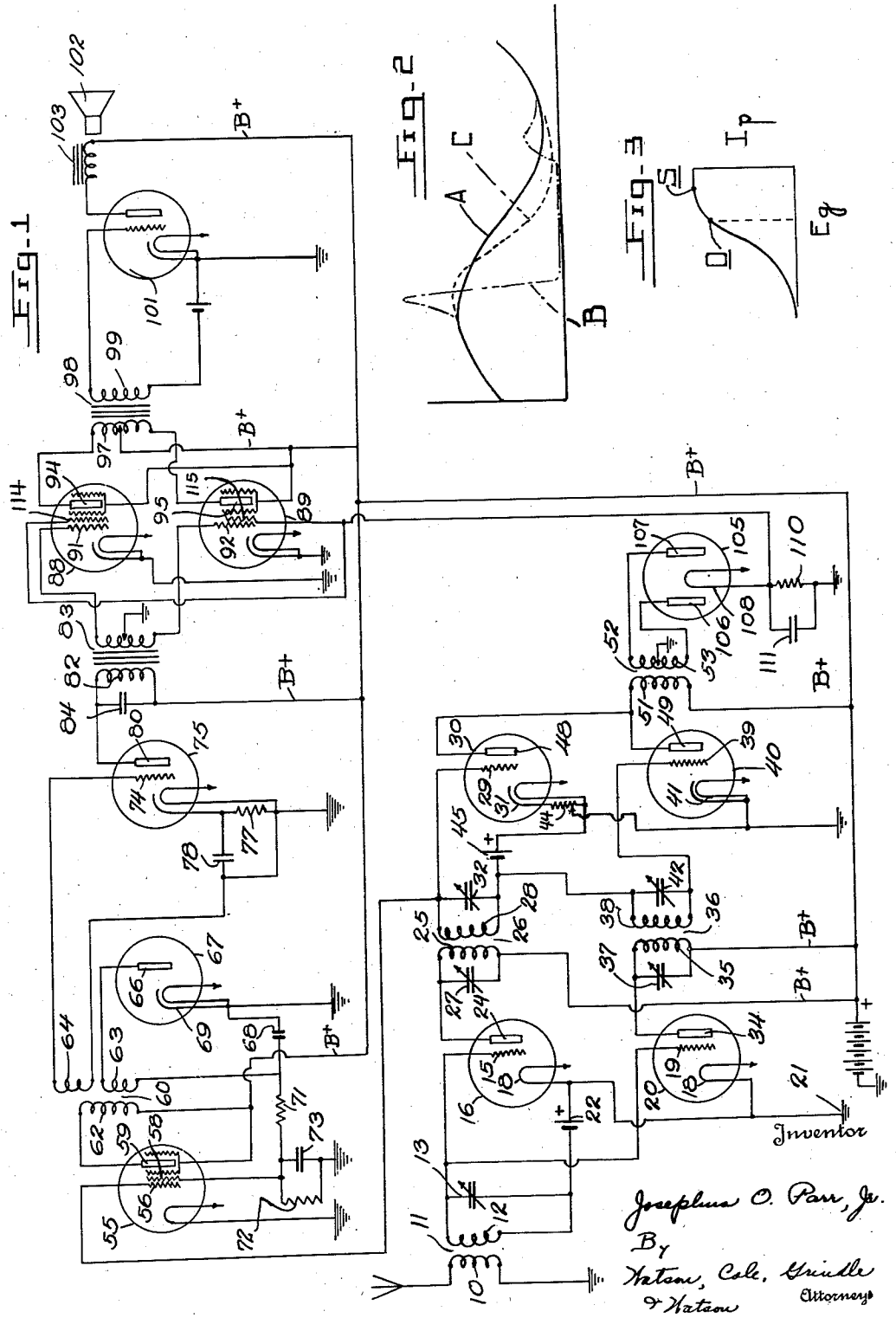
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AMPLIFIER FOR WAVE-FORM SIGNALS

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AMPLIFIER FOR WAVE-FORM SIGNALS

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This invention relates to improvements in apparatus for the reception an amplification of wave form electrical signals and is especially concerned with the elimination of disturbances which produce noise and thereby interfere with the reception of the desired signal, for instance disturbances resulting from static and other electrical discharges.

It has heretofore been proposed to provide control circuits for radio broadcast receivers to effect blocking of the receiver on the arrival of noise impulses, for example as suggested in the patents to Lamb No. 2,101,549 and Burrill No. 2,151,739. However, the control circuits disclosed in these patents are constructed to function in response to a signal which exceeds a predetermined amplitude, and thus may, in the course of reception of signals from different transmitting stations having different field strength, and from stations of comparable field strength which transmit carrier frequencies employing different modulation percentages, act to suppress desired signals in the absence of disturbing noise, provided the received signals exceed the predetermined limit. Furthermore, the control circuits heretofore proposed for this purpose are so constructed and arranged that the interruption and resumption of reception produces an audible disturbance which is almost as annoying as the noise which the circuit is intended to eliminate. Again, the prior arrangements function only in response to disturbances of large amplitude whereas the instant system is responsive to noise impulses which may be even smaller than the desired signals, as well as large impulses.

It is therefore an object of the instant invention to provide control means for a receiver which functions in response to the arrival of unwanted electrical disturbances by reason of distinguishing characteristics of such disturbances other than amplitude, and to so effect the suppression of the receiver that noise resulting from the suppression is minimized or eliminated.

More specifically, it is an object of the instant invention to provide control means functioning in response to the arrival of waves having a sharply sloping wave front, characteristic of static and other electrical disturbances, as disinguished from the more gradual slope of the wave front of desired music and speech signals.

For example, it can be shown that there is little or no difference in the modulation envelope of a modulated carrier wave after passage through either of two receivers of which one is characterized by broad tuning and fairly effective damping and the other by sharp tuning and relatively poor damping, provided the latter gives a fairly uniform response over the entire range of modulation of the carrier. However, when a noise disturbance, either cross-modulated or superimposed upon the carrier, is passed through these same receivers, the modulation envelopes are quite different, the output of the well damped, broadly resonated receiver more nearly following the steep wave front of the disturbance than that of the sharply resonated receiver of low damping. In accordance with the present invention, it is proposed to utilize this difference in the modulation envelopes resulting from noise disturbances when impressed upon a well damped and a poorly damped amplifier, to control and momentarily suppress reception.

A further object of the invention is the provision of means to effect the control or suppression of the receiver by application of the control signal at a point following signal detection. Thus is can be shown that the suppression of reception prior to demodulation of the carrier, as heretofore proposed, inevitably introduces noise in the detector circuit, since the carrier is itself suppressed, the noise being very similar to that caused by static and being almost as annoying.

It is a further feature of the invention that noise is reduced or eliminated by the application, on arrival of static and like disturbances, of a more positive grid bias to a thermionic valve which normally operates near the upper portion of the grid voltage-plate current (E_g—I_p) curve, the application of the suppressing bias voltage causing displacement of the point of operation to the substantially horizontal portion of the curve, as distinguished from the application of a negative bias with consequent increased variation of plate current and resultant noise.

Further objects and features of the invention will be apparent from the following description, taken in connection with the accompanying drawing, in which

Figure 1 is a diagrammatic representation of one form of receiver circuit to which the instant invention may be applied; and

Figures 2 and 3 are curves representing the operating characteristics of certain portions of the receiver shown in Figure 1.

In order to facilitate an understanding of the invention, reference will be made to the several embodiments thereof illustrated in the accompanying drawing and specific language will be employed. It will nevertheless be understood that various further modifications of the devices

illustrated herein, such as would fall within the province of those skilled in the art to construct are contemplated as part of the present invention.

The invention has been illustrated as applied to a simple form of tuned radio frequency receiver, but the application of the invention to other forms of receiver, for example the superheterodyne receiver, will be obvious.

Thus the incoming signal is fed through the primary winding 10 of a transformer 11, the secondary 12 of which is broadly tuned to the desired carrier frequency by variable condenser 13. The signal voltage is then applied to the grid 15 of a thermionic valve 16 and to the grid 19 of a thermionic valve 20, the cathodes 18 of these valves being grounded at 21. Grid bias voltage is supplied by a source 22.

The outputs of the valves 16 and 20 are fed respectively through a circuit which is poorly damped and a circuit which is very well damped. The outputs of these circuits are opposed, and the signal energy thus obtained is employed in the form of a control voltage for the main receiving circuit hereinafter described. Thus the plate 24 of valve 16 is connected to one end of the primary winding 25 of a transformer 26, the circuit being tuned by a variable condenser 27. The secondary winding 28 of the transformer 26 is connected to the grid 29 and the cathode 31 of a valve 30, and is tuned by a variable condenser 32.

The plate 34 of the valve 20 is connected to one end of the primary winding 35 of a transformer 36, the winding being tuned by a variable condenser 37. The secondary winding 38 of the transformer 36 is tuned by a variable condenser 42, one end of the secondary winding being connected to the grid 39 of a valve 40. The cathode 41 of the valve 40 is connected to the cathode 31 of the valve 30, and a potential source 45 supplies the grid bias voltage for both valves. The plates 48 and 49 of the valves 30 and 40 respectively are directly connected, the combined output being fed to the primary winding 51 of a transformer 52.

It will thus be observed that the incoming energy is fed in two paths or channels, and is delivered to the grids of the valves 30 and 40 in opposed phase relation, so that the outputs of the two paths are opposed. There are many alternative and well known methods of opposing the outputs of two signal channels, and in describing the outputs as combined in opposed phase relation, it is intended to include any of these various methods.

The characteristics of the transformer 26 and the associated elements are such that the damping is relatively low, the path which includes this transformer being preferably tuned to afford a band pass effect, so as to respond fairly uniformly to frequencies within the modulation range, but to sharply attenuate frequencies falling outside of such range. The characteristics of transformer 36 and the associated electrical elements, on the contrary, are such as to afford relatively broad tuning and high damping. Obviously these results may be achieved by various other types of circuits, and the circuits shown and described herein are intended merely as illustrative of one method of practicing the invention.

It is of course intended that when desired signals only are being received, the combined outputs of the two paths shall be a minimum or zero, and it will be appreciated that in order to achieve this result some adjustment may be required to compensate for the normally greater output of the more sharply resonated circuit resulting from the higher gain in that circuit. The use of a resistance 44 in the cathode circuit of valve 30 is one method of achieving equalization of the outputs of valves 30 and 40.

If unwanted signal energy in the form of a noise disturbance is received, the outputs of the two paths will no longer cancel, and a surge of energy is fed through the primary 51 through the transformer 52. This effect is illustrated more particularly in Figure 2 of the drawing. Thus the curve A in full line is representative of one side of the envelope of a generally sinusoidally modulated carrier. If a noise disturbance is now superimposed upon the carrier, and the resulting signal energy is fed through a circuit which is broadly tuned and well damped, the envelope will be altered to substantially the form shown at B in dot-and-dash lines. If, however, this same signal energy is passed through a circuit which is relatively poorly damped but capable of reasonable response over the entire modulation range, such as a band pass filter or the like, the envelope will be modified as shown at C in dotted lines.

It is thus apparent that if the same signal energy including a noise disturbance is passed through the two circuits, and the outputs of these circuits are combined in opposed phase, they will not cancel out. If, on the contrary, an undisturbed signal is passed through the same two circuits, the output curve of each circuit will be substantially that shown at A in Figure 2, and the outputs will entirely or substantially cancel.

Turning now to the balance of the main receiving circuit, it will be noted that Figure 1 shows a valve 55 having a control grid 56 to which a control voltage is fed from the secondary winding 28 of transformer 26. Automatic volume control may, if desired, be applied to the auxiliary control grid 58 of valve 55. Thus the plate 59 of valve 55 may be connected to the primary winding 62 of a transformer 60, the latter being provided with secondary windings 63 and 64. Opposite ends of the winding 63 are connected respectively to the anode 66 of a diode valve 67 and through a condenser 68 to the cathode 69 of the valve. The winding 63 is further connected through a resistance 71 to a time-delay device including a resistance 72 and condenser 73 in shunt. This device is returned to the cathode 69 at one side through the ground and is connected at the other side to the auxiliary control grid 58.

It will be appreciated that as the signal energy fed to the transformer 60 increases, the voltage supplied to the anode 66 of the valve 67 by the winding 63 will increase, with consequent variation of voltage across the resistance 72 and on the control grid 58 of the valve 55 in such manner that the amplification of the valve is proportionately reduced. The constants of the circuit, including the resistance 72 and condenser 73, are so selected that variation of voltage on the grid 58 is not effected in response to carrier modulation. Various other types of conventional volume control may be substituted for that illustrated.

The secondary winding 64 of the transformer 60 supplies control voltage to the grid 74 of valve 75 which functions as a detector, the conventional bias resistor 77 and condenser 78 being introduced in the grid circuit. The anode 80 of

the valve 75 delivers the demodulated energy to the primary winding 82 of an audio-frequency transformer 83, the winding being by-passed by a condenser 84. The secondary winding 85 of transformer 83 is connected in a push-pull amplifying circuit including valves 88 and 89, voltage being delivered to the grids 91 and 92 respectively of these valves. The anodes 94 and 95 of the valves are connected to opposite ends of the primary winding 97 of an audio-frequency transformer 98, the secondary winding 99 of which delivers energy to a valve 101. The output of the valve 101 is fed through an output transformer 103 to a speaker or other reproducing device indicated diagrammatically at 102.

It will be appreciated that the main receiving circuit just described is presented merely by way of illustration, the details thereof forming in themselves no essential part of the instant invention.

Returning now to the control circuit, it will be observed that the output of the transformer 52 is fed to a rectifier valve 105, opposite ends of the secondary winding 53 of this transformer being connected to the anodes 106 and 107 of the valve. The cathode 108 of the valve is connected through a time-delay device including a resistance 110 and condenser 111 to the ground, the high potential side of the device being connected to auxiliary control grids 114 and 115 of valves 88 and 89 respectively. The values of resistance 110 and condenser 111 are so selected that following the arrival of a noise disturbance, and the consequent delivery of energy to the rectifier valve 105, voltage will be applied to the auxiliary control grids 114 and 115 for a very short interval of time only, the charge on the condenser leaking off through the resistor. Thus if voltage is applied during a period of about one-twentieth of a second, the valves 88 and 89 of the push-pull audio-stage will be only momentarily blocked, and the normal persistance of hearing will insure that the absence of sound is not noted. If the time constant of the circuit including the resistance 110 and condenser 111 is too long the silence is noticeable, and while not as disconcerting as static may nevertheless be a source of slight irritation. If, on the other hand, the time constant is too short, it will fall within the audible range, and, unless all constants are at critical values, will produce a decided thump in the speaker.

The preferred method in which the voltage applied to the auxiliary control grids 114 and 115 is employed to silence the receiver is illustrated graphically in Figure 3 of the drawing, which represents the E_g—I_p curve of the valves 88 and 89. The normal operating point is indicated at O, near the upper portion of the curve. When voltage is supplied to the auxiliary grid of the valve, the operating point is displaced approximately to S, which lies on the substantially horizontal portion of the curve, so that the output of the valve is minimized or reducer to zero. As hereinbefore explained, control of the valves in this manner requires considerably less voltage to effect the necessary reduction of output and reduces substantially the variation in plate current of the valves which must be balanced out in transformer 98. Thus if valves 88 and 89 are not identical in characteristics, suppression of the output by displacing the operating point to the lower portion of the E_g—I_p curve inevitably produces a "pop" in the speaker. Since little change in plate current is required, however, to displace the operating point from O to S, noise due to suppression is materially reduced or eliminated.

It is advisable to employ radio frequency circuits in which the direct current resistance from the control grids is relatively low, in order to prevent blocking of the valves due to large incoming disturbances. It is also desirable, in the event automatic volume control is employed, to apply the control voltage to a separate control grid in order that a long time constant may be employed in the volume control circuit without danger of blocking the valve. It will be noted that in the practice of the instant invention it is not essential to employ automatic volume control, since the suppression of noise disturbances is not effected in response to variation in amplitude of the incoming signal.

It will be appreciated that the foregoing circuit is capable of use in various fields where it is helpful to eliminate undesired energy having a sharply sloping wave front. For example, in the field of seismic surveying, it can be shown that energy which has traveled through very little soil is characterized by a much steeper wave front than energy which has traveled appreciable distances through the ground. The latter energy, and particularly that which is reflected from strata at considerable depths, is most significant in determining contours, and a circuit of the type shown herein for suppressing signal energy on the arrival of sharply sloping waves can readily be applied to thermionic valve amplifiers of the type commonly used in seismic work, with the result that the less desirable waves are substantially eliminated from the record.

Having thus described the invention, what is claimed as new, and desired to be secured by Letters Patent, is:

1. In a receiver for wave-form signals, the combination with an amplifier for the signals, of means affording two paths for signal energy, one of said paths having relatively high damping and the other of said paths having relatively low damping, means combining the outputs of said paths in opposed phase relation, and means responsive to the combined output of said paths for suppressing signal energy in said amplifier on occurrence of noise disturbances.

2. In a receiver for modulated wave-form signals, the combination with an amplifier for the signals, of means affording two paths for signal energy, one of said paths having relatively high damping, and the other of said paths having relatively low damping but offering a reasonably uniform response to all signal energy falling within the desired range of modulation frequencies, means combining the outputs of said paths in opposed phase relation, and means responsive to the combined output of said paths for suppressing signal energy in said amplifier on occurrence of noise disturbances.

3. In a receiver for modulated wave-form signals, the combination with means for interrupting the output of said receiver, of means operable on arrival at said receiver of noise energy affording disportionate treatment of the modulated wave-form signal and the noise energy, and responsive solely to the sharply sloping wave-front of such noise energy for initiating operation of said interrupting means.

4. In a receiver for modulated wave-form signals, the combination with means for interrupting the output of said receiver, of means operable on arrival at said receiver of noise energy and responsive to the sharply sloping wave-

front of such energy for initiating operation of said interrupting means, said last named means including two electrical paths through which signal energy is fed, one of said paths affording a band-pass for the wanted signal energy, and the other of said paths being broadly resonant and relatively highly damped, the energy output of said paths being combined in opposed phase.

5. In a receiver for modulated wave-form signals including radio frequency and audio-frequency amplifying circuits, the combination with means associated with the audi-frequency circuit for interrupting the output of said receiver, of means operable on arrival at said receiver of noise energy affording disproportionate treatment of the modulated wave-form signal and the noise energy, and responsive solely to the sharply sloping wave-front of such noise energy for initiating operation of said interrupting means.

6. In a receiver for modulated wave-form signals, the combination with means for interrupting the output of said receiver, of means operable on arrival at said receiver of noise energy affording disproportionate treatment of the modulated wave-form signal and the noise energy, and responsive solely to the sharply sloping wave-front of such noise energy for initiating operation of said interrupting means, and a time-delay device for determining the interruption interval.

7. In a receiver for wave-form signals, the combination with means affording two paths for signal energy, one of said paths having relatively high damping and the other of said paths having relatively low damping, of means combining the outputs of said paths in opposed phase relation, signal amplifying means into which energy is fed from one of said paths, signal reproducing means operable by energy derived from said amplifying means, and means responsive to the combined output of said paths for suppressing signal energy in said amplifying means on occurrence of noise disturbances.

8. In a receiver for modulated wave-form signals, the combination with means affording two paths for signal energy, one of said paths having relatively high damping, and the other of said paths having relatively low damping but offering a reasonably uniform response to all signal energy falling within the desired range of modulation frequencies, of means combining the outputs of said paths in opposed phase relation, audio-frequency amplifying means, means including a detecting device for delivering energy from one of said paths to said amplifying means, and means responsive to the combined output of said paths for suppressing signal energy in said amplifying means on occurrence of noise disturbances.

9. In a receiver for modulated wave-form signals, the combination with an amplifier including radio and audio-frequency circuits and a detecting device, of means including said radio frequency circuit and affording separate paths for signal energy, one of said paths having relatively high damping, and the other of said paths having relatively low damping but offering a reasonably uniform response to all signal energy falling within the desired range of modulation frequencies, means combining the outputs of said paths in opposed phase relation, and means responsive to the combined output of said paths for suppressing signal energy in said audio-frequency circuit on occurrence of noise disturbances.

10. In a receiver for wave-form signals, the combination with an amplifier for the signals, of means affording two paths for signal energy, one of said paths having relatively high damping and the other of said paths having relatively low damping, means combining the outputs of said paths in opposed phase relation, and means responsive to the combined output of said paths for suppressing signal energy in said amplifier on occurrence of noise disturbances, said last named means including a valve for amplifying said signals, and means energized by the combined outputs of said paths for applying to said valve a more positive grid bias.

11. In a receiver for modulated wave-form signals, the combination with a thermionic valve for amplifying the signals, of means operable on arrival at said receiver of noise energy and responsive to the sharply sloping wave-front of such energy for applying to said valve a more positive grid bias to momentarily minimize the output of said valve.

12. In a receiver for modulated wave-form signals, the combination with an amplifier including a thermionic valve, of means operable on arrival at said receiver of noise energy for applying momentarily to said valve a more positive grid bias to interrupt the output of said valve.

13. In a receiver for modulated wave-form signals, the combination with signal amplifying means including a thermionic valve of which the grid voltage-plate current curve has an upper portion which is generally horizontal over a substantial length of the curve, said valve having normally a grid bias such that the valve operates adjacent the upper portion of the grid voltage plate current curve, of means responsive to the reception of noise energy for momentarily applying to said valve a more positive grid bias, whereby said valve may be caused to operate on the generally horizontal upper portion of the grid voltage-plate current curve, to interrupt the output of said valve.

14. A method of treating modulated wave-form signal energy to eliminate static disturbances and the like by transmitting the same through separate paths, which includes the steps of amplifying and reproducing the wave-form energy, feeding a portion of the energy through the separate paths, disproportionately treating modulated carrier waves and noise energy in one of said paths and similarly treating the same in the other of said paths, combining the outputs of said paths in opposed phase, and applying said combined output to momentarily interrupt the amplification and reproduction of the signal energy on the arrival of noise energy.

15. In a receiver for modulated wave-form signals, the combination with means for interrupting the output of said receiver, of means operable on arrival at said receiver of noise energy and responsive to the sharply sloping wave-front of such energy for initiating operation of said interrupting means, said last named means including a device responsive to rate of change of incoming signal energy.

16. In a receiver for modulated wave-form signals, the combination with means for interrupting the output of said receiver, of means operable on arrival at said receiver of noise energy having a sharply sloping wave front and responsive solely to the sharpness of slope of such

wave front for initiating operation of said interrupting means.

17. In a receiver for modulated wave-form signals including radio frequency and audio-frequency amplifying circuits, the combination with means associated with the audio-frequency circuit for interrupting the output of said receiver, of means operable on arrival at said receiver of noise energy having a sharply sloping wave front and responsive to the sharpness of slope of such wave front for initiating operation of said interrupting means.

18. In a receiver for modulated wave-form signals, the combination with means for interrupting the output of said receiver, of means operable on arrival at said receiver of noise energy having a sharply sloping wave front and responsive to the sharpness of slope of such wave front for initiating operation of said interrupting means, and a time-delay device for determining the interruption interval.

19. In a receiver for modulated wave form signals, the combination with means for amplifying the signal energy, of means for interrupting the output of said receiver, and means to which a portion of the signal energy is delivered, operable on arrival at said receiver of noise energy having a sharply sloping wave front, and responsive to the sharpness of slope of said wave front for initiating operation of said interrupting means.

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