

Aug. 23, 1932.

R. H. RANGER

1,873,786

SELECTIVE CHANNELING SYSTEM

Filed Sept. 29, 1928

Fig. 1

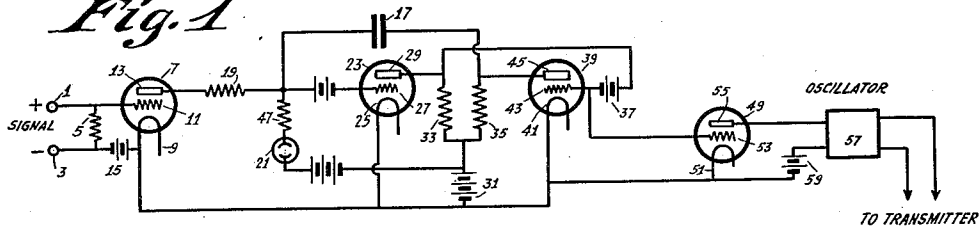
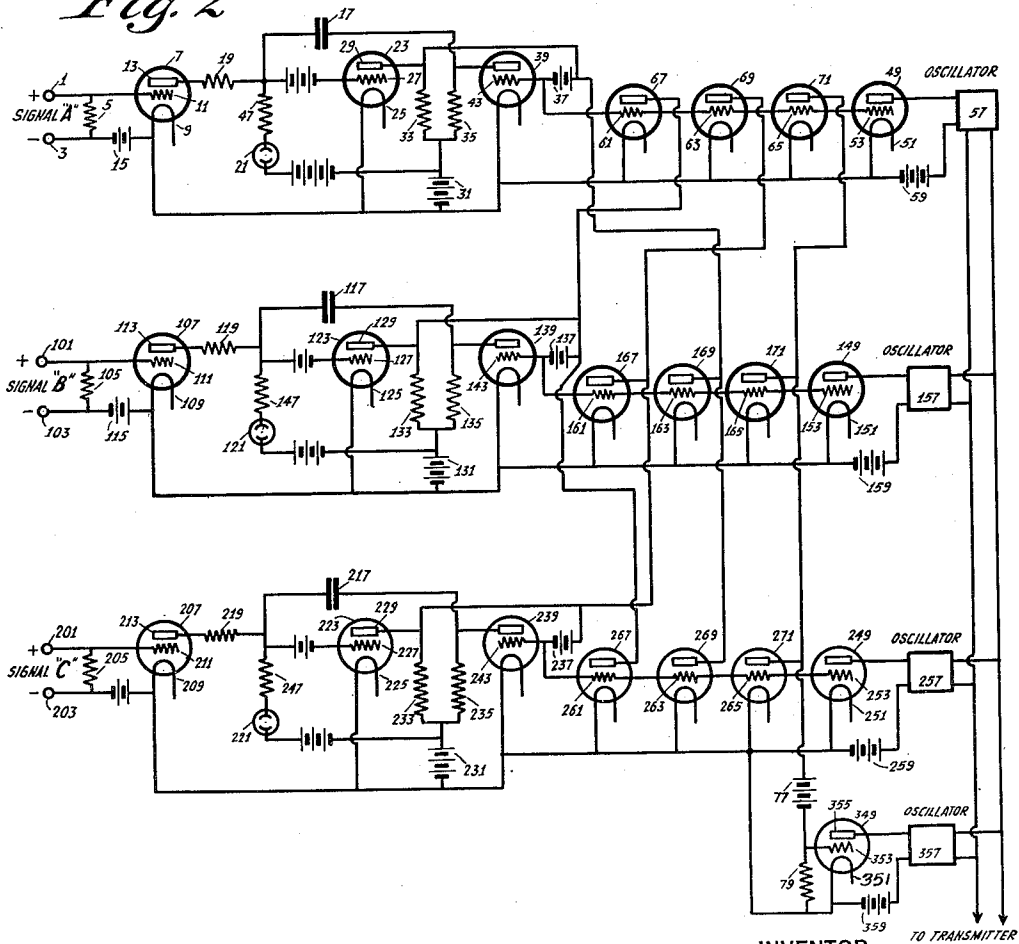


Fig. 2



INVENTOR
R. H. RANGER
BY *Ira J. Adams*
ATTORNEY

UNITED STATES PATENT OFFICE

RICHARD HOWLAND RANGER, OF NEWARK, NEW JERSEY, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

SELECTIVE CHANNELING SYSTEM

Application filed September 29, 1928. Serial No. 309,274.

The invention relates primarily to a method and means for multiplexing signals, especially adapted for radio communication, although its application is not limited thereto but is equally applicable to wire line communication or wired radio systems. The invention further relates to a system for communication wherein a plurality of individual messages may be transmitted from a single transmitting system with a definite time distribution of transmission for each of the messages.

This invention constitutes an improvement upon my previously filed co-pending application for a "tube commutator," filed as Serial No. 269,099 on April 11th, 1928.

As in the above referred to co-pending application, a principal object of my invention is to provide a system wherein it is possible to switch from one channel of communication to another without the need of mechanical commutation systems, and is especially applicable to picture or facsimile transmission by multiplexing or may also be used for television, using a multiple wave communication system, or for transmitting a plurality of coded messages or for other forms of communication, such as, for example, telephony over a plurality of channels or diversity reception, as well as other uses foreign to communication work which will at once suggest themselves with the reading of the specification when considered with the accompanying drawing.

A further object of my invention is to provide a multiplex selective channeling system for communication in which the system is absolutely and totally independent of the use of any mechanical relays for accomplishing the channeling or switching from one channel to another to carry an individual message on one or another channel of the communication system.

A further object of my invention is to provide an arrangement whereby it is possible to use a plurality of frequencies in the transmission of pictures, facsimiles, speech, code, television and the like, and, at the same time, provide a system which is readily arranged to adapt itself to the combining of the indi-

vidual messages into a single finished or joined message at a receiving point.

Still a further object of my invention is to provide an arrangement of selective channeling systems wherein it is possible to increase the number of channels without the necessity of changing or altering the arrangement as initially installed, and wherein the changes and modifications for the enlargement of the system may be carried on by merely making additions and enlargements to the original set-up.

Still a further object of my invention is to provide, in a manner to be hereinafter set forth, a multiplex communication system in which each channel shares a proportionate amount of the total time for communication in accordance with the signals received on each of the separate channels, and in which such channels as have no signalling impulses thereon require no portion of the transmitting time.

Still a further object of my invention is to provide an extra channel of communication which I have hereinafter termed the "spacing channel" to utilize the transmission circuit during all periods when no signalling channel requires this circuit.

Other objects of my invention will appear after a consideration of the following description taken in connection with the accompanying drawing, when the accompanying drawing is read in connection with the hereinafter appended claims. However, it must be borne in mind, that in addition to the objects above named, the invention also has as its objects those of providing a selective channeling system which is simple in construction and arrangement of parts, as well as a system which is durable, compact, conveniently operated, readily set up, efficient in its use, and one which may be installed at a minimum of expense, as well as a system which is most capable of meeting future developments in the art of multiplex communication by readily adapting itself to the enlargement of a number of signalling channels which may be used.

The invention has been illustrated in its

preferred form by the accompanying drawing wherein:

Fig. 1 illustrates a portion of one signal channel for the purpose of explaining the tube operation; and,

Fig. 2 illustrates an embodiment suitable for multiplexing, using three channels, although it is to be understood that the invention readily adapts itself to the use of even two channels or many more than three channels by making appropriate changes in the system, as will be apparent from the following description.

Now referring to Fig. 1, signals from any desired source, as, for example, a photo amplifier (not shown) or any other suitable device having a direct current output, are brought to the terminals 1 and 3 where they are then impressed across the resistor 5 connected across the input circuit of a signal controlled tube 7. The signal controlled tube 7 is of the usual three electrode type and includes a filament 9, a grid or controlling electrode 11, and a plate member 13. The grid 11 of the tube 7 is normally biased negatively by a biasing battery 15 connected in the input circuit of the tube, but at the time of applying signals from a photo amplifier or other appropriate input device the grid 11 is carried positive, since, as shown, the terminal 1 is connected with a positive potential source.

When the grid member 11 becomes positive the tube 7 at once commences to draw plate current and the condenser or capacity element 17 is discharged (assuming that it has previously become fully charged) through the resistor 19, due to the fact that the tube 7 tends to pass as heavy a current as possible when the grid is carried positive. As the condenser 17 discharges the potential across the neon lamp or other appropriate glow-discharge apparatus 21 rises until it finally reaches the flashing point of the lamp.

Under normal conditions the tube 23 composed of the usual three electrodes, including, a filament 25, a controlling electrode or grid member 27, and a plate 29, is drawing current from the source 31. Due to the voltage drop across the resistor 33 and the biasing battery 37 the tube 39 composed of the usual three electrodes, including, the filament 41, the grid 43, and the plate 45 is biased to cut off, since grid member 43 has been kept negative.

It is, therefore, seen that when the neon lamp 21 flashes, the grid 27 of the tube 23 becomes negative due to the I R drop across the resistor 47. This voltage drop causes the grid 27 of tube 23 to become negative and the tube 23 ceases to draw plate current. When the tube 23 ceases to draw current there is no longer the drop in voltage across the resistor 33 and, therefore, the tube 39 will commence to draw current, since the grid member 43 is

no longer biased so strongly negative. This condition continues until the capacity element 17 is again charged and the neon lamp 21 is extinguished, at which time the first condition, above recited, will prevail once more.

If, by this time, signals are still being impressed across the terminals 1 and 3 the condenser 17 will again discharge through the tube 7 and once more the neon lamp 21 will flash and again cause the grid member 27 of the tube 23 to become negative and the grid 43 of the tube 39 become positive. In this case, it will be seen, that the tube 49 will also draw plate current since the grid member 53 is connected to the grid 43 of the tube 39 and, upon the grid 43, assuming positive potential, the grid 53 assumes a similar potential (of course, neglecting the drop through the connecting conductor between the grid elements). Under these conditions current will flow in the output circuit of the tube 49, which includes, the plate member 55, the oscillator 57, the plate potential source 59, and the filament 51. The oscillator 57 is connected in any desired manner to control a transmitting system (not shown) and may supply energy to the transmitter at a frequency of 1200 kilocycles, for example, although, it is to be understood, that I have named this frequency purely by way of example and do not in any way intend to limit myself to any particular frequency.

It is, therefore, seen from the above description how the oscillator 57 may be associated with the transmitter in a case where there is only a single channel of communication and one signal supplied from any desired source.

I will now attempt to explain, by making reference to Fig. 2, a system suitable for multiplexing, using the principle disclosed in the description of Fig. 1 for a single channel. By Fig. 2 I have shown, as above stated, three communication channels "A", "B", and "C" although, it is to be again understood, that the system is not in any way limited to three channels but that I may use as many channels as are convenient and suitable to my needs.

Now specifically referring to Fig. 2, signals from one signal channel, designated as "A", are impressed upon the terminals 1 and 3 in a manner similar to that disclosed in Fig. 1 and in a similar manner signals from a different photo amplifier or other appropriate direct current output source are impressed upon the terminals 101 and 103 of the signal channel "B" and in a likewise similar manner signals from a similar output source are impressed upon the terminals 201 and 203 of a third channel "C".

It will be seen from an examination of the circuit diagram illustrated in Fig. 2 that there are two tubes in each section or channel

"A", "B" and "C" which have their plate members connected to one of each of the other channels and still a third set of tubes, including, one tube in each channel, which has its plate member connected to a grid resistor across the input circuit of another tube separately associated with the transmitter, although independent of any of the signalling channels. I have termed this tube the "spacing arrangement" although for the present I will not describe its operation but will confine the description first to the action of one signalling channel upon another.

Consider now, for example, that signals are applied to all three channels "A", "B" and "C" and, for example, that channel "A" received the signal slightly ahead of channels "B" and "C". Following the description advanced as to Fig. 1 it will be seen that as signals are impressed upon channel "A", the neon lamp 21 is flashed causing the tube 23 to "cut off" or to cease passing plate current. According to the operation described by Fig. 1 this allows or permits the tube 39 to draw plate current.

From a consideration of Fig. 2 it will be noted that the grid members 61, 63, 65, as well as 53 of the tubes 67, 69, 71 and 49 all have their grid members directly connected to the grid 43 of the tube 39 and since the grid 43 has been carried positive due to tube 23 being brought to "cut off" it is obvious that the connected grids 61, 63, 65 and 53 are also positive and the tubes 67, 69, 71 and 49 are, therefore, all drawing plate current. In this condition it will be noted that tube 49 corresponds to the same tube in Fig. 1 that controls the transmitter through the oscillator 57. In this case where a signal is impressed across terminals 1 and 3 it will be seen that channel "A" is, for the time being, controlling the transmitter (not shown) associated with the output of the oscillator 57.

Now considering tube 67 of channel "A", it will be seen, that this tube receives its plate current through the resistor 133 in channel "B". Therefore, all tubes in channel "B" from tube 139 on to the oscillator, such as tubes 167, 169, 171 and 149 are biased to "cut off" position until the neon lamp 21 is extinguished and changes the grid potential of tube 39 to again bias the same to cut off and, therefore, similarly bias the tubes 67, 69, 71 and 49 and cause them to cease drawing plate current.

In a similar manner it will be seen that the tube 69 receives its plate current through the resistor 233 in channel "C" and, therefore, all the tubes in channel "C" following tube 239, for example, tubes, 267, 269, 271 and 249, are biased to cut off potential for a similar reason to that described in cutting off the tubes in channel "B".

When the neon lamp 21 of channel "A" is extinguished either channel "A" or channel

"B" will take control of the transmitter depending upon which one has reached the lowest point in discharging its associated capacity element 117 or 217. Channel "C" has one tube 269 drawing its plate current through the resistor 33 of channel "A" and also one tube 267 drawing its plate current through the resistor 133 in channel "B". The same is true of channel "B" where tube 169 draws its plate current through the resistor 33 of channel "A" and tube 167 draws its plate current through the resistor 233 in channel "C". It, therefore, is readily seen when one channel is "on", meaning that signals are impressed upon the one channel, that due to the action of the signals in passing through the channel the oscillator associated with the particular channel is arranged to control the transmitter. In this case the other two signalling channels, as illustrated, are in "off" position, meaning that the tubes controlling the respective oscillators associated with the separate channels are biased to cut off so that these tubes will not pass current. It is further apparent from the above description that the charging and discharging of the capacity elements 17, 117, and 217 prevents any one channel from remaining "on" continuously. This, it will be seen, provides and explains an interlocking action between the various channels of my selective channeling device.

It is to be noted further in connection with all of the various signal channels that the action of, for example, channels "B" and "C" in response to a signal are identical to those described in connection with channel "A" in considerable detail and further described in connection with Fig. 1, showing one channel without any interlocking means between other channels.

The remaining feature of my invention which I have previously named as a "spacing device" consists in a tube 349 provided with the usual three electrodes, including a filament 351, a grid or control electrode 353 and a plate member 355, controlling a separate oscillator 357.

To now refer to the tubes 71, 171 and 271 of channels "A", "B", and "C", respectively, it will be seen that each of these tubes receive plate current from a source 77 through the resistor 79. Under normal conditions the grid member 353 of the tube 349 is not biased and, therefore, the tube normally draws plate current from the source 359 allowing the "spacing device" to control the transmitter through its associated oscillator 357. However, if a signal is applied to any of channels "A", "B" or "C" tubes 71, 171 or 271 will be drawing plate current through the resistor 79 and source 77 which causes a voltage drop across the resistor 79 due to the I R drop therein. This I R drop in the resistor 79 causes the grid member 353 of the

tube 249 to become negative and, therefore, cuts off the plate current and causes the oscillator 357 to no longer have any effect upon the transmitter.

Although it has not been previously stated it is to be herein understood that the filament members of all tubes in the system are connected in parallel with the same current source and, therefore, when any of tubes 71, 171, and 271, for example, are drawing plate current, the plate circuit may be completed through the cathode of any tube in any other channel.

From the above description it readily follows that each channel will control the transmitter only as its particular circuit needs the time and when no signals are "on" in any channel the extra channel which, as above stated, I have herein designated as a "spacing device" will control the transmitter. This provides a system wherein no time is wasted in passing through channels which do not require the circuit and a system in which at all times one or another channel is connected with the transmitter or, in the absence of any signals, the "spacing device" is connected with the transmitter.

As has been stated in connection with the showing in Fig. 1 I may assume, for example, that the frequency of the oscillator 57 connected with the transmitter of any desired character is 1200 kilocycles and then for the purpose of multiplexing I may space the oscillators 157, 257 and 357, for example, 3000 cycles apart from each other and from the oscillator 57. Here again I wish to specifically state that the above named frequencies are merely given by way of example and I do not, therefore, consider myself to be in any way limited as to what frequencies may be employed to meet the demands of operation most suitably.

As in my above named co-pending application, Serial No. 269,099, it is to be distinctly understood that while the invention has been described only in connection with signalling systems the use is not limited thereto but it may be applied to many other uses as an example of which I will cite the illumination of various electric signs, wherein, each of the respective channels may control lamps of different colors for the sign and the spacing channel will then provide a system for completely shutting off all the light on the sign at desired predetermined intervals.

Still another use to which the above described invention is applicable is in diversity work where, for example, signals are received upon a plurality of geographically spaced antenna systems and are then brought to a single receiving system or combining unit through a plurality of separate connecting paths or channels. In most work of this character it is important to see that the phases of signals received upon the sepa-

rated antenna systems shall not oppose each other in phase when brought to the combining system or receiver and for this reason the invention may be applied to rapidly switch from one receiver to the other in bringing the signals to the receiving or combining means. This will provide a diversity system wherein, signals may be received in such a manner as to substantially avoid the objectionable effects of fading as well as to reduce static and interference to a certain degree.

In accordance with the two illustrated examples of other applications of my invention it will be apparent at once to those skilled in the art to which the invention relates that other and similar uses fall clearly within its scope and I, therefore, desire that the invention shall not be restricted to the specific form illustrated but that it may be broadly construed in accordance with the scope of the last named suggestions.

Having now described my invention in one of its preferred embodiments, it is to be distinctly understood that certain modifications may be made such as fall fairly within its spirit and scope as defined by the following claims wherein I claim:

1. In a multiplex communication system, a transmitting system, a plurality of signal channels for controlling said transmitting system, and means for sequentially controlling said transmitting system only from such of said signal channels as are supplied with signals so as to divide the transmission time period substantially equally between the channels supplied with signals.

2. In a multiplex communication system, a transmitter, a plurality of individual signal channels for controlling said transmitter, means for impressing signalling impulses of a different character on each of said signal channels, and means for sequentially controlling said transmitter only from the number of signal channels to which signals are impressed to divide the time substantially equally therebetween.

3. In a multiplex communication system, a transmitter, a plurality of signal controlled keying channels for controlling the said transmitter, means for impressing a signal of a different character upon each of said keying channels, means for interlocking each of said keying channels one with the other, means provided by said interlocking for keying and controlling said transmitter from only a single channel at any instant, and means for controlling said transmitter from only such keying channels in the system as have signals impressed thereon.

4. In a multiplex communication system, a transmitter, a plurality of oscillators each of a different frequency connected thereto, a plurality of signal controlled channels each connected with one of said oscillators indi-

vidual to each channel, means for impressing signals each of a different character upon said signal controlled channels, and means provided by said signal controlled channels for cyclically connecting said oscillators with said transmitter in accordance with the channels to which signals are supplied.

5 In a multiplex communication system, a transmitter, a plurality of signal controlled channeling systems for controlling said transmitter, a plurality of vacuum tubes included in each of said signalling channels, means for impressing signals of a different character upon each of said channeling systems, and means for cyclically controlling a transmitter from only such signalling channels as have signals impressed thereon.

6. In a multiplex communication system, a transmitter, a plurality of oscillators each of a different frequency connected with said transmitter, a signalling channel for controlling each of said oscillators, means for impressing signals each of a different character upon each of said channels, means for controlling the time operation of each of said channels in accordance with the signals impressed thereon, means associated with each of said channels for blocking each of the other of said channels at periods when signals are passed through the first of said channels, and means for cyclically connecting each of said oscillators to said transmitter through said channels only at periods when signals are impressed upon said channels.

7. In a multiplex communication system, a transmitter, a plurality of oscillators each of a different frequency connected with said transmitter, a signal controlled vacuum tube switching channel connected with each of said oscillators, means for impressing signals each of a different character upon said vacuum tube channels, means associated with each of said channels for controlling the time operation of said channel in accordance with the signal strength applied thereto, means associated with each channel for blocking each of the other of said channels at periods when signals are passed through the first of said channels, means for cyclically switching from one to another of said channels and cyclically connecting thereby different oscillators with said transmitter, and means for connecting only the oscillators associated with channels to which signals are applied with said transmitter.

8. A multiplex communication system including, a transmitter, a plurality of oscillators each of a different frequency connected with said transmitter, a vacuum tube signal controlled channel connected with each of said oscillators, means for impressing signals each of a different character upon each of said vacuum tube signal control channels, means for connecting the vacuum tubes of each of said channels with each of the other

channels for producing an interlocking action between said signal channels, means provided by said interlocking action between signal channels for blocking signal channels to which no signals are supplied, and means for connecting oscillators associated with each of said signal channels with said transmitter in a cyclical manner and connecting only such oscillators as are associated with vacuum tube signal control channels to which signals are supplied.

9. In a multiplex communication system, a transmitter, a plurality of oscillators each of a different frequency associated with said transmitter, a signal controlled vacuum tube switching channel associated with each of said oscillators, means for impressing signals each of a different character upon each of said vacuum tube signal control channels, means provided by said signal controlled channels for cyclically connecting such of said oscillators as are associated with channels to which signals are supplied with said transmitter, a spacing channel, an oscillator connected with said spacing channel and said transmitter, and means for connecting said last named oscillator with said transmitter during the absence of signals upon all of said signal controlling switching channels.

10. In a multiplex communication system, a transmitter, a plurality of signal controlled channel systems connected with said transmitter, an oscillator of different frequency associated with each of said channel systems, means for applying signals each of a different character to each of said channel systems, means for cyclically controlling the transmitting system from each of said signal channels, means for excluding from the control of said transmitting system signal channels to which no signals are supplied, a spacing system, and means for controlling said transmitting system by said spacing system during the absence of signals upon all of said signal control channels.

11. In a multiplex communication system, a transmitting system, a plurality of signal control channeling systems connected with the transmitting system, a plurality of vacuum tubes forming each of said channeling systems, a signal controlled vacuum tube in each of said channeling systems, a controlling tube in each of said channeling systems for controlling the operation of the individual channeling systems in accordance with the signals supplied to the said signal control tube, a plurality of vacuum tubes in each of said signal control channels sensitive to the action of the controlling tube in each channel, means associated with each of said last named tubes for interconnecting each of the said signaling channels one with the other and producing an interlocking action between channels, means provided by the controlling tube in each of said channels for

- blocking each of the other of said plurality of channels at predetermined periods, means for associating each of said signal control channels with the transmitting system in a cyclical manner, and means for excluding the association with said transmitter of signal channels to which no signals are supplied whereby the transmitting system is at all times connected only with signal channels to which energy is supplied.
12. The method of obtaining multiplex communication over a plurality of signal channels which includes impressing signals of different character upon each of the plurality of signal channels, sequentially energizing a transmitting system from each of the signal channels, transmitting from the transmitting system a different character signal during energization thereof from each of said individual signal channels, and utilizing the time of transmission from said transmitting system only for signal channels to which signals are supplied.
13. The method of obtaining multiplex communication over a plurality of signal channels each associated with an oscillator of different frequency and all connected to a single transmitting system which includes impressing signals each of a different character upon the series of communication channels, cyclically controlling the transmitting system through individual oscillators from each of the signal channels, and connecting the individual oscillators associated with the signal channels to the transmitter only at periods when signals are impressed upon the particular signal channel.
14. The method of obtaining multiplex communication through a plurality of signal channels which includes impressing signals of different character upon each of a plurality of signal channels, controlling the time operation of each of the signal channels in accordance with the strength of the impressed signals, cyclically controlling a transmitting system through each of said signal control channels and limiting the control of the transmitting system by the signal channels to only such channels as are supplied with signals.
15. The method of obtaining multiplex communication through a plurality of signal channels which includes impressing signals of different characteristics upon each of the plurality of signal channels, controlling the time operation of each of the signal channels in accordance with the strength of the impressed signals, cyclically controlling a transmitting system by each of the said signal controlled channels, limiting the time control of the transmitting system by the signal channels to only such channels as are supplied with signal energy, and transmitting a spacing signal in the absence of signals on any of the signal control channels.
16. The method of obtaining multiplex communication over a plurality of frequencies through a plurality of signal controlled channels which includes impressing signals of different characteristics upon each of a plurality of signal channels, controlling the time operation of each of the signal channels in accordance with the impressed signals, cyclically energizing a transmitting system with energy of different frequencies for each of said signal control channels, limiting the control of the transmitting system to channels upon which signals are supplied, interconnecting each of the respective signal channels one with the other, blocking all other channels of the system upon the application of signals to one of said channels, and preventing energization of the transmitting system from channels to which no signals are supplied.
17. The method of obtaining multiplex communication with a plurality of signal channels all coordinated with a single transmission system which includes impressing signals of different character 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 signals, sequentially transmitting signals from each of the channels for time periods varying in accordance with the time operation of each of the channels, and limiting the transmission to signal channels to which signals are supplied.
18. 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 cyclically and periodically cause said vacuum tubes to become operative upon impressing signals thereon, and means for continually maintaining channels upon which no signals are impressed in an inoperative state.
19. 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 cyclically and periodically cause said vacuum tubes to become operative for time periods of duration proportionate to the relative signal intensity upon each of the channels, and means for limiting the operative period of the relay system only to signal channels upon which signals are impressed.
20. A thermionic relay system for multiplex telegraphy comprising a vacuum tube circuit for each of a plurality of signal channels in the multiplex system, circuits so connecting each of said vacuum tube circuits as to cause each of said circuits to become sequentially operative, means for changing the number of channels in opera-

tion, and means for varying the operative period of each channel in accordance with the number of signal activated channels.

21. A thermionic relay system for multiplex telegraphy comprising a vacuum tube circuit for each of a plurality of signal channels forming the multiplex system, circuits so connecting each of said vacuum tube circuits as to cause each of said circuits to become sequentially operative for predetermined time periods varying in accordance with the strength of signal energy impressed thereon, and means for limiting the said sequential operation to only such channels as are supplied with signals.

22. 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 continually maintaining such vacuum tube circuits as are free from signals in an inoperative condition.

23. A communication system comprising in combination a plurality of signal channels each including a plurality of interconnected vacuum tubes, means for impressing distinct signals upon each of the signal channels circuits connecting the vacuum tubes of each of said channels 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 limiting the sequential operative condition to only such channels as are supplied with signals.

24. 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, capacity means for varying the time period of operation of each of said vacuum tube circuits in accordance with the strength of the separate signals impressed thereon, and means for limiting the number of operative channels to the number of channels supplied with signals.

25. 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 said signal channels, circuits connecting the vacuum tubes of each of said channels 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, a capac-

ity element associated with each of the vacuum tube circuits for varying the time operation thereof in accordance with the rate of discharge thereof as controlled by the strength of the signal energy impressed on the said vacuum tube channel, and means for limiting the number of operative channels in the system per unit period of time to the number of signal channels supplied with signals.

26. In a multiplex communication system, a plurality of signal channels each including a plurality of vacuum tubes, means for impressing independent signals upon each of said signal channels, circuits connecting the various tubes of all of said channels so as to form an interconnected net work, means for transmitting energy impressed on all of said signal channels, and means for limiting the energy transmission from said signal channels to only such channels as are supplied with signal energy, means for rendering the said channels supplied with energy sequentially operative and means for maintaining the channels to which no energy is supplied in an inoperative state.

27. An electronic relay system comprising a load circuit, a plurality of signal channels connected with the load circuit, and means for sequentially controlling the load circuit only from such of the signal channels as are supplied with signals, so as to divide the controlled time periods of the load circuit substantially equally between the channels supplied with signals.

28. An electronic relay system comprising a load circuit, a plurality of individual signal activated channels for controlling the load circuit, means for impressing signaling impulses, each of a different character, upon each of the signal channels, and means for sequentially controlling the load circuit only from the number of signal channels upon which signals are impressed, so as to divide the controlled time period substantially equally between energized signalling channels.

RICHARD HOWLAND RANGER.