said space paths.

13. The combination according to claim 12 and including a plurality of relays in said signal translating and decoding means, and means for closing the winding circuits of said relays selectively in dependence upon the duration of a particular discharge in one of the tubes of said distributor.

14. A system for translating code signals into selective effects comprising a series of gaseous discharge tubes arranged for successive ignition in response to sense shifts in a train of telegraph signals, an operating potential source connected through different branch circuits which include the output electrodes of said tubes, said branch circuits including a cathode resistor individual to each tube and a plurality of relay windings in shunt with each cathode resistor, and means including other gaseous discharge tubes having output circuits which are series-connected to said relay windings for producing permutational relay circuit closures in dependence upon the significance of said code signals.

15. A system according to claim 14 and including a type printer having type selective means

permutationally operable in accordance with said relay circuit closures.

16. A system according to claim 14 and including time constant circuits associated with said other gaseous discharge tubes whereby the latter are caused to be ignited in predetermined sequences.

17. Apparatus for decoding character code signals comprising an electronic distributor of the aperiodic type, said distributor including a series of discharge devices adapted and arranged for sequential activation in accordance with sense-shifts in a train of said signals, a plurality of parallel-connected circuits arranged in sets, each set being in series with the space path of a respective one of said discharge devices, code-interpreting means in each of said circuits, and time constant means operably associated with each of said circuits whereby the significance of each character code signal is determined.

18. In a telegraph receiving system for effecting character selection by response to character code signals each composed of three variable length code elements the first and last of which are always alike in sense, the method of independently controlling each of six selector units in a selecting mechanism in such manner that a different permutational arrangement of said selector units is provided for each character selection, said method comprising grouping said selector units in three pairs, producing a selective response in one, the other, both, or neither of the selector units of the first pair in accordance with the length of the first code element, and producing selective responses in like manner in the second and third pairs of selector units in accordance with the respective lengths of the second and third code elements of said character code signals.

19. The method according to claim 18 and including the step of inverting the sense of the variable length code elements in successive character code signals, whereby a character code signal containing a first and third element of marking significance is always followed by a character code signal containing a first and third element of spacing significance.

20. Apparatus for receiving and decoding signals comprising a plurality of translating devices, means for grouping variable length code

elements as successively received into groups of three, the first and last of which are always alike in sense, and means for assigning successive groups to different translating devices, thereby to derive character significance respecting a given alphabetical letter, figure, or other character from each group.

21. Apparatus comprising means for receiving and means for translating code signals wherein the composition of each character code combination is defined by a succession of three elements the first and last of which are always alike in sense, said elements being commensurate with one or an integral number of bauds, said translating apparatus including an electronic distributor for grouping the received code elements into threes, and timing means for counting the number of bauds in each element.

22. Telegraph receiving apparatus comprising means for utilizing alternate marking and spacing code elements of a signal train to translate the same into character symbols, each of said symbols being denoted by a group of three code elements, and each of said elements being commensurate with from one to a certain integral number of bauds and means for assigning successive groups of signal code elements to different portions of said translating means thereby to allocate alternate groups of code elements to one such portion and intervening groups to another such portion, so that two multiplexed signal trains are translated into separate pieces of intelligence.

23. In a telegraph system which utilizes alternate marking and spacing elements and always three such elements to formulate a code combination for any letter of the alphabet or other character, an electronic distributor for producing code element channel separation of the signals, means for measuring the duration of each code element in terms of bauds, and translating means for deriving a character significance from each measured code combination.

24. In a device of the class described an electronic distributor comprising means for distributing successive signal elements of variable duration to respectively different translating channels, and means for measuring the duration of each signal element in terms of bauds.

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