Aug. 23, 1932. R. H. RANGER 1,873,785

TUBE COMMUTATOR

Filed April 11, 1928 2 Sheets-Sheet 1

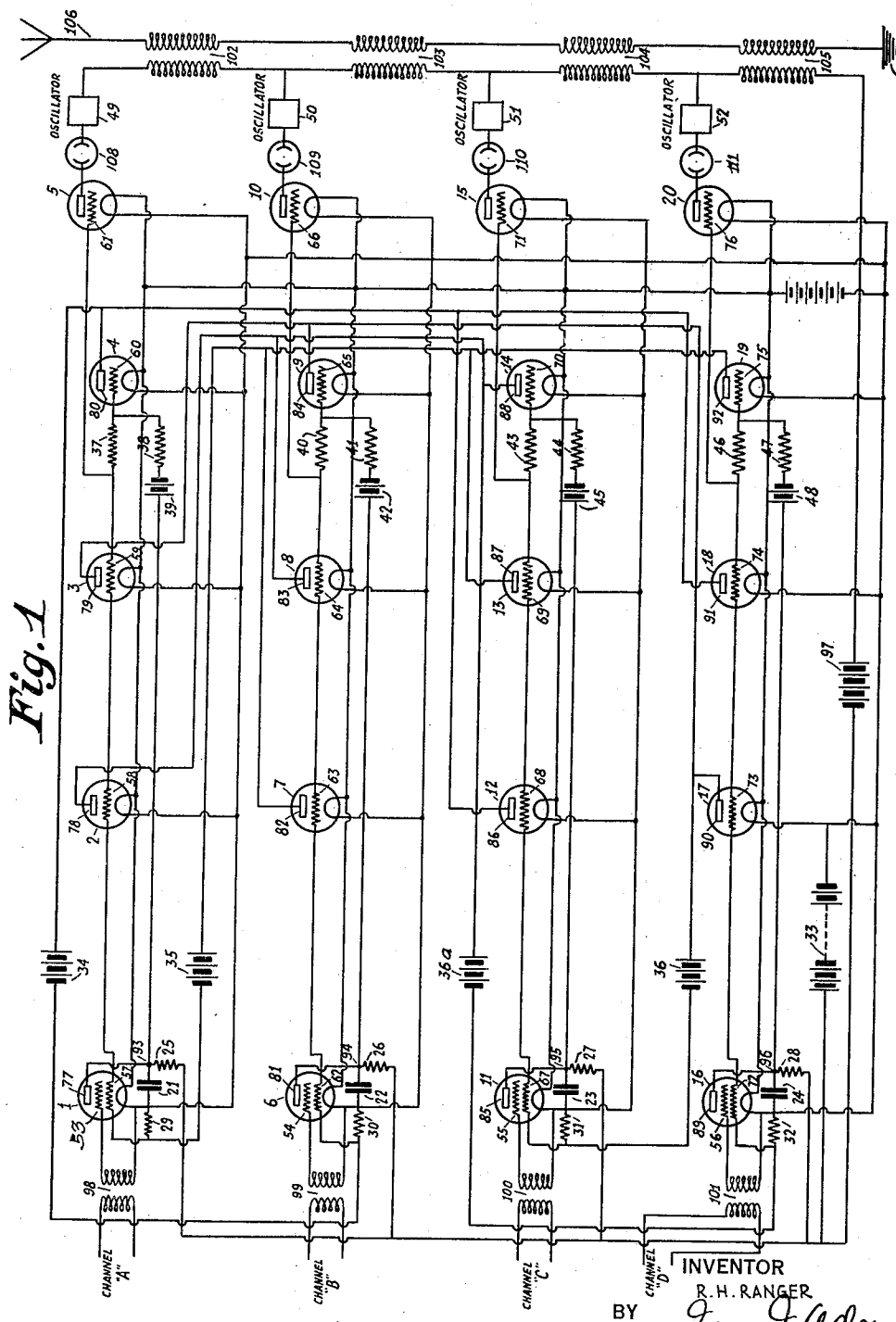

Fig. 1

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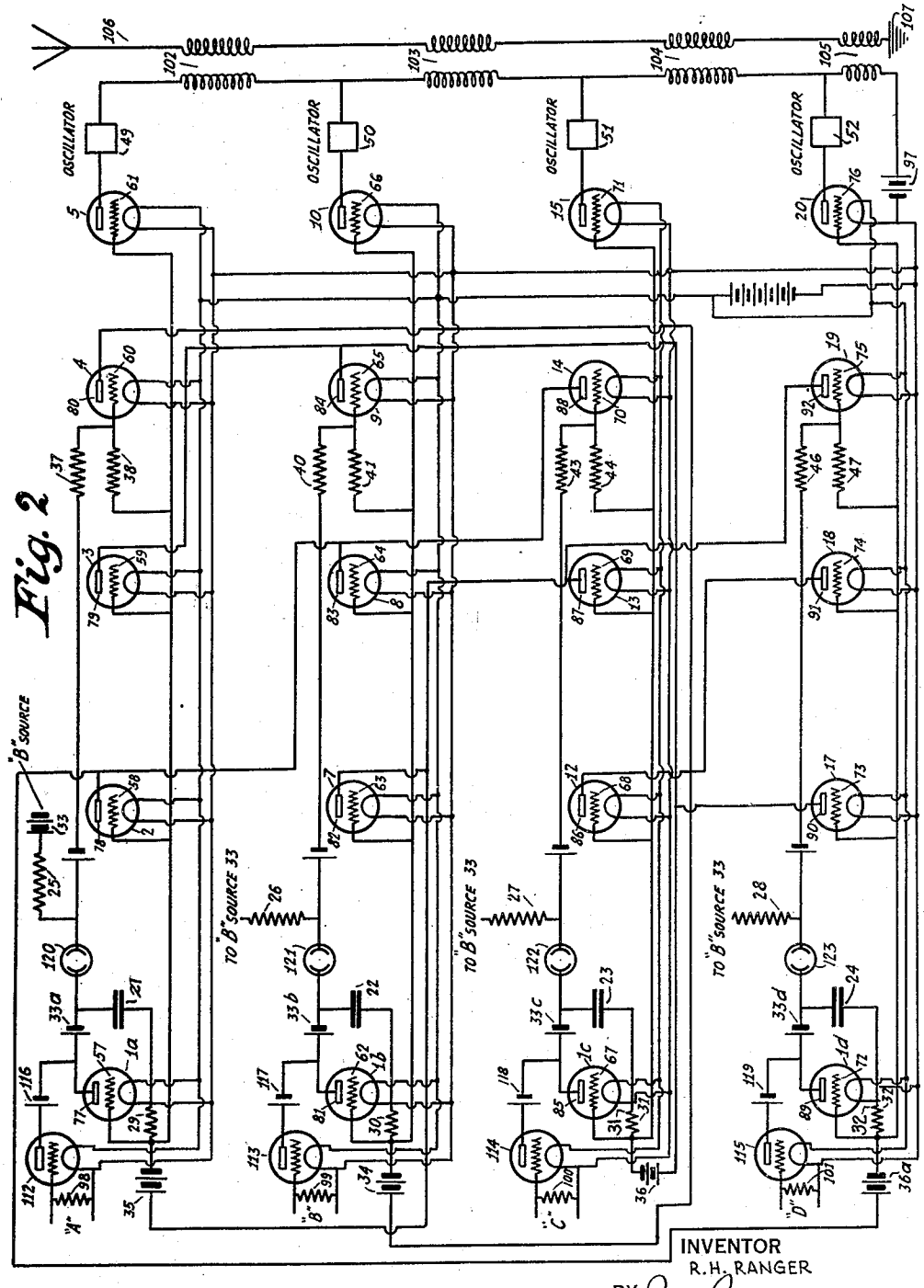

Fig. 2

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UNITED STATES PATENT OFFICE

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TUBE COMMUTATOR

Application filed April 11, 1928. Serial No. 269,099.

The present invention relates to signalling systems and particularly to signalling systems wherein a plurality of signals are to be transmitted, and to a method and means for multiplexing the various signals for transmission.

A principal object of my invention is to provide a tube commutator system whereby it is possible to utilize only vacuum tubes for commutation in a system for either picture of facsimile transmission, multiplexing or for television on a multiple wave communication system.

A further object of my invention is to produce a commutator system wherein it is possible to transmit pictures or facsimile or to utilize the system for television or a plurality of speech communications on a plurality of separate electro-magnetic waves, in which the commutation, or switching from one signal channel to another, is accomplished by means of delayed action vacuum tubes without the use or aid of any mechanical or moving parts.

A still further object of my invention is to provide a system for multiple channeling of communications in which it is possible to work with speeds of communication heretofore impossible with any arrangements depending for their operation upon mechanical commutation.

A still further object of my invention is to provide a system in which the messages or facsimile are transmitted in a far less interrupted manner than is possible with mechanical commutation, since with the latter it has always been necessary to stop the transmitting arrangement at frequent intervals for the purpose of changing the brushes on mechanical commutators.

A still further object of my invention is to provide a tube commutating system for utilizing a plurality of bands of different frequencies for wire or radio communication, in which the tube commutating system is absolutely and totally independent of the use of any relays for accomplishing the channeling or switching from one frequency to another.

A still further object of my invention is to control the time elements in the several channels of communication which may be preferably accomplished by the use of condensers charging through vacuum tubes and preferably having their discharge rate accentuated or retarded by reason of the character of the signal pulse or by a neon lamp, or any other type of glow discharge lamp which is found suitable, for aiding or retarding the rapid discharge of the condenser and speeding or slowing the time of passage of electrical impulses through each separate channel.

A still further object of my invention is to provide a tube commutator, or rotary oscillator, in which the time period of signalling through each channel is regulated, so that if only one channel has a signal at the particular instant it may utilize practically the entire time available for all channels irrespective of the other channels in the commutating system, in contrast to schemes heretofore known, where the time was divided equally between all of a series of separate communication channels.

Still a further object of the invention is to provide an arrangement whereby it is possible to utilize a plurality of frequencies in the transmission of pictures, facsimiles, speech or code, or a television system and to provide at the same time a system which readily adapts itself to the combining of the separate messages into a joint or finished message at a receiving point.

Still a further object of my invention is to provide an arrangement for tube commutation wherein it is extremely easy at any time to increase the number of communication channels without the necessity of changing or altering the arrangement as initially set up, but by merely making additions to the original set-up.

A still further object of my invention is to provide an arrangement wherein great ease of maintenance is experienced.

Other objects of my invention will appear after a consideration of the following description taken in connection with the accompanying drawings, and when the accompanying drawings are read in connec-

tion with the appended claims. However, the invention also has for its objects those of providing a tube commutating device which is simple in its construction and arrangement of parts, a system which is durable, compact, very efficient in the use of the time for signaling available, a system which is conveniently operated, readily set up, and a system which may be installed at a minimum of expense, as well as a system which is highly capable of meeting the conditions of the future by its feature of readily adapting itself to the enlargement of the number of signaling channels used.

The novel features which I believe to be characteristic of my invention are set forth in the appended claims. The invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof will best be understood by reference to the following description read in connection with the accompanying drawings wherein:

Fig. 1 represents one adaptation of my tube commutating system to a system using four separate channels of communication and in which the signals of the separate channels are introduced in the system through multiple grid connecting or modulating tubes. Although, as shown, the system is applied to four signal channels, it will be readily seen how the number could be increased to any number desired; and,

Fig. 2 is a modification of Fig. 1, in which only the usual three electrode tubes are used.

To consider the arrangement shown by Fig. 1 of the drawings, it is believed best to consider first the several channels for introducing the separate signals into the commutator which are indicated broadly as "A", which is composed of the tubes 1, 2, 3 and 4; "B", which is composed of the tubes 6, 7, 8 and 9; "C", which is composed of tubes 11, 12, 13 and 14; and lastly, as shown by the drawing, "D", which includes the tubes 16, 17, 18 and 19. Each of the separate channels A. B, C and D feed their outputs into separate amplifiers 5, 10, 15 and 20 respectively.

Now making specific reference to channel "A", let it be first considered that the grid members 57, 58, 59 and 60 of the tubes 1, 2, 3 and 4 are all positive as well as the grid 61 of the tube 5, although the functioning of the tube 5 will bear no relationship at present, so far as the description of the various signal channels is concerned, to the operation of my commutator arrangement for multiple channeling. At time periods when each of the grids above named are positive each of the separate tubes in channel A tends to pass plate current. The plate 77 of tube 1 is supplied with plate voltage from a source of high potential 33, the plate 78 of tube 2 is energized from a source 36*a*, the plate 79 of tube 3 is energized from a source 36, and, lastly, the plate 80 of tube 4 is energized from a source of high potential 34. Under conditions when each of the separate tubes are passing plate current, and for the time being it will be unnecessary to consider the action of the grid 53 upon the tube 1 of channel A, the tube 1 tends to pass current and the condenser 21 which is connected across the filament and plate lead to this tube has stored up energy so that at the time the tube tends to pass plate current the condenser 21 will tend to discharge due to the sudden rush of current through the tube 1. At this time the point of connection of the resistance 25, which is a very high resistance and is connected in the leads from the plate source 33 supplying the plate 77 of tube 1 with a certain definite plate potential, will tend to become negative with respect to its previous value due to the voltage drop occurring through the resistance and the fact that the condenser 21 is being discharged.

At the same time that tube 1 has its grid 57 positive the grids 58, 59 and 60 of tubes 2, 3 and 4 which are connected to grid member 57 will also be positive, and each of the tubes 2, 3 and 4 will likewise tend to pass plate current. As the tube 4 commences to pass plate current a negative potential is applied to the grid 62 of the tube 6 in channel "B" by reason of the voltage drop in the grid resistor 30 of the tube 6 of channel "B" because tube 4 is drawing current from the plate source 34 which has its return connection through the filament of tube 6, and similarly the tube 3 drawing current from source 36 tends to cause the grid 67 of tube 11 of channel "C" to become negative by virtue of the resistance drop in the grid resistor 31 of tube 11, and the tube 2 drawing current from source 36*a* causes the grid 72 of tube 16 of channel D to become negative by virtue of the resistance drop across the grid resistor 32 of tube 16. This negative potential applied to the grids 62, 67 and 72 of the first tubes 6, 11 and 16 of channels B, C and D, respectively, causes a similar negative potential to be applied to the grids of all the tubes in these respective channels because the grids of the various tubes in each channel are connected. This negative potential cuts off the flow of plate current in all the tubes so that the output of each separate channel excepting A is cut off.

As has been above stated, as soon as the tube 1 commences to pass plate current the condenser 21 is discharged due to the tendency for a heavy rush of current to pass through tube 1 and a voltage drop occurs across the heavy resistance 25 connected in series with the plate source 33 which carries the point 93 to a negative value with respect to the potential which it had an instant be-

fore. At this time the small "C" battery 39 acting through the resistance 38 is strong enough to control the voltage on the grid 60 of the tube 4 so that the grid 60 is carried to a relatively negative potential with respect to its previous potential. Under this condition the current flow through the tube 4 is decreased.

The tube 4 receives its plate current through a source of potential 34 which also connects to the grid resistor 30 of the tube 6 and, as the filaments of all tubes are in parallel, is effectively connected with the filament of tube 4. Upon a decrease in the flow of plate current through tube 4, the grid 62 of the tube 6 is swung positive with respect to the previous potential because of the decrease in the plate current flow from plate 80, source 34, resistor 30 and the filament of tube 6, resulting in a decrease in voltage drop through resistor 30. Consequently, the grid 63 of the tube 7 which is directly associated with grid member 62 will also become positive with respect to the previous potential and the tube 7 will tend to pass plate current through the plate member 82, the source of plate potential 35, grid resistor 29 of tube 1 and the filament of tube 1. Upon such a condition, the grid 57 of the tube 1 will tend to become negative by virtue of the fact that the end of the grid resistor 29 of the tube 1 has changed from a positive to a negative value due to the fact that plate current is being drawn through the tube 7 from the battery 35. This will tend to make the grids 57, 58, 59 and 60 of tubes 1, 2, 3 and 4 respectively all more strongly negative and will, therefore, tend to cut down the plate current drawn by the tube 4 even more strongly than under the condition when the condenser 21 was discharged and the point 93 had assumed a negative value. This action of channel B drawing plate current will, therefore, function as a locking feature for stopping the action of channel "A" and, as can be seen, the time of action is governed in accordance with the rate of discharge of condenser 21.

As the tube 6 tends to draw plate current from source 33 due to the fact that the grid number 62 has become positive by reason of the decrease in the flow of the plate current through the tube 4 and the locking action of tube 7 on channel "A", and since the grids 63, 64 and 65 of tubes 7, 8 and 9, have likewise become positive through connection to grid 62 of tube 6, each of the tubes in channel "B" will commence to pass plate current. In channel "B" the tube 7 draws its plate current from source 35, the tube 8 draws its plate current from the source 36*a* and the tube 9 draws its plate current from the source 36 and, as before stated, the tube 6 draws its plate current from the source of "B" or plate potential 33. Due to an action in channel "B" of discharging of condenser 22 which is similar to the discharging of condenser 21 in channel "A" and the voltage drop in the resistance 26, connected in series with the plate 81 of the tube 6 and the B source 33, the point 94 becomes negative with respect to its previous potential and by a similar action to that above described in connection with channel "A", the "C" battery 42 acting through the resistance 41 is now in control of the potential on the grid 65 of the tube 9 and carries the same negative, so that the flow of plate current through the plate 84 of tube 9, plate source 36, grid resistor 31, the filament of tube 11 and thus the filament of tube 9 is decreased, under which condition the grid 67 of the tube 11 in channel "C" commences to swing toward a strong positive value, due to the fact that the grid resistor 31 at the point of connection to the grid 67 of the tube 11 is no longer negative since no voltage drop is occurring therethrough. This, therefore, will likewise effect the grid members 68, 69 and 70 of the tubes 12, 13 and 14 respectively, and, as can be readily seen after considering the above description as regards the operation of channels "A" and "B", at the time when the tube 12 of channel "C" tends to pass plate current by virtue of the fact that the grid member 68 has become positive through its connection to grid 67, the grid 62 of tube 6 of channel "B" has become negative due to the fact that the tube 12 is drawing plate current from the source 34. The current flow through tube 6 will decrease and, by virtue of the fact that the grids 63, 64, and 65 of tubes 7, 8 and 9 of channel "B" immediately swing negative at the time when the tube 12 is drawing plate current from source 34, the flow of plate current through tube 9 is further decreased so as to carry the grid 67 of tube 11 of channel "C" even more positive than at first. In a similar manner it is easily seen that the grid 57 of tube 1 of channel "A" is likewise strongly negative since the tube 13 is drawing plate current from the source 35 connected between the grid resistor 29 of tube 1 and the plate member 87.

Under similar operating conditions to those of signal channels "A" and "B", at the time when tube 11 of channel "C" tends to pass plate current by reason of the fact that the grid 67 has become positive due to a decrease in voltage drop in grid resistor 31, the condenser 23 is discharged and, for similar reasons to those previously stated as regards channels "A" and "B", the point 95 becomes strongly negative with respect to its previous potential. This negative potential when acting through the "C" battery 45 and resistance 44 tends to swing the grid 70 of the tube 14 negative with respect to the potential previously acting thereon. Therefore, the tube 14 immediately has its plate current flow cut down and, for similar reasons to those above stated, the grid 72 of tube 16 of channel "D"

is carried toward a positive value, since the point of connection of the grid 72 to the grid resistor 32 has turned a positive value upon the tube 14 ceasing to draw plate current from source 36*a*. Similarly, therefore, the grids 73, 74 and 75 of the tubes 17, 18 and 19 of channel "D" have likewise all swung positive, and under this condition the tube 17 is drawing plate current from the source 36 and the grid 67 of tube 11 in channel "C" is, therefore, placed at a negative value because the point of connection of the grid resistor 31 to the grid 67 of tube 11 has become negative. Similarly, tube 18 at once commences to draw plate current from the source 34 and holds the grid 62 of tube 6 at a negative value for the same reason and tube 19 drawing plate current still holds the grid 57 of the tube 1 at a negative value by reason of the fact that plate current is being drawn from the source 35. For similar reasons to those above stated, as soon as the tube 16 tends to draw plate current the condenser 24 is discharged and the point 96 which is connected with the "B" source 33 through the resistance 28 assumes a negative value which places the grid 75 in control of the "C" battery 48 acting through the resistance 47, and the grid 75 is swung to a negative value. As the grid 75 swings to a negative value the tube 19 has its plate current flow substantially decreased and, therefore, the point of connection of the grid 57 of tube 1 to the grid resistor 29 is swung to a relatively positive value because none of tubes 7, 13 or 19 are drawing plate current from source 35. Therefore, the grids 58, 59 and 60 of tubes 2, 3 and 4 are again positive and channel "A" will once more start to function. However, as soon as channel "A" starts to function, the tubes 2, 3 and 4 pass plate current and it may, therefore, be similarly shown by reference to the description above that the tube 2 will control the grid 72 of tube 16 to maintain it at a negative value, because tubes 2, 8 and 14 each draw plate current from source 36*a* connected to the grid resistor 32 of tube 16. Similarly the tube 3 will control the grid 67 of tube 11 to maintain it at a negative value since tubes 3, 9 and 17 all draw plate current from source 36 connected with the grid resistor 31 of tube 11 and the tube 4, which together with tubes 18 and 12 draws plate current from the source 34 connected to the grid resistor 30 of tube 6, will control the grid 62 of tube 6 to maintain it at a negative value until such conditions occur that the condenser 21 is discharged in the manner first described and the grid 62 is carried to a positive value.

It is, therefore, seen that this system functions alternately and successively to switch from one channel to another and that the rate of switching will be totally dependent upon the rate of discharge of the respective condensers 21, 22, 23 and 24 associated with the tubes 1, 6, 11 and 16 of channels "A", "B", "C", and "D" respectively.

Now that I have described in considerable detail how it is possible to switch from one channel to another at any predetermined rate of speed solely governed by the discharging of various condensers of which the capacity is appropriately chosen, I will endeavor to describe how it is possible to distribute the time of operation of each channel, so as to set forth clearly the fact that each channel need not, of necessity, work an exact proportion of the total time available, but may have its time of operation varied in accordance with whether signals are on a particular channel or not.

It is desirable now to consider the action of the secondary grid members 53, 54, 55 and 56 and the tubes 1, 6, 11 and 16, respectively. Each of these secondary grids are connected to a signaling circuit, of any desired or appropriate type, through transformers 98, 99, 100 and 101, or, if desired, through any other suitable coupling such as resistance, impedance, capacity coupling and the like. If it is assumed that the arrangement is being used for facsimile reproduction, it is a well known fact that the greater part of any facsimile is composed of what is known as the "white" portion in contrast to the "black" portion, as in the case of a positive print. Therefore, during periods when the white portion of a facsimile is being transmitted it is desirable to maintain the fastest action through each separate channel over which the white impulsess are passed and, therefore, lose less time and make other channels available for a relatively longer period of time for the marking of the black picture impulses. In accordance with the arrangement disclosed, for a white portion of a facsimile the grid members 53, 54, 55 and 56 are swung quite strongly positive, relatively speaking, to the previous potential, and this condition substantially aids the tubes 1, 6, 11 and 16, respectively, to pass a heavy plate current. Consequently the condensers 21, 22, 23 and 24 associated with channels A, B, C and D and connected with tubes 1, 6, 11 and 16, respectively, are discharged substantially immediately upon the secondary grid members becoming positive, whereas for the black portion of the picture the time action should be slightly slower. Therefore, any black impulses in the system, which are produced by black marks on the facsimile, tend to swing the grids of the various tubes, heretofore described, less positive (which is practically equivalent to a negative value). Therefore, there is a far less influence to a sudden heavy rush of plate current through the first tube of each channel, and the channel consequently functions in a slower or delayed manner because the condensers are not obliged to give up their charge so rapidly.

It may thus be seen, if it is assumed for the moment that channel "A" is the only one that has a signal, or in other words the only channel over which a black portion of the facsimile is being transmitted, that the grid 53 of tube 1 in channel "A" is less positive and nearer a zero potential than the grids 54, 55 and 56 of tubes 6, 11 and 16 of channels "B", "C" and "D" respectively. Therefore, the action of the signal passing through channel "A" is somewhat retarded or delayed, but the action through channels B, C and D is considerably speeded up, due to the fact that the condensers associated with each of these latter channels are discharged almost instantaneously and the tubes of the other channels controlled by the various tubes of each of the channels are, in effect, blocked so that the minimum of time is lost, but in channel "A" the time, of course, is somewhat lengthened, due to the fact that the grid 53 of tube 1 is far less positive and the discharge of condenser 21 less rapid.

Therefore, according to my scheme it is possible to arrange this system, so that if channel "A", or any other separate channel, is the only one that has a signal upon it, that it may utilize approximately 97% of the time available, and the remaining 3% of the time is equally shared between the remaining three channels, as channels "B", "C" and "D". If it is assumed that both channels "A" and "C", or any other two channels, have signals, or in other words are both subjected to black impulses on the facsimile, then channels "A" and "C" would share 98% of the time equally and the remaining 2% of the time would be equally shared between the other two channels, as channels "B" and "D". If all four channels are being used, then each channel would share 25% of the time. It will be noted, therefore, from the above description that considerable time gain and efficiency is accomplished by this type of rotary oscillator or commutator and that this gain may be more easily visualized by noting that the use of an ordinary commutator with only one signal line being energized provides for the use of only 25% of the available time on that channel, in contract to the arrangement which has herein been disclosed, wherein as much as 97% of the total time available may be used for any separate channel, depending, of course, upon the definite values of the individual capacities and resistances used. These values are determined from calculations and experiments as will be obvious.

Each of the secondary grids 53, 54, 55 and 56 of the tubes 1, 6, 11 and 16 of channels "A", "B", "C" and "D" may be associated with some form of input arrangement or connected to the output of a photo cell and associated amplifier by means of any desired form of coupling or the well known resistance, impedance, or capacity couplings, and the output of each of these systems is, therefore, directly impressed upon the secondary grids above named. It is also possible to utilize this system for communication of four (as shown) separate messages, so that if any operator ceases to send messages over one channel that this separate line will not be idle for as great a time as otherwise. This system also lends itself to the even distribution of socalled "peak" loads by dividing the load equally or proportionately between each of the separate channels.

Associated with each of the tube channels "A", "B", "C" and "D" are the tubes 5, 10, 15 and 20, respectively, which have their grid members 61, 66, 71 and 76, respectively, connected to the same input as the grids 60, 65, 70 and 75 of tubes 4, 9, 14 and 19 except that the grid connection of the tubes 5, 10, 15 and 20 is made ahead of the resistance members 37, 40, 43 and 46 so that the group of the tubes 5, 10, 15 and 20 will not reach a negative value until some time after the tubes 4, 9, 14, and 19 become negative by reason of the fact that the resistances 37, 40, 43 and 46 must be first overcome. When the grids of the tubes 5, 10, 15 and 20 are positive each of these tubes pass plate current and their output energy is fed into crystal oscillators or other oscillators of any desired characteristic which are conventionally illustrated at 49, 50, 51 and 52 respectively. The output energy of each oscillator is fed into an antenna 106 through transformers or other forms of couplings generally designated as 102, 103, 104 and 105. The antenna 106 is grounded in any desired manner as at 107.

It is thus seen that as each channel is functioning one channel or the other is feeding its output into the antenna member 106 and it is further desirable and a purpose of the invention to have each of the oscillators 49, 50, 51 and 52 feed different tones or frequencies, as, for example, 1,000, 1,300, 1,500, and 1,900 respectively into the antenna so that four separate channels each carrying a different frequency are being transmitted in effect (since the commutation is so rapid) at all times in accordance with the disclosure as shown by Fig. 1, although it is to be understood, as previously stated, that the invention is capable of utilizing many more channels than have been shown or is also capable of using less channels than four. The battery 97 is shown as a source of potential for all the oscillators 49, 50, 51 and 52. If desired, neon lamps or other glow indicators 108, 109, 110 and 111 may be associated with the output of amplifiers 5, 10, 15 and 20 and the oscillators 49, 50, 51 and 52 for the purpose of indicating the time rate of change of the signal carried from one channel to another as well as to determine whether or not the system is in operation.

Now to make reference to Fig. 2 of the

drawings, a similar arrangement to that of Fig. 1 is shown, with the exception that instead of using the double grid tubes, 1, 6, 11 and 16, these are replaced by the three electrode tubes 1*a*, 1*b*, 1*c* and 1*d*, working in conjunction with the three electrode tubes, 112, 113, 114, 115 each of which last named tubes receive the signals from channels, "A", "B", "C" and "D", respectively. The tubes 112, 113, 114, 115 have their plate electrodes connected with the sources of potential 116, 117, 118 and 119, respectively, in the usual manner. In the arrangement of Fig. 2 neon lamps 120, 121, 122 and 123 are connected with the output circuits of the tubes 1*a*, 1*b*, 1*c* and 1*d* as well as tubes 112, 113, 114 and 115 for a purpose to be hereinafter described.

Referring now to the arrangement shown in Fig. 2, and starting the consideration with the channel "A", as in the previous description of Fig. 1, suppose that all the grids of the tubes in channel "A" are positive under which condition all the tubes of this channel draw plate current, as seen from the accompanying diagram, it can be seen that a negative potential is applied to the grids of the tubes in channels "B", "C" and "D", by reason of the voltage drop in the grid resistors of the first tubes in each respective channel caused by tubes 4, 3 and 2 drawing plate current from sources 34, 36, and 36*a*, respectively, causes the grid potential in the grids of tubes 1*b*, 1*c* and 1*d*, respectively, to be controlled in the same manner as was explained above when making reference to Fig. 1. This negative potential applied to the grid of the first tube in each of channels "B", "C" and "D" cuts off the plate current in all the tubes in the channels so the output of each channel but that of channel "A" is cut off. In channel "A" the positive grid (actually of zero potential but relatively positive) of the first tube 1*a*, permits the condenser 21 to charge. The potential of the condenser acts in conjunction with the "B" battery voltage 33*a*, which is below the extinction voltage of the neon lamp 120.

When the condenser 21 is fully charged, the additional voltage across the neon lamp 120 is of such a value as to flash the lamp. The purpose of the neon lamp is to cause the condenser potential to vary between two limits and the time element depends upon how long this differential potential builds up with respect to time. The mechanism or construction of the neon lamp is such that a definite voltage V_1 is necessary to start the lamps flashing. Once the lamp flashes, it will continue to remain lit while the potential across it is lowered until a critical voltage V_2 is reached, under which condition the lamp goes out. V_1 is called the starting voltage and V_2 the extinction voltage. To start the lamp flashing again, the potential must be equal to V_1 and the lamp will not go out until V_2 is reached. Hence, the time that any particular channel is "on", or in operation, may be determined from the equation

$$t = \frac{C(V_1 - V_2)}{i},$$

where t is the time, C is the capacity of the condenser, V_1 is the starting valtage of the neon lamp, V_2 is the extinction voltage and i is the charging current. Consequently, from a knowledge of the values of C, V_1 and V_2 the time that any particular channel is "on" or operating for both the "signal-on" and the "signal-off" conditions may be fixed a priori by adjusting the charging currents. Incidental to this function of the neon lamp the lamp may also indicate whether the system is functioning if an observer watches whether or not the flashing operation is occurring. When the condenser is discharged a negative potential is applied to the grid of the tube 4 of channel "A" by virtue of the voltage drop in the resistor 25 connected to the B battery for reasons similar to those previously stated.

This negative potential stops the plate current from flowing through the grid resistor of tube 1*b* of channel "B", which cessation of current flow removes the negative potential applied to all the grids of channel "B" and carries them to a positive potential. In the showing of Fig. 2 the grids of the tubes are direct connected in a similar manner to that illustrated by Fig. 1, but all grids connect with the grid resistor of the first tube in the channel and are, therefore, all carried practically instantaneously to the same potential. When this happens, plate current flows and current is cut off in channel "A" in a manner similar to that previously described, and continues to hold channels "B" and "D" in the "off" position due to the plate current flowing through the grid resistor of tubes 1*a*, 1*c* and 1*d* of channels "A", "C" and "D" respectively by reason of the fact that tubes 7, 9 and 8 draw plate current from sources 35, 36 and 36*a* and complete the circuit through the filaments of the last named tubes.

The condenser 22 in channel "B" now begins to charge, and when it is charged sufficiently to flash the neon lamp 121, channel "C" is placed in an operative position which stops the operation of channel "D" and likewise prevents the operation of channels "A" and "B" in a manner which has been previously disclosed. The action of the tube is then passed on to channel "D", and from "D" to "A", and so forth, to complete the cycle of operation over and over again.

This commutating action would be at a uniform rate and hence have no advantage over the ordinary type of commutator if it were not for the signal tubes 112, 113, 114 and 115 in parallel with the first tubes 1*a*, 1*b*, 1*c* and 1*d* of each channel "A", "B", "C" and "D". Due to the presence of the tubes 112, 113, 114

and 115 the charging current of the condenser can be varied, and since it is the charging time of each condenser that controls the length of time any separate channel is operating it is evident that if no signal is on the grid of the signal tube this grid is at zero potential, and the charging current of the condenser is the sum of the plate currents of the signal tube 112 and first tube 1*a* of the channel, if channel "A" is considered. The polarity of the incoming signal voltage applied to the grid of the signal tube in each channel is such as to make the grid go negative when the signal comes on. If it is now assumed that a signal has reached the tube 112, the grid of this signal tube is carried to a negative value so as to cut down substantially and partially cut-off the plate current of the signal tube 112, which reduces the charging current in the condenser and thus increases the time necessary to charge the condenser. As a result of this action, when a signal is received on any particular channel the output of the channel is operative for a longer time than when there is no signal, which is readily seen in view of the fact that the charging rate of the associated condenser is slower. By a suitable adjustment of the circuit constants, the time of action, or in other words the charging time of the various condensers can be made exceedingly short for the "no signal" condition, and relatively long for the "signal" condition. In this manner only channels having signals impressed on them could actuate their outputs for any appreciable length of time. Thus, a saving of time is effected by substantially keeping only the signal channels open, and the "no signal" channels are used for such a small period of time during the cyclic operation of the commutator that their time of operation can be considered as negligible.

The remaining connections as shown in Fig. 2 are similar to those of Fig. 1, and the operation functions in a similar manner. It is believed that it will be clear exactly how the system of Fig. 2 functions when the description which is more amplified with respect to Fig. 1 is considered.

Therefore, it is believed that it will be clear that by the arrangement herein shown and described, I have provided a system for commutation, wherein there are absolutely no mechanical parts to get out of order, or to prevent quick action, and that a very material advantage is gained therefrom, and that a system has been provided in which is preferable to use a plurality of frequencies for transmission of messages, facsimile or television, but at the same time a system which may easily be enlarged to accommodate an indefinite number of signal channels.

Further, it is believed that while in places the specification has referred to picture transmission and signals resulting therefrom, that the arrangement will be considered as applicable to any form of multiplex work or even repetition work and suitable for speech and code transmission. This invention also particularly adapts itself to use in systems for flashing electric signs where there are a plurality of lights or sets of lights to be flashed on and off at either regular or irregular intervals. In the case of flashing signs on and off there would be no essential change over the form of invention shown except that, if desired, each separate set of lights might be controlled directly from the transformers 102, 103, 104, and 105 instead of arranging these transformers to have their secondaries feed into an antenna system. Other similar uses for the invention are to be recognized and it is to be understood that I claim broadly a commutating system for any use possible, and while the terms "picture" and "communication system" or their equivalents occur throughout many claims I specifically intend these terms to be considered generic and illustrative of all applications rather than as limiting terms and confined exclusively to picture and communication work. I, therefore, desire to limit myself only insofar as the scope of the claims necessitate, and believe my invention to cover all modifications of the above described invention such as fall fairly within its spirit and scope as defined in the appended claims.

Having now described my invention, I claim:

1. The method of obtaining multiplex communication with a plurality of signal channels which includes impressing signals upon each of a plurality of signal channels, cyclically varying the time of operation of each of said channels in accordance with the strength of said impressed signal impulses, and transmitting energy from said plurality of signal channels in accordance with said varying time rate of operation.

2. The method of varying the time operation of a plurality of signal channels in a multiplex communication system which includes impressing a plurality of signals upon a series of signal channels, cyclically and successively switching from one to another of said signal channels, controlling the time operation of each of said plurality of signal channels in proportion to the intensity of the said impressed signals, and controlling a signal transmitter for all of said signals in accordance with the time rate of operation of each of said signal channels.

3. The method of obtaining multiplex communication with a plurality of signal channels which includes impressing signals upon each of said plurality of signal channels, transmitting the signal energy from each of said channels, and controlling the time operation of transmission for each of said channels in accordance with the signal intensity impressed upon each of said channels.

4. The method of obtaining multiplex communication with a plurality of signal channels which includes impressing signals of different frequencies upon each of a plurality of signal channels, controlling the time operation of each of said signal channels in accordance with the intensity of the impressed signals, and successively and continuously transmitting the said signals in accordance with the time operation of each of said signal channels.

5. In a multiplex communication system, a plurality of signal channels, vacuum tubes associated with each of said channels, and closed circuits so connecting the vacuum tubes in each of said channels as to cyclically and periodically shift from one to another of said signal channels for time periods varying in accordance with the presence and absence of signals impressed upon each signal channel.

6. A communication system comprising in combination a plurality of signal channels, a plurality of vacuum tubes associated with each of said signal channels, one of said tubes in each of said signal channels functioning as a control tube for said channel, means provided by said control tube for delaying the time of action of the particular signal channel during periods when signals are received and accentuating the rate of operation of said signal channels during non-signalling periods, and an antenna system associated with all of said signal channels for transmitting energy output from said signal channels in accordance with the rate of operation of said channels.

7. In a multiplex communication system, a plurality of signal channels, means for applying signals to each of said channels, a plurality of tubes in each of said channels, said plurality of tubes including one controlling tube, means for cyclically changing the grid potential on said controlling tube, and means for altering the grid potential on the other tubes of said channel, means for delaying the time of passage of a signal through each of said channels for one predetermined condition of grid potential and accentuating the time of travel of signal through said channel for another predetermined condition of grid potential, an antenna system, and means for coupling each of said signal channels with said antenna system and successively and continuously transmitting the energy from said channels through said antenna.

8. In a multiplex communication system, a plurality of signal channels, means for applying signals to each of said channels, a plurality of tubes in each of said channels, said plurality of tubes including one controlling tube, means for cyclically changing the grid potential on said controlling tube in accordance with varying strength signals applied thereto, and means for correspondingly altering the grid potential on the other tubes of said channel, means for delaying the time of passage of a signal through each of said channels for one predetermined condition of grid potential and accentuating the time of travel of signal through said channel for another predetermined condition of grid potential, a modulator tube associated with each of said signal channels, an antenna system, and means for associating said modulator with said antenna and influencing said antenna from each of said modulators in accordance with the time of operation of each of said modulators as controlled by the time of passage of signals through each of said signal channels.

9. In a multiple communication system, a plurality of signal channels, means for applying signals to each of said channels, a plurality of tubes in each of said channels, said plurality of tubes including one controlling tube, means for cyclically changing the grid potential on said controlling tube, and means controlled by said controlling tube for altering the grid potential on the other tubes of said channel, means for delaying the time of passage of a signal through each of said channels for one predetermined condition and accentuating the time of travel of signal through said channel for another predetermined condition, an oscillator associated with each signal channel, means for modulating the frequency generated by said oscillator by said modulating system, an antenna means for radiating the energy output of each of said oscillators during successive periods of operation of each of said tube channels.

10. In a multiplex communication system, a plurality of signal channels, means for applying signals to each of said signal channels, a plurality of thermionic relays in each of said signal channels, means for maintaining the grid electrodes of all of said thermionic relays in each channel at a uniform potential, a circuit connecting successive tubes of said plurality of signal channels, means for switching from one to another of said signal channels in accordance with the potential bias on the grids of the tubes in one of said signal channels and an output circuit for utilizing the energy transferred through said signal channels during the said interrupted periods.

11. A communication system including a plurality of signal channels, means for applying signals to said signal channels, a plurality of thermionic relays associated with each of said signal channels, means for maintaining the controlling electrode of each of the relays of each separate channel at substantially uniform potential, one of said thermionic relays in each channel functioning as a controlling relay for the said channel,

means for connecting successive tubes in successive signal channels together for providing direct communication between successive elements of successive signal channels, means for successively and continuously energizing the various signal channels, and an antenna system associated with all of said signal channels for successively and continuously transmitting the energy from each of said signal channels.

12. In a communication system, a plurality of signal channels, means for applying signals to each of said signal channels, means for delaying the time of passage of a signal through any of said channels under one predetermined intensity of signal strength, and means for accentuating the time of transfer of a signal through said signal channels for another predetermined intensity of signal strength, and means for successively and continuously utilizing the energy from said signal systems.

13. A multiplex communication system including a plurality of signal channels, means for applying a plurality of signals to each of said signal channels, a plurality of vacuum tubes associated with each of said signal channels, one of said vacuum tubes in each of said channels functioning as a controlling tube, means for maintaining the grid members of all vacuum tubes in each channel at a uniform potential, means for cyclically changing the grid potential of the controlling tube in each channel, means associated with said controlling tube for altering the grid potential on successive tubes in each of said signal channels upon a change in grid potential in said controlling tube, an antenna system associated with each of said signal channels, for successively and continuously transmitting cyclically varied energy from each of said signal channels.

14. In a signal energy regulating system, a plurality of signal channels, a plurality of vacuum tubes in each of said signal channels, means for applying signals to each of said signal channels, circuits connecting each of said signal channels for energizing one or another of said channels at predetermined intensity and cyclically varied intervals, means for cyclically and periodically changing from one to another of said signal channels at a rate of speed proportionate to the signal strength introduced on any channel, and an output circuit for utilizing energy from said signal channels transferred thereto at cyclically and periodically interrupted intervals in accordance with the time of passage of a signal through said signal channels.

15. A communication system comprising in combination a plurality of signal channels, a plurality of vacuum tubes associated with each of said signal channels, the number of vacuum tubes in each signal channel being equal to the number of signal channels, a controlling tube for each of said channels, means for cyclically maintaining the grid members of the tubes in each of said separate signal channels at a uniform potential, means for cyclically changing the grid potential on the grid of said controlling tube of each signal channel and simultaneously altering the potential on all the grids of the tubes in a succeeding signal channel, means responsive to signal impulses received on any of said signal chambers for delaying the time of changing the said grid potentials on the said controlling tubes in each channel at periods when signals are received and accentuating the rate of change of potential during non-signalling periods of any of said channels, means by which each tube of the tube channel passing current will tend to block the remaining channels of the system, a modulator tube connected with each of said channels and arranged to pass current simultaneously to the time when its associated signal channel is actuated, an oscillator connected with the output circuit of each of said modulating tubes, and an antenna system associated with all of said oscillators and arranged to transmit the output energy therefrom.

16. In a communication system, a plurality of signal channels, a plurality of thermionic relays including a controlling relay associated with each of said signal channels, means for applying signals of different frequency to the thermionic relays of each of said signal channels, circuits connecting the various relays in each of said signal channels, means for cyclically changing the grid potential on the controlling relay in each of said channels, and means provided by said connecting circuits between the elements of said signal channels for switching from one to another of said channels at predetermined periods governed by signal intensity reaching said channels, an oscillator associated with each of said signal channels, and an output circuit for utilizing the energy from said oscillator at predetermined intervals of time governed by the time of passage of signals through said signal channels.

17. In a communication system, a plurality of signal channels each including a plurality of vacuum tubes, means for introducing signals of different frequency upon each of said signal channels, circuits connecting the various elements of each of said channels and providing a connection between the various elements of each of said channels, means including a glow-discharge lamp for controlling the time of operation of each of said channels, and means for successively and continuously utilizing the energy from each of said signal channels.

18. In a multiplex communication system, a plurality of signal channels each including a plurality of vacuum tubes, circuits connecting each of said signal channels and associ-

ating the controlling element of one vacuum tube of each signal channel with at least one tube of each other channel, glow lamp means for controlling the time of operation of each of said signal channels in proportion to the signal intensity reaching said signal channels, and a load circuit for successively and continuously receiving energy from each of said signal systems.

19. In a multiplex communication system, a plurality of signal channels, a plurality of vacuum tubes associated with each of said signal channels, a controlling tube for each of said signal channels, circuit connecting each of said signal channels with each other and associating the plate elements of the various vacuum tubes of said channels and the grid elements of the controlling tubes of each of said signal channels, and glow lamp means for controlling the time of operation of each of said signal channels in proportion to the signal intensity reaching the control tube of each of said channels, and means for successively and continuously transmitting energy from said signal channels.

20. In a multiplex communication system, a plurality of signal channels, a plurality of vacuum tubes associated with each of said signal channels, a controlling tube in each of said signal channels, means for introducing signals of different frequencies upon each of said signal channels, means for cyclically and at interrupted intervals controlling the grid potential on the controlling tube in accordance with the signal strength applied, a modulator associated with each of said signal channels, an oscillator of different frequency associated with each of said signal channels, a common load circuit for all of said oscillators, means for associating each of said oscillators with said common load circuit, means provided by said modulator for modulating energy generated by said oscillator in accordance with the signals transmitted through said signal channels and means for cyclically, successively, and at variable rates of speed governed in accordance with the signal intensity applied to said signal channels controlling the time of action of said oscillators upon a said common load circuit.

21. In a multiplex communication system, a plurality of signal channels, a plurality of vacuum tubes included in each of said signal channels, a controlling tube for each of said signal channels, a grid resistor associated with each of said controlling tubes, means for cyclically changing the grid potential upon each of said controlling tubes at periods when signals reach the same whereby for predetermined signal strength predetermined grid potentials are established, means provided by said controlling tube for correspondingly changing the grid potential on all the other tubes of each of said signal channels, means provided by variations in signal strength reaching each of said controlling tubes for proportionately delaying and accentuating the time of signal travel through each of said signal channels, an oscillator of different frequency associated with each of said signal channels, a common load circuit associated with all of said oscillators, and means provided by said time controlled signal channels for controlling the time of operation of each of said oscillators upon said load circuit.

22. The system claimed in claim 21 comprising, in addition, means for connecting one tube of each signal channel with the grid resistor of the controlling tube of each other signal channel whereby the time of operation of each of said signal channels is controlled in accordance with the potential drop occurring through said grid resistor.

23. The system claimed in claim 21 comprising, in addition, means for associating one tube in each signal channel with one tube of each other channel and regulating the potential bias on the controlling tube of each other signal channel in accordance with the current strength in each of said tubes.

24. The method of obtaining multiplex communication with a plurality of signal channels which comprises impressing signals upon each of a plurality of signal channels, directing the signals by commutating to each of said channels for time periods varying in accordance with the strength of said impressed signal impulses, and transmitting energy from said plurality of signal channels in accordance with said varying time rate of operation.

25. The method of operating a plurality of signal channels in a multiplex communication system which comprises impressing signals upon each of the plurality of signal channels, sequentially directing the signals by commutating between said plurality of signal channels, and varying the time period of commutation for each of said plurality of signal channels in proportion to the intensity of the signal impressed thereon.

26. The method of obtaining multiplex communication with a plurality of signal channels which comprises impressing signals upon each of a plurality of signal channels and cyclically varying the time of operation of each of said channels in accordance with the strength of said impressed signal impulses for transmitting energy from said plurality of signal channels in accordance with said varying-time rate of operation.

27. The method of operating a plurality of signal channels in a multiplex communication system which comprises impressing signals upon each of the plurality of signal channels, sequentially switching from one to another of said signal channels, and varying the time operation of each of said plu-

rality of signal channels in proportion to the intensity of the signal impressed thereon.

28. The method of operating a series of signal channels in a multiplex communication system which comprises impressing signals of different characteristics upon each of the series of signal channels, sequentially switching from one to another of said signal channels, and varying the time period of passage of signals through each of the signal channels in proportion to the intensity of the signal impressed thereon.

29. The method of obtaining multiplex communication with a plurality of signal channels which includes impressing signals of different characteristics upon each of the plurality of signal channels, transmitting the energy passed through each of the signal channels, and varying the time operation of the transmission period for each of the said signal channels in accordance with the signal intensity of each of the distinct signals impressed on each of the signal channels.

30. The method of obtaining multiplex communication with a plurality of tone signal channels all coordinated with a single transmission system which includes impressing signals of different tone frequencies upon each of the plurality of signal channels, controlling the time period of passage of signals through each of the signal channels in accordance with the signal intensity of the individually impressed tone frequencies, and sequentially transmitting signals from each of the channels for time periods varying in accordance with the time operation of each of the channels.

31. A thermionic relay system for multiplex telegraphy comprising a vacuum tube circuit for each signal channel and closed circuits so connecting said vacuum tube circuits as to cyclically and periodically cause said vacuum tubes to become operative for variable time periods.

32. A thermionic relay system for multiplex telegraphy comprising a vacuum tube circuit for each signal channel and circuits so connecting said vacuum tube circuits as to cyclically and periodically cause said vacuum tubes to become operative for time periods of durations proportional to the relative signal intensity on each of the signal channels.

33. A thermionic relay system for multiplex telegraphy comprising a vacuum tube circuit for each of a plurality of signal channels and closed circuits so connecting all of said vacuum tube circuits as to cause each of said vacuum tube circuits to become sequentially operative for predetermined variable time periods.

34. A thermionic relay system for multiplex telegraphy comprising a vacuum tube circuit for each of a plurality of signal channels and circuits so connecting each of said vacuum tube circuits as to cause each of said vacuum tube circuits to become sequentially operative for time periods varying in accordance with the signal strength impressed thereon.

35. A thermionic relay system for multiplex telegraphy comprising a vacuum tube circuit for each of a plurality of signal channels, circuits so connecting said vacuum tube circuits as to sequentially cause one of said vacuum tube circuits to become operative and the remaining vacuum tube circuits inoperative, and means for varying the time period of operation of each of said vacuum tube circuits in accordance with the signal strength of the independent signals impressed on each of the vacuum tube circuits.

36. A communication system comprising in combination a plurality of signal channels each including a plurality of vacuum tubes, means for impressing distinct signals upon each of the signal channels, circuits connecting the vacuum tubes of each of said circuits so as to form an interconnected net work, means for sequentially switching between said various signal channels so as to cause one of said channels to become operative and the remaining channels inoperative, and means for varying the time operation of each of said channels in accordance with the strength of signal energy impressed thereon.

37. A thermionic relay system for multiplex telegraphy comprising a vacuum tube circuit for each of a plurality of signal channels, circuits so connecting said vacuum tube circuits as to sequentially cause one of said vacuum tube circuits to become operative and the remaining vacuum tube circuits inoperative, and capacity means for varying the time period of operation of each of said vacuum tube circuits in accordance with the signal strength of the independent signals impressed on each of the vacuum tube circuits.

38. A communication system comprising in combination a plurality of signal channels each including a plurality of vacuum tubes, means for impressing distinct signals upon each of the signal channels, circuits connecting the vacuum tubes of each of said circuits so as to form an interconnected net work, means for sequentially switching between said various signal channels so as to cause one of said channels to become operative and the remaining channels inoperative, and a capacity element associated with each of said vacuum tube circuits for varying the time operation of each of said channels in accordance with the rate of discharge thereof as varied by strength of signal energy impressed on the associated vacuum tube.

39. In a multiplex communication system, a plurality of signal channels each including a plurality of vacuum tubes, means for im-

pressing independent signals upon each of said channels, circuits connecting the various tubes of all of said channels so as to form an interconnected net work, means for transmitting the energy impressed on all of said signal channels, and means for varying the rate of transmission of the said energy in accordance with the intensity of the independent signals impressed on said channels.

40. An electronic relay system comprising in combination a plurality of signal channels, a plurality of vacuum tubes associated with each of the signal channels, one of the tubes in each of the channels functioning as a control tube for the channel, means provided by the control tube for delaying the time of action of the particular signal channel during time periods when signals are supplied and accentuating the rate of operation of the signal channel during non-signaling periods, and a load circuit associated with all of the signal channels for utilizing the combined energy output from the signal channels in accordance with the rate of operation of the individual channels.

RICHARD HOWLAND RANGER.

CERTIFICATE OF CORRECTION.

Patent No. 1,873,785. August 23, 1932.

RICHARD HOWLAND RANGER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, line 50, for "contract" read "contrast"; page 6, line 73, for the misspelled word "valtage" read "voltage"; page 9, line 76, claim 15, for "chambers" read "channels"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 10th day of January, A. D. 1933.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.