

Aug. 14, 1945.

H. BAUMGARTNER

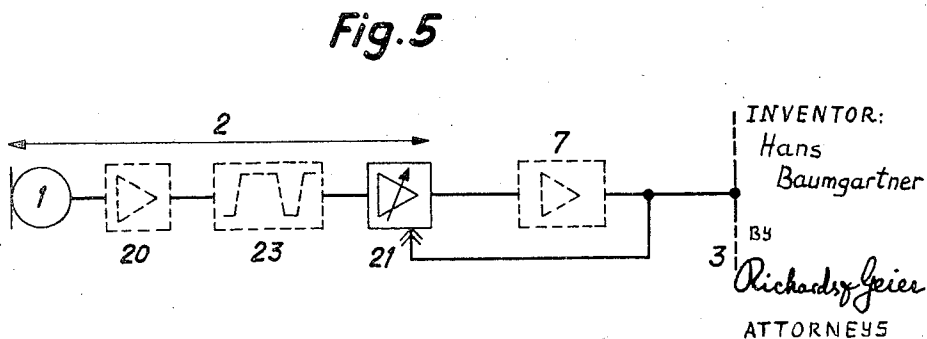
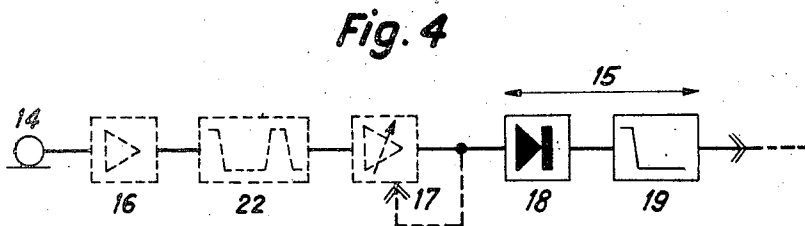
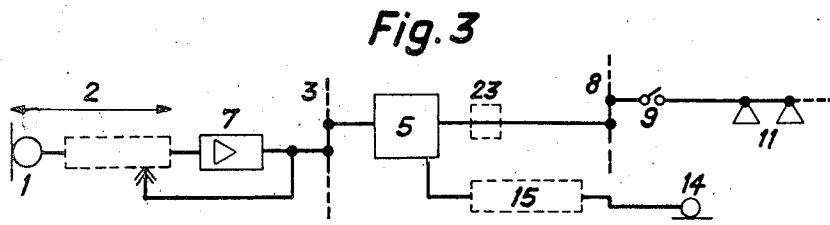
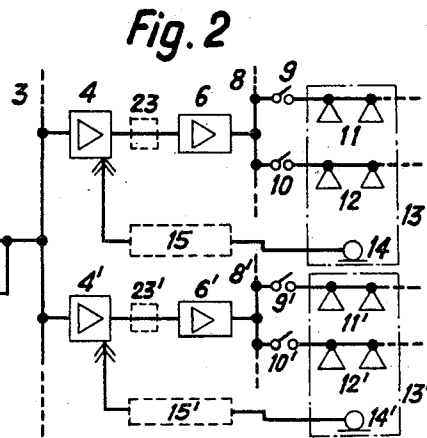
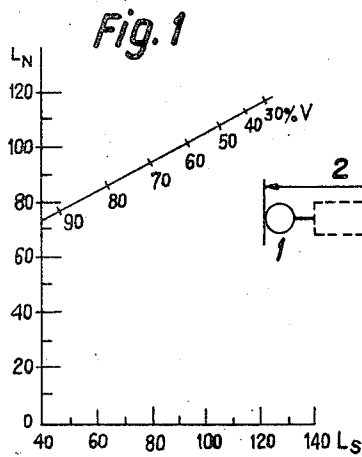
2,382,848

ELECTRO-ACOUSTIC TRANSMISSION PLANT FOR REPRODUCTION

IN PLACES WITH NOISE DISTURBANCES

Filed Dec. 6, 1943

2 Sheets-Sheet 1



Aug. 14, 1945.

H. BAUMGARTNER

2,382,848

ELECTRO-ACOUSTIC TRANSMISSION PLANT FOR REPRODUCTION

IN PLACES WITH NOISE DISTURBANCES

Filed Dec. 6, 1943

2 Sheets-Sheet 2

Fig. 6

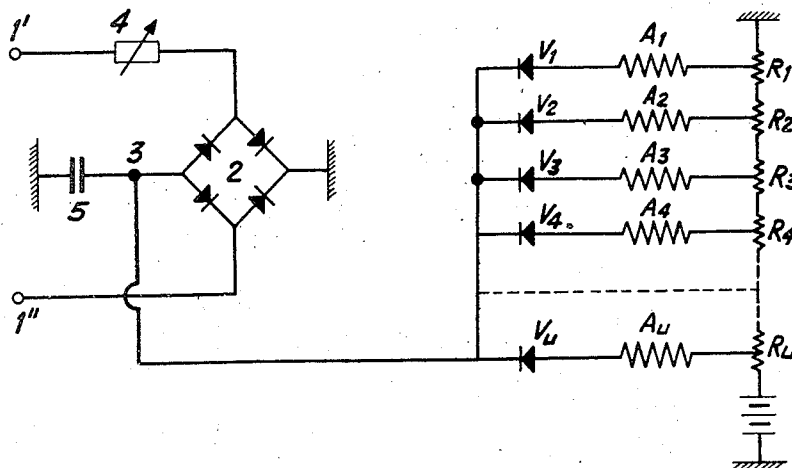


Fig. 7

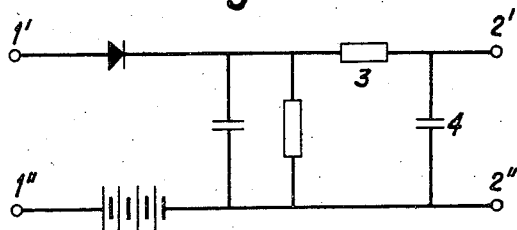


Fig. 8

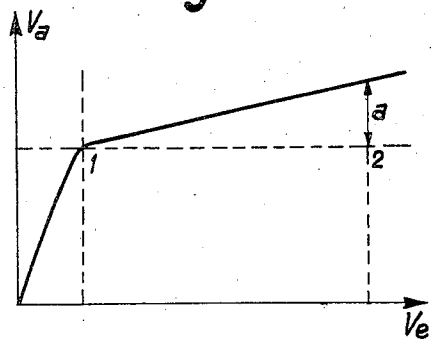
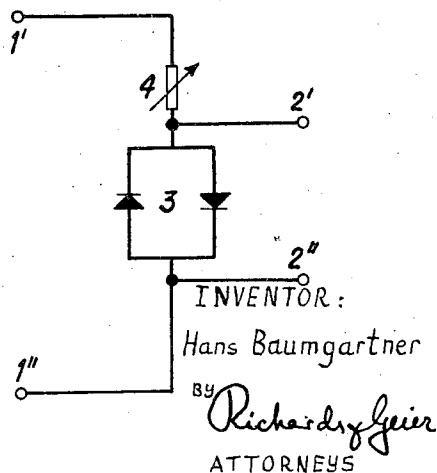


Fig. 9



INVENTOR:

Hans Baumgartner

By *Richard D. Geier*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,382,848

ELECTROACOUSTIC TRANSMISSION PLANT
FOR REPRODUCTION IN PLACES WITH
NOISE DISTURBANCES

Hans Baumgartner, Zurich, Switzerland

Application December 6, 1943, Serial No. 513,137
In Switzerland October 7, 1942

16 Claims. (Cl. 179-1)

The present invention refers to an electro-acoustic transmission plant (public address system mostly) for reproduction in places with noise disturbances.

If the acoustic reproduction of a transmission is to be clearly heard, the sound intensity must be the greater, the louder the disturbing noise at the place where the reproduction takes place. For instance, in speech reproduction it is possible to ascertain for each disturbing sound level the corresponding best transmission level for securing the maximum degree of clearness obtainable.

Fig. 1 shows such a connection, found by experiment, between clearness and disturbing sound intensity.

L_N is the speech level, L_s the disturbing sound level, both measured in decibels. Reference point: 0 decibels refers to a flow of sound energy of 10^{-16} W/cm.² at 1000 cycles. The corresponding degrees of clearness V are entered in percentages on the curve. If, for instance, at the listener's ear the disturbing sound level is 120 decibels, and the speech level 94 decibels, the speech will be utterly unintelligible. If the speech level is 114 decibels, the syllable clearness will be 41 percent. A further increase of the speech sound intensity again leads to impairment of audibility. If, on the other hand, the disturbing sound level drops to 40 decibels, the speech level standing at 114 decibels, the clearness will improve to 70%. An improvement in clearness is obtained by lowering the speech level according to the lower disturbing sound level. With the speech level standing at 74 decibels, the syllable clearness reaches 93%. At a still lower speech level, there is again an impairment of audibility. Therefore, with a disturbing sound level standing at 40 decibels, the highest obtainable degree of clearness is 93% and can only be secured with a speech level standing at 74 decibels. With a disturbing sound level standing at 120 decibels, the highest obtainable degree of clearness is 41%, the corresponding speech level standing at 114 decibels.

A regulation by hand of sound intensity, depending on the disturbing sound, carried out in accordance with definite regulating instructions—for instance according to the curve in Fig. 1—involves the drawback that it is impossible to keep pace with rapid disturbance fluctuations. This drawback is more particularly felt when taking in consideration the modern tendency towards increasing centralisation of command and inquiry organs. The more intricate such a transmission installation is, the greater—under certain conditions—the number of reproducing appliances

subjected to various disturbance level fluctuations, which appliances would have to be—by way of example—individually regulated from one central spot. This would make a regulation by hand of the reproduction sound intensity practically impossible.

The present invention provides the remedy. It refers to an electro-acoustic transmission installation for places with noise disturbances, and is characterised by the provision of suitable devices for regulating automatically the reproduction sound intensity according to the specific properties of the disturbing noise prevailing at the place of reproduction—with a view to securing the greatest possible clearness.

Among the properties of the disturbing noise to be chiefly considered here are its level (loudness, sonorousness, sound intensity, sound pressure) and its frequency spectrum.

It is particularly convenient to design the transmission installation in such a manner that the devices provided include at least one or more sound receiving appliances at the place or reproduction, and one regulating device. The sound registered by the sound receiving appliance at the place of reproduction is converted by way of a regulating channel into a control value sufficiently characterising the disturbing sound, which value—by means of the regulating device placed in the path of the transmission channel—so controls the reproduction as to take into account, besides the dependence on the properties of the disturbing sound, the dependence as well as clearness conditions on the co-ordination of the speech level to the disturbing sound level. The transmission channel connects the speaking microphone with the reproducing appliances, for instance a loud-speaker. The regulating channel leads from the sound receiving appliance to the regulating device placed in the transmission channel and, by a kind of feed back, under certain conditions influence the sound receiving appliance by way of the loud-speaker.

If, in order to mark the difference between the disturbing sound and the sound radiating from the loud-speaker, we designate the latter by "useful sound," it will be advisable to distinguish the following three cases:

Case 1.—The sound receiving apparatus practically receives disturbing sound only. This may happen with special radiation conditions of the loud-speakers and a special configuration of the room in which the noise disturbance takes place, in the case of a peculiar distribution of the disturbing noise within the room, etc., so that the

sound receiving apparatus may be conceivably set up so as to exclude all and any influence of the useful sound on the apparatus.

Case 2.—The radiation of the loud-speakers, the configuration of the room and the distribution of the disturbing sound within that room are such that both disturbing sound and useful sound reach the sound receiving apparatus. The disturbing sound, however, is of such a nature that its frequency band lies outside of the frequency band of the useful sound.

Case 3.—Similar to case 2, with the difference that the disturbing sound spectrum and the useful sound spectrum have common frequencies. This is the case most generally met with in practice. The design of the installation according to the present invention with reference to this particular case is therefore of special importance.

It is furthermore expedient to distinguish between the means serving to form the control value, and those means intended to create such frequency conditions as will cause the control value to characterise the disturbing sounds only. The means last mentioned may differ in all three cases; the first mentioned ones may be the same.

It is obvious that in regulating the reproduction sound intensity according to the disturbing sound level there is no intention to follow up each and any amplitude fluctuation of the disturbing sound spectrum. It will suffice to follow up these fluctuations within a desired mean approximation; in other words, the regulating action takes place according to the fluctuations in bulk, whilst fluctuations of lesser extent are not taken into account. The means of the transmission installation shall therefore be suitably so designed that they make it possible to affect the regulating process with the course of time. It is more particularly advantageous to design these means in such a manner that they shall be acting in the sense of the mean approximation, i. e., in the sense of a slowing-down or "flattening" of the regulating process. In regulating technics, as is well known, the regulating fluctuation from the peak value to the lowest value and again to the peak value is designated by the expression "regulating period," and consequently the expression "regulating frequency" is in common use. This frequency generally varies continuously according to time. For regulating reproduction it is important that the regulating frequency should mainly lie below the audible frequency range, somewhat below 16 C. P. S., since otherwise the regulating process would result in a disturbing sound impression. On the other hand, the transient time shall not be too long, since otherwise the clearness of audition would substantially suffer. Experience has shown that it is advisable to select 60—100 msec. as adjusting time. This corresponds to a resulting regulating frequency of 8–5 C. P. S., i. e., to a mean time of approximately $1\frac{1}{2}$ syllable.

The control value may be an electric regulating voltage; it may also be another value, for instance a mechanical or magnetic value. In order that this value, in regulating the reproduction over the regulating device, should take into account, besides the dependence on the properties of the disturbing sound, also the dependence of clearness conditions on the co-ordination to the disturbing sound level of the speech level, the regulating mechanism shall conveniently include at least one organ by means of which the sound intensity to be reproduced shall be regulated according to a definite regulating curve. Such a

regulating curve was fully explained with reference to Fig. 1.

Various constructional examples of the transmission plant according to the present invention are described below.

The general disposition of the transmission plant shall be described in the first place in its main lines with reference to Fig. 2. From the speech receiving appliance 1 the transmission channel leads over 2, 3, 4, 6, 8, 9 to the loud-speaker 11 in the room 13 where a disturbing noise prevails. In this room 13 is set up at least one sound receiving apparatus 14. A frequency spectrum corresponding to the disturbing sound is then converted, by means of a converting device 15 in the path of the regulating channel, into a control value controlling the sound reproduction over a regulating device—for instance 4 in Fig. 2. 6 designates the terminal amplifier in the transmission channel.

A microphone may be used as sound receiving apparatus 14. Other sound receiving appliances recording the disturbing sound energy may also be used, for instance mechanical-electromagnetic, electromagnetic, mechanical-electric or mechanical-electro-acoustic appliances.

Several loud-speakers 11, 12 may be set up in the reproduction room 13, as shown in Fig. 2. The loud-speakers can be arranged in such a manner that the greatest possible clearness of audition with reference to the disturbing and useful sound is, at least approximately, reached in the case of as many listeners as possible. The loud-speakers 11, 12 can be connected severally or in groups with the auxiliary bus-bar (collecting bar) 8 by switching means 9, 10.

Several reproduction or audition rooms may also be available, with the possibility that diversified sound disturbance conditions may prevail in the various rooms 13, 13', etc. The reproduction sound intensity can then be individually regulated for each room 13, 13', etc.—by coordinating to each loud-speaker or to each group of loud-speakers 11, 12 or 11', 12', etc., one adjusting device 4 or 4', and one converting device 15 or 15' together with accessories 6 or 6', 8, or 8' 9 or 9', 10 or 10'. All regulating devices 4 or 4' can be fed from one common useful frequency bus-bar 3.

In the constructional example according to Fig. 2 the terminal amplifiers 6 and 6' are disposed behind the regulating mechanism 4 and 4', as the case may be. A further constructional example, as illustrated in Fig. 3, mainly differs from the one just described as far as the disposition of the terminal amplifiers and of the regulating mechanism is concerned, since the terminal amplifiers are assembled into one single terminal amplifier 7 in front of the bus-bar 3. Under certain conditions different regulating devices 5, to be described later on, are needed.

The regulating channel is schematically represented in Fig. 4. It consists of at least one rectifier 18 with one slowing-down device 19, for instance a low-pass filter. According to requirements there are added one microphone amplifier 16 and one amplifier 17, with the possible inclusion of a self-acting auxiliary regulating mechanism if conditions require it.

Fig. 5 shows the initial part 2 of the transmission channel, to which—in the constructional example according to Fig. 3—the terminal amplifier 7 is further added. Part 2 includes at least one microphone 1 to be described later on, together with corresponding pre-amplifier 20 and amplifier 21—if required.

The purpose of the filters 22 and 23 as appearing in Figs. 4 and 5 will be explained later on.

The means for arriving at the control value may—by way of example—consist of a rectifier 18 and a low-pass filter 19, as shown in Fig. 4. The disturbing sound spectrum is rectified by the rectifier 18. It is conceivable to imagine the rectified fluctuations as constituting a succession of non-periodic signals represented with the assistance of the Fourier series, including—generally speaking—all frequencies from 0 to ∞ . In the low-pass filter—exhibiting by way of example a limiting frequency of 20 Hz—the upper frequencies are suppressed, thus bringing about a levelling or retardation of the disturbing sound fluctuations. In the example represented in Fig. 6, the rectifier 2 corresponds to the rectifier 18 of Fig. 4, and the RC element 4, 5—to the low-pass filter of Fig. 4.

In place of the elements 18, 19 other means known in practice may also be used, as for instance thermoelectric converters, electrostatic-mechanical systems. Relays pawls, step switches driven by electric motors, based on a principle embodied, for instance, in indicating devices, may be used in connection with the main regulating means 5. Arrangements are further conceivable in the sense of known measuring systems, as for instance electrostatic voltmeters—which are performing at the same time the functions of the organs 18, 19.

In the example of Fig. 2, the regulating appliances 4 may comply with the guiding principles of control circuits known in practice, with the difference, however, that with increasing control voltage the amplification increases instead of decreasing as is generally the case. The regulating process may take place continuously or by steps.

In the constructional example as per Fig. 3 regulating appliances 4 as per Fig. 2 cannot be used any more since the latter mostly involve valve circuits, and more particularly input stages (with variable μ -valves) and small grid control voltages—in which clearness of speech shall not be impaired by the curvature of the characteristic, impossible to avoid with variable μ -tubes.

A regulating appliance 5 may—by way of example—consist of relay combinations in themselves known, fed from the control value. These, in their turn, actuate contacts which—by way of example—modify by steps the loud-speaker sound intensity by connecting it to different tapings on the secondary winding of the output transformer or of a voltage divider.

It is especially advisable to co-ordinate to the individual elements, for instance to the relays of the regulating mechanism, auxiliary components to be set in advance. If, for instance, the control value actuates a combination of relays it will prove advisable to throw in—in addition to the individual relays—adjustable resistances by means of which the voltage at the individual relays can be modified at will within wide limits. It is furthermore advantageous to connect the regulating organs and their coordinated components in such a manner that the latter may be set independently from one another. This measure makes it comparatively easy to realise any desired regulating curve. It has furthermore proved useful for clearness of audition to make suitable provision for the regulating organs to respond at lower voltages with decreasing control value than with increasing control value. Thus the adapting capacity of the ear is taken into consideration in the sense of an hysteresis loop of the sound intensity regulation at the place of reproduction.

An example of a regulating mechanism is shown in Fig. 6. The regulating voltage lying at the terminals 1', 1'' is rectified by the valves 2. Point 3 always shows a potential below, or equal to, zero. The regulating organs consist of some relays $A_1, A_2 \dots A_n$ connected in parallel to the rectifier 2. Connected in series to each relay there is a rectifier $V_1, V_2 \dots V_n$. There are further, co-ordinated to the relays, resistances $R_1, R_2 \dots R_n$ individually adjustable. The whole path of the continuous current is being blocked for one direction by the rectifiers 2 and V . If the voltage at 3 (with negative sign) increases, the relays $A_1, A_2 \dots A_n$ operate consecutively. These relays connect the loud-speaker to different tapings on the output transformer of the speech amplifier, or on a voltage divider, or both together. In this manner sound intensity is regulated. By adjusting suitably the tapings on the resistances, and by giving the relays the correct characteristics, it is possible to obtain the regulation in accordance with a desired regulating curve. Similarly, by selecting suitable values for the resistances R and by taking suitable measures in setting up the combination of relays A , the points of operation and release of these relays can be varied, thus securing the regulation according to the adapting capacity of the ear.

The regulating means may also consist of a voltage dividing arrangement similar to the known step or slide transformers. The drive is, for instance, entrusted to a mechanical system controlled either electrically by the rectifier 18 and the delaying device 19—according to Fig. 4—or mechanically by an electrostatic or electrodynamic measuring system.

In order to make up for subjective influences originating with the speaker, as for instance his sound intensity, the distance at which he stands from the microphone, etc. it is advisable to insert in the path of the transmission channel an auxiliary regulating appliance, with a view to keeping constant to a certain degree the effective value of the transmission voltage at the entrance to the means for regulating the reproduction sound intensity, for instance at the bus-bars 3 (see Figs. 2, 3, 5).

Such a back regulation is indicated with 21 in Fig. 5. The principle of this regulation may be explained with the help of Fig. 7. The terminals 1', 1'' of the four terminal network are connected to tapping points of the output transformer of the speech amplifier—the terminals 2', 2'' to the grids of the first stages of this amplifier. By operating at a convenient working point it is possible to secure a regulating characteristic in accordance with Fig. 8. On the abscissa is entered the input voltage V_e , on the ordinate the output voltage V_a of the amplifier. The admissible tolerance value a of the regulation within the range 1, 2—corresponding to a remaining control value—varies within wide limits according to circumstances. In this auxiliary regulation as well, the regulating frequency shall not make itself heard as a nuisance within the listening range. Therefore, for reasons similar to those described above with reference to the low-pass filter 19, the quadripole of Fig. 7 also includes a low-pass filter, by way of example an RC member 3, 4.

When a disturbing sound amplifier, for instance 17 in Fig. 4, is co-ordinated to the regulating channel, it is advisable to provide here

as well an auxiliary regulating device. The control value as a function of the disturbance level may then be influenced by means of this self-acting auxiliary regulating device to such an extent that any risk of overrunning the regulating organs is eliminated. By way of example, the automatic action in the regulating process may conform to the guiding principles of known thermionic valve circuits (for instance automatic volume control in radio receiving sets), with the difference that the regulation does not aim at a constant output-level, but is effected so as to secure that the control value shall remain available to the desired extent. The automatic regulating action acts to such a purpose that with low disturbance levels the amplifiers show up a higher sensitivity than with high disturbance levels. A simple solution of this regulating problem consists in connecting the terminals 1', 1'' of a resistance element 3—whereby this latter shows up a definite relation between resistance and voltage—to the output of the input-stage of the disturbing sound amplifier, as represented in Fig. 9. Such an element consists, by way of example, of two rectifiers connected in parallel and opposed to one another and co-ordinated resistance 4. The output 2', 2'' is fed to the grid of the output stage of the disturbing sound amplifier. Fig. 8 gives the output-voltage versus input-voltage characteristic of an amplifier with such a coupling link.

At the beginning of this description we have discriminated between three cases according to the nature of the disturbing sound.

In the first case, when no useful sound reaches the sound receiving appliance 14, the means hitherto described are sufficient for securing the desired regulation of the reproduction sound intensity.

In the second case, in which both disturbing sound and useful sound reach the sound receiving appliance, there is a possibility that the useful sound as well will influence the regulating organs—in the sense of an undesirable increase of the reproduction sound intensity. The regulating appliance would run out to the upper end of its regulating range. In order to eliminate this risk the useful frequencies must be prevented from affecting the control value, and consequently the regulating appliance. The transmitting channel must therefore be equipped with means making it possible to convert exclusively disturbing sound frequencies of the sound prevailing in the reproduction room into a control value. This can be secured, by way of example, by providing in the path of the regulating means, i. e., in the regulating channel, at least one filtering device passing out of the mixture of frequencies taken up by the sound receiving appliance disturbing sound frequencies only. This may be, for instance, an electric filter, as indicated by 22 in Fig. 4.

The filters may, however, be of other design, for instance consist of acoustic or mechanical filter chains, or the same purpose may be fulfilled on basis of another principle, for instance by influencing the output-frequency characteristic of the disturbing sound receiving appliance. The data of the filtering means shall be such as to secure by means of the pass-frequency range a sufficiently accurate reproduction of the disturbing sound.

In the third case, which differs from the second case by the fact the disturbing sound spectrum and the useful sound spectrum have same

frequencies in common, a frequency band is selected out of the disturbing sound spectrum constituting a sufficiently faithful image of the disturbing sound. The filtering means in the regulating channel—as described with reference to the second case—must command exhibit a pass-range sufficient to allow this frequency band to pass. Should the band fall within the useful frequency range, these disturbing sound frequencies will have to be suppressed by additional blocking filter arrangements in the path of the useful sound channel, so that they shall not reach the regulating device via the sound receiving appliance, thus avoiding feed-back.

The additional blocking filter arrangements may be electric filters, as for instance indicated with 23 in Fig. 5. However, they also may consist of acoustic or mechanical filtering means disposed in the path of the useful sound channel. The function of these filters can also be performed by a special shaping of the frequency characteristic, for instance of the speech microphone and of the loud-speaker.

The attenuation and pass ranges of the filters, as well as the corresponding decrements, depend on the situation of the important disturbing and useful frequencies and are suitably set in such a manner that the quality of sound reproduction, for instance clearness of speech, shall be as high as possible and that nevertheless the regulation of the reproduction sound intensity shall conform to a prescribed curve similar to that shown in Fig. 1.

When using filtering means proper, for instance electric or acoustic filters disposed in the regulating channel or in the useful sound channel, or in both, the nature of these filters furthermore depends on the frequency characteristic and mounting place of the sound receiving, transmitting and reproducing organs, on the acoustic room properties, etc.

On basis of measurements of the disturbing sound intensity which varies from one place to another, the whole acoustic frequency range can be divided up into pass bands and blocked ranges. In the signaling field and sounding Morse transmission the automatic sound intensity regulation can be made especially efficient, since there are only one or a few useful frequencies to be dealt with. These are sieved out of the disturbance frequency band.

There are various kinds, and various causes, of disturbing noises to be considered, for instance noise from machines, from vehicles, braking noises, noises from crowd gatherings. The frequency spectrum of the disturbing noise will generally consist of a mixture of all possible frequencies. The amplitudes of the different harmonics can fluctuate in time within wide limits. Reproduction appliances, listeners and noise sources may move in relation to one another. In order that the plant may be adapted to varying local and disturbing sound conditions it will be advisable to have at least one filter made adjustable in relation to passage attenuation and frequency band.

I claim:

1. An electro-acoustic transmitting plant, comprising, in combination, means reproducing useful sound, means adjacent the first-mentioned means for receiving disturbing sound prevailing at the place of reproduction, and means connected with the first-mentioned means and the second-mentioned means for automatically regulating the intensity of said useful sound depend-

ing upon the properties of said disturbing sound, for the purpose of securing the maximum possible intelligibility for the useful sound.

2. An electro-acoustic transmitting plant, comprising, in combination, a transmitting channel for useful sound, said channel having a regulating device; a sound-reproducer connected with said channel, at least one appliance for receiving disturbing sound prevailing at the place of reproduction, and means connected with said appliance and said regulating device for converting the recorded disturbing sound into a control value sufficiently characterizing the same; said regulating device comprising means actuated by said control value to control reproduction of useful sound depending upon the properties of the disturbing sound and the coordination of speech level to the disturbing sound level.

3. A transmitting plant in accordance with claim 2, wherein said regulating device includes means for setting the intensity of useful sound to a definite regulating curve.

4. A transmitting plant in accordance with claim 2, wherein said regulating device includes individual organs for setting the intensity of useful sound to a definite regulating curve, and auxiliary organs coordinated to said individual organs and adapted to be set in advance to determine the regulating curve.

5. A transmitting plant in accordance with claim 2, wherein said regulating device includes individual organs for setting the intensity of useful sound to a definite regulating curve, and auxiliary organs coordinated to said individual organs and adapted to be set in advance independently of said individual organs to determine the regulating curve.

6. A transmitting plant in accordance with claim 2, wherein said regulating device includes individual organs for setting the intensity of useful sound to a definite regulating curve and regulating differently with increasing and decreasing control value, and auxiliary organs coordinated to said individual organs and adapted to be set in advance to determine the regulating curve, whereby sound intensity regulation in accordance with the adapting capacity of the human ear is secured.

7. A transmitting plant in accordance with claim 2, wherein said regulating device includes means influencing the time course of the regulating process.

8. A transmitting plant in accordance with claim 2, wherein said regulating device includes means influencing the time course of the regulating process by causing the regulation to follow disturbing sound fluctuations within a mean approximation only and suppressing by retardation fluctuations over small time intervals.

9. A transmitting plant in accordance with claim 2, wherein said regulating device includes means influencing the time course of the regulating process by causing the regulation to follow disturbing sound fluctuations within a mean ap-

proximation only and suppressing by retardation fluctuations over small time intervals, the maximum retardation being such as not to impair intelligibility.

10. A transmitting plant in accordance with claim 2, wherein said regulating device includes means influencing the time course of the regulating process by causing the regulation to follow disturbing sound fluctuations within a mean approximation only and suppressing by retardation fluctuations over small time intervals, the retardation of the regulating process having a value so as not to lead to sound impressions originating from the regulating frequency.

11. A transmitting plant in accordance with claim 2, wherein said regulating device includes means influencing the time course of the regulating process, said channel further comprising an auxiliary regulating device for keeping constant the effective value of the transmission voltage at the entrance to the first-mentioned regulating device.

12. A transmitting plant in accordance with claim 2, wherein said regulating device includes means influencing the time course of the regulating process, said channel further comprising an auxiliary regulating device for influencing the control value to avoid any excess control of the first-mentioned regulating device.

13. A transmitting plant in accordance with claim 2, wherein said converting means include means converting into a control value exclusively disturbing sound frequencies of the sound recorded at the place of reproduction.

14. A transmitting plant in accordance with claim 2, wherein said regulating device further comprises at least one filtering device allowing to pass through only disturbing sound frequencies out of the mixture of frequencies reaching said appliance.

15. A transmitting plant in accordance with claim 2, wherein said regulating device further comprises at least one filtering device allowing to pass through only disturbing sound frequencies out of the mixture of frequencies reaching said appliance, and wherein said transmitting channel comprises at least one other filtering device giving free passage to at least the blocking frequencies of the first-mentioned filtering device, and blocking at least its free-passage frequencies.

16. A transmitting plant in accordance with claim 2, wherein said regulating device further comprises at least one filtering device allowing to pass through only disturbing sound frequencies out of the mixture of frequencies reaching said appliance, and wherein said transmitting channel comprises at least one other filtering device giving free passage to at least the blocking frequencies of the first-mentioned filtering device, and blocking at least its free-passage frequencies, at least one of said filtering devices having means for adjusting it in relation to attenuation in the pass range and cut-off frequencies.

HANS BAUMGARTNER.