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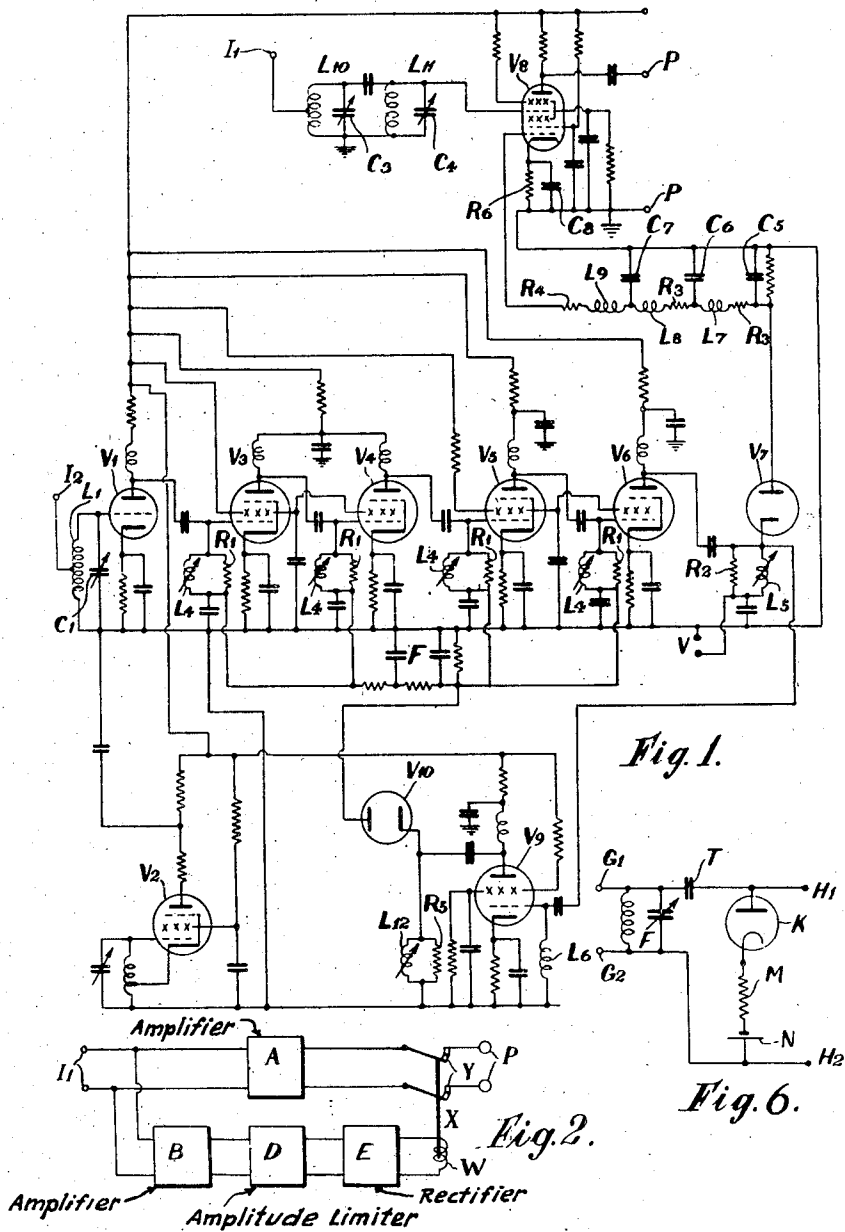
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2,151,145

REDUCTION OF INTERFERENCE IN ELECTRIC SIGNAL TRANSMISSION SYSTEMS

Filed Jan. 11, 1937

2 Sheets-Sheet 1



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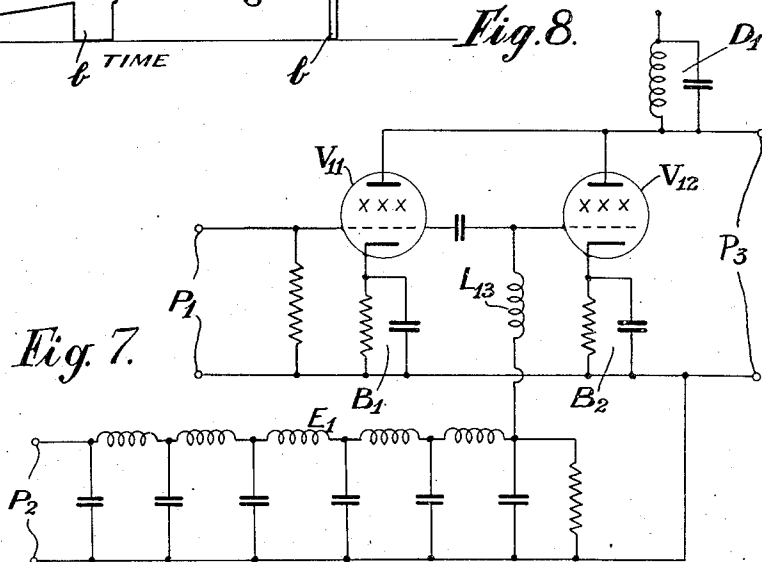
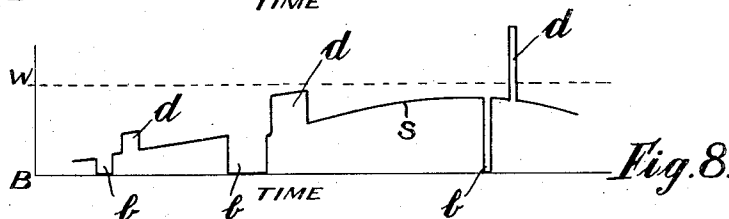
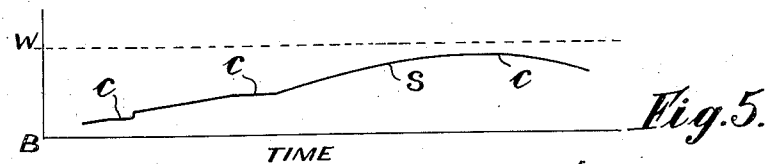
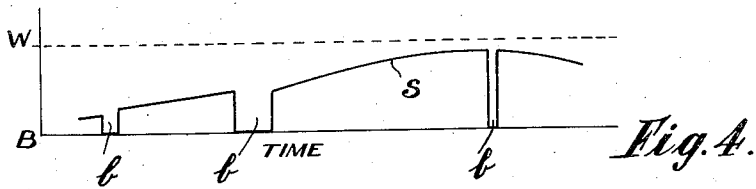
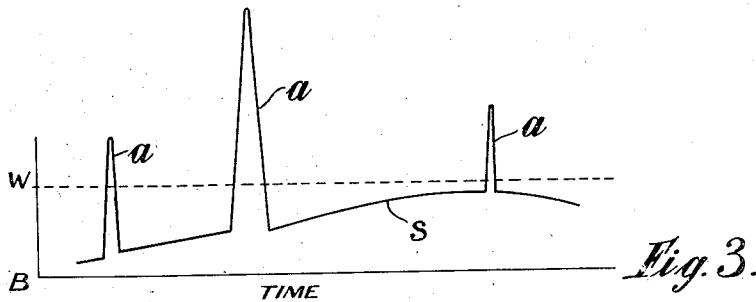
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REDUCTION OF INTERFERENCE IN ELECTRIC SIGNAL TRANSMISSION SYSTEMS

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,151,145

REDUCTION OF INTERFERENCE IN ELECTRIC SIGNAL TRANSMISSION SYSTEMS

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In Great Britain November 8, 1935

3 Claims. (Cl. 250—20)

The present invention relates to electric signal transmission systems, and is particularly concerned with the reduction of the effect of interference in such systems, due to disturbing signals.

Considerable interference is experienced, more particularly in wireless and other carrier wave transmission systems, due to disturbing signals of a transient nature, such as are produced, for example, by the ignition systems of internal combustion engines; these disturbing signals are often of very great amplitude, and are believed to consist of short trains of heavily damped oscillations with a natural frequency of the order, approximately, of 40 megacycles per second, each train lasting about 1 micro-second or less. It is believed that the decay period of such a train, that is, the time taken for the amplitude to decay to

$$\frac{1}{e}$$

(that is, about 0.368) of its initial value, is about 0.05 micro-second, corresponding to about 2 or 3 complete cycles of oscillation, and, on account of this high damping, such a disturbing signal may cause interference within a wide frequency band.

It will be clear that if such a disturbing signal is applied to a sharply-tuned, lightly-damped circuit, the time for which the resulting interference lasts may be many times the duration of the signal itself, due to the lightly-damped circuit oscillating at its own natural frequency under the influence of the disturbing signal. By way of example, if a transient disturbing signal having an amplitude p times the maximum amplitude of a desired signal is applied, together with the desired signal, to a tuned circuit, the disturbing signal will require a period

$$t = (1 + \log eP) \left(\frac{1}{2\pi f} \right)$$

seconds to decay to an amplitude which is

$$\frac{1}{e}$$

times the maximum amplitude of the desired signal, where f is the cut-off frequency of the tuned circuit measured from the resonant frequency; thus for a single tuned circuit cutting off at 1.5 megacycles, the value of t when p is 20, for example, is 0.43 micro-second, while if f is 10 kilocycles, and p is again 20, t is 72 micro-seconds. It is clear from these examples that since transient disturbing signals are found to cause marked interference in sound transmission systems, such signals must be of very large

amplitude; in picture transmission systems, any disturbing signal which produces a signal at the picture reproducer corresponding to a picture brightness value or in the whiter than white region may produce interference, since persistence of vision may cause the effect of the disturbing signal to be prolonged.

Other disturbing signals, such as those due to atmospherics, are also known to be of a transient nature, and may also have a very large amplitude.

It is known to provide means whereby in the presence of interference the signal amplitude is reduced to produce "gaps" in the signal. Thus it has been proposed to provide in an auxiliary channel an amplitude limiting device capable of passing only signals exceeding a predetermined amplitude equal to that of the maximum desired signal and to utilize signals passed by the limiting device, which are interfering signals, to reduce the amplitude of the received signal in the main signal channel.

In my co-pending United States patent application Serial No. 102,485, filed September 25, 1936, there are described means responsive to transient interference of both greater and less amplitude than the maximum desired signal for reducing the amplitude of the received signals during the presence of the transient interference.

It has been found that in certain circumstances interference is rendered unobjectionable simply by gapping as above described. On the other hand in other circumstances it is not entirely satisfactory. For example the undesirable effect of interference arising from sparking at the commutator of an electric motor may be removed by gapping alone in the absence of a carrier wave. In the presence of a strong carrier, however, interference re-appears, not in its original irregular form, but as a pronounced hum caused by the suppression of the carrier during the sparking at each commutator segment.

Further, in some cases, particularly where the interfering signals are removed, and hence the "gaps" are of relatively long duration, the "gaps" themselves may produce objectionable effects even in the absence of a carrier wave. For instance where the signals correspond to sounds, the "gaps" may produce audible effects.

It is the object of the present invention to provide means whereby the effect of the "gaps" may be rendered unobjectionable.

According to the present invention there is provided a circuit arrangement for reducing or removing the effect of interference from received signals, in which means are provided for reducing

the amplitude of the received signals in the presence of said interference to produce "gaps" in said signal, the circuit arrangement being characterised by the provision of means for reducing the loss of signal energy which would otherwise result from the "gaps". Thus in one arrangement means are provided for causing the signal wave form during the "gapping" periods to assume either a value which is a function of the amplitude of the received signals in the neighbourhood of the "gap" or else a predetermined fixed value, which is other than zero.

In an alternative arrangement, interference is removed by "gapping" and before or after the "gaps", the amplification of an amplifier through which the signal is passed is increased, preferably to such an extent and for such a time that the loss of signal energy due to the gapping is substantially counterbalanced.

In this case it is preferably arranged that $t_1 g_1 = t_2 g_2$ where t_1 and t_2 are the times over which the gain is decreased by the gapping and increased for compensation, respectively, and g_1 and g_2 are the loss and increase in gain (measured in decibels) corresponding to the gapping and the increase in amplification respectively. Thus, if the gain is reduced substantially to zero at a "gap", the amplification may be doubled before or after the occurrence of the gap for a time equal to the duration of the gap.

The invention is illustrated by way of example with reference to the accompanying drawings in which Fig. 1 is a diagram of a circuit for producing "gaps" in a signal,

Fig. 2 is a block diagram illustrating a further "gapping" arrangement,

Figs. 3, 4, 5, and 8 are curves showing the effect of "gapping" and of applying the present invention to "gapped" signals, and

Figs. 6 and 7 are circuit diagrams showing two ways in which the present invention may be applied to "gapping" arrangements such as those of Fig. 1 or 2.

Certain forms of circuit whereby the "gapping", which is an essential part of the present invention, can be carried out will first be described with reference to Figs. 1 and 2.

Referring to Fig. 1, terminal I_1 is the input terminal to the main channel and terminal I_2 is the input terminal to an auxiliary channel. These terminals are connected to the same or different receiving aerials. The main channel is relatively sharply tuned to the frequency of the carrier it is desired to receive, that is to say it has a relatively narrow pass band, while the auxiliary channel is relatively flatly tuned.

The auxiliary channel comprises a circuit $L_1 C_1$ tuned to the frequency of the desired carrier or to some other frequency. A valve V_1 acts as a mixer valve for mixing the oscillations from circuit $L_1 C_1$ with local oscillations from an oscillator V_2 . In one example circuit $L_1 C_1$ is tuned to a frequency between 15 and 45 megacycles per second and the oscillator V_2 serves to produce an intermediate frequency of 4.8 megacycles per second. The valves V_3 , V_4 , V_5 , and V_6 , are arranged to amplify at this intermediate frequency. Tuning of the intermediate frequency stages is effected with the aid of variable inductances L_2 and L_3 which are damped by means of resistances R_1 and R_2 . The tuning of the various stages may be staggered so that with the damping resistances the desired breadth of tuning is obtained. The pass-band for the intermediate frequency amplifier may be 150 kilocycles per second.

The output of the intermediate frequency amplifier is coupled to a diode detector V_7 and the output of which passes through a filter to the inner grid of a heptode valve V_8 which constitutes the first valve of the main channel. The filter comprises shunt condensers C_5 , C_6 and C_7 and series elements, each comprising a resistance and an inductance, $R_3 L_7$, $R_3 L_8$ and $R_4 L_9$. The filter is so designed as to remove the carrier frequency of 4.8 megacycles per second and to pass without substantial attenuation the modulation frequencies passed by the intermediate frequency amplifier, that is frequencies below about 75 kilocycles per second. It is also designed so as to avoid resonances which might cause transients to give rise to variations of an oscillatory character on the inner grid of valve V_8 . The output of valve V_8 is taken from terminals P to a receiver of normal type which with the valve V_8 constitutes the main channel and passes a narrower band of frequencies than the intermediate frequency amplifier V_3 , V_4 , V_5 , and V_6 .

A suitable positive bias is applied to the cathode of valve V_8 relative to its control grids by means of a resistance R_6 shunted by a by-pass condenser C_8 . A suitable voltage may be impressed between terminals V to make the cathode of the diode V_7 somewhat positive relatively to the anode thereof and thus to delay the diode and prevent it passing current for signals below a predetermined amplitude.

The input terminal I_1 of the main channel is connected to the outer control grid of the valve V_8 through a band-pass delay network $L_{10} C_3 L_{11} C_4$ which is designed to give to the signals passed therethrough a delay equal to or slightly greater than the delay introduced in signals passing from terminal I_2 to the valve V_8 .

The operation of the circuit above described is as follows:

It will first be assumed that, whether the input I_2 is connected to the same aerial as or to a different aerial from the input I_1 , the circuit $L_1 C_1$ is tuned to a frequency different from that to which the main channel is tuned and that the frequency chosen for circuit $L_1 C_1$ is such that no carrier of substantial strength is received. Both terminals I_1 and I_2 however, receive the same transient interference and that in the auxiliary channel is detected at V_1 if the transient is above the minimum amplitude (determined by the voltage at V) to which the detector V_7 is responsive, and is applied as a negative pulse to the inner control grid of valve V_8 . It is arranged by a suitable choice of valve and bias for V_8 that even a small transient interference signal is capable of cutting off the valve V_8 by arresting the flow of electrons therein. Since the delay in the main channel is equal to or slightly greater than that in the auxiliary channel, the amplification of valve V_8 and hence that of the main channel, will have been reduced substantially to zero by the time a transient reaches the outer control grid of valve V_8 from terminal I_1 .

It is also preferable to arrange that the condenser C_5 with the resistance in parallel therewith has a sufficiently long time constant to maintain the valve V_8 cut-off for a suitable short period after the transient has ceased at the input to diode V_7 . In this way the necessity for a precise adjustment of the delay in the main and auxiliary channels which may be difficult especially when the two channels are operated at different carrier frequencies, can be avoided.

The voltage from the filter in the output of valve V_7 may of course be used to cut-off valves of the main amplifier other than or additional to V_8 .

It has been found that with certain types of transient interference, such as that due to switching, a connection such as that shown, capable of passing direct current between the valves V_7 and V_8 is essential to obtain the best results. However, with other forms of transient interference such as that arising from the ignition systems of motor cars which is of short duration, this is not the case and the output from the detector V_7 may then conveniently be amplified before applying it to cut-off the valve V_8 . In this case any delaying which may be required can be done with advantage in the added amplifier instead of in the detector V_7 .

By making the voltage V very small or zero it can be arranged that transient interference even of very small amplitudes serves to cut-off the valve V_8 .

With the arrangement so far described, it has been assumed that no carrier of substantial amplitude is present in the input to the auxiliary channel and the circuit described can then be used to reduce, if desired substantially to zero, transient interference appearing in the main channel. The circuit can be made responsive to transients which in the main channel are of amplitude less than that of the desired carrier as well as to transients of greater amplitude.

Even where the input to the auxiliary channel is tuned to the same frequency as the main channel, the apparatus described is capable of cutting off the valve V_8 in response to transients which in the main channel have an amplitude somewhat less than that of the maximum desired signal, as well as in response to larger transients. This is because owing to the flatter tuning of the auxiliary channel the ratio of transient amplitude to desired signal amplitude is greater in the auxiliary channel than in the main channel. In the main channel the transient will tend to persist longer than in the auxiliary channel but by a suitable choice of the condenser C_5 and its parallel resistance the valve V_8 can be maintained cut-off until the transient in the main channel has substantially died away.

However, in order to be able to eliminate from the main channel transient interference of substantially smaller amplitude than the maximum desired signal, it is necessary to arrange that the auxiliary channel does not pass the desired signal, or any other continuous wave, at any substantial strength.

As already stated, the diode V_7 may be delayed so as to respond only to signals above a predetermined amplitude. It is of course desirable to make this predetermined amplitude as low as possible provided that it exceeds that of any continuous wave which may appear at the diode V_7 . Accordingly, there may be provided a circuit whereby the valve V_7 may be set to be responsive to a relatively low amplitude and nevertheless it remains unresponsive to continuous waves (whether they be of the same frequency as or a different frequency from that of the desired signal), even though the amplitude of these continuous waves may change due to fading for example.

For this purpose a special form of automatic volume control circuit is shown in Fig. 1. This comprises an additional intermediate frequency stage including a valve V_9 and a tuned circuit

$L_{12}R_5$ connected to the output of valve V_9 . The valve V_9 is of such type that when given a low screen-grid voltage it operates as a limiter, partly by grid current damping and partly by anode current cut-off. The output of this valve V_9 is fed to a diode detector V_{10} and the output of the latter is fed through a filter F to the grids of one or more of the valves of the intermediate frequency amplifier V_3, V_4, V_5, V_6 .

The valve V_9 ensures that only signals of relatively low amplitude have any effect upon the A. V. C. voltage developed. Since the energy content of transients of the same amplitude as a continuous wave is much smaller than the energy content of the continuous wave, transients of the same amplitude as the continuous wave have but little influence on the A. V. C. voltage developed. Thus the A. V. C. voltage is mainly dependent upon the continuous waves and it can be arranged that the amplification of the intermediate frequency amplifier V_3, V_4, V_5, V_6 varies as the amplitude of continuous waves varies in such a way as to maintain the output of continuous waves from the valve V_6 substantially constant and that the action is substantially unaffected even by transients of very large amplitude.

It may often be advantageous to associate the two channels with different aerials. For example the aerial supplying the main channel may be arranged so as to be more sensitive than the other aerial to the desired signal. The latter aerial on the other hand may be made relatively more sensitive to transient interference by suitable location or orientation thereof. For example, the aerial of the auxiliary channel may be a length of wire taken close to a source of interference, the effect of which on the main channel it is required to eliminate.

The two channels may if desired both be arranged to convey useful intelligence. For instance the main, sharply tuned channel may form part of a wireless receiver for a carrier modulated with sound signals whilst the broader auxiliary channel may form part of a television receiver for reproducing pictures to which the sounds are an accompaniment. A detector separate from V_7 may be provided to rectify the output of valve V_6 and pass the rectified signals to a television reproducer.

The circuit L_{10}, C_3-L_{11}, C_4 may be preceded if desired by an amplifier having a broader pass band than the rest of the main channel followed by an amplitude limiter set to pass only signals having an amplitude equal to or less than that of the maximum desired signal. In this way the tendency for shock excitation of the sharply tuned circuits of the main channel amplifier is reduced because only transients of relatively small amplitude reach the sharply tuned circuits.

It is not necessary that the auxiliary channel should have a continuous pass band, nor is it necessary that it should pass equally all frequencies within its pass band. For example one or more bands of continuous wave interference or the desired signal band may be substantially suppressed in the auxiliary channel with the aid of one or more suitable band stop filters or the like.

An alternative "gapping" arrangement will be described with reference to Fig. 2. A main channel extends between input terminals I_1 and output terminals P and contains an amplifier A . An auxiliary channel is branched from the main channel and contains an amplifier B , an amplitude limiting device D and a rectifier E . The

auxiliary channel may, if desired, be fed with signals from a different source from the main channel as described in connection with Fig. 1.

The limiting device D is arranged to pass only signals of amplitude exceeding the maximum desired signal amplitude. Any transient or other interference of amplitude greater than that of the maximum desired signal is rectified at E and causes a direct current to flow in the winding W of a relay X and to break relay contacts Y which are in the main channel. A gap is thus produced in the signal at the terminals P in place of the interference.

The diagram of Fig. 2 is only intended to indicate the general way in which "gapping" may be obtained in response only to signals exceeding the desired signal amplitude. Thus the current from E, instead of operating a mechanical switch, may be used to operate a thermionic valve arranged to act as a switch. Thus the current from E can be arranged to develop a voltage which biases a valve of the amplifier A in such a way as to reduce its amplification preferably substantially to zero.

Alternatively, the rectifier E may be omitted and the signals from D may be superimposed upon the signals from A in opposition so that interference tends to be cancelled out in the main channel.

There have been described above examples of circuits whereby interference can be replaced by "gaps." Although particular reference has been made to interference of a transient nature, it is to be understood that the present invention is applicable wherever interference of any kind is replaced by "gaps."

The effect of "gapping" will be clearly understood by reference to Figs. 3 and 4. In Fig. 3 there is shown a part of a signal wave form *s*. The signal in this example is a television signal and full black and full white levels are indicated by lines B and W respectively which are parallel to the "time" co-ordinate. At *a* in Fig. 3 are shown pulses of transient interference which extend considerably above full white level and consequently would produce bright flashes on the receiving screen.

With the aid of a "gapping" circuit, such as one of those already described, at each of the times when a pulse *a* of interference arrives the gain of the main channel is reduced substantially to zero and "gaps" *b* as shown in Fig. 4 are produced.

According to one feature of this invention, the signal is caused to assume, during a "gapping" period, a level substantially equal to the signal level immediately preceding the "gap." It therefore takes the form shown in Fig. 5 where the "gaps" are replaced by portions *c*.

One circuit with which this can be done will be described with reference to Fig. 6.

The circuit of Fig. 6 comprises a sharply tuned circuit F having effectively in parallel with it a circuit comprising a diode K, a resistance M and a bias source N, a condenser T being interposed as shown. To associate the circuit of Fig. 6 with the "gapping" circuit of Fig. 1, the input terminals G₁ and G₂ of Fig. 6 are connected to the terminals P of Fig. 1 and the output terminals H₁, H₂ of Fig. 6 are connected to the inner grid of valve V₈ and the lower end of resistance R₆ respectively of Fig. 1. The circuit F is tuned to the frequency of the desired carrier. The circuit F is normally damped by the resistance M through the diode K.

When the valve V₈ tends to be cut off by an interfering signal acting through the auxiliary channel in Fig. 1, the anode of the diode K, which is connected to the inner grid of the valve V₈, becomes negative and the diode insulates. The tuned circuit F then continues to ring, or sustain oscillations, at the amplitude previously impressed upon it, that is to say at the amplitude of the signal immediately preceding the "gapping" period and thus maintain the signal amplitude at the desired level.

A similar arrangement can readily be applied to a "gapping" circuit of the kind illustrated in Fig. 2.

It will be understood that the circuit of Fig. 6 acts by preventing the signal level from falling appreciably below that prevailing before the interference which is being removed occurred. With this arrangement therefore no "gaps" are actually produced although the effect is the same as if the "gaps" had been formed and later filled in.

If desired, instead of arranging that the amplitude of the signal in the "gap" is dependent upon the amplitude of the signal preceding the "gap", the amplitude may be determined by the amplitude of the signal following the gap, suitable delay circuits being included for this purpose. Further, as a development of the two arrangements described, the amplitude of the signal during "gaps" can be made to depend upon the average of the signal amplitude before and after the gap.

The signal may also be made to assume during the "gaps" a fixed amplitude, other than zero, which is preferably approximately half the maximum desired signal amplitude. In a television system the signal level in the "gaps" would then correspond to grey.

In the elementary circuit shown in Fig. 2 as applied to television reception this may be done as follows: Assuming that the main channel is passing a modulated carrier, there is provided a detector followed by a switch, which may be linked with switch Y, and which applies between the output terminals a fixed bias. This bias may correspond to grey. It is then arranged that whenever switch Y is opened the bias switch is closed so that a voltage corresponding to grey is maintained across the output terminals.

Clearly the mechanical switches can be replaced by thermionic valves acting as electrical switches.

Fig. 7 shows a circuit whereby the "gaps" are arranged to be followed by an increase in gain so that the loss of signal energy which would occur due to the "gaps" is substantially compensated for.

Terminals P₁ are connected to a main channel containing "gapped" signals, for example they may be connected to terminals P of Fig. 1. Terminals P₂ are connected to an auxiliary channel containing "gapping" pulses. For example they may be connected to the lower end of resistance R₆ and the inner grid of valve V₈ in Fig. 1 but in this case a valve must be interposed to reverse the sign of the pulses since the pulses are required to make the upper terminal P₂ more positive.

The terminals P₁ are connected to a valve V₁₁ acting as an amplifier which has its grid connected through a condenser to the grid of a valve V₁₂. The anodes and cathodes of valves V₁₁ and V₁₂ are connected in parallel with the interposition of suitable self-biasing circuits B₁ and B₂.

The anodes of valves V_{11} and V_{12} are connected through a common anode impedance circuit D_1 to the positive terminal of a source of high tension voltage the negative terminal of the source being connected to the lower terminal P_1 . The impedance of the circuit D_1 is arranged to be small compared with the impedance of both of the valves V_{11} and V_{12} taken separately.

The terminals P_2 are connected through a delay network E_1 and an inductance L_{13} to the grid and cathode of valve V_{12} as shown.

The valve V_{11} is given a normal bias by means of the circuit B_1 so that it acts as an amplifier of the signals fed at P_1 from the main channel. The valve V_{12} on the other hand is arranged to be biased by circuit B_2 substantially to anode current cut-off so that normally its amplification is substantially zero. When a pulse arrives from terminals P_2 at the grid of valve V_{12} it serves to reduce the large negative grid bias thereon and the valves V_{11} and V_{12} then function as amplifiers in parallel. Because of the low value of impedance D_1 relatively to the valve impedances, the effect of the pulse is substantially to double the gain. The output is taken at terminals P_3 . The delay network E_1 serves to delay the pulses so that the increase in gain occurs after the "gapping". The purpose of the inductance L_{13} is to provide a high impedance path between the network E_1 and the grids of valves V_{11} and V_{12} .

The effect of the arrangement of Fig. 7 is indicated in Fig. 8. Signals such as shown in Fig. 4 are assumed to be applied at terminals P_1 and the pulses d are produced when the gain of the circuit of Fig. 7 is doubled as described. Assuming that the time occupied by a "gap" b and the following pulse d is not unduly long, the eye will be incapable of resolving the dark and white spots produced on the screen and the effect will therefore be the same as that produced by a signal of the form shown in Fig. 5. Similarly, where the signals represent sounds the ear will average the "gap" and pulse provided that they are of short duration.

It will be clear that the increase in amplification may, if desired, be arranged to take place before, instead of after, the "gaps". For this purpose, where the same pulses are used both for "gapping" and for increasing the amplification, suitable delay circuits are used to delay the "gapped" signals more than the pulses which increase the amplification.

If desired switching pulses may be used to switch one of the two valves into operation and the other out of operation, for example by producing suitable changes in the grid bias on these valves, the valves being of suitably different magnifications.

It is not necessary that the same switching signals as are used for "gapping" should also be used for increasing the gain, although this is a convenient arrangement in many cases.

I claim:

1. In combination with a signal receiver having at least one tube provided with a tuned signal input circuit, a control network adapted to reduce the signal transmission efficiency of said receiver during the reception of transient inter-

ference, said control network comprising a rectifier having a resonant input circuit tuned to a radio frequency, means for impressing on said rectifier input circuit transient interference impressed on said signal input circuit, means responsive to the rectifier output for reducing the gain of said receiver tube, said signal input circuit being of relatively high selectivity, said rectifier input circuit having a relatively low selectivity, additional means for minimizing the loss of signal energy which would otherwise result from said gain reduction, the last means comprising a resonant circuit adapted to be coupled to said receiver tube output, the resonant circuit being tuned to the desired signal frequency, a device for normally damping said resonant circuit to prevent sustained oscillations therein, and means responsive to said gain reducing means for rendering the device ineffective thereby to permit said last resonant circuit to produce sustained oscillations of said signal frequency.

2. In a radio receiver of the type including a tube having at least a cathode, signal grid, output electrode and a gain control electrode shielded from the signal grid, a signal input circuit connected to the signal grid and cathode, an output circuit connected to said output electrode, a noise control network comprising a rectifier, an amplifier having an input circuit tuned to said signal frequency and adapted to have combined signal and noise energy impressed thereon, said amplifier being coupled to the rectifier, means for developing potential pulses from the rectified noise energy, means for impressing the pulses on said gain control electrode in a sense to reduce the receiver tube gain substantially to zero, an auxiliary network for minimizing the loss of signal energy which would otherwise result from said gain reduction, the latter network comprising means to sustain oscillations substantially at the amplitude of the signal, a device for rendering the last means ineffective, and means responsive to said pulses for rendering the device ineffective whereby said last means produces said oscillations.

3. In combination with a signal receiver having at least one tube provided with a tuned signal input circuit, a control network adapted to reduce the signal transmission efficiency of said receiver during the reception of transient interference, said control network comprising a rectifier having a resonant input circuit tuned to a radio frequency, means for impressing on said rectifier input circuit transient interference impressed on said signal input circuit, means responsive to the rectifier output for reducing the gain of said receiver tube, an auxiliary network for minimizing the loss of signal energy which would otherwise result from said gain reduction, said last network comprising a device coupled to said receiver tube output circuit adapted to transmit signal energy through the receiver, means normally rendering the device inefficient to transmit said energy, and additional means responsive to said gain reducing means for rendering the last means ineffective whereby said signal transmission takes place.

WILLIAM SPENCER PERCIVAL.