

Aug. 16, 1949.

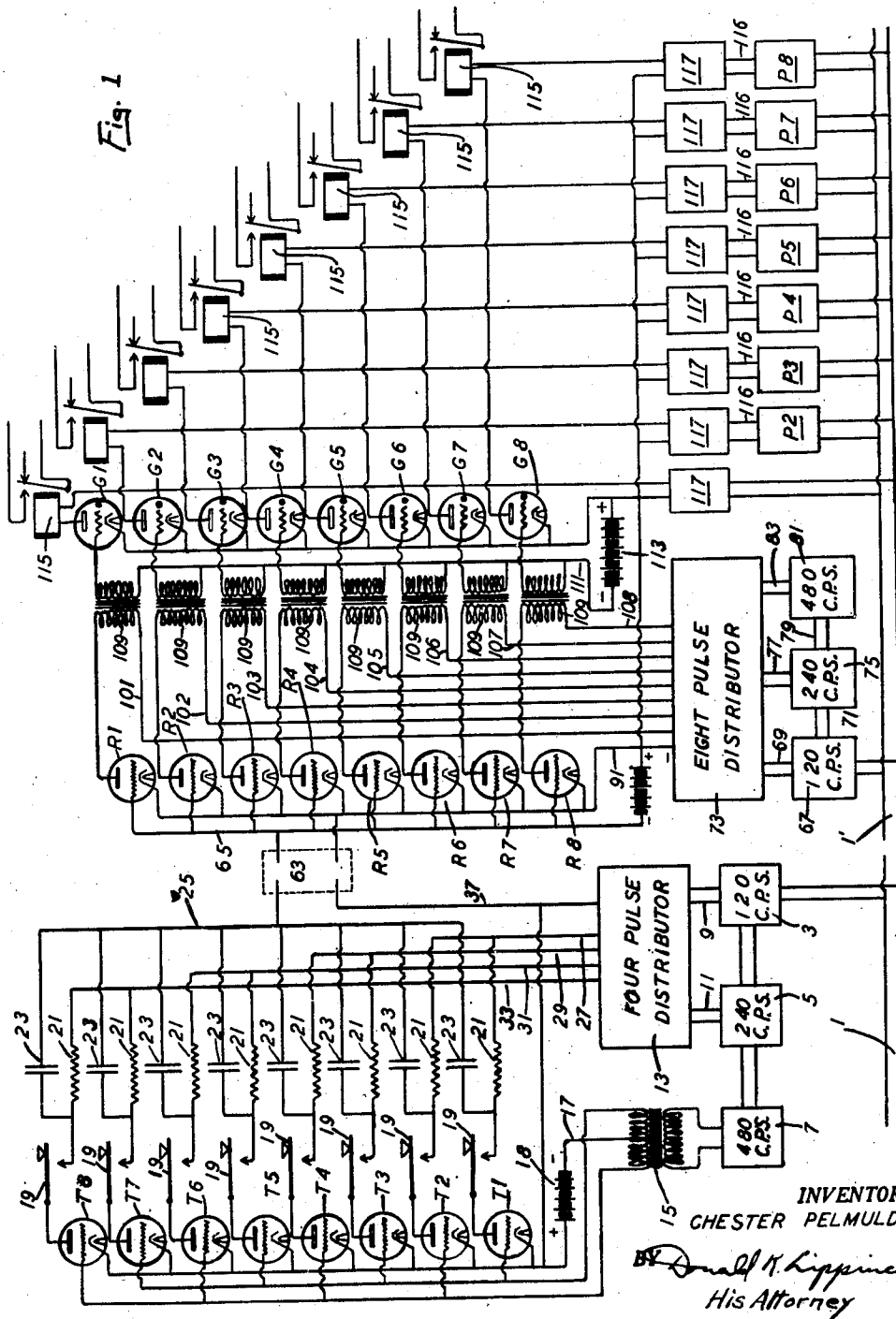
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2,479,020

MULTIPLEX SIGNALING SYSTEM

Filed Sept. 2, 1947

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

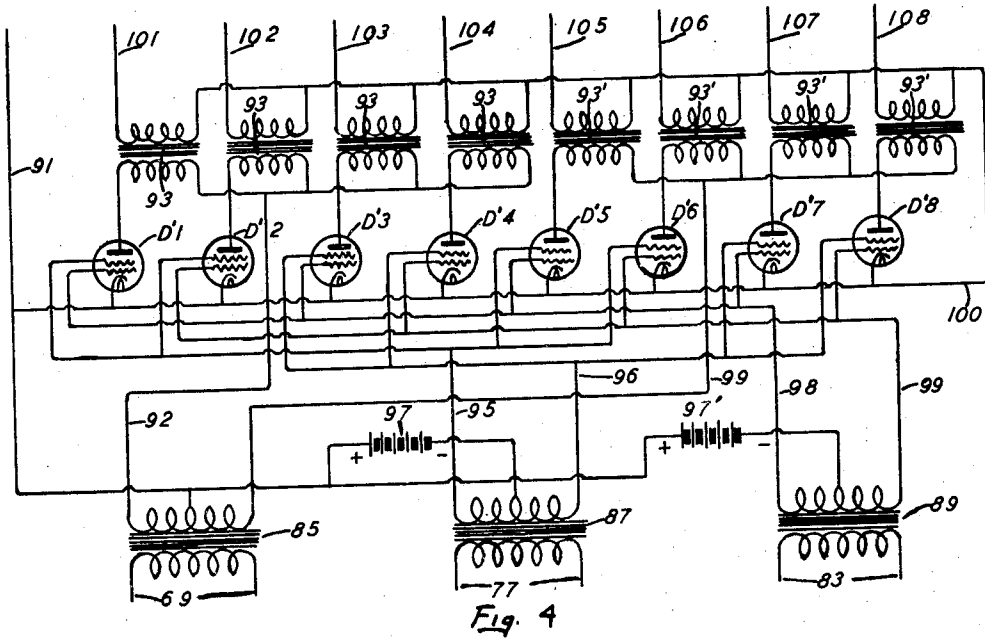


Fig. 4

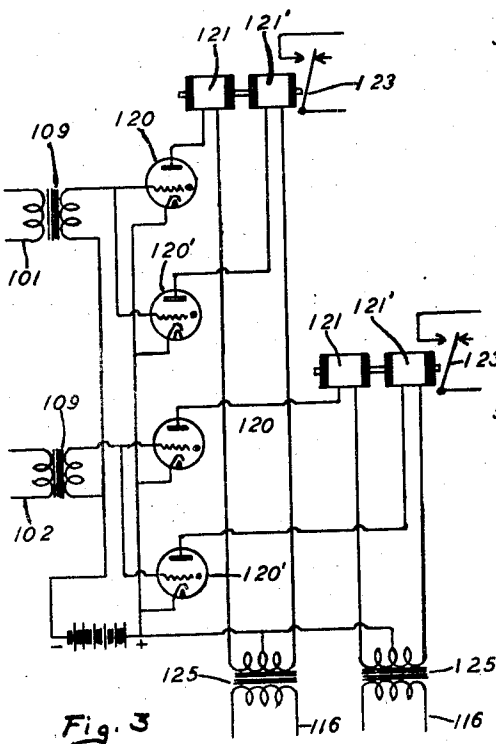


Fig. 3

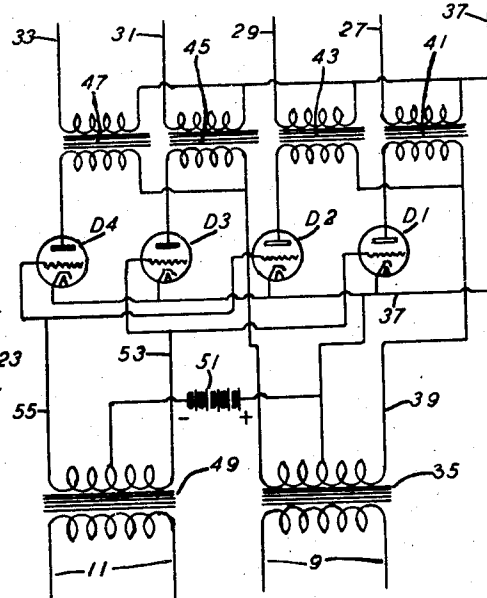


Fig. 2

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4 Sheets-Sheet 3

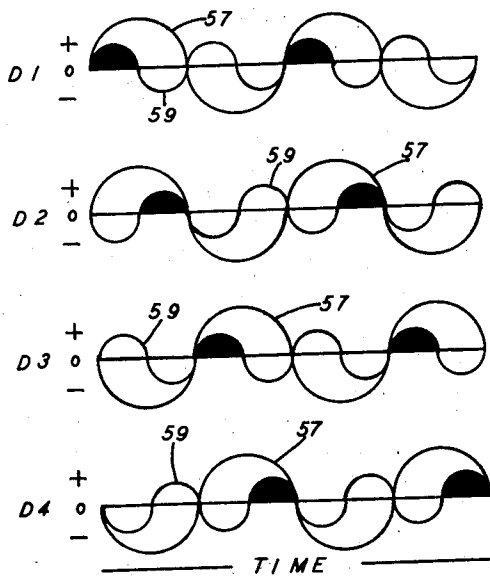


Fig. 5

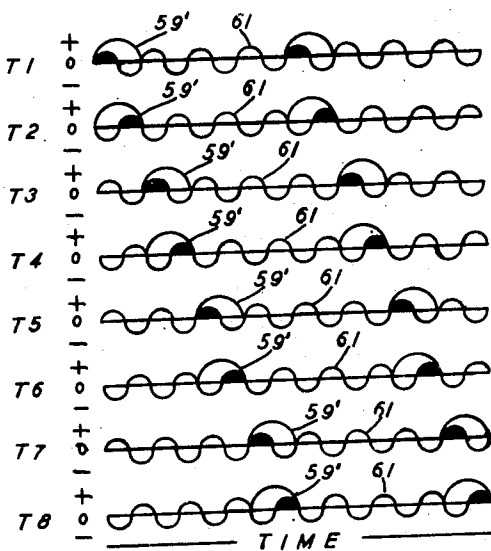


Fig. 6

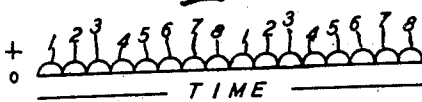


Fig. 7

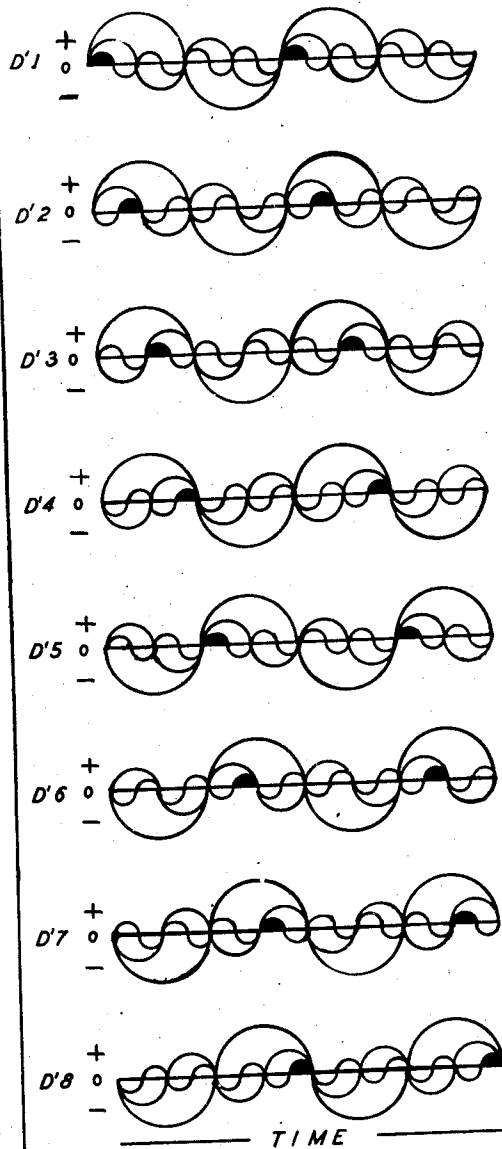


Fig. 8

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4 Sheets-Sheet 4

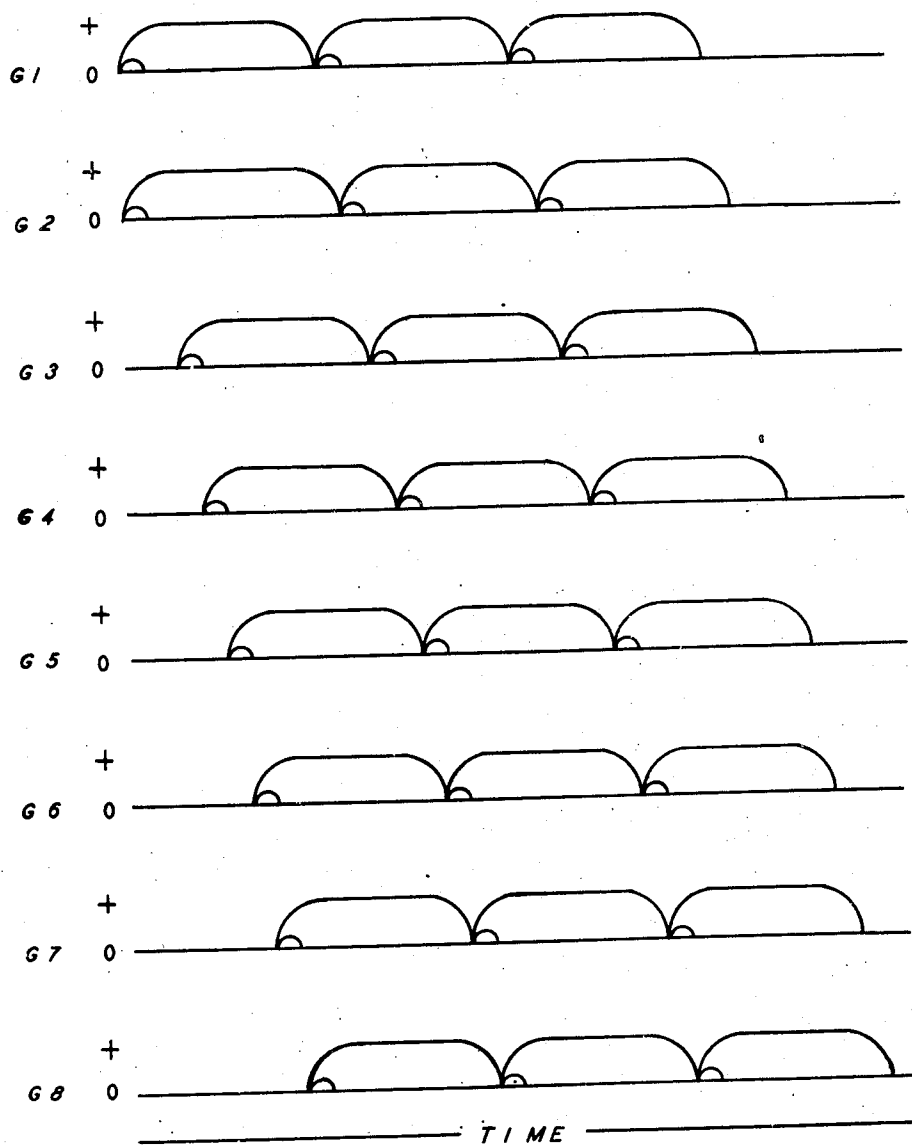


Fig. 9

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UNITED STATES PATENT OFFICE

2,479,020

MULTIPLEX SIGNALING SYSTEM

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Application September 2, 1947, Serial No. 771,633

9 Claims. (Cl. 177-353)

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This invention relates to multiplex signaling systems, that is to say, systems whereby signals originating from a number of separate sources can be mixed and transmitted over a single communication channel, whether by wire or radio, and sorted out at the receiving end so that the signal from a specific source arrives at one and only one destination, and is unaffected by the other signals which may have been transmitted over the same link.

Such systems are best known in connection with multiplex telegraphy, but they have many other uses. Among such uses are remote control, whereby signals designed to accomplish a number of different functions, such as, for example, operating the rudder, ailerons, and elevator of an airplane, as well as the throttle and pitch control of the propeller, are desired to be transmitted over the same channel. Another example is supervisory operations, wherein it is desired to transmit the readings of a number of different meters to a distant observation point. There are many other applications, and the system disclosed herein is applicable to substantially all of them.

So-called "time division" systems of multiplexing are well known. In such systems the transmission time is divided into a number of discrete periods cyclically repeated, each period being allotted to a separate channel and the cycle repeating itself indefinitely. The instant invention falls within this general class.

Among the objects of my invention are to provide a multiplex system wherein the time division is wholly electronic, so that there are no mechanical limitations, due to inertia or the like, imposed upon the system. Another object of my invention is to provide a system in which the number of channels is practically unlimited; still another object of my invention is to provide a system which is equally applicable to radio or wire communications; and a further object of my invention is to provide a system which, considering the number of channels which may be handled, is relatively simple and inexpensive.

Other objects and advantages of my invention will be mentioned or will become apparent by reference to the following specification, taken in connection with the appended drawings, wherein:

Fig. 1 is a circuit diagram, partly in block form, of an eight-channel transmitting and receiving system constructed in accordance with this invention;

Fig. 2 is a circuit diagram of a four-pulse distributor, used in connection with the transmitting portion of Fig. 1;

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Fig. 3 is an alternative output circuit which may be substituted for a portion of the circuit shown in Fig. 1;

Fig. 4 is a circuit diagram of an eight-pulse distributor, such as is used in the receiving portion of the system shown in Fig. 1;

Fig. 5 is a wave diagram, showing the permutations of a primary frequency and a doubled frequency each in direct and reversed phase relationship, which is applicable to the explanation of Fig. 2;

Fig. 6 is a similar diagram showing the permutations obtainable after an additional frequency doubling, which is applicable to the explanation of the transmitting portion of Fig. 1;

Fig. 7 is a wave diagram showing the sequence and relative duration of the signal pulses which may be generated by the transmitting portion of Fig. 1;

Fig. 8 is a wave diagram of the same general character as Figs. 5 and 6, showing the action of the eight-pulse distributor in Fig. 4;

Fig. 9 is a wave diagram illustrating the reconstruction of substantially continuous currents from the instantaneous pulses generated as illustrated in Figs. 5 through 8.

The operation of this invention is based upon the unidirectional conducting characteristic of vacuum tubes. More precisely, it may be said to depend upon the multiple unidirectional characteristic, for there is for each element in a vacuum tube a cut-off potential which is usually zero for the anode and may be zero, positive, or negative for the other electrodes, depending on the tube characteristics. When the electrode is positive with respect to the cut-off potential the tube will carry current; when it is negative with respect to this potential it will not carry current. The tube will carry current only if all of the electrodes within it, with the exception of the cathode, are positive with respect to this cut-off potential.

Suppose, now, we take a group of such tubes (say four) and supply one set of electrodes of each of them with alternating current at some primary frequency, phasing the connections so that one-half of the electrodes are positive during the first half cycle and the other half of the tubes have their electrodes positive during the second half cycle. We now supply a second set of electrodes within each of the tubes with alternating current at double the primary frequency, again exciting one-half of these electrodes in one phase and the other half in the opposite phase, but we permute the phasing of the dou-

bled frequency so that a positive half cycle will be applied to one tube whose other electrode is positive and to one whose other electrode is negative.

There will thus be, for each half cycle of the doubled frequency, only one tube which will carry current. If all of the tubes have their outputs connected into the same circuit, and if all are excited, the result, in that output circuit, will be a continuous succession of pulses, transmitted without interruption. If, on the contrary, we open the output circuit, or otherwise key the tubes so that only one tube is operating at a time, the result will be a succession of pulses occurring regularly, but spaced by three-quarters of a cycle of the primary current. A similar set of pulses will be sent out no matter which of the tubes is in operation, but the epoch of the cycle of the primary frequency at which the signal is sent out will differ for each tube.

If, now, we increase the tubes to eight, or double the original number (all tubes containing an additional electrode), and apply to this extra electrode alternating current of redoubled frequency, similarly permuting all applied frequencies as between the tubes, we will obtain a series of eight pulses for each cycle of the primary frequency, each pulse being one-half as long, but each unique as to the epoch in which an individual tube transmits its pulse.

This process can be continued almost indefinitely. There is a limit, of course, to the number of electrodes which can satisfactorily be used in any single tube, but by connecting tubes in series, either directly or effectively through a transformer or other coupling means, the number of electrodes can be effectively increased as far as may be desired. With each effective addition of an electrode the number of pulses per cycle of the primary frequency can be doubled.

Consider next a similar set of tubes having their control electrodes connected in parallel, and having additional electrodes, either within the tubes themselves or effectively in series therewith, similarly supplied by alternating currents of primary and multiplied frequencies which are synchronous with the supply currents of the first set of tubes.

This second set of tubes has separate output circuits, in which individual translating devices may be connected. It should be apparent that each tube of this second set will be operative by the pulses transmitted by one and only one of the first set of tubes. The pulses conveyed by the second set of tubes to the translating devices will, of course, be short, and only occupy a portion of the total time of transmission. By including in each output circuit, between the receiving tubes and the translating devices, a grid glow tube, the anode circuit of which is excited by a base current with a frequency one-half that of the primary frequency, the pulse passed by the receiving tube can be made to fire the grid glow tube and the discharge of this tube will continue for the full half cycle of the base frequency, at the end of which time another pulse will arrive from the corresponding transmitting tube if it is still being keyed. The result is an almost continuous succession of pulses which continues as long as the corresponding transmitting tube is keyed, and, if desired, the slight fluctuations in this pulsating direct current can be disposed of as will be described hereinafter.

Viewed from another aspect the anode-cathode circuit or work circuit of a grid-controlled

vacuum tube, when operated with each electrode therein, including the anode, biased to cut off when all other electrodes are at their maximum positive potential with respect to the cathode, may be considered as a circuit having a plurality of switches in series therein so that all must be closed if current is to flow in the circuit. From this point of view the anode and grid or grids are all switching elements, operative to open when negative or zero, and close when positive.

My invention may therefore be considered broadly as comprising a plurality of work circuits, each including a plurality of switching elements in series, each operative to complete its portion of the circuit when actuated by one-half of an A. C. cycle and to open the circuit on the other half of the cycle. When each of the switching elements is actuated by a different frequency, the frequencies being integrally related and permuted as to phase combinations between the different work circuits, each such circuit will pass current during but one-half cycle of the highest of the frequencies applied in each cycle of the lowest. My invention comprises so applying such frequencies.

Carrying this concept further, the invention includes additional switching elements in each work circuit with which it may be keyed. The additional element may be a mechanical keyer, as at a transmitter, or it may be an additional grid at either transmitter or receiver. In the complete system the additional switching elements are separately actuated at the transmitter and the work circuits are connected to a common output circuit. A like system of work circuits is provided at the receiving end and is supplied with alternating currents of the same frequencies, synchronized with those supplying the transmitter, the additional switching elements are all connected for actuation by the common output circuit of the transmitter, and the various work circuits feed individual translating devices.

This latter concept of the invention is valuable in that it brings out clearly that a fundamental of the invention is the operation of the multiplex time-division circuits by phase coincidence between a plurality of integrally related frequencies, permuted between the various circuits, rather than the specific connections used to affect the permutations or even the type of switching elements used, for the latter may be mechanical, as, for example, vibrating reeds.

Fig. 1 is an over-all diagram of a system illustrating my invention. In this figure a supply line 1 furnishes the original frequency, which will be taken, for purely illustrative purposes, as being the ordinary commercial 60 cycles. The line 1 feeds a series of frequency doublers which will not be described in detail since numerous types are known in the art.

The lowest frequency is identified herein as the base frequency and the output of the first doubler, which in this case would be 120 cycles, is identified as the primary frequency. It is to be understood, however, that instead of arriving at the various frequencies by the process which has been described, it may be the higher frequency that is originally supplied, and the primary and intermediate frequencies which are also well known in the communication art. In such a case there would be no need for a base frequency for the operation of the transmitter shown in Fig. 1, but it would

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still be required for operation of the receiver. What is desired, for the operation of this invention, is currents of integrally related frequencies, however they are obtained, and the method of generating them shown here is chosen merely because it is often the easiest and is well understood.

The first doubler 3 converts the 60 cycles into 120 cycle current. This is fed to a second doubler 5, which converts the 120 cycles to 240 cycles and thence to a third doubler 7, converging the 240 cycles to 480. Frequency doublers 3 and 5 also feed, through lines 9 and 11 respectively, a distributor 13 which will be described below. Doubler 7 feeds its 480 cycle current to the primary of a transformer 15.

This transformer has a center tapped secondary winding. The lead 17 from the center tap connects through a biasing source 18 (which may be omitted in certain types of tubes which operate at cut-off with zero grid bias) to the cathodes of a group of eight transmitting tubes, numbered T1 to T8 inclusive. One side of the secondary connects to the grids of one-half of the tubes, namely, those designated by odd-numbered reference characters; the other side of the transformer secondary connects to the grids of the even-numbered tubes.

Keying means 19 is provided for each of the tubes. In the present instance this is shown as a hand-operated key which interrupts the plate circuit of the tube, but this is only for illustrative purposes, since the other circuits may be broken or shorted in any of the well-known methods of keying vacuum tubes, and the hand-operated key may be, instead, a printer telegraph or other more complicated device. Each of the tubes is provided with an individual plate resistor 21, the upper end of which is coupled through a blocking condenser 23 with a common output circuit 25. The other ends of the plate resistors 21 are connected in successive pairs, through the leads 27, 29, 31 and 33 respectively, to the distributor 13, which will next be described.

The distributor 13, as shown in Fig. 2, comprises four triodes or distributor tubes, numbered D1 to D4 inclusive. The plates of these tubes are supplied with 120 cycle current from the line 9 through a transformer 35, having a center tapped secondary whose neutral is connected through the line 37 to the common cathode circuit for all of these four tubes. One end of the secondary of transformer 35 connects through a lead 39 to the primaries of two transformers, 41 and 43, connected in parallel, and thence to the anodes of tubes D1 and D2. The other end of the secondary of transformer 35 connects similarly to the primaries of transformers 45 and 47 and to the anodes of tubes D3 and D4.

The grids of the four distributor tubes are fed with 240 cycle current from the line 11 through a transformer 49. A center tap on the secondary of this transformer connects through a biasing battery 51 to the cathode circuit 37. One end of the secondary connects through line 53 to the control electrodes of tubes D1 and D3. The other end of the secondary of transformer 49 connects through line 55 to the grids of D2 and D4.

Fig. 5 is a diagram of relative potentials illustrating the result of these connections. The figure comprises four sets of curves, each set being numbered to correspond with the distributor tube to which it refers. It will be noted that curve 57, representing the 120 cycle wave, is applied in positive polarity to tubes D1 and D2, and in negative polarity to tubes D3 and D4, the

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polarity being defined arbitrarily as being the polarity of the first half cycle of the two complete cycles of 120 cycle current chosen for illustration. Curves 59 are illustrative of the potentials applied to the grids of the same tubes. It will be noted that there is only one-half cycle of the 240 cycle current in each cycle of the 120 cycle current when both grid and plate of any one of the four tubes are positive (as is indicated by the shaded portions of the curves) and it is only during this half cycle of the 240 cycle current that this tube will be conductive. Furthermore, no two of the tubes are conductive at the same time, but if all are excited they each send out their pulses in succession. The first pulse of the succession, from tube D1, goes out through line 27 and (provided the respective keys are closed) to the plates of tubes T1 and T2. The second pulse, from tube D2 to line 29, can supply the plates of tubes T3 and T4, the third pulse tubes T5 and T6, and the fourth and last pulse tubes T7 and T8.

Fig. 6 comprises sets of curves illustrating this. The curves corresponding to each of the tubes T1 through T8 are distinguished by the characters in the margin. The pulses arriving at the plates of the respective tubes are designated by the reference characters 59'. The grid of each of these tubes is continuously excited by a 480 cycle current as illustrated by the curves 61. Two tubes at a time are excited by the pulses 59', but of these two tubes one has its grid positive while the other has its grid negative, and accordingly only one will transmit at a time. The shaded areas of the curve indicate the epochs at which each tube can send out its pulse, and it will be seen that there is only one-half cycle of the 480 cycle current during each cycle of the 120 cycle current when any one of the tubes can transmit, and that each of the eight tubes T1 to T8 goes through this epoch in succession.

If all of the keys 19 are depressed at the same time the result is a continuous succession of pulses going into the common output circuit consisting of lines 25 and 37. Failure to depress any one of the keys results in a gap in this succession of pulses. Anywhere from 0 to 8 pulses can go out onto the line in each cycle of the 120 cycle current, depending upon the number of keys which are depressed, and the position of these pulses with respect to the 120 cycle current will depend upon which key is depressed. Fig. 7, which is in scale with the other diagrams, illustrates these transmitted pulses with all keys closed.

The block 63 in Fig. 1 represents a transmitting link. This can be a wire line or a radio link. If radio, it can be amplitude modulated or frequency or phase modulated, or (what is practically the same thing as a frequency modulated link) it can be a frequency shift transmitter of the type which has of late years become common in transmission practice. The link 63 can be assumed to include the usual radio transmitting and receiving equipment, since this factor is not included as part of this invention but is a matter of the prior art.

Whatever the mode of the transmission of the pulses may be, they are applied through a common receiving circuit 65 to the grids of a series of tubes, R1 through R8, connected in parallel. The plates of these tubes are pulsed successively in synchronism with the excitation of the corresponding transmitting tubes T1 to T8, and since only the tube which is being pulsed at the in-

stant of arrival of the pulse from the transmitting tube will carry current, this determines which of the circuits operates.

This pulsing is accomplished by frequency multiplying and distributing circuits which are the same in principle as those used in the transmitter. The base frequency is supplied through the line 1'. For some services this line may be supplied from a common source as the line 1, but for others this is not feasible. In such cases there are known means of keeping circuits in isochronism over long periods, and any of these may be applied.

Various methods are available for making the circuit self-synchronizing; i. e., of utilizing the received pulses themselves to hold the circuits in step. For the purposes of the present invention, however, it is enough to state that the circuits are isochronous in the sense that the pulses as received from the transmitter arrive in step with the pulses applied to the plates of the respective tubes, and this requires that the current supplied through the line 1' must not only be of the same frequency, identically, as that supplied through line 1, but also must be in phase, due account being taken of the phase delay due to the transmission time of the signals.

The base frequency from line 1' is fed to a doubler 67, which supplies 120 cycle current to lines 69 and 71. Line 69 feeds into a distributor 73. Another portion of the output of doubler 67 feeds through the line 71 to a second doubler 75 which delivers its 240 cycle current in part through line 77 to the distributor 73 and in part through line 79 to a third doubler 81, supplying 480 cycle current through line 83 to the distributor 73.

Each of the lines 69, 77, and 83 feeds the primary of a transformer 85, 87 and 89 respectively, as is shown in Fig. 4. The secondary of each of these transformers is center tapped to a common line 91 connecting to the cathodes of the tubes D'1 to D'8 inclusive. One side of the secondary coil of transformer 85 connects, by lead 92, through the primaries of a series of transformers 93 to the plates of four distributor tubes D'1 to D'4 inclusive. The other side of the secondary of transformer 85 connects in a like manner to the plates of tubes D'5 to D'8 inclusive, through the primaries of a similar series of transformers 93'.

One side of the transformer 87 connects through leads 95 to the second grids of tubes D'1, D'2, D'5 and D'6. The other side of the secondary of transformer 87 connects through lead 96 to the second grids of tubes D'3, D'4, D'7 and D'8. The proper bias can be applied to all of the second grids by means of a suitable source 97 connected between the center tap of the transformer secondary and lead 91.

The secondary of transformer 89 is connected to the first grids of the various tubes, one side connecting through lead 98 to the first grids of tubes D'1, D'3, D'5 and D'7, and the other side connecting through lead 99 to the first grids of D'2, D'4, D'6 and D'8. Bias for all of the first grids may be provided through a source 97'.

Fig. 8, which is of the same character as Figs. 5 and 6, shows the resulting coincidence in circuits of the respective tubes of the positive potentials which permit their excitation in various epochs of the 120 cycle current cycle, the shaded area in each curve indicating the only periods, during the two successive cycles shown, within which the respective tubes are excited.

One side of each of the secondary coils of the transformers 93, 93' is connected through a common lead 100 to the cathodes of the distributor tubes (and thence to lead 91 connecting to the cathodes of the receiving tubes.) The other side of each of these secondaries connects through leads, numbered 101 to 108 inclusive, to the primary of a corresponding output transformer, each of which is designated by reference character 109, and thence to the plate of one of the corresponding receiving tubes R1 to R8, which are thus excited in synchronism with the signal pulses from the transmitting link 63.

One side of the secondaries of the output transformers 109 are connected through a common lead 111 to a biasing source 113, and thence to the cathodes of a plurality of grid controlled glow discharge tubes numbered G1 to G8 respectively, the other sides of the secondaries being connected individually to the grids of these tubes.

The anode of each of the grid glow tubes connects through a translating device, here indicated as a relay 115, to a full wave unfiltered rectifier 117. The first of these rectifiers, feeding tube G1, can be fed directly from the line 1' with base frequency current of 60 cycles. The remainder of the rectifiers 117 are supplied through leads 116 from phase shifting networks P2 to P8, which rotate the phase of the base frequency current by successive steps of $22\frac{1}{2}$ degrees, so that as supplied to each of the tubes G1 through G8, the beginning of the half cycle of supply current corresponds with the instant of initiation of the pulse which will excite that particular tube. As a result, a momentary pulse supplied to the grid of one of the glow tubes (say G1) will fire the tube. Cessation of the pulse will not cause discharge through the tube to cease, since the discharge will be transferred to the anode of the tube and will continue until near the end of the half cycle, when the anode's potential drops to zero. (The rectifier is unfiltered so that this will occur.) The translating device or relay 115 is not, therefore, excited merely by the extremely short pulse from the transmitter, as passed on by the tube R1, but current continues to flow through it during a full half cycle of the base frequency current.

If desired, the relay may be given a slight delayed action so that it will not release immediately upon cessation of current through it. This will permit a succeeding pulse from the transmitting tube again to fire tube G1, before the relay releases, thus holding it closed without interruption as long as the series of transmitted pulses continues. The delay in the action of the relay may be made very slight, so that the relay will release in a very small portion of the half base-frequency cycle if no pulse is forthcoming.

Fig. 9 shows the timing of the current flow through each of the tubes G1 through G8. The instantaneous drop of the current to zero after each half cycle of the base frequency is without effect on the slow acting relays.

Fig. 3 shows an alternative arrangement for the output circuits of the tubes R1 to R8, which does away with the necessity for separate full-wave rectifiers feeding each of the gas tubes. In this case two gas tubes are used in the output of each of the receiving tubes. The drawing shows only two of the transformers 109, those fed by leads 101 and 102. Each of the transformers 109 is connected to the control electrodes, in parallel, of two grid glow tubes 120 and 120'. The anodes of these tubes connect to the respective windings 121 and 121' of a double wound relay 123. These

windings are excited from the two ends of the center tapped secondary of a transformer 125. The transformers 125 are fed with base frequency current from the leads 116. The phase rotating networks P2 to P8 are required by all but one of the translating circuits in this case, as in the case of Fig. 1.

This latter arrangement differs from that first shown primarily in the fact that tubes 120, 120' act as their own rectifiers, and one or the other of these tubes will fire, depending upon which half of the cycle obtains at the instant the firing impulse arrives. Because each anode swings negative for half of each cycle there is no possibility of the discharge "hanging on," as is possible in the form first described, which makes operation more certain. The current diagram of Fig. 9 illustrates the timing of the output currents exactly as in the case of the first figure.

It will be understood that the system shown in the drawings is subject to many modifications. Transformer couplings are shown, but it is well understood that many circuits exist which are equivalent for the purposes shown. Transformer couplings may be replaced by resistance-capacity couplings, inductance-capacity couplings, or even by direct coupled tubes. It is convenient to put the lowest frequencies on the plates of the distributor tubes, and the multiple frequencies upon the grids, but this is not necessary; if desired, the lowest frequency could be put upon the control grid and the highest frequency upon the plate. Any other combination may be used. The plate circuits, however, require the greatest power, and it is generally easier and more economical to obtain this power when fewer doublings have been used.

As shown, the frequency is doubled before it is fed to the distributor, since this permits substantially continuous flow in the output circuit, utilizing each half of the base frequency waves. In certain circumstances, however, half cycle operation may be sufficient and in such cases the initial doubling is unnecessary.

It has already been pointed out that it is immaterial whether the permutations of the base frequencies and the doubled frequencies occur in the same tube or in a succession of tubes which are effectively in series. Thus the four-pulse distributor 13 plus the tubes T1 to T8 are effectively the equivalent of the eight-pulse distributor 73. So considered, the receiving tubes R1 to R8 are the equivalents of the keys 19. By taking advantage of such equivalence, the number of doublings and re-doublings of frequencies may be continued practically indefinitely, and the number of channels doubled with each doubling of the frequency, with standard types of tubes having only a normal number of grids. Moreover, it is not necessary that the frequency multiplication be obtained by doubling; triple frequencies can be permuted in the same general manner, and so, if desired, can other multiple frequencies, the number of permutations possible by these expedients being a matter of simple mathematical computation.

It has already been indicated that the keys 19 of Fig. 1 are symbolic, and that printer telegraph circuits can be substituted for the hand keyed circuits. There are two general methods of employing this invention to operate printing telegraph systems and other similar devices. One or the other of these methods may be used exclusively, or the two methods may be combined in a single system. A considerable variety of

multiplex systems can thus be devised within the limits of the useable signal and base frequencies.

The first of these methods uses a single channel, for the entire operation of the printer, by means of which the coding pulses are transmitted and received in succession. This first method is comparable, for each channel, to methods that have been used heretofore on ordinary metallic circuits. To ensure positive action of the apparatus, when this method is used, the base current, which furnishes power for the plates of the grid glow tubes, must alternate with a frequency sufficient to permit the occurrence of several half cycles during each coding pulse. A sixty-cycle base current will meet this requirement for speeds up to sixty words per minute using a five or six unit code, but the base frequency should be increased for higher speeds.

The second system uses a different channel to transmit and receive each of the coding pulses that go to make up any character or action the system is capable of handling. Five channels are therefore required for a five unit printer, six channels for a six unit printer, and so on. The output of each channel is used to directly control each permutation bar of the printer receiving unit. A concerted action of the permutation bars may be obtained since, although the short transmitted pulses occur in succession, the longer output pulses, from the grid glow tubes, can be arranged so that they have a simultaneous existence of sufficient duration for selection of the desired characters or action.

The base current in these systems can be of such a low frequency that a single one-half cycle will complete the operation required to select any character or action and, in systems that have more than eight channels, even shorter pulses may be employed on the plates of the grid glow tubes. By the use of additional channels, printers can be equipped to handle any number of characters within the limits of mechanical utility. The channels of a system can also be divided among a number of printers, depending upon the extent to which they have been made available by doubling and re-doubling. Such expedients as these, however, are not directly related to the instant invention, on which I desire as broad protection as possible within the scope of the following claims.

I claim:

1. In a multiplex signalling system, means for supplying alternating potentials at a plurality of integrally related frequencies, a plurality of vacuum tube means, each such means including at least one cathode and a plurality of other electrodes, and passing current only when each of such other electrodes is positive with respect to its mean operating potential, and circuits for applying all of said alternating potentials to each of said vacuum tube means, each potential being applied between a cathode and one other electrode of said vacuum tube means, the phases of said potentials being permuted between the various vacuum tube means so that all of said other electrodes of any one thereof are positive during only one-half cycle of the highest frequency so applied in each cycle of the lowest frequency, and this occurs with respect to a different vacuum tube means for each half cycle of the highest frequency.

2. Receiving equipment in accordance with claim 1 including a common input circuit for each of said vacuum tube means, an additional

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electrode in each such means which must be positive with respect to its mean operating potential when said vacuum tube means passes current, and a separate output circuit for each of said vacuum tube means.

3. Receiving equipment in accordance with claim 1, including a common input circuit for each of said vacuum tube means, an additional electrode in each such means which must be positive with respect to its mean operating potential when said vacuum tube means passes current, a separate output circuit for each of said vacuum tube means, a grid controlled glow discharge tube connected for control by each of said output circuits, means for supplying alternating current to each of said glow discharge tubes at one-half the frequency of the lowest frequency mentioned in claim 1, and a translating device supplied by said last mentioned current through said glow tube.

4. A distributor for multiplex signalling systems comprising a plurality of multi-electrode vacuum tubes, each including a cathode, an anode, and at least one control electrode, means for supplying alternating current at a plurality of integrally related frequencies, and circuits for applying each of said frequencies between the cathodes and one of the other electrodes of each of said tubes, said circuits being connected to apply said frequencies to corresponding electrodes of each of said tubes, one-half in one phase and one-half in opposite phase, and so to permute said phases between the tubes that all phases are in positive coincidence with respect to the cathode of but one of said tubes at a time.

5. Apparatus comprising a distributor in accordance with claim 4, a second plurality of vacuum tubes greater in number than the tubes of said distributor, each of said second tubes having an anode, a cathode and a control electrode, the anode and cathode of a pair of said second tubes being connected for supply by each of said distributor tubes, and means for supplying an alternating current of an additional integrally related frequency in opposite phases to the control electrodes of each of said pairs of tubes.

6. In a multiplex signalling system, distributor means comprising a source of alternating current of a base frequency, means for driving from said base frequency at least one other integrally related frequency, a plurality of multi-electrode vacuum tubes each having a cathode, and other electrodes including an anode and at least one control electrode, and circuits for applying each of said frequencies between the cathodes and one of said other electrodes of a pair of said tubes in opposite phase, said frequency being so permuted between said tubes so that all of said other electrodes of one only of said tubes is positive in any

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one half cycle of the highest of said frequencies and all of said other electrodes of each of said tubes are positive at some time within each cycle of the lowest of said frequencies.

7. In a multiplex signalling system, distributor means comprising means for supplying base-frequency alternating current, frequency doubling means actuated by said current for supplying alternating current at a plurality of higher harmonics of said base-frequency currents, a plurality of vacuum tubes each comprising a cathode and a plurality of other electrodes including an anode and at least one control electrode, circuits for applying each of said harmonic frequencies in opposite phase between the cathodes and the other electrodes of pairs of said tubes, said harmonics being permuted between the tubes so that all of said other electrodes of one only of said tubes is positive at any one time and all of said other electrodes of each of said tubes is positive during some portion of each half-cycle of said base frequency; separated grid-glow tube means connected for excitation from the anode of each of said vacuum tubes, circuits for supplying each of said grid-glow tube means with successive half-cycles of said base-frequency current in positive phase, and a work circuit connected in the output of each of said grid-glow tube means.

8. Apparatus in accordance with claim 7 wherein each of said grid-glow tube means comprises a single tube, and including a full wave unfiltered rectifier for supplying said grid-glow tube with rectified base-frequency current.

9. Apparatus in accordance with claim 7 including phase-shifting means included in the circuits for supplying said grid-glow tube means with base-frequency current, whereby the current supplied thereto falls to zero at a predetermined epoch with respect to the half-cycle of harmonic frequency at which the tube so supplied is excited.

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