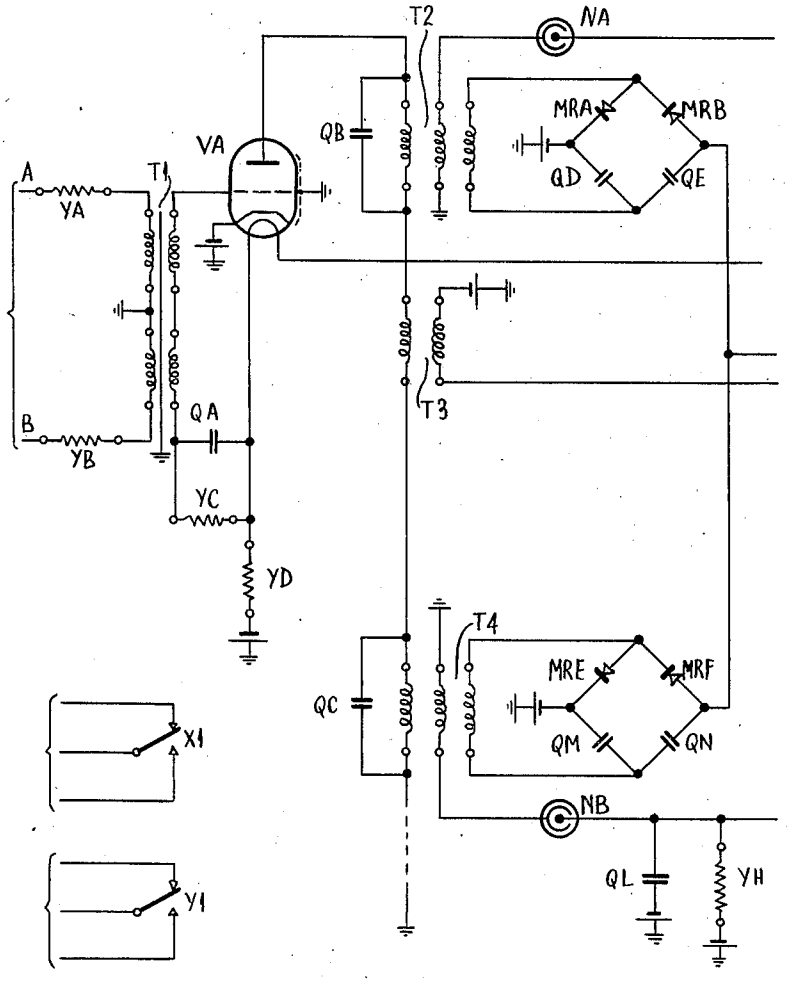
May 5, 1942. T. B. D. TERRONI ET AL 2,282,271

ELECTRICAL SIGNALING SYSTEM

Filed Oct. 19, 1938 2 Sheets-Sheet 1

Fig. 1.



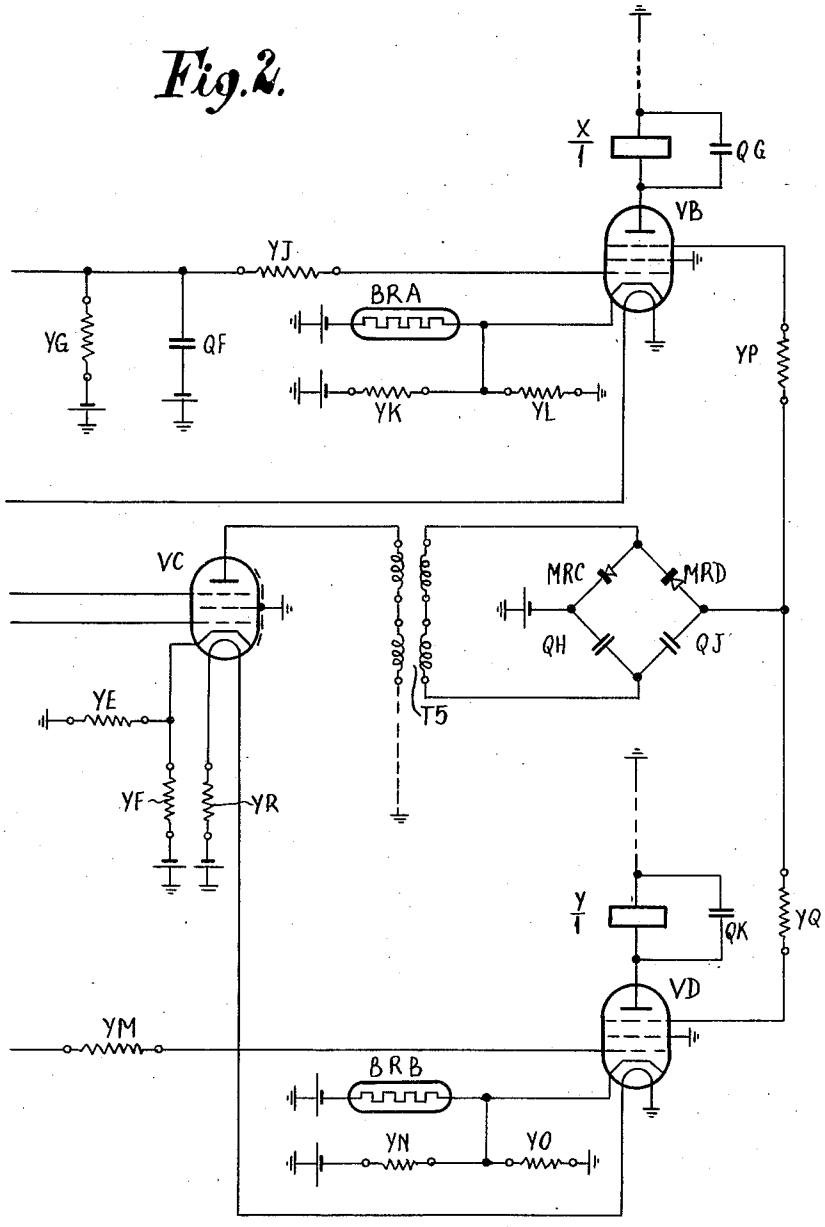
INVENTORS
TESEO BRUNO DANTE TERRONI
JOSEPH BERNARD Mc CUSKER
BY Chas. Tu. Candy.
ATTORNEY

May 5, 1942. T. B. D. TERRONI ET AL 2,282,271

ELECTRICAL SIGNALING SYSTEM

Filed Oct. 19, 1938 2 Sheets-Sheet 2

Fig. 2.



INVENTORS
TESEO BRUNO DANTE TERRONI
JOSEPH BERNARD McCUSKER
BY Chas. W. Candy
ATTORNEY

Patented May 5, 1942 2,282,271

UNITED STATES PATENT OFFICE

2,282,271

ELECTRICAL SIGNALING SYSTEM

Teseo Bruno Dante Terroni and Joseph Bernard McCusker, Liverpool, England, assignors to Associated Telephone and Telegraph Company, Chicago, Ill., a corporation of Delaware

Application October 19, 1938, Serial No. 235,746
In Great Britain November 12, 1937

20 Claims. (Cl. 179—84)

The present invention relates to electrical signaling systems and is more particularly concerned with systems in which alternating current signals are transmitted over channels which are also employed for the transmission of complex currents which include said alternating currents.

Such a signaling system is particularly applicable to a telephone system in which alternating current signals of one or more predetermined frequencies are employed for control and supervisory purposes and the problem then arises of providing a signal circuit which will respond to the alternating current signals but will not respond to the components of the complex currents which have the frequency of the alternating current signals. In this case of course the complex currents will be speech currents.

The object of the present invention is to provide improved circuit arrangements whereby effective discrimination is obtained in the receiver between the signal currents and the complex currents.

According to one feature of the invention incoming currents are applied to the grid of a thermionic valve arranged to act as a current limiting device and in the anode circuit of the valve are arranged a plurality of responding circuits, one at least of which is tuned to a signaling frequency while a second tends to prevent the operation of signal responding devices the second circuit being rendered ineffective when signaling frequencies predominate to enable the appropriate signal responding device to operate.

According to another feature of the invention incoming currents are applied to the grid of a valve amplifier arranged to be operated in an over-loaded condition so as to act as a current limiting device and included in the anode circuit of the valve is a signal responding circuit having a predominating response to currents of a particular frequency and a second signal responding circuit adapted to respond to currents of all frequencies, the first signal responding circuit being effective to cause the operation of a signal responding device while the second is effective in preventing the operation of the signal responding device when complex currents are being received.

According to a further feature of the invention incoming currents are applied to the grid of a thermionic valve arranged to act as a current limiting device and included in the anode circuit of the valve is a signal responding circuit having a large impedance relative to the impedance of a second circuit when signaling currents are being received while when complex currents are being received the impedance of said first circuit is small relative to that of the second circuit whereby when signaling currents are being received the first circuit exerts a predominating effect to cause the operation of a signal responding device while when complex currents are being received the second circuit exerts a predominating effect to prevent the operation of said signal responding device.

Another feature of the invention is that the signaling currents and the complex currents are passed through a limiting device and are then applied to signal responding circuits each of which has a predominating response to current of a particular frequency the voltage thereby developed being employed to cause a glow discharge tube to strike and apply a voltage to the grid of a valve the anode circuit of which includes a signal responding device, the arrangement being such that the voltage applied to the grid of the valve is substantially the same whether currents of one or more than one signal frequency are being received provided the current strength of the signal is sufficient to cause the striking of the appropriate glow discharge tube.

Still a further feature of the invention is that discrimination between the signaling currents and the components of the complex currents having the signaling frequency is effected due to the relative voltages developed across two circuits one of which has a predominating response to currents of the signaling frequency while the other has substantially the same response to currents of all frequencies, the voltages developed across said circuits being each applied to a grid of a multi-electrode valve to control the current flow therethrough whereby the valve is enabled to exert a control over signal responding devices to ensure that they operate only in response to currents of signaling frequency.

It will be understood that the invention is equally applicable to transmission over a voice frequency channel or over a carrier channel.

The invention will be better understood from the following description of the one embodiment taken in conjunction with the accompanying drawings comprising Figures 1 and 2 which should be placed side by side with Fig. 1 to the left of Fig. 2 to show the complete circuit of the receiver.

The incoming line is represented in Figure 1

by the conductors A and B which are connected over resistances YA and YB respectively to the ends of the primary winding of a screened input transformer T1, the centre point of the primary winding being earthed. The secondary winding of the transformer T1 is connected between the grid and cathode of a valve VA, the connection to the cathode being effected over a high resistance YC in parallel with a condenser QA. Filament current is supplied to the valve VA and to the valve VB over a series circuit which includes a resistance YD.

The anode circuit of the valve includes the primary windings of three transformers T2, T3 and T4 of which T2 is tuned by the condenser QB to one signaling frequency, say for example 750 cycles per second, T4 is tuned by the condenser QC to the second signaling frequency say 600 cycles per second and T3 is untuned.

The valve VA is arranged to give a constant output independent of the strength of the incoming signal and this is effected by operating the valve in an overloaded condition. The grid bias applied to the valve is such that due to the high resistance YC the grid is at zero or slightly positive with respect to the cathode in the absence of a signal so that an incoming signal when applied to the grid causes grid current to flow and a negative voltage is built up on the grid by the condenser QA. The effect of this steady negative voltage is to move the datum line on the grid volts/anode current curve about which the signals are applied to a position such that for the particular signal amplitude being received the positive grid swing extends just to the extent on the grid volts/grid current curve as will give the steady negative bias. By this means theoretically the amplitude of the output voltage is maintained substantially constant, but actually owing to the decrease of the ratio of the base to the amplitude the output current decreases with increase of level. This is, however, avoided by the use of resistances YA and YB which flatten the peaks of the signal voltage as the level increases.

The two tuned transformers T2 and T4 in the anode circuit of the valve VA each have two secondary windings one of which is connected over neon tubes NA and NB and resistances YJ and YM respectively to the control grids of the receiving pentodes VB and VD respectively. The other secondary windings are connected over voltage doubler networks MRA, MRB, QD, QE and MRE, MRF, QM, QN respectively the outputs from which are connected in parallel to the suppressor grid of the suppression pentode VC.

The secondary winding of the untuned transformer T3 is connected to the control grid of the pentode VC and is biased by means of the reristances YE and YF to act as an amplifier. Cathode heater current is supplied to the valves VC and VD over a series circuit which includes the resistance YR. The output from the valve VC is applied over the transformer T5 to a voltage doubler network MRC, MRD, QH and QJ, the output of which is applied to the suppressor grid of the two receiving pentodes VB and VD, over resistances YP and YQ respectively. The anode circuit of each of the valves VB and VD includes a receiving relay X and Y respectively having contacts *x1* and *y1* in one or more signaling circuits, each relay being provided with a by-pass condenser QG and QK respectively. Each of the pentodes VB and VD is provided with a resistance network comprising resistances YK, YL, barretter BRA and resistances YN, YO, barretter BRB respectively arranged as shown in order to compensate for the fluctuations in the supply voltage.

With regard to the operation of the circuit, assume that a signal having a frequency of 750 cycles per second is received over conductors A and B. This is passed through the valve VA and produces a voltage across the primary of the tuned transformer T2 and a considerably smaller voltage across the untuned transformer T3. The first voltage is stepped up by the transformer and flashes the neon lamp NA whereupon a positive potential is applied to the control grid of the receiving valve VB thereby causing anode current to flow to operate the relay X. In addition the voltage across the untuned transformer T3 would normally cause a positive potential to be applied to the control electrode of the valve VC whereupon current flows in the anode circuit thereby applying a negative potential to the suppressor grids of the valves VB and VD to prevent their operation. In this case however means are provided, comprising the third winding of the transformer T2, to prevent the valve VC from passing current by the connection between the output of the voltage doubler network associated with the third winding and the suppressor grid of the valve VC whereby a negative potential is applied to the suppressor grid. It will be understood of course that a similar operation will occur when a 600 cycle signal is received or when 600 cycle and 750 cycle signals are received simultaneously.

When speech is received over the line, however, a greater comparative voltage is developed across the untuned transformer T3 and consequently current flows in the anode circuit of the valve VC. A negative potential is therefore applied to the suppressor grids of each of the valves VB and VD to prevent their operation. It will be understood that if the incoming speech includes currents of the signal frequency, these will only be of a transitory nature and hence the potential applied to the suppressor grid of valve VC will be only transitory. Further since the potential applied to the control grid of valve VC is comparatively great, that portion of the potential applied to the suppressors grid would be insufficiently strong to paralyse the valve. The relays X or Y are thus prevented from operating when speech is received.

The operation of the arrangement can also be considered from the point of view of the impedance of the tuned and untuned circuits. When signals are being received the impedance of the tuned circuit is high compared to that of the untuned circuit and energy is thus fed to the valve VB (or VD) at the expense of the untuned circuit. However, when speech is being received the impedance of the tuned circuit to frequencies other than the signal frequency is low compared with that of the untuned circuit and hence the voltage developed across the untuned circuit predominates.

It will be understood that the use of the pentode valve VC in the manner described above affords increasing selectivity since reliance is not placed wholly on the resonance characteristics of the tuned circuits to give a desired selective response.

The two neon tubes NA and NB are provided to prevent any considerable fluctuation of the potential applied to the grids of the valves VB and VD which would otherwise occur since the signaling frequencies are used either separately or

in combination. Thus if a single frequency only is being received the voltage across the transformer T2 say will be very much greater than if the two signal frequencies are present together in view of the current limiting valve VA. With the neon tubes NA and NB however this is avoided and in addition the voltage applied to the grids of the valves VB and VD in substantially independent of any variation in the operation of the limiting valve VA.

We claim:

1. In combination with a line over which currents of audio-frequency are transmitted at various power levels, a grid controlled thermionic valve, means associated with said line for receiving said audio-frequency currents and applying them to the control grid of said valve, means for operating said valve in an overloaded condition to act as a current limiting device having a substantially constant output, thereby to retransmit at a substantially constant power level the audio-frequency currents applied to said grid, two responding circuits connected to the output of said valve, one of said circuits being responsive only to currents of a certain frequency while the other is responsive to currents of another frequency, a responding device controlled conjointly by said two circuits, said one circuit having means tending to operate said device responsive to the receipt of currents of said certain frequency and said other circuit having means tending to prevent the operation of said device responsive to the receipt of currents of said other frequency, and means for rendering said preventing means ineffective responsive to the concurrent receipt of currents of both of said frequencies if the currents of said certain frequencies are predominant.

2. In combination, a line for the transmission of currents of audio frequency, a circuit connected to said line and tuned to respond only to currents of a particular frequency transmitted over said line, an untuned responding circuit also connected to said line, a device, means tending to operate said device responsive to the energization of said tuned circuit, means tending to block the operation of said device responsive to energization of said untuned circuit and means controlled by said tuned circuit and independent of any control by said untuned circuit for at times disabling said blocking means responsive to energization to said tuned circuit concurrently with said energization of said untuned circuit.

3. In combination, a line for the transmission of currents of audio-frequency, a circuit connected to said line and tuned to respond only to currents of a particular frequency transmitted over said line, an untuned responding circuit also connected to said line, a thermionic valve having both a control grid and a suppressor grid, a connection from said tuned circuit to the control grid of said valve normally rendering said valve operative responsive to the energization of said tuned circuit, a connection from said untuned circuit to the suppressor grid of said valve at times disabling the valve responsive to the energization of said untuned circuit, and means included in said connection to the suppressor grid and controlled by said tuned circuit for at times, responsive to the energization of said tuned circuit, rendering said connection to the suppressor grid ineffective to disable said valve.

4. A combination as claimed in claim 3, wherein potential is supplied to the cathode of said valve through a resistance network to compensate for variations in the value of said potential, one branch of said network including a barretter.

5. In combination, a line for the transmission of currents of audio-frequency, a plurality of responding circuits tuned to different frequencies connected to said line, a plurality of thermionic valves respectively corresponding to said circuits, each of said valves having both a control grid and a suppressor grid, a connection from each of said tuned circuits to the control grid of the corresponding valve normally rendering said valve operative responsive to the energization of that circuit, an untuned responding circuit also connected to said line, and a connection from said untuned circuit to the suppressor grid of each of said valves at times disabling that valve responsive to the energization of said untuned circuit.

6. In a combination as claimed in claim 5, means controlled by one of said tuned circuits for at times rendering the connection from said untuned circuit to the suppressor grid of the valve corresponding to said one circuit ineffective responsive to the energization of said one tuned circuit.

7. In combination with a line over which currents of different frequencies may be transmitted at the same time, a first circuit responsive to currents of one frequency transmitted thereover, a second circuit responsive to currents of other frequencies transmitted thereover, two thermionic valves each having a control grid and a suppressor grid, means connecting said first circuit to the control grid of one of said valves, means connecting said second circuit to the control grid of the other valve, means connecting said first circuit also to the suppressor grid of said other valve, means connecting the anode of said other valve to the suppressor grid of said one valve, and means connected to the anode of said one valve and operated thereby when the currents transmitted over said line are predominantly of said one frequency.

8. A combination according to claim 7, wherein said third means includes a voltage doubling circuit.

9. A combination according to claim 7, wherein said fourth means includes a voltage doubling circuit.

10. A combination according to claim 7, wherein said first means includes a space discharge device to prevent said first circuit from applying a potential to the control grid of said one valve until the currents of said one frequency transmitted over the line exceed a certain value.

11. In combination with a line over which currents of different frequencies may be transmitted at the same time, a first circuit coupled to said line and responsive only to currents of one frequency transmitted thereover, a second circuit coupled to said line and responsive to currents of another frequency transmitted thereover, a third circuit, means linked to said first two circuits and controlled conjointly by them for energizing said third circuit in accordance with the relative energizations of said first two circuits, a fourth circuit coupled to said line and responsive only to currents of one frequency transmitted thereover, a fifth circuit, and means linked to said third circuit and said fourth circuit and controlled conjointly by them for energizing said fifth circuit in accordance with the relative ener-

gizations of said third circuit and said fourth circuit.

12. In combination with a line over which currents of different frequencies may be transmitted at the same time, a first circuit responsive only to currents of one frequency transmitted thereover, a second circuit responsive to currents of another frequency transmitted thereover, a third circuit, means tending to energize said third circuit in accordance with the energization of said second circuit, means restraining said energization of the third circuit by said means in accordance with the energization of said first circuit, a fourth circuit, means tending to energize said fourth circuit in accordance with the energization of said first circuit, and means restraining said energization of the fourth circuit by said last means in accordance with the energization of said third circuit.

13. In a combination as claimed in claim 12, means for preventing said third means from tending to energize said fourth circuit in accordance with the energization of said first circuit if said energization of the first circuit does not exceed a predetermined amount.

14. In combination with a line over which currents of audio frequency are transmitted at various power levels, a first circuit for receiving said currents and retransmitting them at a substantially constant power level, two responding circuits connected to the output of said first circuit, one of said responding circuits being responsive only to currents of a certain frequency while the other is responsive to currents of another frequency, a fourth circuit, means controlled conjointly by said two responding circuits for energizing said fourth circuit in accordance with the relative energizations of said two responding circuits, a fifth circuit, another responding circuit connected to the output of said first circuit and responsive only to currents of a certain frequency, and means controlled conjointly by said fourth circuit and said last responding circuit for energizing said fifth circuit in accordance with the relative energizations of said fourth circuit and said last responding circuit.

15. In combination with a line over which currents of different frequencies may be transmitted at the same time, a circuit connected to said line and tuned to respond only to currents of a particular frequency transmitted over said line, an untuned responding circuit also connected to said line, a first thermionic valve controlled conjointly by said circuits to energize its plate circuit in accordance with the relative energizations of said tuned and untuned circuits, and a second thermionic valve controlled conjointly by said tuned circuit and the plate circuit of said first valve to energize the plate circuit of said second valve in accordance with the relative energizations of said tuned circuit and said plate circuit of the first valve.

16. In combination, a line, an untuned responding circuit connected to said line, a thermionic valve controlled by said circuit normally effective to energize its plate circuit responsive to the energization of said untuned circuit by currents impressed upon said line, another circuit connected to said line and tuned to respond to said currents impressed upon the line only if they are of a particular frequency, said tuned circuit effective to control said valve to substantially prevent the energization of its plate circuit whenever said impressed currents are of such frequency as to energize said tuned circuit, a second thermionic valve controlled by said tuned circuit and normally effective to energize its plate circuit responsive to said energization of said tuned circuit, and means controlled by said first valve to substantially prevent the energization of the plate circuit of the second valve whenever the plate circuit of said first valve is energized.

17. In combination with a line over which currents of audio frequency are transmitted at various power levels, a first circuit for receiving said currents and retransmitting them at a subtrantially constant power level, a tuned responding circuit and an untuned responding circuit connected to the output of said first circuit, said tuned responding circuit being energized only by the currents of a particular audio-frequency which appear in the output of said first circuit, and said untuned responding circuit being energized by currents of all audio-frequencies which appear in the output of said first circuit, a first thermionic valve controlled conjointly by said two responding circuits to energize its plate circuit in accordance with the relative energizations of said responding circuits, and a second thermionic valve controlled conjointly by said tuned circuit and the plate circuit of said first valve to energize the plate circuit of said second valve in accordance with the relative energizations of said tuned circuit and said plate circuit of the first valve.

18. In combination, a line circuit over which currents of audio-frequency are transmitted, a plurality of circuits linked to said line circuit and each tuned to respond only to currents of a particular frequency transmitted over said line circuit, a responding device in each of said tuned circuits made effective responsive to receipt of currents of the particular frequency to which that circuit is tuned, an untuned circuit also linked to said line circuit, a responding device in said untuned circuit responsive to the receipt of currents of all frequencies to produce a paralyzing effect upon said devices in all of said tuned circuits, and a link circuit from each tuned circuit tending to paralyze the responding device in said untuned circuit responsive to the receipt of current of the particular frequency to which that tuned circuit is tuned, thereby to prevent the responding device in said untuned circuit from having any effect upon the devices in said tuned circuits.

19. In combination with a line upon which alternating current signals of different frequencies may be impressed at the same time, a first receiving circuit and a second receiving circuit, means for coupling said first circuit to said line to receive therefrom signals of at least a certain frequency, means for coupling said second circuit to said line to receive therefrom signals of a different frequency, means for tuning said second circuit to prevent it from receiving signals of said certain frequency when same are impressed on said line, a device in each of said circuits intermediate the input and the output of that circuit for controlling the ratio of the input signal strength to the output signal strength in that circuit, means controlling said device in one of said circuits to automatically vary the ratio of the input signal strength to the output signal strength in said one circuit in accordance with the strength of the signals present in the input of the other of said circuits, and means controlling said device in said other circuit to automatically vary the ratio of the input signal strength

to the output signal strength in said other circuit in accordance with the strength of the signals present in the output of said one circuit.

20. In combination with a line upon which alternating current signals of different frequencies may be impressed at the same time, three receiving circuits, means for coupling the first of said circuits to said line to receive therefrom signals of at least a certain frequency, means for coupling the second and third of said circuits to said line to receive therefrom signals of a different frequency, means for tuning said second and third circuits to prevent them from receiving signals of said certain frequency when same are impressed upon said line, a device in said first circuit intermediate the input and the output of that circuit, said device having means controlled by the signals in said second circuit for varying, in accordance with the strength of said signals in said second circuit, the ratio of the input signal strength to the output signal strength in said first circuit, a device in said third circuit intermediate the input and the output of that circuit, said device having means controlled by the signals in the output of said first circuit for varying, in accordance with the strength of said signals in the output of said first circuit, the ratio of the input signal strength to the output signal strength in said third circuit.

TESEO BRUNO DANTE TERRONI.
JOSEPH BERNARD McCUSKER.