

July 29, 1941.

H. WEBER

2,250,559

AMPLIFIER GAIN CONTROL CIRCUIT

Filed July 28, 1938

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Fig. 1

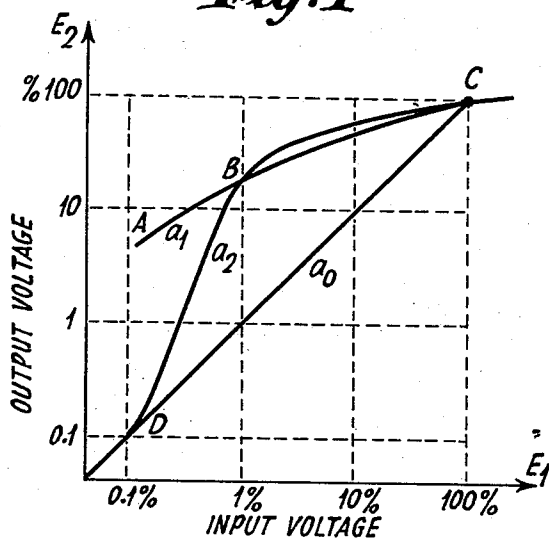
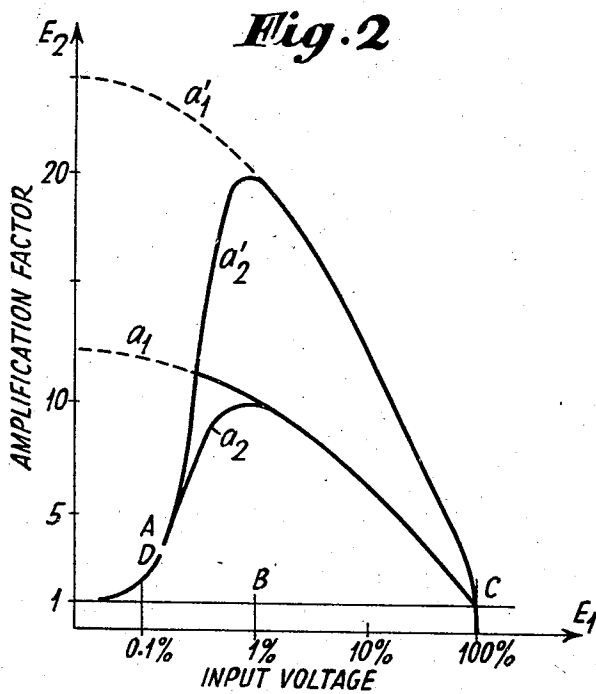


Fig. 2



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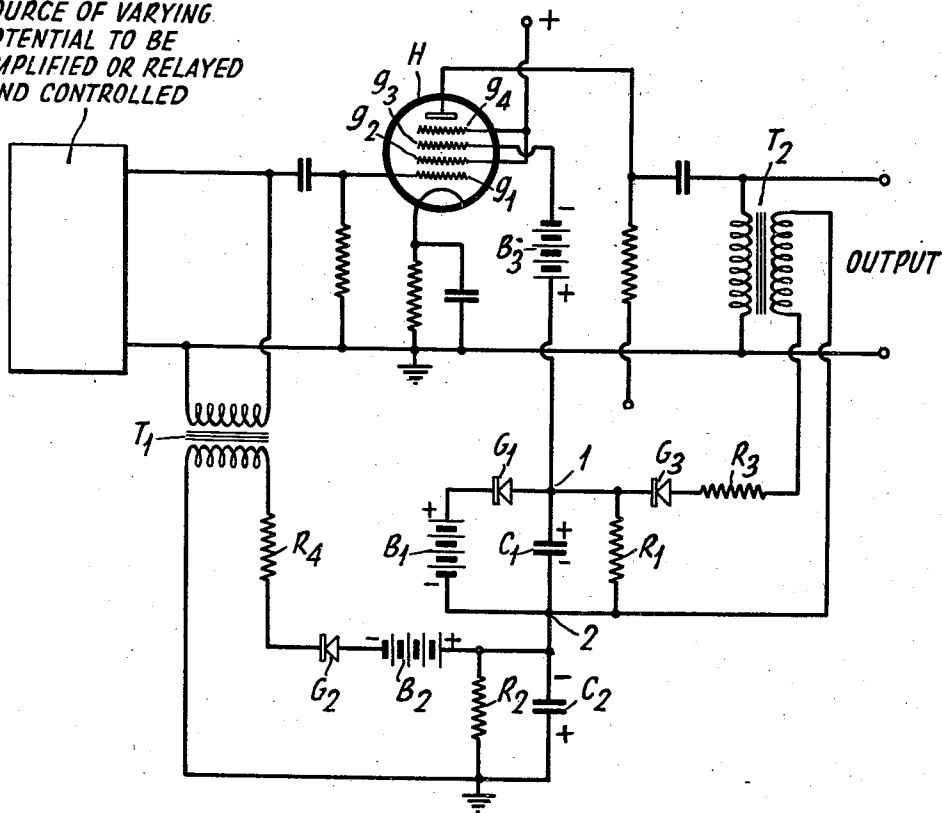
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Fig. 3

SOURCE OF VARYING
POTENTIAL TO BE
AMPLIFIED OR RELAYED
AND CONTROLLED



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AMPLIFIER GAIN CONTROL CIRCUIT

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4 Claims. (Cl. 179-171)

The object of the invention is to provide trans-
mitter equipment which comprises means de-
signed to insure compensation of fluctuations of
the acoustic intensity or signal strength auto-
matically (AVC). In electro-acoustic transducers
or transmitter equipment one important factor
is that the acoustic impulses rendered by the
loudspeaker should always be more or less of
the same sound intensity, for this insures a
maximum of intelligibility. In other words, re-
gardless of the particular intensity or sound
volume which is brought to act upon the micro-
phone, the loudspeaker should always give off
roughly the same power. Thus, whether the
sound action impacting the microphone is in
the form of a whisper or a loud cry, the acoustic
volume at the loudspeaker should be approxi-
mately the same in both cases. Moreover, dif-
ferences in the angle of action by sound upon
the pick-up microphone due to changes in di-
rection of the vocal waves and to changes in
position should be compensated.

According to the present invention this is ob-
tained by providing automatic regulators of the
transmission measure or gain of a kind well
known in the prior art which are interposed be-
tween the pick-up microphone and the loud-
speaker, the said volume control means being
so designed that equalization of acoustic volume
variations reaching the microphone is insured
to a point so that the sound volume rendered
by the corresponding or associated loudspeaker
will give the impression of being practically con-
stant. This tends to secure an appreciable im-
provement in the conditions of intelligibility.
Practical experiments have demonstrated that it
will be sufficient to the said end if sound volume
variations at the microphone at the ratio of 1:100
are reduced to variations of a ratio of 1:15 to
1:10 in the energy supplied to the loudspeaker.

Now, it has been ascertained that also in
equipment of the kind here concerned inherent
noises as well as such noises as are always pres-
ent at the microphone during vocal intermissions
become audible to a magnified degree, for the
reason that the gain which is a function of the
average transmission level, is greatly raised,
whenever the signal strength level is low, and
this is particularly true during intermissions.
This difficulty, according to another object of
the present invention, may be obviated by caus-
ing the regulating means, in the presence of
extremely low amplitudes, to act like a plain
amplifier, and by causing the large increase in
gain required for sound leveling to be initiated

only when the signal or useful volume has reached
a certain value, such gain increase to extend
up to a certain amplitude whereafter the gain is
allowed to diminish again to normal. As a result
the output amplitude will be sensed by the ear
as being stable between the said two points.

It is known in the prior art that in long-
distance telephone lines repeaters designed to
maintain a constant sound level are provided for
stabilization of volume. Changes in this energy
level as a result of changes in attenuation on the
lines due to temperature effects, hygroscopic in-
fluences, variations in the working voltages of
the intermediate or through-line repeaters, or
the like are thus equalized. However, in such
schemes the relationship between the low and
the high sound volumes known as the volume or
dynamic ratio is as a general rule maintained.
In other words, stabilizing means of the said
sort do not act in the sense of a dynamic com-
pression or of sound-volume equalization. In
fact, it is for this reason that these leveling de-
vices are usually controlled by a pilot frequency,
which is also sent out over the line, in order to
cause the variations of the pilot or control fre-
quency to behave just like the variations in voice
frequencies which are occasioned by changes in
the conditions of attenuation of long lines.

To carry the basic idea of this invention in
practice, recourse could be had to regulator means
designed to act upon the transmission measure
or gain, say, regulators of the volume ratio. Reg-
ulating means of this kind have a characteristic
such that the requisite volume balance will be
insured. In other words, these devices are quasi-
dynamic regulators by which the ratio is com-
pressed to an appreciable degree.

Now, the object of the invention shall be ex-
plained in more detail by reference to the graphs
of Figures 1 and 2, and to the circuit diagram
of Figure 3 wherein is illustrated an embodiment
of my controlled amplifier system.

Figure 1 shows the inter-dependence of the
input voltage E_1 and the output voltage E_2 in
terms of percent, plotted to a double logarithmic
scale. Values of 100% are to denote the maxi-
mum permissible input and output potential.
Graph a_0 shows the operation of the standard
amplifier, and graph a_1 the fundamental opera-
tion of a volume equalizer and regulator.

Now, in order that perfect utilization of the
amplifier may be insured it is recommendable
to make conditions so that when the input po-
tential is 100% also the output potential should
be 100%. This particular point of the charac-

teristic is designated by C. The shape of the graphs shows that the gain increases too much in the direction of low amplitudes. For instance, when the input potential drops to 0.1% which means a reduction to one-thousandth of the maximum input potential, the output potential still amounts to 5 percent of the maximum output potential. In other words, it has dropped to only one-twentieth. Hence, the amplification factor at this point is 50 times higher than for point C. Consequently, when using a regulator or control device which operates on the graph A—C, the noise present during intermissions will be markedly amplified.

According to another object of this invention the regulator or control curve is made to follow the curve D—B—C, Figure 1. Thus, in the presence of very low amplitudes the control device works like a standard or plain amplifier (straight line portion at an angle of 45°). That is to say, there exists a substantially linear relationship between the average values of input and output voltages of the amplifier. As soon as a certain signal amplitude has been reached, say, point D of curve a_0 or a_2 , a pronounced rise in the amplifier gain occurs which extends as far as point B. Thereafter the gain falls off again to the normal value at C. So far as aural perception is concerned, the output amplitude is stable and constant from B to C.

Figure 2 illustrates the amplification factor as a function of the input potential E_i plotted in terms of percentage. Points A—B—C which correspond to the points similarly denoted in Figure 1 are also indicated in this figure. The gain is plotted to an arbitrary scale, unity value = 1 being present at maximum working level corresponding to point C. Curves a_1 and a'_1 illustrate the shape and variation of the amplification factor or gain for different control characteristics which, basically, correspond to the form of curve a_1 in Figure 1. Curves a_2 and a'_2 show the corresponding, though dissimilar, control characteristics according to the fundamental curve form a_2 , Figure 1. It will be seen from graphs a_1 and a'_1 that for low volume levels there exists a considerable gain, whereas in the case of curves a_2 and a'_2 , for values less than 1% the gain drops with extremely great rapidity. Hence, from D to B the gain rises at a definite rate. From B—C, this increment in gain is eliminated.

A graph A—C, Figure 1 may be readily obtained with conventional circuit organizations suitably modified for acting upon the gain. The origination of curve D—C, Figure 1 shall now be described by reference to a circuit organization as shown in Figure 3. From Fig. 2 it will be seen that for input voltages above a predetermined low amplitude there occurs an increase in amplifier gain at a relatively rapid rate, whereas the gain decreases at a relatively slower rate for input voltages whose amplitude substantially exceed the aforesaid predetermined amplitude.

In the exemplified embodiment here illustrated the controlled amplifier tube consists of a hexode H, though it will be understood that the basic idea of the invention may be used also in combination with other tubes, and that also other types of circuits such as push-pull schemes may be employed. A varying potential to be amplified is supplied from any source to the control grid g_1 and cathode of tube H. From the output circuit of the amplifier tube by way of the transformer T_2 and the charging resistance R_3 ,

which could consist also of the inner resistance of the transformer and/or the rectifier G_2 , signal frequency impulses are fed to the rectifier G_3 which after rectification charge the condenser C_1 . Between point I which corresponds to the positive potential of the condenser C_1 and the regulator grid g_3 is interposed a battery B_3 which impresses upon the said regulator grid a negative biasing voltage such that the desired low gain will be present. As long as the input alternating potentials are low (point D, Figures 1 and 2), the amplifier operates as a straight amplifier with usual gain and the potential is taken off at the output circuit. In other words, up to point D in Fig. 1 there exists a substantially linear relation between the average values of input and output voltages. When the voltages grow larger, i. e., exceed 1%, the condenser C_1 is charged up by way of the rectifier G_3 . This charge opposes source B_3 and the grid G_3 becomes less negative to increase the gain of the tube H. But the charge cannot be higher than the level of the potential of the battery B_1 , which, with interposition of a rectifier, say, an oxide-type rectifier G_1 is shunted across the condenser C_1 . The battery potential of B_1 corresponds about to the voltage of B_3 . Inasmuch as the negative biasing voltage B_3 of the regulator grid is then compensated by the voltage which arises across the condenser C_1 , this means that then the highest gain is prevailing in the regulated tube. (Point B, Figure 1.) As the voltage rises still further, as will thus be seen, the potentials taken off at T_2 in the output circuit are no longer able to contribute to a change in the regulator or biasing voltage.

In order to obtain curve shape B—C another regulator potential is required. This potential may be derived from the alternating input voltage through transformer T_1 , the charging resistance R_4 (which may consist of the inner resistance of the transformer and/or of the rectifier G_2), and the rectifier G_2 . These elements operate to produce the additional potential across condenser C_2 . The battery B_2 included in this circuit is such that the rectifier G_2 becomes operative only from a certain value of the alternating input potential to charge C_2 and oppose the drop across C_1 . Consequently, in the presence of alternating input voltage above the said critical value, the negative biasing potential impressed upon grid g_3 by B_3 is increased and the amplification of tube H is decreased. Thus, with increase of the alternating input voltage the desired curve shape D—B—C, shown in Fig. 1, is secured.

The rectifier G_3 follows a square law relation between input and output for relatively weak signals, as is well known to those skilled in the art. In other words, up to the relatively low amplitude point D in Fig. 1 no bias voltage will be developed across R_1 by G_3 . Hence, bias from B_3 will maintain the amplifier gain reduced to such a point that a substantially linear relation exists between input and output voltages.

In the exemplified embodiment here shown the circuit arrangement is so made that, in the presence of low amplitudes, amplified energy is taken away from the output circuit which is utilized for control or regulation purposes, while it is only in cases where the amplitudes are greater, that the unamplified input potential is used for further regulation. This offers advantages in view of the size of the signal alternating potentials to be rectified. It will be understood that arrangements could also be made in such a way

that both accessory regulator potentials are taken off, from the input circuit as well as from the output circuit, or else that the circuits are disposed inversely as shown in Figure 3.

If the circuit organization is chosen in a suitable way, the regulator action could be effected also with another grid.

I claim:

1. In a wave transmission system, an amplifier having a wave input circuit and a wave output circuit, a source of wave voltage whose voltage amplitude is adapted to extend over a wide range of values, means coupling said source to said input circuit, said amplifier having its constants chosen to provide a linear relation between the average values of input and output voltages over a minimum amplitude portion of said range, means, responsive to amplified wave voltage in said output circuit, for controlling the gain of said amplifier in an increasing sense upon said source voltage value exceeding said minimum amplitude, and additional means for controlling the amplifier gain in a decreasing sense for voltages whose values are in the maximum amplitude portion of said range, said amplifier comprising a tube having input and output electrodes connected to said input and output circuits respectively, said tube including a special gain control electrode, and each of said gain control means being connected to said special electrode to adjust the potential thereof.

2. In a wave transmission system, an amplifier having a wave input circuit and a wave output circuit, a source of wave voltage whose voltage amplitude is adapted to extend over a wide range of values, means coupling said source to said input circuit, said amplifier having its constants chosen to provide a linear relation between the average values of input and output voltages over a minimum amplitude portion of said range, means, responsive to amplified wave voltage in said output circuit, for controlling the gain of said amplifier in an increasing sense upon said source

voltage value exceeding said minimum amplitude, and an auxiliary control network, responsive to the input circuit voltage, for decreasing the gain of the amplifier upon the source voltage exceeding a predetermined intermediate value of said range, said amplifier comprising a tube having input and output electrodes connected to said input and output circuits respectively, said tube including a special gain control electrode, and each of said gain control means being connected to said special electrode to adjust the potential thereof.

3. In combination with a signal amplifier having input and output circuits, means responsive to signals of an intensity in excess of a predetermined amplitude for increasing the gain of the amplifier at a relatively fast rate, means to prevent operation of said responsive means for signals having an intensity of a predetermined amount higher than said predetermined amplitude, and an auxiliary control means responsive to signals whose intensity exceed an amplitude substantially higher than said predetermined amplitude, for decreasing the amplifier gain at a substantially slower rate than said first rate.

4. In combination with a signal amplifier having input and output circuits, means responsive to signals of an intensity in excess of a predetermined amplitude for increasing the gain of the amplifier at a relatively fast rate, means to prevent operation of said responsive means for signals having an intensity of a predetermined amount higher than said predetermined amplitude, and an auxiliary control means, responsive to signals whose intensity exceed an amplitude substantially higher than said predetermined amplitude, for decreasing the amplifier gain at a substantially slower rate than said first rate, said first means being connected to said output circuit, said auxiliary means being connected to said input circuit.

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