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J. L. CALLAHAN ET AL

2,010,505

TIME DIVISION MULTIPLEX SYSTEM

Filed March 11, 1933

2 Sheets-Sheet 1

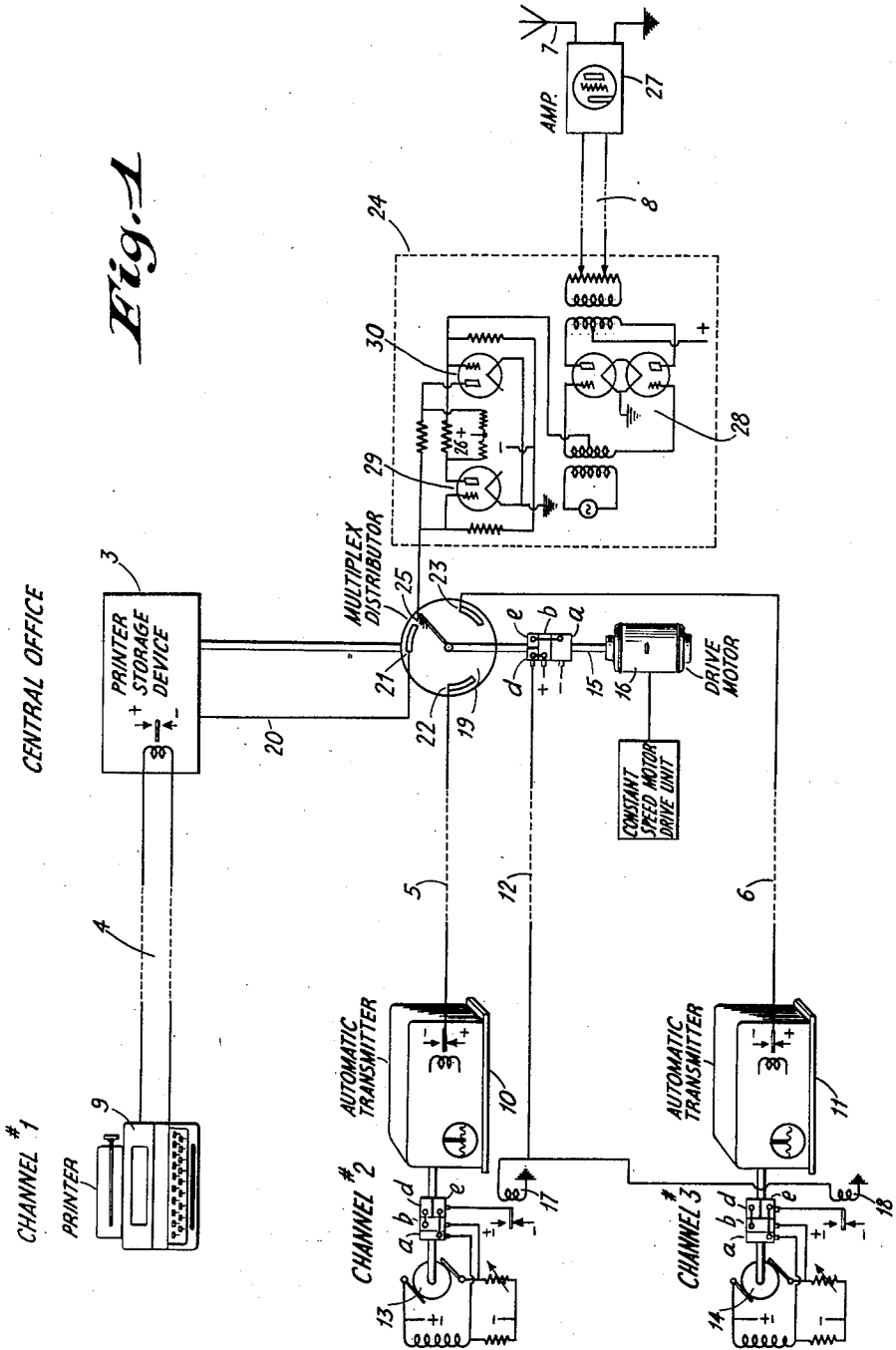


Fig. 1

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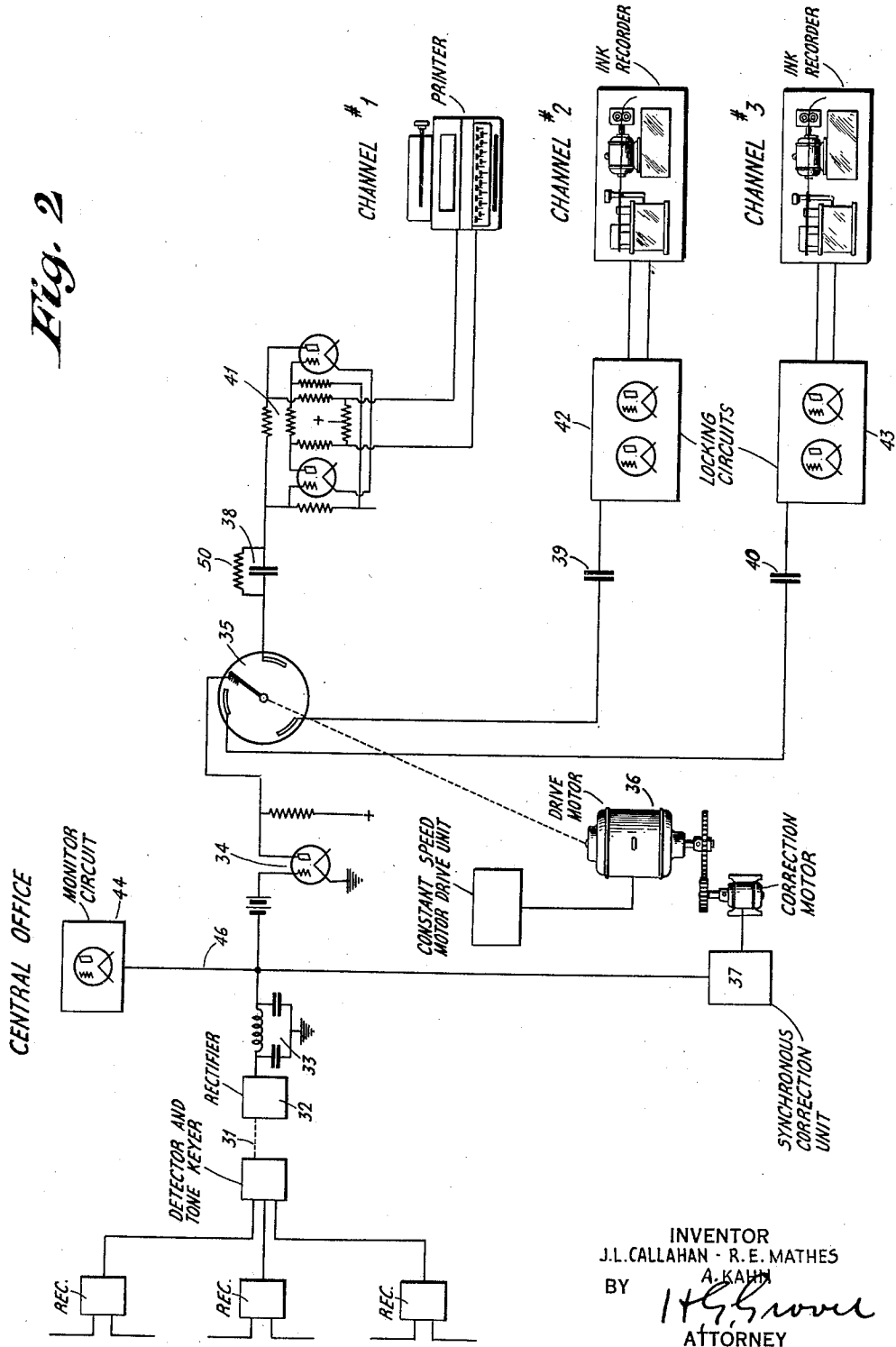
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2 Sheets-Sheet 2

Fig. 2



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2,010,505

TIME DIVISION MULTIPLEX SYSTEM

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Application March 11, 1933, Serial No. 660,366

18 Claims. (Cl. 178—52)

This invention relates to multiplex telegraph communication systems.

A primary object of the present invention is to enable the transmission and reception of telegraphic signals in a highly efficient manner and with a great degree of secrecy.

A secondary object is to provide a multiplex system which can efficiently transmit a combination of signals having equal length code characters and signals having unequal length code characters, such as may emanate from printer apparatus and Morse code automatic telegraph transmitting devices, respectively.

A still further object is to obtain a communication system which functions, as nearly as possible, completely by automatic machine operation.

These and other objects, which will appear later, are accomplished in the present invention by the use of a multiplex system operating on the time division principle whereby a predetermined length of code unit, in the present case the dot length, is regarded as the basic unit and the successive basic units of the signal characters of each channel are divided into equal portions of like number as the several channels. In this type of system the transmission circuit is assigned consecutively to successive channels for a time interval equivalent to one of these equal portions, the remaining portion of each basic unit of each channel being discarded and subsequently restored at the receiving unit of the circuit. In other words, the transmission line time is arranged to be divided equally among the different channels so that each channel has a period of transmission time allotted to it which is equal at most to the longest period of which the duration of the individual signal units forming the code are exact multiples, so that each signal unit comprises an equal number of components. Inasmuch as the printer signals used in the preferred embodiment of this invention consist of a definite number of equal length units, each of which is made equivalent to the basic dot length unit, only the unequal length Morse signal units will comprise more than one basic unit. For a more detailed description of the use of the time division principle in multiplex systems reference is herein made to United States Patent No. 1,979,484, granted Nov. 6, 1934, to Richard E. Mathes.

In general, the present invention comprises a time division multiplex radio telegraph system for transmitting printer signals which have equal length code unit characters and Morse signals which have unequal length code unit characters. It is proposed to store the printer signals which are

produced at the transmitter by any well known type of apparatus such as the Kleinschmidt or teletype machine, after being set up, at a central location in a printer storage device from which the signals are repeated to the multiplex equipment under control of a distributor. The Morse characters, however, are impressed on paper tape in the form of perforations, the tape being arranged to operate any suitable automatic telegraph transmitter such as the standard Wheatstone type, or Creed arrangement, from which the signals are sent to the multiplex distributor for transmission at predetermined intervals into the multiplex equipment.

The multiplex distributor and the printer storage device are controlled from a drive motor which is responsive to any suitable constant speed motor control unit of extremely high accuracy, while the automatic transmitters are under control of the motor control unit. In the system to be described later a specially designed brush and commutator device which is associated with the shaft of the drive motor is employed for this purpose. The distributor functions to assign the multiplex equipment and its associated communication circuit to the various individual signalling channels successively whereby only certain portions of the code signal units of each channel are assigned and transmitted and the remaining portions discarded.

At the receiver, the signals are assigned by a distributor, whose rate of speed is synchronized and phased by the incoming signals, to a special arrangement for rebuilding the discarded portions of the basic time units of each channel so that the signals are restored to their original character. Any suitable utilization circuit may be connected to the rebuilding device.

This particular method of communication by discarding portions of the signals and combining other portions from a plurality of channels has been found to be extremely confusing to unauthorized listeners, and thus results in a practical commercial secrecy arrangement.

An advantage of the present invention is that it lends itself readily for use with the Baudot-Verdan signal repetition scheme for overcoming fading, a scheme wherein signal characters are transmitted a plurality of times and only those signal characters which are received accurately a predetermined number of times are utilized to operate the receiving device. Such an arrangement of signal repetition is adequately described in United States Patent No. 1,677,062, granted July 10, 1928, to C. Verdan and L. M. J. Loiseau.

A further advantage resides in the use of a single high speed channel for accommodating several slow speed channels, a mode of operation which practice has shown to be the most economical way of handling commercial traffic.

In the drawings, Figures 1 and 2 illustrate transmitting and receiving systems, respectively, of a complete multiplex system in accordance with the present invention.

10 Referring to Figure 1 in more detail, there are shown three landline channels over one of which printer signals are transmitted and over the other two regular Morse signal characters of unequal length. The machines for transmitting the
 15 signals are located at some distance from the multiplex distributor equipment and are connected thereto by landlines herein indicated as 4, 5 and 6. Of course, if desired, the multiplex equipment and the transmitters may be located in
 20 the same building, the latter in the customary installation being located at some distance from the actual radio antenna equipment, herein designated as 7, and connected thereto by a landline, such as 8. For effecting signalling over
 25 channel 1 there is provided a printer 9 which may be of any desired type functioning with a signal code comprising a predetermined number of units of equal length. In the present case, it is preferred to use the well known teletype start-stop printer of the kind described by H. H. Harrison in his book on "Printing Telegraph Systems and Mechanisms", published by Longmans, Green & Company, London, 1923. This printer
 30 utilizes a start pulse, a stop pulse and a predetermined number of signal pulses, usually five, for the letter character, each of the latter pulses being equal to a dot length, a length which is used in the present invention as the basic unit. For transmitting the Morse signals over
 35 channels 2 and 3 there are shown automatic transmitters 10 and 11 which are controlled by perforated tape, the perforations in the tape being made in accordance with the desired signal characters, and by well known means, not shown. These automatic transmitters are of the Wheatstone type, although it will be obvious that, if
 40 desired, the Creed or similar apparatus may be employed. The rate at which the signals are transmitted from each of the machines 10 and 11 is determined by the respective motors 13 and 14, the latter, in turn, being under control of the multiplex equipment which functions to transmit alternate positive and negative pulses to the motor equipment over line 12. A brush and commutator arrangement on the common distributor
 45 drive shaft 15 provides a control frequency for the automatic transmitters 10 and 11, whose motors are thus held in absolute synchronism as regards speed and phase by the drive motor 16. Line 12 extending from the brush and commutator arrangement on the distributor shaft is in circuit with polar relays 17 and 18 which are respectively individual to the drive motors 13 and 14 of the automatic transmitters 10 and 11. The contacts of these polar relays, in conjunction
 50 with commutator and brush combinations on the shafts of the respective motors 13 and 14, which are similar in construction to that on the distributor shaft 15, act to hold the motors 13 and 14 to a constant speed and phase by cutting resistance in and out of the fields or the armatures of the motors, as shown. At the desired constant speed and phase, the automatic transmitters 10 and 11 will transmit the signalling pulses to the
 55 multiplex distributor 19 at the proper predeter-

mined intervals. The signalling speed of the printer or transmitter apparatus, however, should be equal to or an exact sub-multiple of the distributor speed of assignment to the individual channels.

The brush and commutator arrangement shown associated with motors 13, 14 and 16 merely comprises two full length insulated segments *a* and *b* and two half length insulated segments *d* and *e*, all of which are insulated from one another, as shown in the drawings. One of the half segments *e* is connected to a full length segment *a* and the other half segment *d* is connected to a full length segment *b* in such manner that individual brushes which are associated with the full length segmented portions are alternately connected through segments *d* and *e* to a third brush in circuit with the half length segments as the drive shaft revolves. In this manner, positive and negative pulses are transmitted from the multiplex driving unit over line 12 to the polar relays 17 and 18, causing these relays to vibrate and, in turn, to apply positive and negative pulses to their respective commutator and brush assembly units for controlling the speed and phase of the drive motor units 13 and 14. This method of control is well known in the art and is obvious from a mere inspection of the drawings. A somewhat similar method of motor control is described in United States Patent No. 1,829,420, granted October 27, 1931, to which reference is made for a more detailed explanation of the operation of the motor synchronizing scheme.

Although a single frequency control line 12 has been shown for both of the polar relays 17 and 18, it will be understood that, if desired, individual lines 12 may extend to each of the automatic transmitters, and such would be the case if the transmitters are separated from each other any appreciable distance.

As the central office, the printer signals arriving over line 4 are stored in any suitable printer storage device for retransmission into the multiplex distributor equipment over line 20 and segment 21, under control of the drive motor unit 16 whose shaft is herein shown connected to the storage device. The latter may be of any desired mechanical or electrical construction, although it is preferred to use electrical storage by means of condensers in a system such as is described in United States Patent No. 2,006,532, granted July 2, 1935, to John L. Callahan and Richard E. Mathes. In this latter system the printer signals are stored on condensers and the stored signals discharged through a suitable cam contact or distributor arrangement into the multiplex system at the proper time. The start and stop pulses are arranged to be supplied by the storage device.

The multiplex distributor 19 consists of any suitable means for assigning the various channels to the multiplex transmitting keyer equipment 24. In the arrangement shown in the drawings, the distributor comprises a plurality of segments 21, 22 and 23, each segment being individual to a channel, and a brush assemblage 25 adapted to sweep over the segments and to obtain therefrom the signal units or pulses transmitted by the land channel equipment. The brush assemblage 25, which is connected to multiplex equipment 24, is arranged to make one revolution for each dot length of the automatic transmitter equipment, this dot length comprising the basic unit which is equal in length to the individual unit pulse transmitted over the printer channel. In the

present instance, since a three channel circuit is shown, the distributor is arranged to supply to the multiplex transmitting keyer one-third of a dot length of each unit of signal received from the respective channels successively, thus throwing away the other two-thirds of the dot unit of each signal in each channel which is later restored by a rebuilding circuit in the receiver. The multiplex transmitting keyer equipment 24 which, in turn, actuates the radio transmitting equipment 27, is assigned to the successive channels 1, 2 and 3 and their respective landlines 4, 5 and 6, consecutively, for a time equal to one of these one-third dot portions.

It will be apparent from Figure 1 that although three channels are shown any number of channels may be used. For three channel working, clearly only one-third of each signal component is actually operative for each channel, and similarly for other numbers of channels. This manner of dividing the line time of the multiplex equipment into the various channels is described in great detail in United States Patents Nos. 1,979,484 and 1,963,587, granted to Richard E. Mathes to which reference is made. Although, for the sake of simplicity, it has been mentioned that one-third of a dot length of each unit is assigned to the transmitting keyer 24, actually it is preferred to use only a very small part of each one-third portion, and to discard the remainder of the dot length of each channel unit. This mode of operation has been found to increase the tolerance of variation permitted the signal due to fortuitous and bias distortion, noise, etc.

The multiplex transmitting equipment 24 functions to produce a composite signal composed of successive one-third dot length portions from the three channels consecutively. This equipment, with which the distributing brush assemblage 25 is connected, comprises, essentially, a locking circuit 26 and a tone keyer arrangement 28 for producing tone signals in transmission line 8 extending to the antenna equipment 7 which tone signals correspond to the composite signal received from the multiplex distributor 19. Locking circuit 26 consists, essentially, of two electron discharge devices 29 and 30 which have their anodes and their control electrodes resistively interconnected in a manner such that the apparatus has two degrees of electrical stability. These devices are unstable when both are drawing current, but stable when one tube is passing current and the other tube blocked, or prevented from passing current. The change from one condition of stable equilibrium, such as when device 29 is blocked and device 30 is passing, to the other condition when device 29 is passing and device 30 blocked, or the reverse, is caused by the presence of a suitable predetermined potential on the brush assemblage 25. That is to say, there exists a predetermined maximum anode current flow in one of the electron discharge devices and a predetermined minimum anode current flow in the other electron discharge device, or the reverse, at the same time. The change is controlled by potential applied to the input terminals of the devices; in this case, those obtained through the brush assemblage, and the change is very rapidly accomplished. By utilizing the current flow through one of the devices 29 or 30 the energization of the antenna 7 through the intermediary of the apparatus 28 may readily be controlled. This particular manner of controlling an antenna system by means of the multiplex equipment shown, comprising a locking circuit 26 and a tone keyer 28,

is adequately described in the literature relating to communication systems and, therefore, need not be further described herein. For a more amplified description of such manner of telegraph communication, however, reference is made to United States Patent 1,844,950, granted February 16, 1932 to J. L. Finch.

Referring now to Figure 2, the composite signals are received over any suitable type of antenna system, amplified, and detected in a well known manner, and then transmitted to the central office. It is preferred, in the present system, to use a diversity receiving antenna arrangement of the type which is described in United States Patent 1,874,866 granted August 30, 1932 to H. H. Beverage, et al. In this particular arrangement the signals are received over a plurality of geographically separated antennae, amplified, detected and combined in a suitable device for operating a tone keyer which is arranged to transmit audible frequencies which are interrupted in accordance with the received signal. These audible interrupted frequencies are fed from the antenna system into a landline 31 for transmission to the distant central office at which they are detected by apparatus 32, then passed through a suitable flow pass filter 33, herein shown in conventional form as comprising series inductance and shunt capacitance elements, before being applied to coupling tube 34 in circuit with the distributor apparatus 35. Filter 33 serves the purpose of smoothing out whatever tone components remain in the rectified signal in the output of rectifier 32.

Tube 34 and distributor 35 comprise, essentially, a coupling system for assigning the received incoming signals to their respective channels, and for enabling the received signals to be rebuilt to their original form as at the transmitting station whereby the suppressed portions of the transmitted signals are restored. Distributor arrangement 35 is driven by drive motor 36 which is held in synchronism with the multiplex distributor driving mechanism at the transmitting station, Figure 1, by means of correction unit 37, the latter, in turn, being controlled by the incoming signal. Associated with the individual segments of distributor 35 are condensers 38, 39 and 40 and locking circuits 41, 42 and 43 which are individual to the respective channels. These condensers may, if desired, be shunted by very high resistances 50 for improving the stability of the circuit. The locking circuits are of the type described in Finch United States Patent 1,844,950, supra, and function to operate suitable utilization means in the output circuits of the channels to reproduce the original signal characters transmitted, whether they are of the Morse or printer type. The particular manner in which the coupling device 34 and distributor 35 with the associated locking circuits function to reproduce the transmitted signal is described in United States Patent No. 1,995,181, granted March 19, 1935, to Alfred Kahn.

For maintaining drive motor 36 in synchronism, there is employed any suitable type of synchronous correction circuit which is under control of the received signals. It is preferred to use a synchronous arrangement which is controlled by the steep slope or wave front of the rectified signal for operating a correction motor. A system of this type is described in a copending application of R. E. Mathes, Serial No. 645,171, filed December 1, 1932.

If desired, a monitoring circuit, such as 44, may 75

be employed for observing the incoming composite signal after rectification, either before or after application of the signal to the coupling tube 34, depending upon the location of lead 46 which respect to the coupling tube 34. This monitor circuit may employ a coupling system similar to device 34, shown in the drawings.

The utilization circuits in the receiver for channels 2 and 3 are shown as ink recorders merely by way of example since it will be understood that any relay, printer, local tone oscillator, or other apparatus may well be used instead.

In the operation of the system, positive and negative five unit signal characters are transmitted from the printer apparatus 9 and stored in the printer storage device 3 from which, under control of the multiplex distributor 19, they are fed over lead 20 onto segment 21 which, in conjunction with segments 22 and 23 associated with automatic transmitters 10 and 11, is arranged to deliver to the multiplex system, as brush assemblage 25 sweeps over the segments, only a portion of the basic unit of each signal comprising the dot length, the remaining portion of the dot length unit being discarded. Multiplex distributor 19 is driven at constant speed under control of motor drive unit 16, the latter, in turn, functioning to control the rotating mechanism at the distant automatic Morse code transmitting stations. In this manner, all signals in the various channels remain under control of the multiplex distributor which assigns the multiplex equipment at predetermined intervals to each of the channels successively, for an interval equal to a predetermined portion of the basic dot length unit. The composite signal, composed of positive and negative pulses, received by the multiplex equipment 24 is utilized to control energization of the radiating antenna equipment 27. At the receiving end of the system the signals are picked up by a suitable energy collector, rectified, and the rectified portions of the composite signal applied to a coupling system which, in combination with a distributor 35, synchronously controlled by the incoming signals to rotate at a rate of speed the same as, and in phase with, the distributor of the transmitting station, allowing for time lag of the circuit, assigns portions of the received signal, which correspond to the portions obtained from the transmitting channel at the transmitting station, to the respective receiving channels where, through a suitable condenser and locking circuit arrangement, as shown, spacing and marking pulses are generated, similar in form and duration to those originally transmitted, to affect the respective utilization circuits.

Although the principles of the present invention have been described with special reference to the two unit code, i. e. positive and negative pulses, it will be apparent to those skilled in the art that the invention is not limited thereto, but that apparatus utilizing open and closed signals, or combinations of open and closed and positive and negative signals may be used, provided suitable well known coupling means are employed.

It will also be understood that any number of printers and/or automatic telegraph transmitters may be used in various combinations, and that these apparatuses may be located as near or far removed from each other and from the central office as is conveniently desirable.

If desired, auxiliary equipment may be utilized to transmit the same signal consecutively in accordance with the Verdant principle, supra, the

perforated tape being arranged to affect the different channels successively.

From the foregoing, it will be evident that numerous modifications may be made in the apparatus described in the present invention without departing from the spirit and scope thereof.

What is claimed is:

1. In a multiplex telegraph system, the method of signal communication which includes transmitting a message on one system of signals comprising certain combinations of impulses to form an alphabet, transmitting another message on another system of signals comprising different combinations of impulses to form the same alphabet, combining the message signals of said different signals to form a composite signal, transmitting the same, receiving said composite signal and breaking it down to form a plurality of messages corresponding with the individually transmitted message signals.

2. In a multiplex telegraph system utilizing printer apparatus functioning on a code of equal length signal characters and other apparatus functioning on a code having unequal length signal characters, and wherein the characters of the messages transmitted by both said printer and other apparatus are exact multiples of a fundamental unit length, the method of communication which comprises dividing the time of the multiplex channel equally among the different channels associated with the different apparatuses whereby each of the different channels has the multiplex channel assigned to it for a period of time equal at most to the longest period of which the duration of the individual signal unit characters forming the equal length code are exact multiples.

3. In a multiplex telegraph system the method of signal communication, which comprises generating a plurality of message signals corresponding to the number of channels in the system, at least two of said message signals having different codes, one having equal length characters and the other unequal length characters, dividing the successive basic time units of the message characters of each channel into equal portions of like number as the total number of channels used and transmitting a composite signal formed by combining equal portions from the successive channels consecutively.

4. In a multiplex radio telegraph system the method of signal communication by means of different codes, one of which has unequal length characters and another of which has equal length characters, which comprises generating a plurality of message signals corresponding to the number of channels in the system, dividing the successive basic time units of the message characters of each channel into equal portions of like number as the total number of channels used and transmitting, by electromagnetic waves, the composite signal formed by combining equal portions from the successive channels consecutively and discarding the remaining portions of the basic time units, subsequently receiving said electromagnetic wave composite signal, rectifying the same, and utilizing the rectified signal to restore the individual message signals of each channel.

5. In a multiplex telegraph system wherein the dot mark of the individual channel is used as the fundamental time unit, the method of signal communication by means of printer apparatus utilizing a predetermined number of signal units of the fundamental time unit length to form each letter character, and transmitter apparatus uti-

lizing unequal length dot and dash signal units, which comprises generating signals corresponding to the individual messages for each of the channels, dividing the successive message fundamental time units of each channel into equal portions of like number as the total number of channels used, and transmitting a composite signal formed by combining equal portions from the various channels consecutively.

6. In a multiplex system, the combination with printer apparatus for transmitting characters composed of multiple signal units of fundamental time duration and automatic transmitter apparatus for transmitting characters composed of marking and spacing signal units of unequal length, said marking and spacing units being exact multiples of said printer signal units, of multiplex equipment, distributor apparatus in said equipment for assigning said multiplex equipment to said printer and transmitter apparatus successively and to each for a period of time equal at most to the longest period of which the duration of the fundamental time unit is an exact multiple of the number of channels, whereby only equal portions of the fundamental time unit from the printer and automatic transmitter channels are obtained consecutively and the remaining portions of the fundamental time unit discarded, said multiplex equipment being arranged to form a composite signal by combining said portions obtained from said channels, and circuit means for transmitting said composite signal.

7. In a multiplex system, the combination with printer apparatus for transmitting marking and spacing signal characters of fundamental time unit length and automatic transmitter apparatus for transmitting marking and spacing signal characters of unequal length, said latter characters being exact multiples of the printer signal unit characters, of multiplex equipment and distributor apparatus for assigning said multiplex equipment to said printer and transmitter apparatus for periods of time equal at most to the longest period of which the duration of the fundamental time unit is an exact multiple, whereby only equal portions of the fundamental time unit from the printer and automatic transmitter channels are obtained consecutively and the remaining portions of the fundamental time unit discarded, said distributor apparatus being adapted to control the rate of transmission from said automatic transmitter apparatus and the rate of receipt of the printer signals from said printer apparatus, said multiplex equipment being arranged to form a composite signal by combining said portions obtained from said channels, and circuit means for transmitting said composite signal.

8. A multiplex system in accordance with claim 6, characterized in this, that the signals transmitted from said automatic apparatus comprise positive and negative pulses.

9. In a multiplex telegraph system, the method of signal communication which includes transmitting message signals of a particular code over a landline, transmitting signals of another code over a second landline, combining both types of signals to form a composite signal, and transmitting said composite signal over a third line.

10. In a multiplex telegraph system, the method of signal communication which includes transmitting printer signals of the five-unit code over one channel, transmitting Morse code signals

over another channel, and combining both types of signals to form a composite signal.

11. In a multiplex telegraph system, the method of signal communication which includes transmitting printer signals of the five-unit code over one channel, storing the printer signals, transmitting Morse code signals over another channel, and subsequently combining the stored printer signals and the Morse code signals to form a composite signal.

12. In a multiplex telegraph system, the method of communication which includes transmitting multiple equal length code character signals over one channel, transmitting unequal length code character signals over another channel, the code characters of both signals being integral multiples of a basic unit, dividing the successive basic units of the message characters of each signal into equal portions of like number as the total number of channels used, transmitting a composite signal formed by combining equal portions from the successive channels consecutively and discarding the remaining portions of the basic units.

13. In a multiplex telegraph system, the method of communication which includes transmitting signals of one telegraph code over one channel, transmitting signals of another telegraph code over a second channel, the signals of both codes being comprised of characters which are exact multiples of a basic unit, and assigning a common multiplex channel equally among the individual channels over which signals are transmitted and to each individual channel for a period of time equal at most to the longest period of which the duration of the basic unit is an exact multiple of the number of channels.

14. In combination, a telegraph printer, an automatic telegraph transmitter, a multiplex distributor, a multiplex channel, individual connections from said printer and transmitter to said distributor, signal storage means located between said printer and said distributor and under control of said distributor, said distributor functioning to assign said multiplex channel at predetermined intervals to said printer and automatic telegraph transmitter.

15. In combination, a telegraph printer, an automatic telegraph transmitter, a continuously rotating multiplex distributor, a drive shaft for rotating said distributor, segments on said distributor individual to said printer and automatic telegraph transmitter, a multiplex channel, individual connections from said segments to the printer and transmitter respectively, signal storing means located between said printer and said distributor, said storage means and said automatic transmitter being synchronized from said drive shaft, said distributor functioning to assign said multiplex channel at predetermined intervals to said printer and automatic telegraph transmitter.

16. In a multiplex telegraph system, the method of signal communication which includes transmitting a message signal on one code, transmitting another message signal on another code, discarding portions of the signals from each code, combining the remaining portions of the different codes to form a composite signal, transmitting the composite signal, receiving said opposite signal and breaking it down to separate the message signals forming the different codes, and restoring the discarded portions of said signals.

17. In a multiplex system, the method of communication which includes transmitting a mes-

- sage signal on one code, transmitting another message signal on another code, dividing the time period of transmission for each of said message signals into a plurality of sequentially recurring periods each of a duration no greater than the time duration of the briefest signal to be transmitted, combining selected portions of the signals from said two codes, and transmitting only said selected portions.
- 10 18. In a multiplex system, the method of communication which includes transmitting a message signal on one code, transmitting another message signal on another code, dividing the time period of transmission for each of said message signals into a plurality of sequentially recurring periods each of a duration no greater than the time duration of the briefest signal to be transmitted, combining selected portions of the signals from said two codes, and transmitting only said selected portions, receiving signals corresponding to said selected portions, breaking down said received signals into the different selected message portions of the two codes, and restoring the latter to have periods of time corresponding with those of the original message signals prior to division and selection at the transmitter.
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