

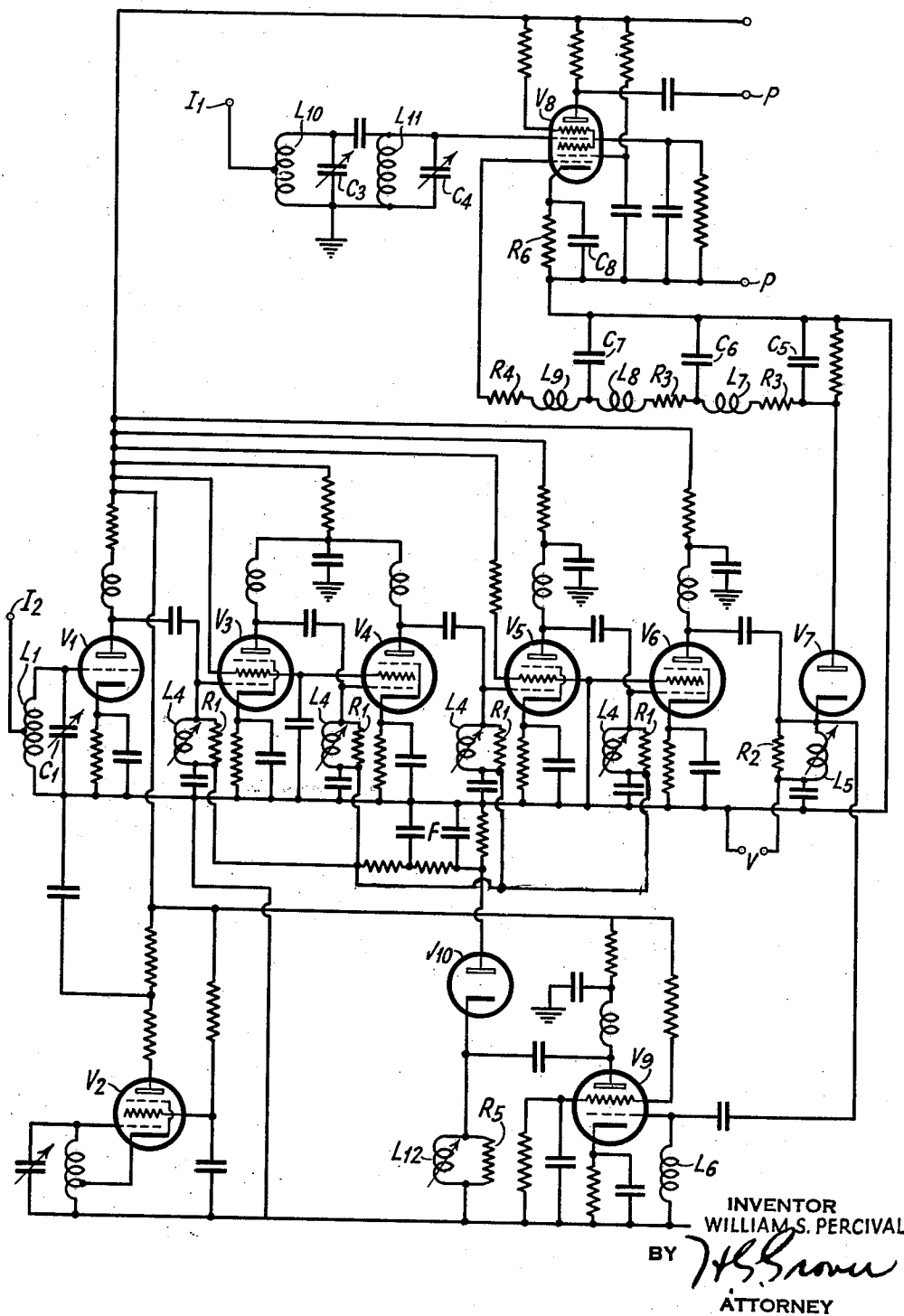
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HIGH FREQUENCY SIGNAL TRANSMISSION SYSTEM

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HIGH FREQUENCY SIGNAL TRANSMISSION
SYSTEM

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The present invention relates to electric sig-
nal transmission systems, and is particularly con-
cerned with the reduction of transient interfer-
ence in such systems, due to disturbing signals.
The expression transient interference is intended
to include any interference other than a modu-
lated or unmodulated continuous wave.

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 ex-
ample, by the ignition systems of internal com-
bustion engines; these disturbing signals are
often of very great amplitude, and are believed
to consist of short trains of heavily damped os-
cillations 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 cir-
cuit, 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 de-
sired signal, to a tuned circuit, the disturbing
signal will require a period

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

seconds to decay to an amplitude which is

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

times the maximum amplitude of the desired sig-
nal, 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 exam-
ple, is 0.48 micro-second, while if f is 10 kilo-
cycles, and p is again 20, t is 72 micro-seconds.
It is clear from these examples that since tran-
sient disturbing signals are found to cause marked
interference in sound transmission systems, such
signals must be of very large amplitude; in pic-
ture 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 inter-
ference, 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 tran-
sient nature, and may also have a very large am-
plitude.

It is the principal object of the present inven-
tion to provide means capable of reducing the ef-
fect of this and other kinds of transient inter-
ference, whether the amplitude of the interfer-
ence is greater or less than that of the desired
signal.

It is a further object of the present invention to
provide improved means responsive to transient
interference of amplitude greater than that of
the desired signal for reducing the effect of such
interference.

According to the present invention there is pro-
vided a circuit arrangement comprising a signal
receiving circuit which is subject to transient in-
terference both of greater and less amplitude
than that of the maximum desired signal and
means responsive to said transient interference
for reducing the amplitude of the received sig-
nals in said circuit during the presence therein of
said transient interference.

According to a feature of the present invention,
a circuit arrangement for reducing or removing
the effect of transient interference from received
signals comprises a main signal channel with
means for applying thereto received signals which
are subject to transient interference, an auxiliary
channel with means for applying thereto the
same transient interference and means for uti-
lising the transient interference in the auxiliary
channel to reduce substantially to zero the ampli-
fication of the main channel in the presence
therein of said transient interference. The aux-
iliary channel may be provided with a limiting
device arranged to pass only signals exceeding a
predetermined amplitude, which is usually that
of the maximum desired signal, the signals so
passed being utilised to reduce substantially to
zero the amplification of the main channel.

The present invention also provides a circuit
arrangement for the reception of modulated car-
rier oscillations which comprises a main signal
channel of relatively high selectivity with means
for applying thereto received signals which are
subject to transient interference, an auxiliary
channel of relatively low selectivity with means
for applying thereto the same transient inter-
ference and means for utilising the transient in-
terference in the auxiliary channel to reduce the
amplification or increase the attenuation of the
main channel in the presence therein of said
transient interference.

The invention will be described by way of ex-

ample with reference to the accompanying drawing illustrating one circuit embodying the present invention.

Terminal I_1 is the input terminal to a 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_1C_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_1C_1 with local oscillations from an oscillator V_2 . In one example circuit L_1C_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 4.3 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_4 and L_5 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 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_3L_7 , R_3L_8 and R_4L_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_1C_1 is tuned to a frequency different from that to which the main channel is tuned and that the frequency chosen for circuit L_1C_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_7 , 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 amplitude 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 . According to a feature of the present invention therefore, there is 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 provided. 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_8 . 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.

The invention is not confined to circuits dealing with modulated carrier oscillations. For example, the main channel may be constituted by a telephone line carrying speech currents and the auxiliary channel may be a line which is subject to the same interference signals as the main channel but which does not convey the speech currents.

The output of the auxiliary channel may be used to switch off any desired number of main channels.

The result of the application of the present invention is to produce gaps (or regions of zero amplitude) in the desired signal in place of transient interference. In many cases, particularly where the interference is of very short duration, the gaps may not introduce any appreciable effect. In any case they are greatly to be preferred to transients of amplitude which may in practice reach values many times that of the maximum desired signal.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

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 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, said signal input circuit being of relatively high selectivity, and said rectifier input circuit having a relatively low selectivity.

2. 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 re-

ceiver tube, said signal input circuit being of relatively high selectivity, said rectifier input circuit having a relatively low selectivity, said rectifier input circuit comprising a plurality of cascaded, broadly tuned circuits, and said signal input circuit having its constants chosen to delay the signal transmission to an extent at least as great as the delay experienced by signals in the rectifier input circuit.

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, said signal input circuit being of relatively high selectivity, and said rectifier input circuit having a relatively low selectivity, said responsive means including a network having a relatively long time constant whereby the duration of the rectifier output applied to the receiver tube is made greater than that of the transient interference applied to the rectifier.

4. 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, said signal input circuit being of relatively high selectivity, said rectifier input circuit having a relatively low selectivity, and means responsive to variations in continuous wave amplitude in said control network for controlling the continuous wave transmission to the rectifier.

5. 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, said signal input circuit being of relatively high selectivity, and said rectifier input circuit having a relatively low selectivity, said receiver tube being of the type having a signal grid and special gain control grid, and the said responsive means impressing said rectifier output on said special grid in a sense to cause said gain reduction.

6. 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, said signal input circuit being of relatively high selectivity, said rectifier input circuit having a relatively low selectivity, said rectifier input circuit including a converter network constructed to reduce the frequency of continuous waves impressed thereon, an amplifier for the reduced frequency energy, and an automatic gain control circuit for maintaining the amplitude of the amplified energy at the rectifier substantially constant.

7. 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, said signal input circuit being of relatively high selectivity, said rectifier input circuit having a relatively low selectivity, said rectifier input circuit including at least one broadly tuned amplifier, and means responsive to waves impressed on the control network for controlling the amplifier gain.

8. In a radio receiver of the type including a tube having at least a cathode, signal grid, output electrode and a gain control electrode, 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, responsive to the said energy intensity at the rectifier input, for varying the amplifier gain, means for developing potential pulses from the rectified noise energy, and means for impressing the pulses on said gain control electrode in a sense to reduce the receiver tube gain substantially to zero.

9. In a radio receiver of the type including a tube having at least a cathode, signal grid, output electrode and a gain control electrode, 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, said amplifier input circuit being substantially less selective than said receiver tube input circuit, and said rectifier being biased to delay rectification of noise energy until the latter increases above the predetermined amplitude.

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