May 3, 1949. J. R. DAY 2,469,066

PULSE MULTIPLEX RECEIVER

Filed June 1, 1946 5 Sheets-Sheet 1

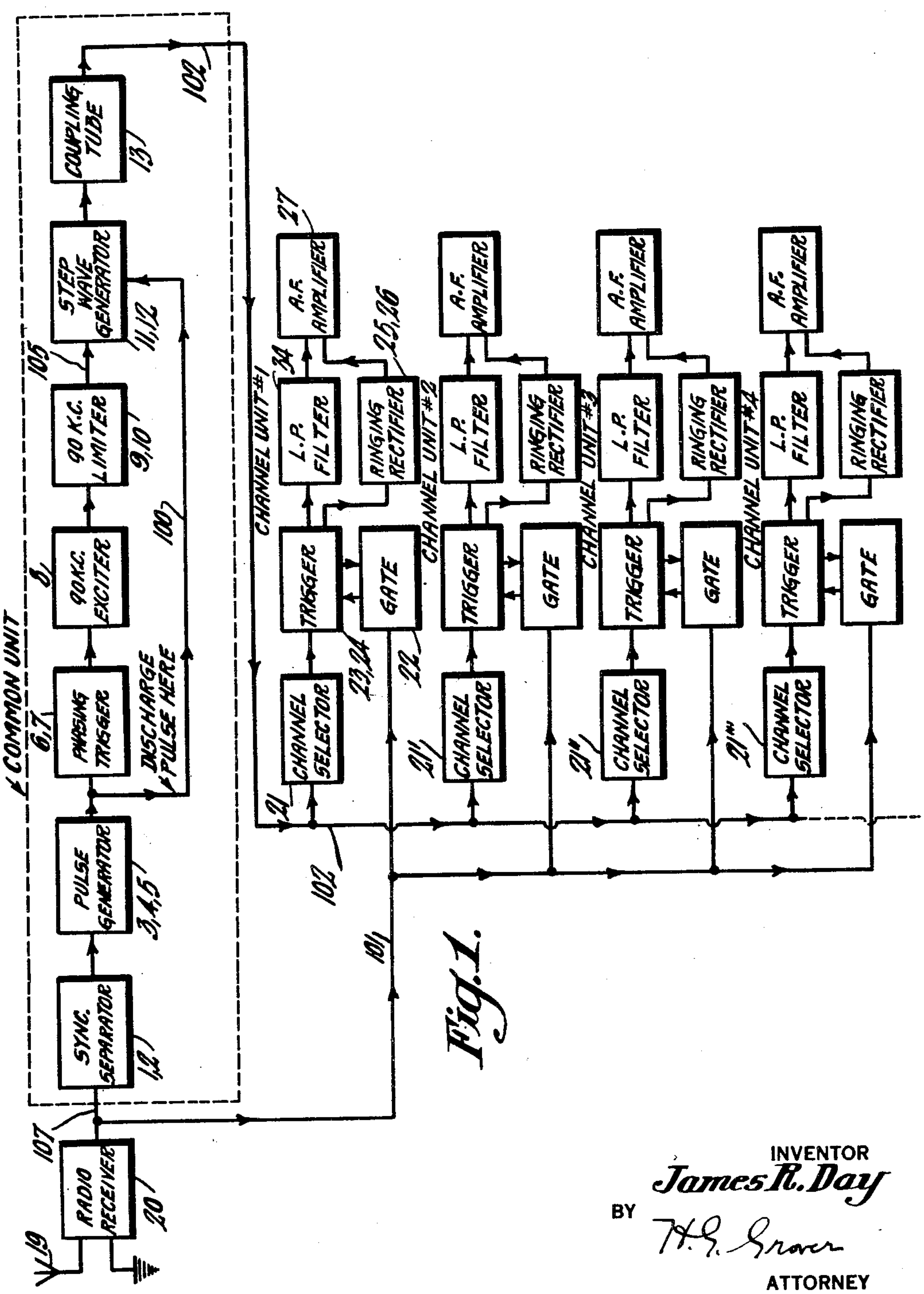

Fig. 1.

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Filed June 1, 1946 5 Sheets-Sheet 2

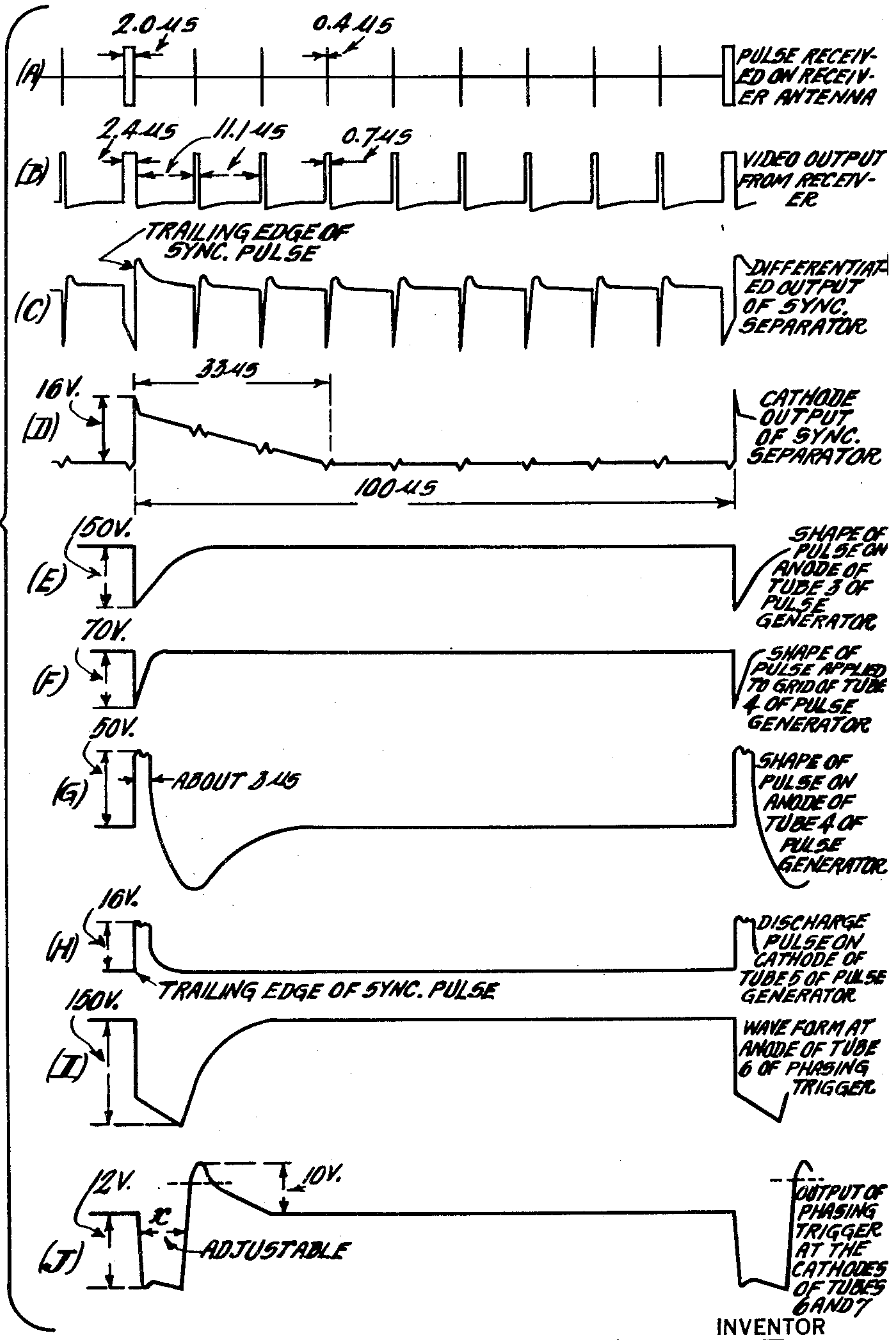

Fig. 2a.

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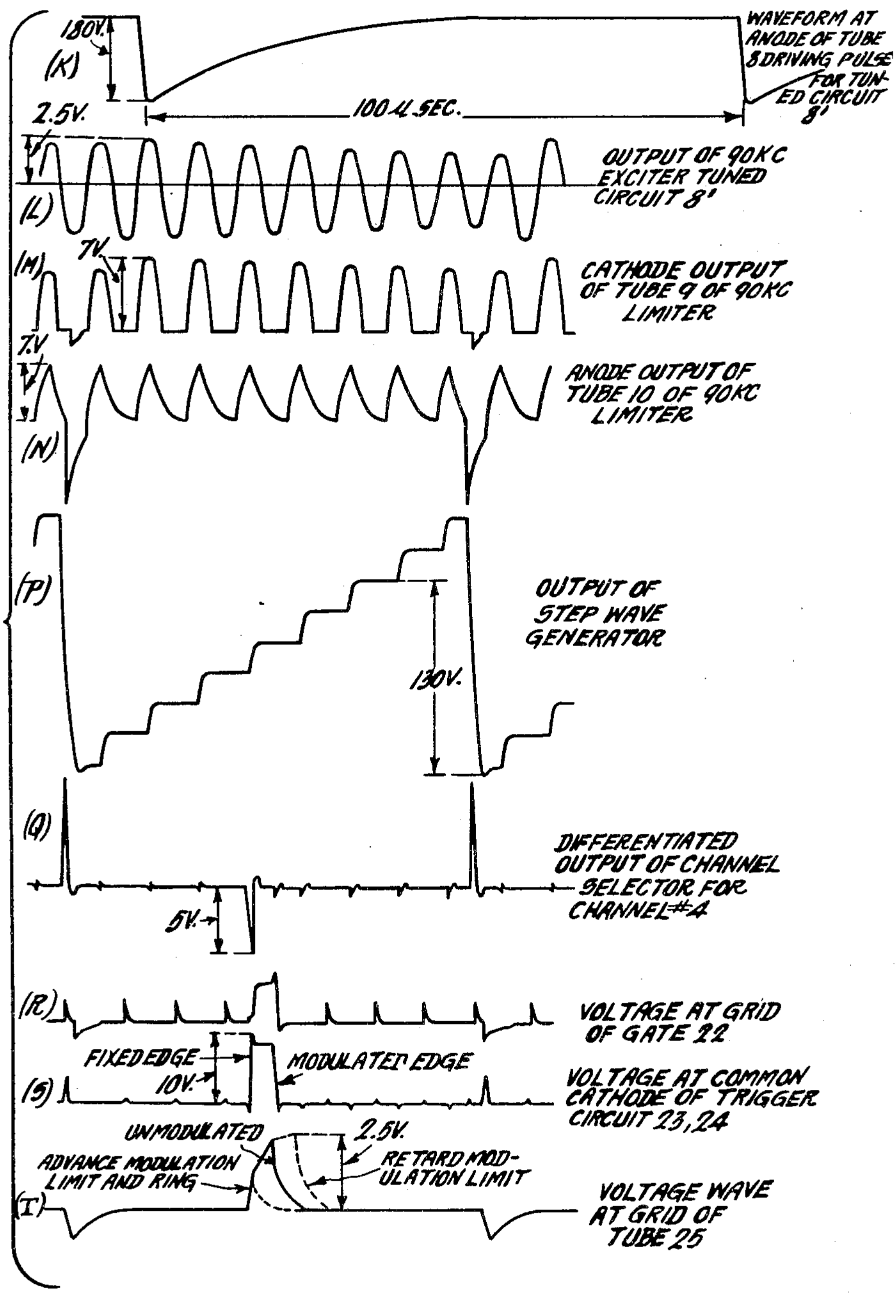

Fig. 2b.

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PULSE MULTIPLEX RECEIVER

Filed June 1, 1946 5 Sheets-Sheet 4

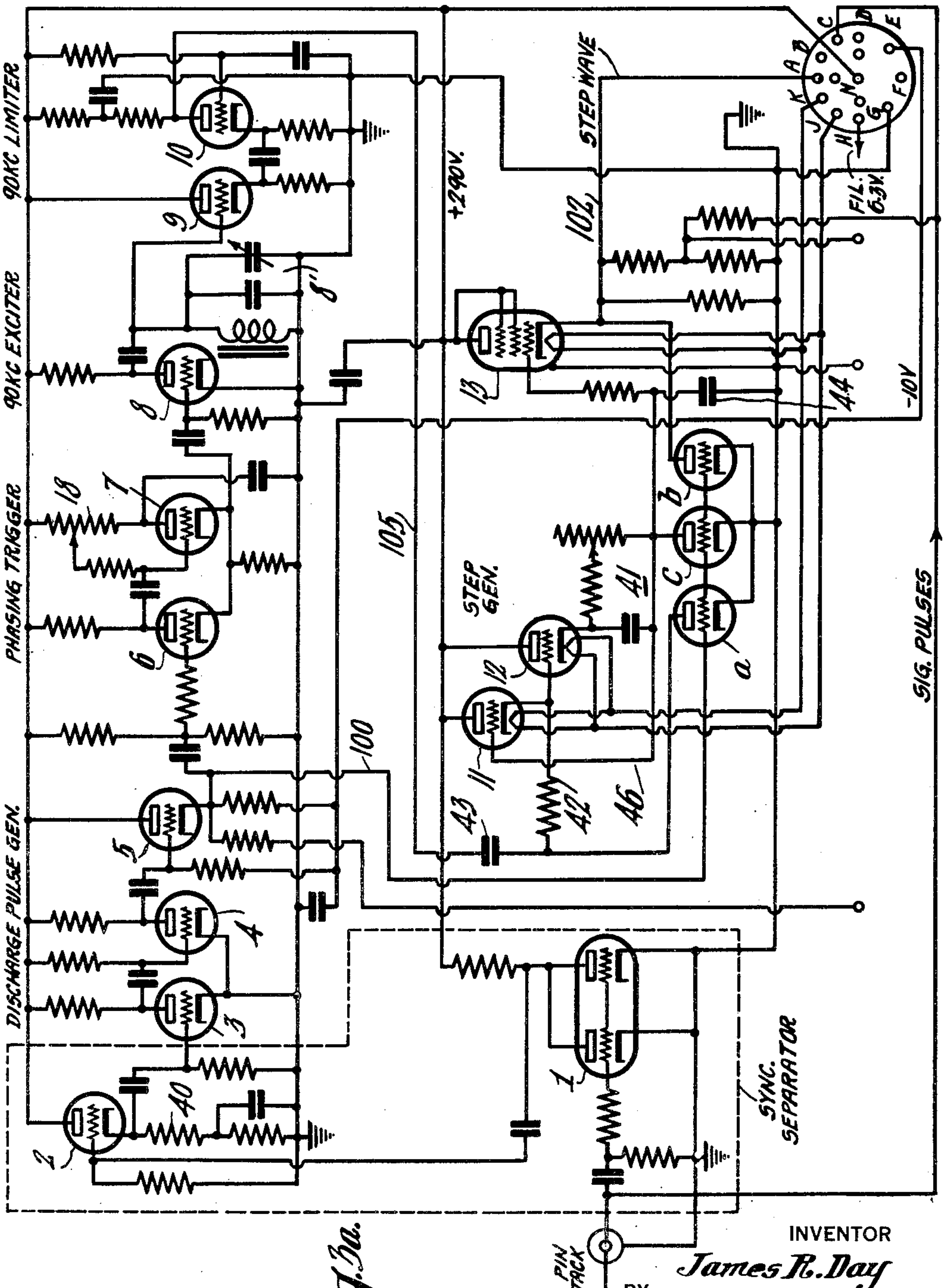

Fig. 3a.

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Filed June 1, 1946 5 Sheets-Sheet 5

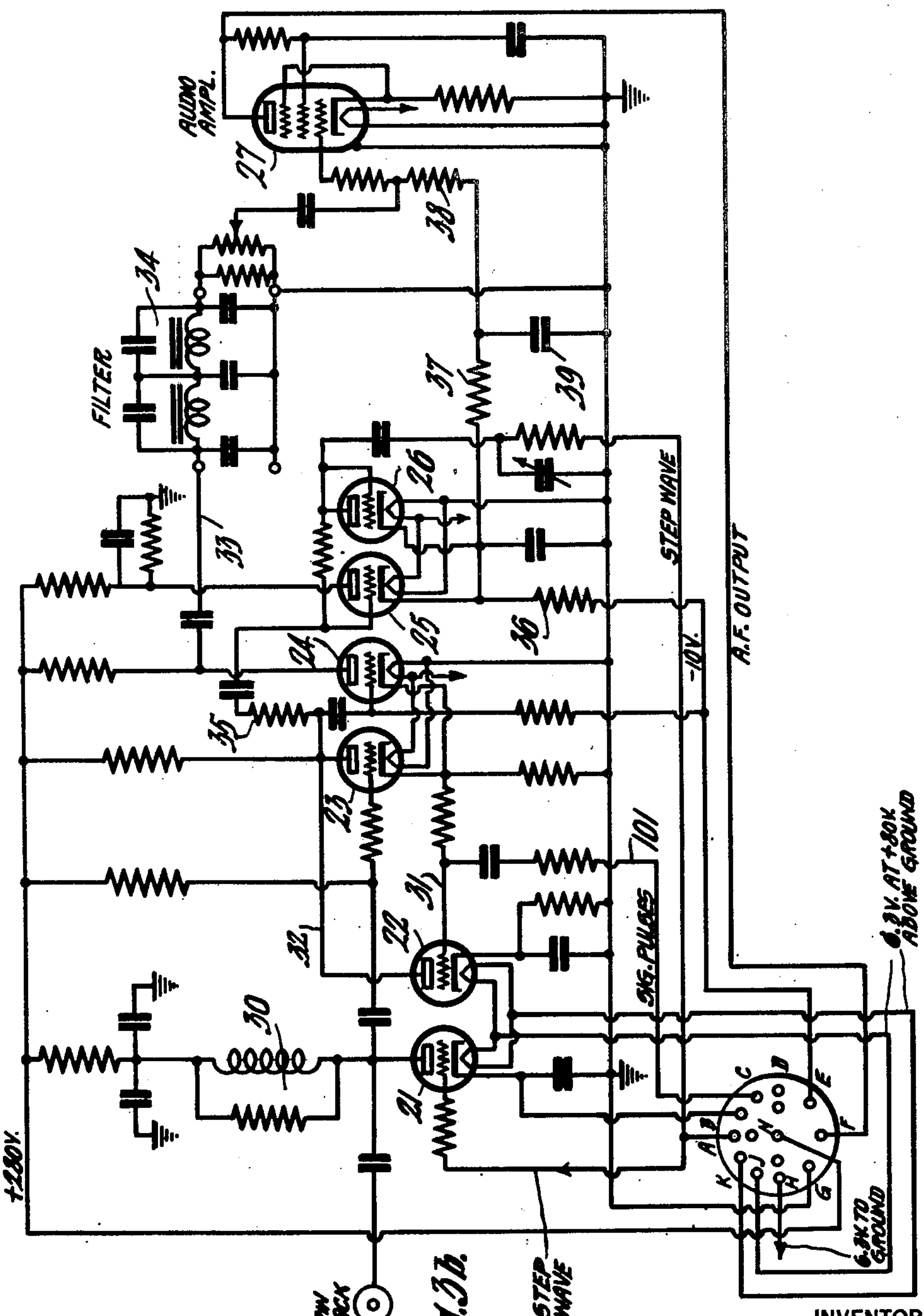

Fig. 3b.

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UNITED STATES PATENT OFFICE

2,469,066

PULSE MULTIPLEX RECEIVER

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Application June 1, 1946, Serial No. 673,746

7 Claims. (Cl. 179—15)

1

This invention relates to multiplex systems, and particularly to the receiving portion of a multiplex communication system employing short pulses of electrical energy.

The invention is particularly described in connection with an eight channel multiplex wherein the pulses are time displaced at the remote transmitter by the modulation. The transmitter which can be used is described in detail in copending application Serial No. 608,957, filed August 4, 1945 by W. D. Houghton to which reference is herein made, and its general mode of operation will now be given: In order to achieve multiplexing, the pulses corresponding to the separate channels are separately and consecutively generated at a fixed repetition rate known as the synchronization rate, corresponding to a fixed time interval which may be called the synchronization period. In the transmitter, the synchronization rate is 10 kc. and the corresponding period 100 μ sec. (microseconds). A pulse occurs once each synchronization period for each channel. The individual rates and periods of the channels are consequently the same and equal to the synchronization rate and period. Each channel pulse occurs at a rate of 10 kc. and the separation between adjacent pulses in each channel for an unmodulated condition is 100 μ sec. (microseconds). Because the unmodulated signal pulses are similarly located in each channel, adjacent pulses from different channels are therefore about 11.1 microseconds apart in the common output circuit. The pulses on each channel can be modulated ± 4 μ second (peak modulation) thus leaving a guard space between pulses from succeeding channels of about 3.1 μ sec. This guard space is important in reducing cross-modulation. The pulses from other channels occur in the interval between adjacent pulses from any one channel. The synchronization pulses occupy the ninth interval of 11.1 microseconds. The output pulses from the channels are of constant length and amplitude and the time between two adjacent pulses is measured from the leading edges. The modulation consists of varying the occurrence time of the pulses with respect to the synchronization pulse. The channel pulses may be 0.4 microsecond long and the synchronizing pulse 2.0 microseconds. Thus, in each cycle or frame there are eight channel pulses followed by a single longer duration synchronizing pulse, and each such cycle or frame will consume 100 microseconds.

The present invention relates to that portion of the receiving system which converts the video

2

pulses in the output of the receiver to a step voltage wave whose amplitude is adjustable over a small range and whose phase is adjustable with respect to the synchronizing pulse. The term "video" is employed to identify the nature of the voltages and currents in a circuit as consisting of D. C. pulses. The step voltage wave comprises a plurality of steps or risers of progressively increasing voltages, and each of these steps is utilized to cause a particular receiving channel to pass current (conduct). The invention also concerns that portion of the receiving system beyond the channel selector, wherein the pulses of varying occurrence time are converted to pulses of variable width whose variations in width correspond to the channel modulation.

A more detailed description of the invention follows in conjunction with a drawing wherein:

Fig. 1 illustrates, in box form, the complete receiving system for a pulse type multiplex communication system in which the invention is employed;

Figs. 2*a* and 2*b* taken together are a series of curves graphically illustrating different voltage waveforms appearing in different parts of the receiving system;

Fig. 3*a* illustrates the circuit details of the apparatus coupled to the output of the superheterodyne receiver and shown in Fig. 1 as the "common unit"; and

Fig. 3*b* illustrates the circuit details of the apparatus constituting a channel unit of which there are as many as there are channels in the system.

Throughout the figures of the drawing the same parts are designated by the same reference characters.

The pulses which the receiving system is designed to receive are short spaced pulses of radio frequency energy which are transmitted from a remote multiplex transmitter, not shown. These ultra short wave pulses may be in the form illustrated in curve A of Fig. 2*a* which shows eight channel pulses of short duration and one synchronizing pulse of longer duration for each frame or cycle. The showing of curve A, Fig. 2*a* is for the condition of no modulation and is given by way of example only. It should be noted that the pulses are evenly spaced from each other.

The pulses of curve A, Fig. 2*a*, are collected by antenna **19** and impressed upon superheterodyne receiver **20**, Fig. 1, the output of which is in the form of video pulses which may take the form shown in curve B of Fig. 2*a*. These video pulses are impressed via lead **107** upon a common unit shown as a box in dash lines, and also via lead 101, to the different channel units of which there are eight, in the assumption that the system describes an eight channel multiplex system.

The video pulses which are impressed upon the common unit are first applied to a synchronizing pulse separator circuit 1, 2 wherein only the synchronizing pulse is effective to produce a pulse which is applied to a pulse generator circuit 3, 4, 5. This synchronizing pulse separator circuit 1, 2 suppresses the channel pulses because of the fact that the channel pulses are of shorter duration than the synchronizing pulse. In effect, the synchronizing pulse separator circuit comprises a pair of vacuum tubes 1, 2 of which vacuum tube 1 serves as a limiter.

The pulse generator 3, 4, 5 comprises three vacuum tubes whose functions will appear in more detail later on in connection with the description of Fig. 3*a*. This pulse generator in effect, is a discharge pulse generator which produces a discharge pulse which is sent over two paths, one of which extends to the phasing trigger circuit 6, 7 and the other of which extends via lead 100 to a step wave generator 11, 12.

The phasing trigger comprises two vacuum tubes 6, 7 which provide a pulse of adjustable phase for driving a 90 kc. exciter vacuum tube 8. This tube has as its output, a circuit 8′ which is tuned to 90 kilocycles. The output of the 90 kc. exciter, as derived from the tuned circuit therein, is in the form of a 90 kc. sine wave, which is fed to a 90 kc. limiter 9, 10. This limiter comprises a pair of vacuum tubes 9, 10 which serve to convert the applied 90 kc. sine wave to peaked positive pulses, in turn, applied via lead 105 to the step wave generator 11, 12.

The step wave generator comprises several vacuum tubes which function to produce a step wave voltage having a plurality of steps or risers corresponding in number to the number of channels of the system. The discharge pulse supplied from the discharge pulse generator 3, 4, 5 via lead 100 to the step wave generator serves to terminate the step wave voltage after a desired number of risers or steps.

The output from the step wave generator is passed through a coupling vacuum tube 13 and then via lead 102 to the various channel selectors 21, 21′, 21″ of the different channel units, it being understood that there are as many channel units as there are channels in the system; in this case eight channels.

The channel selectors in the different channels are differently biased so as to become conductive on different risers or steps of the applied step wave voltage. The output of each channel selector is applied to a trigger circuit 23, 24 which is in turn associated with a gate 22, the latter obtaining the signal or video pulses from lead 101. The arrangement of the channel selector trigger circuit and gate are such as to convert the applied signal video pulses whose times of occurrence vary in accordance with the signal modulation to variable width pulses whose duration or width correspond to the signal modulation.

The variable width pulses from the output of the trigger circuit 23, 24 are supplied to a low pass filter 34 which removes all high frequency components and passes the audio signal to the audio amplifier tube 27.

A ringing circuit 25, 26 is also provided for calling the attention of the attendant when it is desired to apply ringing currents to a particular channel.

From the foregoing, it will be seen that the receiving system has amplified the weak radio frequency pulses, converted them to D. C. pulses (video) and then supplied these pulses to the receiving multiplex at a suitable amplifier level. The receiving multiplex system regenerates the synchronizing period (100 microseconds) directly from the incoming signal, and with it separates the channel pulses in the same order that they were originally generated. The separated pulses are then demodulated to give eight voice frequency outputs.

A description will now be given of Figs. 3*a* and 3*b* which illustrate the circuit details of the system of the invention.

The synchronizing separator comprises a triode tube 1 normally biased to cut off and also tube 2 which is coupled to the output of triode 1 through a differentiator circuit. Tube 1 acts as a limiter. The video pulses (curve B) from the radio receiver are applied to the grid of triode 1. Tube 1 is biased to be normally non-conducting and conducts only during the presence of a pulse, or, putting it in other words, it conducts only during the time of the individual pulses, whether channel or synchronizing pulses. Tube 1 acts as a limiter and its output comprises spaced pulses whose polarity are reversed relative to the input pulses. These reversed polarity pulses in the output of tube 1 are differentiated and applied to the grid of tube 2. (Note curve C.) Tube 2 is also normally non-conducting, and is so biased that only the peaked positive-going impulse produced from the trailing edge of the synchronizing pulse will cause it to conduct. This is because the peaked impulses produced from the synchronizing pulses are of larger amplitude than the peaked impulses produced from the channel pulses, due to the fact that the synchronizing pulse is of longer duration than the channel pulses.

The discharge pulse generator comprises tubes 3, 4 and 5. The output from the synchronizing separator, taken from the cathode of tube 2, is a peaked pulse in the positive direction which gradually diminishes over about 33 microseconds, and this gradual diminution of the pulse is caused by the discharge time of the capacity to ground through the high cathode resistor 40 of tube 2 and the grid of the following tube 3 in the discharge pulse generator. (Note curve D.)

Tube 3 is normally non-conducting and the application of the positive pulse thereto from the synchronizing separator causes it to conduct, as a result of which a negative pulse of sloping trailing edge is produced on its anode (curve E) which causes a negative pulse (curve F) to be supplied to the grid of tube 4. Tube 4, however, is normally conducting and the application of a negative pulse thereto causes it to cease conducting for a short period of time, thus producing a positive output pulse in its anode circuit of about 3 microseconds which looks like curve G. Tube 5 is a coupling tube and is normally non-conducting. The application of a positive pulse to its grid from the anode of tube 4 produces a discharge pulse on its cathode of positive polarity which looks like curve H.

The discharge pulse from the discharge pulse generator is supplied both to the phasing trigger and to the step wave generator. The phasing trigger is a self-restoring trigger circuit having one degree of electrical stability and comprises tubes 6 and 7. In effect, this phasing trigger is nothing more or less than a delay circuit for delaying the pulses passed thereto by a predetermined amount. Normally, tube 6 is nonconductive and tube 7 conductive. When this trigger circuit is fired, it remains in its active state for a time determined by the time constant of the circuit. The amount of delay is adjusted by means of a tap on the anode resistor of tube 7. The positive pulse from the cathode of tube 5 of the pulse generator is applied to the grid of tube 6 of the phasing trigger and fires the trigger circuit to its active state. Output from the phasing trigger is taken from the common cathode circuit and 's primarily a negative pulse whose trailing edge has an overshoot or positive peak, so to speak, which is utilized to excite the 90 kilocycle exciter 8 (note curve J).

The 90 kilocycle exciter comprises a vacuum tube 8 having in its anode a parallel tuned circuit 8' whose resonant frequency is 90 kilocycles. This tuned circuit is loosely coupled to the anode of the exciter tube. The exciter tube 8 has a self-bias which adjusts itself so that it passes current only on the overshoot or peaks of the waves supplied to it by the phasing trigger. Note curve J. This overshoot occurs once each frame; or, putting it in other words, once for each synchronizing pulse but not necessarily at the synchronizing pulse time. When the exciter tube passes current, it supplies a driving pulse or kick (curve K) to the 90 kilocycle tuned circuit 8'. This driving pulse or kick sets the tuned circuit into oscillations at a 90 kilocycle rate. These oscillations are of sine wave form and tend to decay slightly. In this particular case, the driving pulses from the 90 kilocycle exciter occur at intervals of 100 microseconds corresponding to a rate of 10,000 per second. Thus, one driving pulse is supplied to the tuned circuit for every nine cycles of sine wave oscillation generated in the tuned circuit. This is shown in curve L.

The portion X of the curve J is adjustable by adjustment of the resistor 18 of the phasing trigger.

The output of the tuned circuit 8' is passed to the grid of vacuum tube 9 of the 90 kilocycle limiter. This tube passes only the positive halves of the sine wave cycles (curve L) generated by the tuned circuit, as shown in curve M, and passes these positive halves on to the cathode of vacuum tube 10 of the 90 kilocycle limiter. It should be noted that one pulse in each nine pulses passed by tube 9 to tube 10 is of larger amplitude than the others in each frame. This larger pulse immediately follows the driving pulse from the 90 kilocycle exciter; and the decaying amplitude of the pulse of curve M is caused by the inherent damping of the 90 kilocycle tuned circuit 8'. Thus, this 90 kilocycle tuned circuit 8' is maintained in oscillation by its exciting pulse.

Tube 10 of the 90 kilocycle limiter converts the pulses of waveform M to more peaked pulses of wave form N. The negative going pulse of curve N is caused by the reaction from the step wave generator which is coupled to the output of tube 10 of the 90 kilocycle limiter.

Output from the 90 kc. limiter is taken from the anode circuit of tube 10 via lead 105 and this output of curve N is passed onto the grid of vacuum tube 12 of the step wave generator as a series of recurring positive pulses. The step wave generator is of the form described in my copending application Serial No. 629,169 filed November 16, 1945 wherein the legend "positive input pulse" in the drawing thereof, corresponds to the pulses passed by the 90 kilocycle limiter 9, 10 to the step wave generator. The legend "synchronizing pulses" in my copending application Serial No. 629,169 corresponds to the discharge pulse passed to the step wave generator directly from the cathode of tube 5 of the pulse generator over lead 100.

The coupling vacuum tube 13 corresponds to the cathode follower tube G of my copending application Serial No. 629,169. Step wave output is taken from the cathode of this coupling tube and supplied via lead 102 to the channel selector circuits 21, 21', 21'' etc., of the different channel units shown in Fig. 1. This step wave output supplied to the channel units is curve P. The channel units also have supplied thereto the video pulses from the radio receiver over lead 101.

In my step wave generator, the anodes of vacuum tubes 11, 12 and 13 are connected to a common source of anode polarizing potential +290 volts. Triode tube 12 is biased by the resistor-condenser combination 41 in its cathode circuit so as to be normally non-conducting. The grid of triode 12 is connected through a resistor 42 and a coupling condenser 43 to lead 105 which supplies D. C. input pulses of positive polarity (curve N) from the output of tube 10 of the 90 c. c. limiter. Each of these input pulses (curve N) is of sufficient magnitude to overcome the cut-off bias of tube 12 and cause it to conduct for the duration of the applied pulse.

A storage or step condenser 44 is connected between ground and the circuit combination 41, as a result of which an incremental charge of voltage is built up on this condenser whenever tube 12 conducts. A step wave voltage is built up across condenser 44, and this step wave voltage has a plurality of steps of increasing amplitude corresponding in number to a desired number of input pulses (curve P).

Tube 11 is a normally non-conductive vacuum tube which, when it conducts, serves to restore coupling condenser 43 to its original condition after each input pulse. The cathode of tube 11 is connected to the grid of tube 12, while the grid of tube 11 is connected via lead 46 to the circuit combination 41.

Tubes *a*, *b* and *c* are normally non-conductive and become conductive simultaneously. The grids of these tubes are connected together and their cathodes are also connected together and to ground. The space path of tube *c* is effectively across step condenser 44, and when this tube conducts, it forms a low impedance discharge path across condenser 44. Tube *b*, when it conducts, insures the quick discharge of the load capacity connected to the cathode of tube 13. Tube *a* serves to prevent tube 12 from conducting during the discharge of step condenser 44. In Fig. 1, the channel selectors 21, 21', 21'' are differently self-biased, and each channel selector is normally biased well beyond the current cut-off condition.

The channel selector is substantially like that shown in Houghton copending application Serial No. 608,957, supra, except for the fact that in the anode circuit, a coil 30 is used instead of a resistor. This coil 30, Fig. 3*b* is a differentiating coil and its purpose is to provide a much shorter pulse than that provided by the output of the channel selector described in the Houghton copending application. The channel selectors are differently biased to operate on successive risers of the step wave output (curve P) from the step wave generator 11, 12. Each step or rise in the step wave voltage appearing in lead 102 is great enough to insure that during its occurrence the current of the corresponding biased channel selector shall be driven rapidly from beyond the current cut-off condition to a zero bias value. Once a channel selector, which is normally cut-off, passes current, (it responds to the increase in voltage on the particular step rise), it will continue to pass current until the completion of the step wave voltage. The differentiated short pulse output from the channel selector 21 is in the negative direction, as shown in curve Q, for example, (corresponding to channel 4) and is passed on to a self-restoring trigger circuit comprising vacuum tubes 23 and 24.

Tube 23 of the trigger circuit is normally conducting while tube 24 is non-conducting. The trigger circuit has one degree of electrical stability and has a stable state and an active state. Its time constant is such that it would normally restore to normal (the stable state) if left alone after it has been fired to the active state, restoring itself after a time interval considerably longer than the time allotted for one channel.

However, the trigger circuit is made to restore itself to normal by the video signal pulse supplied to a gate 22 at a time interval after being fired which is considerably shorter than the time allotted for one channel. Putting it in other words, the channel selector 21 fires the trigger circuit to its active state, while the gate 22 turns off or restores the trigger circuit to its stable state. The output from the trigger circuit is thus a pulse of variable width, depending upon the time interval between the channel selector output pulse and the incoming video signal pulse for that channel. Thus, it will be seen that the channel selector 21, the gate 22 and the trigger circuit 23, 24 constitute in effect a system for transforming the time-displaced video signal pulses to variable width pulses, the variation in width corresponding to the signal modulation at the remote transmitter which varies the timing of the transmitted pulses. It should be understood, of course, that I am now considering the pulses for a single channel, inasmuch as the different channel units have similar equipment for effecting the same results for their own respective channel pulses.

The video pulses from the output of the radio receiver are applied over lead 101 to the grid of the gate 22. Gate vacuum tube 22 is normally non-conductive. These video pulses are of positive polarity and are not of themselves of sufficient amplitude to make the gate 22 conduct. However, when the trigger circuit 23, 24 is fired and is in its active state, there is supplied to the grid of the gate 22 over lead 31 a positive voltage pulse from the common cathode circuit of the trigger circuit. This positive voltage pulse from the trigger circuit applied to the grid is of sufficient magnitude to reduce the cut-off bias on the tube 22 to an extent such that if at this time a video signal pulse of positive polarity is also applied to the grid via lead 101, the resulting voltage from both the video signal pulse and the trigger pulse are sufficient to overcome the bias on the gate 22 and cause it to conduct. It will thus be seen that only in the simultaneous presence of both the video signal pulses and a positive pulse from the trigger circuit will the gate 22 of any one chanel pass current. When the gate 22 passes current, the voltage on its anode will drop and cause the effective application via lead 32 of a negative pulse to the anode of tube 23 of the trigger circuit of a magnitude sufficient to restore the trigger circuit to normal. Output from the trigger circuit in the form of a variable width pulse is taken from the anode of tube 24 via lead 33 and fed to a low pass filter 34. This low pass filter removes all high frequency components and passes the audio signal to the audio amplifier tube 27.

Curve R illustrates the voltage wave form appearing on the grid of gate 22. The short sharp pulses correspond to the signal pulses and these short sharp pulses are not sufficient of themselves to overcome the cut-off bias of the gate. The large, longer duration pulse corresponds to the voltage occurring on the grid of 22 due to the simultaneous application of both a video signal pulse and a positive pulse from the trigger circuit, and the peak of this larger amplitude longer duration pulse has a magnitude sufficient to overcome the cut-off bias on the gate 22.

Curve S shows the voltage variation at the common cathode of the trigger circuit 23, 24. The fixed edge is determined by the firing pulse for the trigger circuit 23, 24 supplied from the channel selector, while the trailing or modulated edge is determined by the restoring pulse supplied by the gate 22.

Pulse rectifier tube 25 and rectifier tube 26 comprise the ringing system. The rectifier 25 has an input pulse supplied to its grid from the anode of tube 23 of the trigger circuit through a low pass filter comprising a high resistance 35 and a capacity formed by the grid-to-ground capacity of tube 25. The pulses from the trigger circuit, after passing through the low pass filter, appear on the grid of tube 25 in the form shown in curve T.

In the absence of signal modulation for this particular channel, the wave form at the grid of tube 25 has the form of the solid line of curve T. Pulse rectifier tube 25 is supplied with a floating fixed bias from the rectifier 26. This bias is adjusted to a value such that the pulse of the solid line of curve T causes conduction near the peak of this pulse. This conduction current flows through resistance 36 in the cathode of tube 25 to a source of negative bias −10 volts. The conduction current through resistor 36 is sufficient to maintain the cathode of tube 25 at a potential in the neighborhood of +5 volts with respect to ground.

This bias is supplied to the grid of audio amplifier tube 27 through a low pass filter comprising resistances 37, 38 and capacitor 39. This condition causes audio amplifier tube 27 to conduct in normal fashion as an audio amplifier.

In the presence of modulation, the pulses applied to the grid of tube 25 are shown in their extreme modulated positions by the dotted lines of curves T. It should be kept in mind that the positive going pulse appearing at the anode of trigger tube 23 has a variable width corresponding with the channel modulation. This variable width pulse undergoes a wave form distortion upon passing the low pass filter between the anode of tube 23 and the grid of tube 25. This distortion is such that a wide pulse is passed with a small amplitude, as shown in curve T. It will be observed that tube 25 conducts only on pulses greater than a certain amplitude near the peak value of the pulses shown in curve T and hence conducts during these pulses with or without the presence of modulation; thus, audio amplifier tube 27 remains in its conducting condition.

As described in copending Houghton application, Serial No. 608,957 supra, the ringing is accomplished by advancing a channel pulse to its extreme position, where it remains for the duration of a ring. This ringing condition produces a narrow pulse at the anode of trigger tube 23 and this pulse, after passing the low pass filter to the grid of tube 25, is of such low amplitude that it cannot overcome the fixed bias on tube 25; hence tube 25 remains completely non-conducting. Under this condition, the voltage at the cathode to tube 25 is maintained at a value close to minus 10 volts with respect to ground. This condition provides this same negative bias at the grid of audio amplifier tube 27 causing it to be essentially at cut-off. In the plate circuit of tube 27 is connected, along with the audio output transformer, a ringing relay which is kept closed by the normal plate current of this tube. When this tube is cut off, the ringing relay opens and causes a twenty cycle ringing channel generator to be started and switched on to the outgoing line.

What is claimed is:

1. A pulse multiplex receiving system for receiving from a remote transmitting system a plurality of equal duration spaced channel pulses followed by a synchronizing pulse, comprising a receiver for producing spaced video pulses which occur at time intervals corresponding to the received pulses, a separator circuit for separating the video pulse representative of the synchronizing pulse from the channel pulses, a discharge pulse generator coupled to said separator circuit for producing a pulse for each synchronizing video pulse supplied thereto, a phasing trigger circuit coupled to the output of said discharge pulse generator, said phasing trigger circuit having means for producing a peak voltage which occurs an adjustable interval of time after the pulse supplied thereto by said discharge pulse generator, a sine wave generator coupled to the output of said phasing trigger circuit and responsive to the peak voltage passed thereto, a limiter in the output of said sine wave generator, a step wave generator coupled to the output of said limiter and responsive to the limited waves for producing a step voltage wave having a desired number of steps or risers, a connection from the output of said discharge pulse generator to said step wave generator for controlling the termination of the step voltage wave produced by said step wave generator, a plurality of channel units coupled to the output of said step wave generator, a connection from said channel units to the output of said receiver to obtain therefrom video channel pulses, said channel units having individual selector circuits which are differently biased to become conductive on different risers of the step voltage wave, and said channel units having apparatus for converting the video channel pulses to variable width pulses.

2. In a pulse multiplex system wherein a plurality of equal duration spaced channel pulses and a single longer duration synchronizing pulse are transmitted for each frame or cycle of operations and wherein the occurrence time of each channel pulse is variable over a range by the signal modulation for that particular channel, a receiving system including apparatus for producing D. C. pulses representative of said channel and synchronizing pulses, a circuit responsive only to the D. C. synchronizing pulse for producing another pulse, a discharge pulse generator coupled to said last circuit for producing a pulse in response to each pulse supplied to said generator by said last circuit, means for producing a voltage wave of adjustable occurrence time from

the pulse produced by said pulse generator, a shock-excited sine wave generator coupled to said means for producing a number of sine waves corresponding in number to the received pulses for each frame or cycle of operations, a step wave generator coupled to the output of said shock-excited sine wave generator for producing a step voltage wave having a plurality of steps or risers corresponding in number to the number of received pulses for each frame or cycle of operations, a connection from the output of said discharge pulse generator to said step wave generator for supplying a discharge pulse to said step wave generator, a plurality of channel units coupled to the output of said step wave generator, said channel units having individual circuits which are differently biased to become responsive on different risers of the step voltage wave, and means for supplying D. C. channel pulses from said apparatus to said channel units.

3. In a pulse multiplex system wherein a plurality of equal duration spaced channel pulses and a single longer duration synchronizing pulse are transmitted for each frame or cycle of operations and wherein the occurrence time of each channel pulse is variable over a range by the signal modulation for that particular channel, a receiving system including apparatus for producing D. C. pulses representative of said channel and synchronizing pulses, a discharge pulse generator normally biased to cut-off and responsive to said synchronizing pulses to thereby produce other pulses, a shock excited oscillator normally biased to cut-off and coupled to said pulse generator and responsive to a pulse produced by said generator for in turn producing a plurality of equally spaced waves corresponding in number to the number of channel and synchronizing pulses in each frame or cycle of operations, a step wave generator coupled to the output of said shock excited oscillator for producing a step voltage wave having a plurality of steps or risers corresponding in number to the number of received waves for each frame or cycle of operations, a plurality of individual channel circuits coupled to the output of said step wave generator and a connection for supplying D. C. channel pulses to said channel circuits, said channel circuits being so constructed and arranged as to become responsive on different risers of the step voltage wave, and having apparatus for converting the D. C. channel pulses of varying occurrence time to variable width pulses.

4. In a pulse multiplex system wherein a plurality of equal duration spaced channel pulses and a synchronizing pulse are transmitted for each frame or cycle of operations and wherein the occurrence time of each channel pulse is variable over a range by the signal modulation for that particular channel, a receiving system including apparatus for producing D. C. pulses representative of said channel and synchronizing pulses, normally non-conductive means responsive only to the D. C. synchronizing pulse for producing a plurality of equally spaced waves corresponding in number to the number of channel and synchronizing pulses in each frame or cycle of operations, said means including a shock excited damped tuned circuit and a circuit preceding said shock excited damped tuned circuit for varying the phasing or time of initiation of the equally spaced waves produced by said tuned circuit, a step wave generator coupled to said means for producing a step voltage wave having a plurality of steps or risers corresponding in number

to the number of received waves for each frame or cycle of operations, a plurality of individual channel circuits coupled to the output of said step wave generator and a connection for supplying D. C. channel pulses to said channel circuits, said channel circuits being so constructed and arranged as to become responsive on different risers of the step voltage wave, and having apparatus for converting the D. C. channel pulses of varying occurrence time to variable width pulses.

5. In a pulse multiplex system wherein a plurality of equal duration spaced channel pulses and a synchronizing pulse are transmitted for each frame or cycle of operations and wherein the occurrence time of each channel pulse is variable over a range by the signal modulation for that particular channel, the method of operation which includes receiving the transmitted pulses, producing from only the received synchronizing pulse a plurality of equally spaced sinusoidal waves corresponding in number to the number of pulses received during each frame or cycle of operations and commencing at an adjustable time after the receipt of said synchronizing pulse, producing from said equally spaced waves a step voltage wave having a plurality of steps or risers corresponding in number to the number of pulses received during each frame or cycle of operations, feeding the received pulses to a plurality of individual channels, and causing different channels to become responsive at different times corresponding to the occurrence time of the risers of said step voltage wave.

6. In a pulse multiplex system wherein a plurality of equal duration spaced channel pulses and a synchronizing pulse are transmitted for each frame or cycle of operations and wherein the occurrence time of each channel pulse is variable over a range by the signal modulation for that particular channel, the method of operation which includes receiving the transmitted pulses, producing from only the received synchronizing pulse a plurality of equally spaced waves corresponding in number to the number of pulses received during each frame or cycle of operations and commencing at an adjustable time after the receipt of said synchronizing pulse, producing from said equally spaced waves a step voltage wave having a plurality of steps or risers corresponding in number to the number of pulses received during each frame or cycle of operations, feeding the received pulses to a plurality of individual channels, causing different channels to become responsive at different times corresponding to the occurrence time of the risers of said step voltage wave, and converting the received pulses of variable occurrence time fed into said channels to variable width pulses.

7. In a pulse multiplex system producing a plurality of spaced channel pulses and a synchronizing pulse for each frame or cycle of operations, a receiving system therefor comprising a circuit for separating the synchronizing pulse from the channel pulses, an electron discharge device biased to the current cut-off condition and a circuit therefor for producing sine waves, and means located between said device and said separator circuit and responsive only to the separated synchronizing pulse in the output of said separator circuit for producing a pulse which overcomes said cut-off bias to thereby cause said device and associated circuit to produce a plurality of sine waves corresponding in number to the number of received pulses for each frame or cycle of operations, said means including self-restoring trigger circuit having only one degree of electrical stability for varying the phasing or time of initiation of said plurality of waves, and a step wave generator coupled to and responsive to the output of said means for producing a step voltage wave having a plurality of steps or risers corresponding in number to the number of received pulses in each frame.

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