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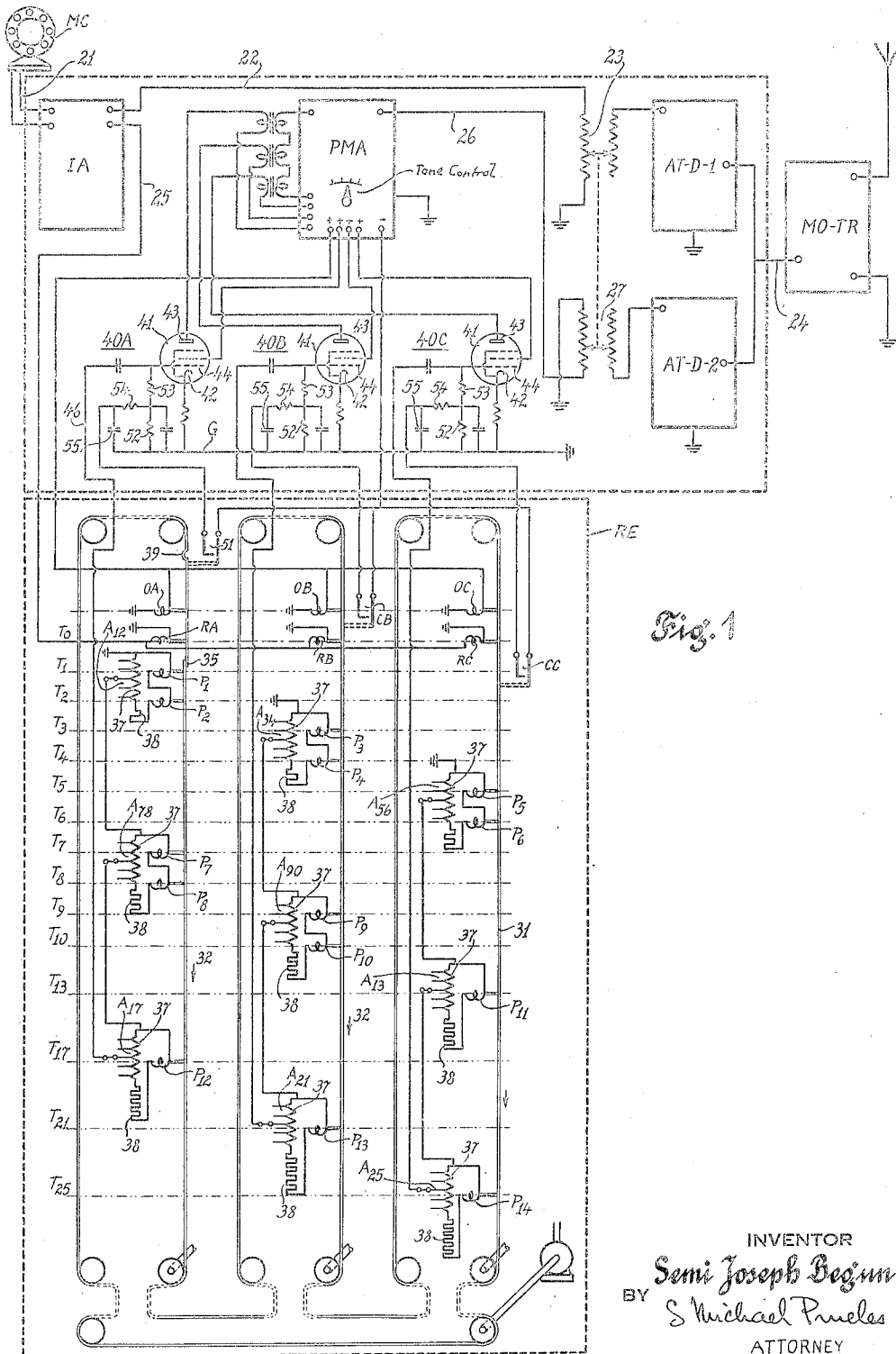
S. J. BEGUN

2,327,956

MAGNETIC RECORDING AND REPRODUCING

Filed Dec. 16, 1940

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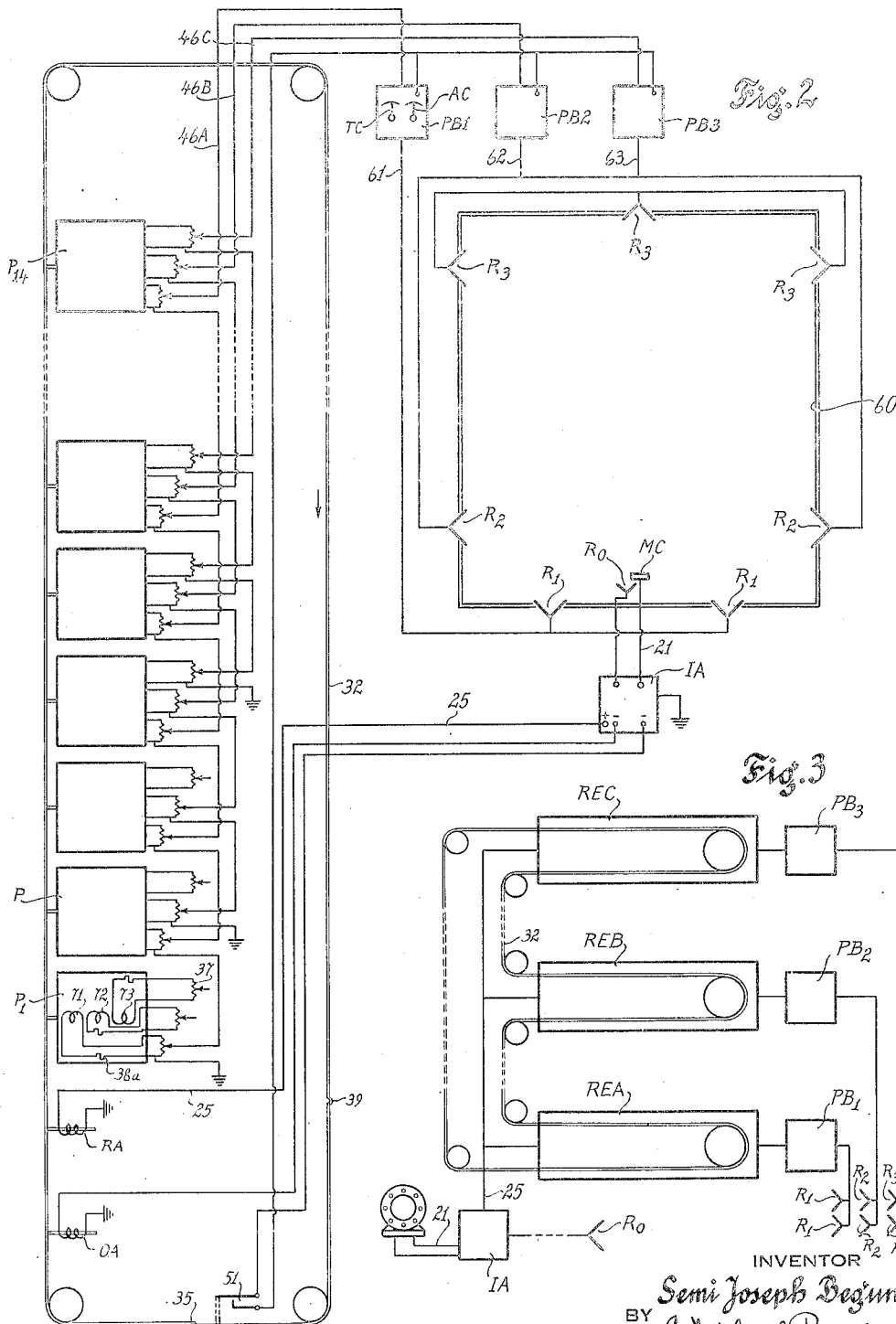
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MAGNETIC RECORDING AND REPRODUCING

Filed Dec. 16, 1940

6 Sheets-Sheet 2



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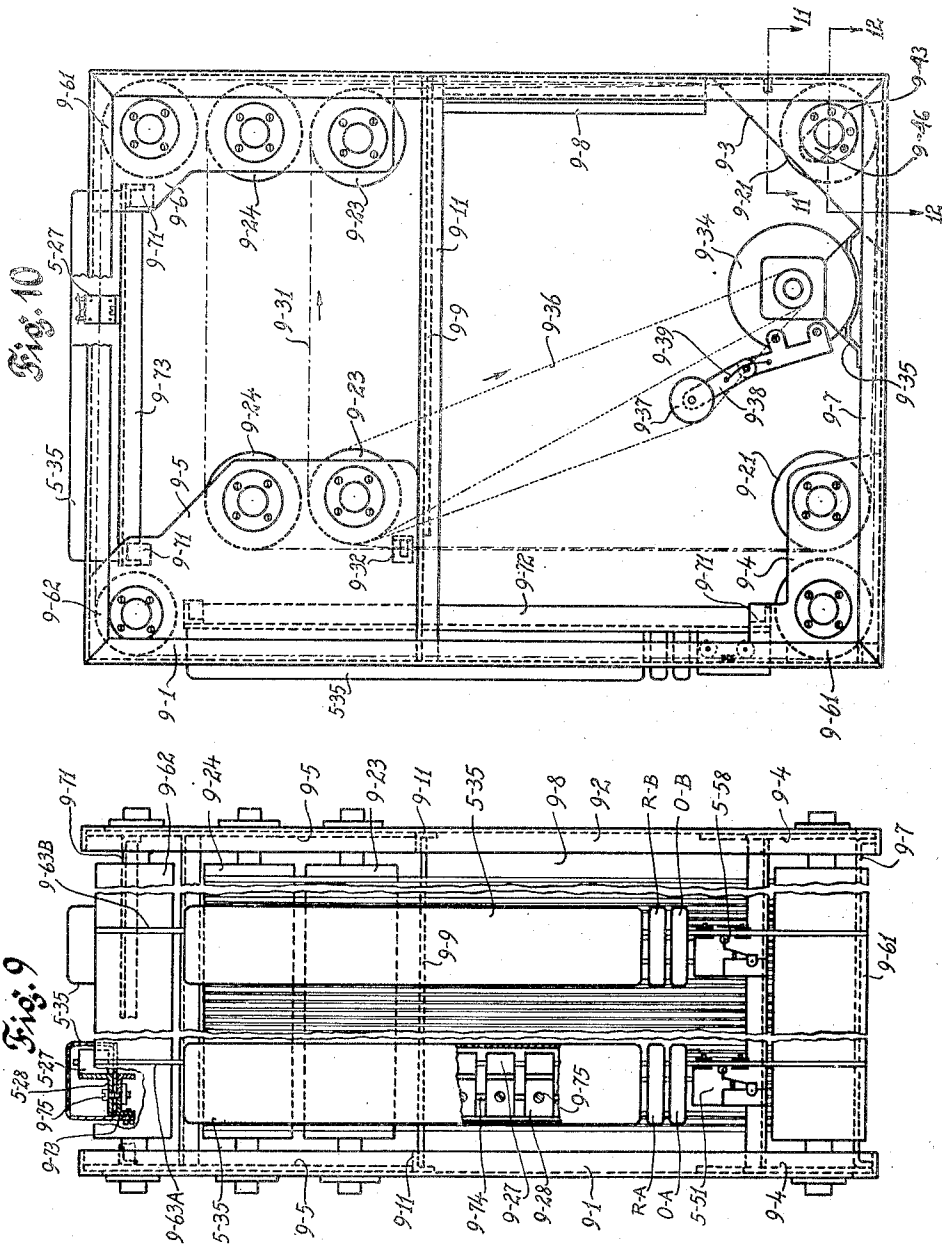
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2,327,956

MAGNETIC RECORDING AND REPRODUCING

Filed Dec. 16, 1940

6 Sheets-Sheet 5



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2,327,956

MAGNETIC RECORDING AND REPRODUCING

Filed Dec. 16, 1940

6 Sheets—Sheet 6

Fig. 11

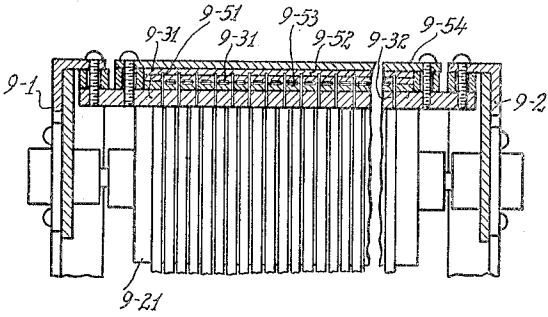


Fig. 14

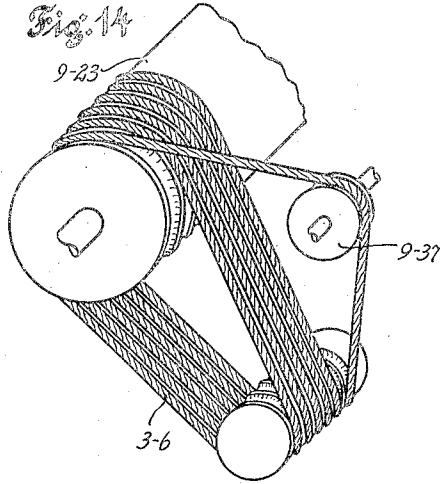


Fig. 12

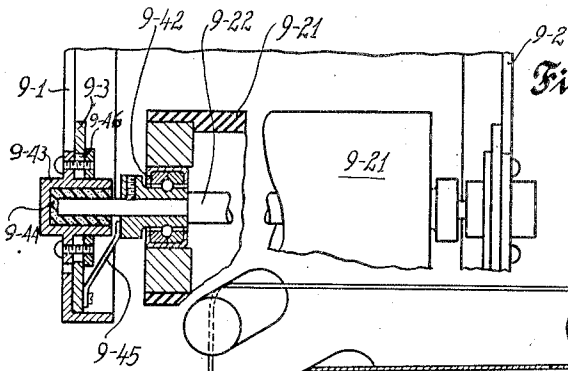
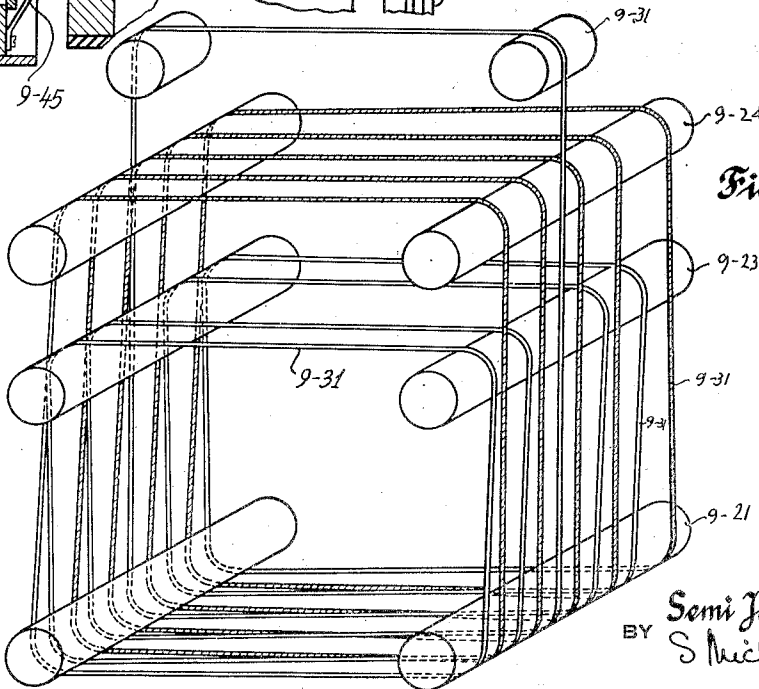


Fig. 13



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# UNITED STATES PATENT OFFICE

2,327,956

## MAGNETIC RECORDING AND REPRODUCING

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Application December 16, 1940, Serial No. 370,417

17 Claims. (Cl. 179—100.2)

This invention relates to magnetic recording and reproducing, and it has among its objects improved novel magnetic recording and reproducing methods and arrangements which are particularly useful for applications, such as time delay systems, although the various features of the invention are not limited thereto.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings wherein

Fig. 1 is a diagrammatic view of the circuits and the operating elements of an endless magnetic recording arrangement designed to supply artificial reverberation in accordance with the principles of the invention;

Figs. 2 to 4 are diagrammatic views similar to Fig. 1 illustrating other exemplifications of the invention;

Fig. 5 is an elevational view illustrating the structural features of an endless tape magnetic recording device designed in accordance with the principles of the invention;

Fig. 6 is a top view of Fig. 5 with parts shown in section;

Fig. 7 is an elevational view of the switching unit associated with the recording device of Fig. 5;

Fig. 8 is a side view of the switching unit shown in Fig. 7;

Fig. 9 is an elevational view of another form of endless magnetic recording device exemplifying another form of the invention;

Fig. 10 is a side view of the devices shown in Fig. 9;

Fig. 11 is a cross-sectional view along line 11—11 of Fig. 10;

Fig. 12 is a cross-sectional view along line 12—12 of Fig. 10;

Fig. 13 is a perspective view illustrating the method of winding the endless magnetic tape on the device of Figs. 9 and 10; and

Fig. 14 is a perspective view illustrating the driving arrangement of the device shown in Figs. 9 and 10.

time delay, for instance, of the order of  $\frac{1}{4}$  of a second or more is required, time delay systems, formed of electric network elements only, are very expensive and bulky particularly if used in the lower frequency range, such as at audio-frequencies, requiring magnetic core inductances.

It has also been suggested that under conditions requiring such longer time delays, sound recording should be used instead of electric network elements as the time delay medium. Thus, for instance, Arnold Patent 1,859,423 proposes the production of reverberation effects by recording the sound and reproducing the record with a plurality of pickups located at closely succeeding intervals along the sound record track and controllably attenuating and combining the outputs of the pickups so as to reproduce the recorded sound with delayed echo and reverberation effects.

Although disc recording and other long known sound recording media, such as magnetic recording, which enable instantaneous playback of recorded sound, make it possible to add artificial reverberation effects to sound sequences, prior efforts to use sound recording for applications, such as artificial reverberation systems, never came into use because the discontinuity between the end and beginning of a sound track formed on such recording medium make it impossible to use such time delay systems for supplying the reverberation effects during prolonged continuous periods.

Although an endless magnetic recording tape might have seemed to be useful as a continuously operating sound recording medium suitable for artificial reverberation systems, the discontinuity at the junction or the soldering point which has to be provided in order to join the ends of a length of magnetic tape into an endless tape would, on passing through the large number of closely spaced playbacks required to supply the prolonged artificial reverberation time delay effects, induce in each playback head disturbing high electric potentials, thereby introducing into the playback reverberation channel a series of disturbing clicks. As a result, such endless magnetic recording tape proved heretofore to be without practical value as a reverberation medium because the desired reverberation effect was being destroyed by the repetition of prolonged click disturbances.

To overcome the difficulties brought about by the discontinuity in the sound tracks of disc and magnetic recording media, efforts have been made

Time delay systems have been long known in the communication field. Thus, for instance, Mills Patent 1,647,242 describes how a time delay network consisting of inductances and condensers may be utilized for supplying artificial reverberation in the reproduction of sound for broadcasting, sound recording and the like. It has also been long recognized that if a longer

to devise an artificial reverberation system utilizing recording on an endless phosphorescent record surface as the time delay medium. However, although phosphorescent sound recording media have the advantage that they may be readily designed to form a continuous endless sound track without any discontinuity, the practical adaptation of such phosphorescent surface record media for artificial reverberation encountered great difficulties and have never reached practical acceptance.

One phase of the invention is based on the discovery that an endless magnetic tape with a soldering junction discontinuity may be used for supplying artificial reverberation during prolonged continuous periods, and that such endless tape magnetic recording medium may be designed so as to suppress the disturbing effect of the soldering junction without in any way diminishing the effectiveness of the endless tape recording medium in producing artificial reverberation effects.

If sound proceeds from a source located in a room and strikes a wall surface, it is partly reflected therefrom and travels until it reaches another surface where it is again partly reflected. At each sound impact, some of the energy of the sound is absorbed by the wall surface and the reflected sound is weaker than the original. Such action results in a succession of tones of diminishing intensity which give the listener the impression that the original sound dies out slowly, and is known as reverberation. The reverberation time of a room is usually defined as the time necessary for the sound of a source, that is suddenly stopped, to decay 60 decibels.

In many applications, it is desired to change the reverberation time of a room. Orchestra music, for instance, has more appeal if it is richer in reverberation, and the voice of a singer is more pleasing if it is heard with less reverberation.

The absorption of the sound in a room will depend on the vapor content of the air, particularly for high frequencies, and on the absorption characteristics of the walls, and the furniture in the room. Accordingly, the sound decay will vary for different frequencies. In general, the rate at which the sounds of the different frequencies decay has an exponential characteristic, and the higher frequencies have a faster decay time than the lower frequencies.

A satisfactory artificial reverberation device should, therefore, operate in relation to a constant frequency impulse as follows: At the termination of the sound impulse, the device should bring about a gradual decay of the impulse from full amplitude to inaudibility.

The magnetic recording device of the invention is designed to function as a time delay medium operating in accordance with the following principles: A recording head and a plurality of magnetic playback heads are placed successively along portions of an endless magnetic tape, so that the successive playback heads reproduce each recorded sound impulse with a greater time delay, and the output of the successive heads is exponentially attenuated so that the combined output of all the playback heads shall blend and, on being converted into sound, create the illusion of an exponentially decaying true reverberation effect.

For reproducing sound with reverberation, the output of the amplifier which output of an additional playback head placed immediately behind

the recording head may be used, or the output of the amplifier which drives the recording head is combined with the blended output of the series of playback heads which reproduces the recorded sound with an exponential attenuation effect.

In the simplest form of an endless magnetic tape recording machine designed to supply reverberation in accordance with the invention, an endless magnetic recording tape is continuously moved during each cycle of its total recording length through an obliterating head, a recording head, and then in sequence through a series of closely spaced playback heads so that each successive playback head reproduces the recorded signal with a greater time delay, and the output of each playback head is exponentially attenuated with relation to the preceding playback head, so that the combined output of all the playback heads represents thus a blending of the signal with discrete time delays and exponential attenuation.

It might seem that the best reverberation effects would be obtained by placing an infinite number of playback heads close to each other along the magnetic tape in order to secure output characteristics approaching as close as possible the exponential decay of natural reverberation. However, assuming that such conditions would be possible, and that the outputs of the playback heads are not attenuated, their mixed output will always contain two output components which are reproducing voltages of the same amplitude, 100° out of phase, thereby cancelling the signal. This reasoning applies for any frequency. An arrangement of this character, even if the output of the successive playback heads is subjected to successively increased attenuation, would actually operate as a frequency discriminating system which attenuates high frequencies more than low frequencies. Accordingly, such system would be undesirable.

With respect to the spacing between the playback heads, the following considerations are of great importance: If a record of a short sudden sound impulse is played back with time delay intervals between successive playback heads, a listener will distinguish individual repetitions of the short signal rather than the blending of the successive playback outputs if the time delay interval between two adjacent heads is too large. I have found that in order to blend the time delayed outputs of the successive pickup heads in a manner that would create the illusion of natural reverberation, it is important that at least the first few playback heads should be spaced as closely as possible following the recording head, and that the distance between them, measured in the time delay intervals, should be of the order between about  $1/20$  to  $1/40$  of a second or even closer, if possible.

I have found that by taking advantage of the fact that even a small studio has a certain small reverberation time, a universally adaptable endless magnetic recording tape reverberation device may be provided if the playback heads are placed sufficiently close to play back the recorded signal with successive time delays of the order of between about  $1/20$ th and  $1/40$ th of a second between the first group of successive playback heads, which contribute the major part of the reverberation output with an attenuation up to about 12 decibels relatively to the original signal level, although relatively good results are obtained if such spacing is maintained only between the playback heads which deliver the re-

corded signal output with an attenuation up to about 6 to 8 decibels.

Satisfactory operating conditions have been obtained by spacing the first ten playback heads so that each picks up the recorded signal with a time delay of approximately  $\frac{1}{20}$ th of a second relatively to the preceding magnetic head, and that the additional playback heads picks up the recorded sound with successive time delays of  $\frac{1}{4}$ th of a second, and that the last playback head picks up the signal about one second after it was recorded.

By increasing the attenuation of the output of the first ten playback heads in  $1\frac{1}{2}$  decibel steps, that is, attenuating the output of the first head with relation to the original signal  $1\frac{1}{2}$  decibels, and the second head 3 decibels, and each successive head up to the tenth head  $1\frac{1}{2}$  decibels per step, the output level of the tenth head is 15 decibels lower than the original signal level. The output of the next four or five playback heads may be attenuated 3 decibels per step so that the last head is about 30 decibels attenuated below the original signal level.

The outputs of the different heads are then combined in a mixer amplifier and the output in this amplifier again is combined in proper relationship either with the original signal or with the signal supplied by a playback head placed in ahead of the first reverberation playback head.

In designing such a system, the following precautions must be observed: The signals contributed from each of the pickup heads must be mixed so that one does not interfere with the signal obtained from another playback head. To this end, the output of each playback head may be impressed on two series connected resistance elements, one being a fixed decoupling resistor, the other being a variable tap resistor, so as to permit proper adjusting of the attenuation while making it impossible for a signal picked up by one playback head from being impressed on another head and cause it to record the impressed signal.

In the arrangement shown, satisfactory operating conditions were obtained by connecting the first five pairs of magnetic heads in series across a potentiometer element formed of a fixed decoupling resistance and an adjustable tap resistor. The variable tap resistance section of each potentiometer unit is designed so that in the successive stages it gives at its terminals a smaller output voltage in the ratio described above, the overall resistance of each potentiometer remaining the same.

Since in an endless magnetic tape time delay recording device required for producing reverberation effects, the soldering junction must pass through a large number of magnetic heads, it causes not only electrical disturbances, but the mechanical impact of the soldering junction on the thin pole pieces of the magnetic heads imposes thereon also serious mechanical strains which affect their magnetic properties.

I have discovered that the disturbing effect of the soldering point may be completely eliminated without in any way diminishing the illusion of the artificial reverberation produced by an endless magnetic tape, if the output of the successive playback heads is cut off during the period while the soldering point passes through them, particularly if the time required for the soldering point to pass through the succession of playback heads is less than about 50 to 100 times the total recording period of the endless tape.

I have found that for best performance, the endless magnetic tape used in such recording arrangement should have a recording length of at least of the order of  $\frac{1}{2}$  of a minute, but preferably at least of the order of one minute.

I have also found that it is not necessary to cut off the output of each playback head individually at the moment when the soldering joint passes through it, and that very good results are obtained if the output of all adjacently placed playback heads used for producing the reverberation effect are cutoff momentarily for a short instant when the soldering joint reaches the pole piece of the first playback head and provision is made to gradually bring up the level of the output as the soldering joint moves from the heads which operate with the smallest attenuation and are closest to the recording head toward the farther removed playback heads which operate with the maximum attenuation, since the much greater level of the first group of playback heads is not perceptibly affected by their output while the soldering joint moves past them.

In other words, the output or gain of the amplifier is cutoff completely only while the soldering joint is moving through the first few playback heads which contribute the major portion of the output level, and after the soldering joint has passed through them and moves through the playback heads which contribute only the minor fraction of the output level, the gain of the amplifier is gradually restored, restoring the effectiveness of the first few magnetic heads which contribute the major part of the output level, and the restored gain is not sufficient to permit the soldering joint to cause any disturbing effects while it is passing through the last few heads, their amplified disturbing signal being kept sufficiently down below the level of the signal contributed by the first playback heads.

According to another phase of the invention, the effect of cutting out the output of the playback heads on the overall reverberation effect is further reduced by distributing the magnetic playback heads required for producing the desired reverberation effect on a plurality of different sections of the endless magnetic tape, so as to provide each tape section with its subgroup of playback heads and its own recording head which are cooperating to supply complementary parts of the overall reverberation effect.

Thus, if an endless magnetic tape, having 20 magnetic playback heads reproducing the recorded signal with time delays of  $\frac{1}{20}$ th of a second, is to be used for supplying artificial reverberation, the magnetic heads are distributed not on one continuous section of the endless tape, but, for instance, on four sections as follows: On the first section, a recording head with playback heads reproducing the signal with 1, 5, 9, 13 and 17 times greater delay than the minimum time delay of  $\frac{1}{20}$ th of a second; on the second section, a recording head with playback heads reproducing the signal with 2, 6, 10, 14 and 18 times greater delay; on the third section, a recording head with playback heads reproducing the signal with 3, 7, 11, 15 and 19 times greater delay; and on the fourth section, a recording head with playback heads reproducing the signal with 4, 8, 12, 16 and 20 times greater delay.

I have found that an endless magnetic tape reverberation equipment will supply an illusion of a 60 decibel reverberation time, although only enough playback heads are used for playing back the recorded signal with a gradual attenuation

down to 30 decibels only, dispensing with additional playback heads that would be required in order to attenuate the original signal to full 60 decibels.

An endless tape magnetic recording time delay machine designed for supplying artificial reverberation may also be used for producing artificial echos or other sound effects. Thus, by providing an endless magnetic tape recording machine designed for supplying artificial reverberation with one or more recording heads located a distance ahead of the reverberation recording head used for producing artificial reverberation by a distance corresponding to the desired echo time, such machine will operate as an echo machine if the additionally provided recording heads are used in lieu of the reverberation recording head. For instance, if an echo effect of one second is desired, the additional recording head is displaced relatively to the first of the succession of playback heads used for producing artificial reverberation by a distance corresponding to one second.

When using such endless magnetic tape recording device for producing echo effects, the limitations with regard to the exponential attenuation of the successive pickup heads do not apply, and the ratio of the output level of the playback heads relatively to the recorded signal may be so chosen as to give the desired echo or other sound effects.

The output channel of the playback heads used for producing reverberation, echo and other sound effects may be provided with suitable frequency discriminating networks so as to make it possible to modify the frequency characteristics of the output in any well known way.

An endless magnetic tape reverberation equipment of the invention permits ready change of the reverberation time and may be operated to supply a short reverberation time, for instance, if the voice of a singer is to be transmitted, and a longer reverberation time, for instance, if the music of an orchestra accompanying the singer is to be transmitted. In such case, one microphone setup may be used for picking up the voice of the singer, and another microphone setup may be used for picking up the music of the orchestra, and two different reverberation effects, one with a shorter reverberation time and one with a longer reverberation time, are combined with the outputs of the two microphone setups.

A single endless magnetic tape driven by a single motor drive system may be used for operating one or more of such reverberation systems operating with different reverberation times.

An endless magnetic tape recording equipment exemplifying one practical form of a time delay arrangement which in actual operation proved to be very effective in supplying a perfect illusion of actual reverberation, is illustrated diagrammatically in Fig. 1. In the form shown, a microphone MC, representing a setup of several microphones, impresses its electric output, generated by the sound to which it is exposed, into electric energy impressed through input lead 21 on the input side of a pre-amplifier IA. The pre-amplifier IA impresses the amplified microphone output through a direct channel lead 22 by way of an intermediate constant impedance attenuator 23 and an attenuator decoupling network ATD-1 to an output lead 24 which is connected, for instance, to a modulator transmitter equipment MOTR of a broadcasting station, so as to transmit a radio broadcast modulated by the sound to which the microphone MC is exposed.

In addition, the pre-amplifier IA also impresses the amplified microphone output through a reverberation channel lead 25 on a time delay or artificial reverberation equipment RE, the output of which is impressed on amplifier PMA, the output of which is impressed through a reverberation channel output lead 26 and a constant impedance amplifier 27 connected in series with an attenuator and decoupling network ATD-2 on the common output lead 24, so that the radio broadcast transmitter shall be modulated by the combined output of the direct transmission channel and the reverberation transmission channel.

In the form shown, the time delay or reverberation equipment RE comprises an endless magnetic tape 31 driven by a guide roller 33 engaging a portion of the tape and driven by a suitably energized electric motor 34, for instance, so as to impel the tape 31 at a uniform speed, for instance, in clockwise direction indicated by an arrow. The endless magnetic tape recording arrangement is preferably of the type disclosed in my copending application Serial No. 197,851, filed March 24, 1938 as a continuation-in-part of my application Serial No. 82,962, filed June 1, 1936, which will issue as Patent 2,224,854, or it may be of the type disclosed in my copending application Serial No. 359,177, filed September 23, 1940.

An endless magnetic recording medium, such as the tape 31, has to be formed by joining the ends of a long tape of magnetic steel, through soldering, for instance, at a soldering junction 35, although the various features of the invention are not limited to an endless magnetic tape of this particular material. The endless tape is guided and driven at a uniform speed and, in the form of arrangement shown, three sets of obliterating and recording heads OA, OB, OC, RA, RB, RC, respectively, are placed along different sections of the endless tape so that upon passing through the magnetic heads OA, RA, a new signal will be recorded thereon by the recording head RA, and after an interval, upon passing through the obliterating and recording heads, OB, RB, another signal will be recorded thereon by the recording head RB, and after a further interval, another signal will be similarly recorded thereon by the magnetic head RC.

As explained hereinabove, to produce the desired artificial reverberation effect, a set or array of playback heads has to be placed following one of the recording heads, such as RA, so that the recorded signal shall be reproduced by the successive playback heads with successively greater time delays. For instance, assuming that a series of successive time intervals are indicated in Fig. 1 by the distances between a series of time interval double-dot dash lines T-0 to T-25, extending transversely to the indicated directions of the motion of the tape, and a set of playback heads P1 to P14, such as indicated on the drawings is placed successively in the direction of the motion of the tape immediately following the recording head RA, the successive playback heads will reproduce the recorded signal with a successively greater time delay represented by the distance of the successive time interval lines T-1 to T-25 from the zero line T-0.

According to one phase of the invention, the same effect is obtained by distributing the set of time-delay playback heads P1 to P14 into a number of subgroups or subarrays, for instance, as shown, in three subgroups, and arranging them

so that, with the three recording heads RA, RB, RC recording simultaneously the same signal, the signal recorded by the recording head RA is reproduced only by the playback heads P1, P2, P7, P8, P12 with time delays indicated by the time interval lines T-1, T-2, T-7, T-8, T-17; that the signal recorded by the recording head RB is reproduced only with the playback heads P3, P4, P9, P10, P13 so that they play back with time delays indicated by the time interval lines T-3, T-4, T-9, T-10, T-21; and that the signal recorded by the recording head RC is reproduced only by the playback heads P5, P6, P11, P14 with time delays indicated by the time interval lines T-5, T-6, T-13, T-25, the combined output of all playback heads P1 to P14 being equivalent to that obtained if all playback heads are placed so that they reproduce the signal, for instance, recorded by the head RA, with the indicated successively greater time delays T-1 to T-25. Taking the time interval represented by the distance between lines T-3 and T-1 as  $\frac{1}{200}$ th of a second, the array of the time intervals T-0 to T-5 represents the time intervals of a practical reverberation equipment which proved successful in actual operation.

Such distribution of the playback heads along different endless magnetic tape sections for cooperation with different recording heads so as to reproduce the same signal with successively greater time delays, or, in general, to give the same overall effect as if all the playback heads were arranged to reproduce the signal of a single recording head, has many advantages.

Thus, the frictional forces exerted by the pole pieces of the playback heads are distributed on a greater length of tape and thereby reduces the strain imposed on the tape, and keeping below the magnitude that would impair its magnetic as well as mechanical properties.

This arrangement makes it also possible to impart independent driving forces to each tape section passing through the individual magnetic heads, for instance, by applying the force of a driving roller to each of the sections of the tape passing through the different subgroups of playback heads, thereby reducing the total driving tension which has to be imposed upon the tape.

Furthermore, the greater spacing with which the successive playback heads of each subgroup have to operate enables also closer spacing of the playback heads of each subgroup, or a larger number of playback heads for producing the same overall time delay effect than could be possible otherwise, and thus makes it possible to reduce the time delays between the outputs of the successive heads of the sequence and give better blending of their outputs. With the greater spacing between the successive playback heads thus made possible, the problem of mechanical mounting of the playback heads and their crowding, is eliminated.

The foregoing advantages apply to the distributions of the several subgroups of playbacks, either on different sections of a single endless magnetic tape, or on several distinct endless magnetic recording tapes moving at the desired speed, or different speeds. In addition, such distribution of the magnetic playback heads makes it possible to decrease the disturbing effect of the soldering joint discontinuity on the reverberation supplied by the equipment. Each of the array of time-delay playback heads forming part

of such reverberation equipment, is associated with a suitable attenuator so that the output component derived from each playback head has the proper exponential in decay relation with respect to the output component supplied by the preceding playback head, suitable decoupling means, such as decoupling resistors, being combined with such attenuator so as to prevent the output of one playback head from becoming impressed on another playback head and bringing about a recording of the impressed signal.

In the practical form of reverberation equipment illustrated in the drawings, it was found sufficient to provide a single attenuator unit for the playback heads which operate with a smaller time delay. Thus, as shown, the pairs of playback heads P1-P2, P3-P4, P5-P6, P7-P8, P9-P10, which operate with shorter time delay intervals, are connected in series to the attenuator units A12, A34, A56, A78, A90, respectively, while the playback heads P11 to P14, which operate with larger time delay intervals, are each connected to a separate attenuator unit A13, A17, A21, A25, respectively.

Each attenuator unit is provided with an adjustable rheostat element 37 connected in series with a decoupling resistor 36, which are so proportioned that the fraction of the output voltage of the playback heads applied to the rheostat elements 37 of the successive playback heads A12 is attenuated to a greater degree with generally exponential characteristics in the way indicated by the increased length of decoupling resistor elements 38 of each attenuator unit.

Various ways may be used for combining the outputs of the successive time delay playback heads, for instance, by decoupling networks interconnecting the various heads. If all the playback heads reproduce the signal recorded by a single recording head, the attenuators of all the playback heads may be interconnected so as to add fractions of their outputs in series and combine them in the way indicated in the drawings, the so-combined or mixed outputs of all the playback heads cooperating with the same recording head being applied to an input stage of the playback amplifier PMA.

In an arrangement, such as shown in Fig. 1, in which the array of playback heads required for producing the overall reverberation effect is segregated into a plurality of groups, cooperating with different tape sections, each associated with a separate recording head, the combined attenuated output of the playback heads associated with the individual different recording heads may individually be impressed on a different input amplifier stage 40-A, 40-B, 40-C, so as to form separate channels in the way shown. The outputs of the three input amplifier stages 40-A, 40-B, 40-C of the three channels, are suitably mixed and further amplified, for instance, by the playback and mixing amplifier PMA.

In combining the outputs of the three tubes 41, it is important to make it impossible for the output of one channel to modify the operation of the other channel. Any arrangement which combines the output of the three channels with suitable decoupling means may be used for this purpose. In the arrangement shown, the output circuits of the three tubes are coupled through independent transformers, the secondaries of which are connected in series and are feeding into the mixing amplifier PMA. In order to eliminate any interference between the microphone amplifier IA on one hand and the pickup mixing am-

plifier on the other hand, decoupling attenuator networks are provided in the direct channel and in the reverberation channel. The pickup mixing amplifier PMA is equipped with a frequency discriminating network or tone control so as to give the reverberated signal any desired frequency response, thus being able to simulate sound effects in a reverberated hall having walls of different sound absorbing and sound reflecting characteristics, such as a large church with a dome, or a large auditorium.

As shown in Fig. 1, the input stage of such amplifier may comprise, for instance, an amplifier tube 41 having a cathode 42, an anode 43 and a control grid 44, the cathode being shown, for instance, connected through a self-biasing resistor to a ground lead G, and the control grid 44 being connected by way of a conventional coupling condenser to the input lead 45 which impresses thereon the combined properly attenuated outputs of the several time-delay playback heads.

Since in the arrangement shown in Fig. 1, the array of playback heads P1 to P14 is divided into subgroups, each subgroup cooperating with a separate recording head RA, RB, RC, respectively, three similar input amplifier stages are provided, and the control grid 44 of each tube is similarly connected to the serially connected output taps of the attenuator units associated with the respective groups of playback heads, the low potential side of the rheostat element 37 of the attenuator unit A12, A34, A56 associated with the playback heads of each subgroup supplying the greatest output component being shown grounded to complete the input circuit for each input amplifier stage.

As explained hereinabove, the discontinuity, such as the soldering junction 35, which has to be provided in each endless magnetic tape, produces a succession of high voltage impulses as it passes through the relatively large number of successive magnetic heads required to supply artificial reverberation, thereby impressing on the playback channel a prolonged disturbance that has heretofore made it impossible to use an endless magnetic recording tape as a time delay medium for artificial reverberation or the like.

By using a long endless magnetic tape so that, during each complete endless tape cycle, a long interval will pass before the soldering point passes through the magnetic head, its disturbing effect is rendered less objectionable. In addition, according to the invention, the disturbing effect impressed by the soldering junction of an endless magnetic recording tape on the playback channel is suppressed by providing automatic means for momentarily cutting off the outputs of the playback heads without disturbing the overall operating results desired from the equipment.

In the arrangement shown, at a point of the endless magnetic tape 31 which passes the playback heads somewhat later than the soldering joint, is provided a depression 39 cut, for instance, along the edge of the tape, and a switch 51 placed along the path of the motion of the tape is arranged to be actuated by the depression to a position in which it momentarily cuts off the output of the playback heads and prevents the electric disturbance induced in the playback heads by the soldering joint 35 from being impressed on the playback amplifier.

Various arrangements may be utilized for carrying out such control operation in response to the operation of such cutoff unit. In the ar-

5 rangement shown, a point between two series grid resistors 52, 53 is connected through a resistor 54 to one contact of the switch 51, the other contact of which is connected to a source of negative blocking voltage, indicated by a minus terminal of the playback amplifier PMA, so that when the cutoff switch 51, which is normally in the open position, is momentarily released by the tape depression 39 to its closed position, it 10 instantaneously applies a negative blocking potential to the control grid 44 of the amplifier stage and instantaneously cuts off the amplifying action of the amplifier tube 41.

15 The network through which the negative blocking potential is applied to the control grid 44 includes also a condenser 55, and the elements of the network so formed are so proportioned that when switch 51, after momentarily closing and applying the blocking potential and cutting off the gain of the amplifier stage 41, is immediately 20 reopened, the blocking potential is not immediately removed from the control grid 44 of the amplifier tube 41, but is only gradually decreased as the charge on the condenser 55 leaks through the resistors 52, 54, so as to gradually restore the effectiveness of the input amplifier stage, while the soldering point 35, having already moved past 25 the first group of playback heads, is still passing through the remaining playback heads.

30 However, since the playback heads which are farther away from the recording head contribute only a minor fraction of the output level compared to the contribution of the first few magnetic heads through which the soldering point has moved while the amplifier stage was completely cutoff, the gradual increase in the gain 35 of the amplifier stage will not be sufficient to cause any disturbing effects while the soldering point is passing through the last few heads, because the amplified disturbing signal outputs of these last few heads has negligible effect compared to the amplified signal level derived from the first few heads, which operate with the least amount of attenuation.

45 In other words, while the soldering joint passes the first few reproducing heads which contribute most of the channel output required for creating the artificial reverberation effect, the amplifier is cutoff, and as soon as the soldering joint reaches the heads which contribute only a smaller portion of the channel output, the normal gain of the amplifier is gradually restored.

50 In the arrangement described above, a depression along the edge of the tape located back of the soldering joint is arranged to operate a control element located along the edge of the tape so that the depression actuates the control element to operate for a split second and by so doing 55 apply a blocking potential to an amplifier which instantaneously stops amplification and reduces the gain to zero, in combination with a time delay means, which becomes effective immediately after gain was cutoff to gradually restore the gain at a rate which assures that the synthetic reverberation effect is cutoff only for a negligibly short time and is restored so quickly that the momentary absence of the reverberation effect is not noticeable at all.

60 In the arrangement shown, the individual rheostat 37 of the attenuator units A12 to A25 associated with the individual playback heads may be provided either with a slider tap or with individual switch taps so that they may be controlled all as a unit, and that the attenuation of all the 65 attenuator units associated with the playbacks 75

may be simultaneously increased or decreased by operating a single actuating element, such as a handle or push button.

All the rheostat taps of all the playback heads are arranged to be controlled in common so as to permit simultaneous varying of the attenuation tension of the outputs of the different playback heads, but nevertheless keep their different attenuation levels in the proper exponential relation. By moving them all at the same time in one direction or in the other direction, the reverberation time may thus be increased or decreased. Instead of operating them by a continuous movement, they may be operated by push buttons, marked, for instance,  $\frac{1}{4}$  second,  $\frac{1}{2}$  second,  $\frac{3}{5}$  second, 1 second and 2 seconds.

Alternatively, sufficient illusions of a different reverberation time can be obtained without actually changing the attenuation of the outputs of the individual playback heads, but by adjusting the reverberation equipment as a whole to give a long reverberation time and changing the level ratio of the direct channel output through lead 22, with relation to the reverberated channel output through lead 26. While this procedure is not in accordance with more strict theoretical considerations, it has been found that the illusion is generally satisfactory for broadcasting applications.

In the arrangement of Fig. 1, such attenuation mixers are shown at 23 and 27 by combining in each a constant impedance attenuator connected in the direct channel with a constant impedance attenuator in the reverberation channel, and operating them manually so that while the attenuation is increased in one channel, it is decreased in the other channel.

The endless magnetic tape recording arrangement of the type shown in Fig. 1 may be also utilized for providing a plurality of independent reverberation channels, for instance, one reverberation channel for supplying one type of reverberation to a singer, another type of reverberation to the orchestra music and another type of reverberation to a choir. It is merely necessary to provide each tape section, such as shown in Fig. 1, with a full complement of magnetic playback heads, so that each of the three tape sections having its own recording head RA, RB, RC, respectively, operates with a full array of playback heads P1, P2, P3 . . . P13, P14, as an independent complete reverberation channel, the combined output of all the playback heads of each independent channel being impressed upon the initial amplification stage, such as shown at 40—A, for instance, of its own individual playback amplifier equipped with its tone control and other accessories. The outputs of the amplifiers of each playback channel so formed are then properly combined through a suitable mixer and impressed in the desired proportions on the output lead 24, as described above.

The acoustic characteristic of a room are determined by its reverberation time. This reverberation time depends upon the acoustical treatment of the walls, floors, ceiling, furniture, and other object in the room. If more sound absorbing material is used on the walls, ceiling, etc. of the room, its reverberation time will be shorter, and the acoustic liveliness of the room is considerably reduced.

In many cases, it is desirable to have flexible room acoustics, particularly if performances of different character take place in the same room, for instance, public meetings, concerts, theatrical

performances, since music requires different reverberation time than intelligible speech. In order to modify the reverberation time of a room, some of the radio broadcasting studios have to be built with movable walls and special curtains having high sound absorbing qualities. To change the acoustic liveliness of such studio, the physical dimensions of the room are changed, and the curtains are raised or dropped. This is not only complicated, but requires time. In addition, such studios are expensive to build and their layout is complicated, and their adaptability to different conditions is limited.

According to the invention, an endless magnetic tape time delay recording arrangement of the type shown in Fig. 1 is utilized for varying the acoustics of a room, such as radio broadcasting studios, without in any way changing its physical dimensions or resorting to furniture treatment, curtains or the like. The invention is based on the following considerations: The acoustic liveliness of a room depends on the sound reflected from the walls, ceiling, floor and other objects in the room. If the walls, ceiling and other objects of the room absorb 100% of the sound energy, the room is completely sound dead.

In accordance with the principles of the invention, a room which is substantially sound dead is provided with different sources of sound, such as loudspeakers, distributed at different points of the room and operated by a time delay sound recording arrangement so as to reproduce sound from a source, such as microphones suitably located in the room, an effect that would be produced in such a room if the room would be of different dimensions or have different wall treatment. Sound from a sound source placed in a room equipped with such artificial acoustic system will travel in all directions until it reaches the boundaries of the room where it will be completely absorbed, but at the same moment the sound delay recording system to which the loudspeakers, distributed along the walls of the room, are connected, will reproduce sound of the desired reflected character, such as would be produced by the source in a room of different dimensions having a special acoustic treatment of its interior.

The loudspeakers for producing the illusion of an acoustically alive room are distributed around the walls and the ceiling, and at least one loudspeaker is placed in the neighborhood of the source of sound where, for instance, the microphone setup is placed. The microphone or microphone setup is connected through suitable amplifiers to a number of time delay sound recording channels, and these sound delay channels are connected to the individual loudspeakers, the individual channels being provided with frequency discriminating and attenuating networks so that the individual loudspeakers reproduce the sound so that the overall sound delivered from the loudspeakers has the same character of reverberated acoustic energy.

In other words, the reverberation channels connected to the different loudspeakers are so designed and arranged as to deliver through the loudspeakers sound which, when blended, will create in the room the illusion of the selected desired character of liveliness. Thus, a room provided with an artificial acoustic treatment system of the invention may be given acoustic characteristics of a big church or a very small intimate room. It is merely necessary to know

the reverberation time of the particular church and the particular small room, and adjust the electrical control elements of the reverberation channels to operate with the same reverberation time, and supply the loudspeakers with an output having the same frequency characteristics.

Fig. 2 illustrates diagrammatically and in simplified form one exemplification of an artificial room acoustic system. A room 60, having sound dead interior walls, is provided with a loudspeaker R0 located near the source of sound, for instance, a speaker, next to whom a microphone MC is placed, and several groups of loudspeakers R1, R2, R3, etc. are distributed along the walls of the room.

In the arrangement shown, it is assumed that the microphone MC is located at the source of sound. The loudspeakers R2 are shown located along points of the wall which will be reached by sound from the source in two time intervals required for the sound to reach the loudspeakers R1, and three such time intervals will be required for the sound to reach the location of the loudspeakers R3. There is also provided a magnetic recording time delay arrangement comprising an endless magnetic tape 32, such as shown in Fig. 1, driven at a uniform speed in clockwise direction, for instance, past an obliterating head OA, a recording head RA, and a succession of playback heads P1 to P14, for instance, so that the playback heads reproduce with a series of time delay intervals the sound recorded by the recording head, which is shown connected to an output lead 25 from an amplifier IA, the input lead 21 of which is connected to the microphone MC.

The magnetic recording arrangement operates similar to that described in Fig. 1, and is provided with a cutoff switch 51 for momentarily cutting off the output of the playback heads at the moment the soldering junction 35 reaches the first playback head. Since the several sets of loudspeakers R1, R2, R3 are shown symmetrically located in the room, the reverberation effect of the room will be symmetrical, and it is sufficient to operate each of the groups of loudspeakers from the same energy source.

The loudspeaker R0 which is located adjacent the sound source, should be supplied directly with unmodified amplified energy representing, in effect, the usual public address system loudspeaker. The three groups of loudspeakers R1, R2, R3, are supplied through three different reverberation channels which may be designed to have the same reverberation time, but they should distinguish from each other as follows: The group of loudspeakers R1 which are closest to the sound source, should reproduce the sound with a time delay corresponding to the time interval required for the sound of the sound source to reach them. The loudspeakers R2, which are spaced from the source by a time interval that is twice greater, should reproduce the sound with a twice greater time delay interval, and the loudspeakers R3 with a three times greater time delay interval. Assuming, for instance, that the sound has to travel from the sound source to the speakers R1  $\frac{1}{20}$ th of a second, to the speakers R2  $\frac{1}{10}$ th of a second and to the speakers R3  $\frac{1}{4}$ th of a second, the speakers R1 will be supplied through different reverberation channels corresponding to these requirements.

According to the invention, the output of the individual playback heads of an endless magnetic tape time delay recording device designed for

supplying artificial reverberation, for instance, is utilized for supplying different reverberation channels with time delayed playbacks of the recorded sound, each channel being independently controlled to operate with different reverberation characteristics.

In order to produce the effect of the three different reverberation channels, it is merely necessary to combine fractions of the output of the successive playback heads P1 to P14 which reproduce the signal recorded by the recording head so as to operate in the same way as if three separate sets of playback heads were used for providing three different reverberation channels, in the way described in connection with Fig. 1, for instance. Thus, assuming that the time delay interval between the successive playback heads P1 to P14 is  $\frac{1}{20}$ th of a second, then for supplying the reverberation effect required for the loudspeakers R1, a component of the output of all the playback heads should be combined; for supplying the reverberation effect required for the loudspeakers R2, a portion of all the playback heads, except the first one, should be combined; and for supplying the reverberation effect required for the loudspeakers R3, a portion of the output of all the playback heads, except the first three playback heads, should be combined.

Various known ways may be used for supplying a portion of the output of the same playback head to different amplifier or reverberation channels, while assuring that no energy is fed back to the playback head. In the arrangement shown, the outputs of the various playback heads are combined without using special decoupling networks by providing the pole piece of each head with a plurality of distinct windings and connecting them into different channels with the properly graduated attenuation to produce the desired reverberation effect.

In the arrangement shown in Fig. 2, the three sets of loudspeakers R1, R2, R3 are connected to three output leads 61, 62, 63 of the three playback amplifiers PB-1, PB-2, PB-3, on the inside of which is impressed the input of three different reverberation channel leads 46-A, 46-B, 46-C, respectively. As shown in Fig. 2, each playback head P1 to P14 has a pole piece interlinked with three output coils 71, 72, 73, each connected to an attenuator unit formed of an adjustable rheostat element 37 and a decoupling resistor 38 designed so that the output applied to the resistance element of the successive heads is exponentially attenuated relatively to the preceding playback head.

In order to supply the reverberation channel lead 46-A with the required reverberation effect output, the rheostat elements 37 connected to the playback coil 71 of all the playback heads are interconnected in series to the playback amplifier channel lead 46-A. Similarly, in order to supply the required reverberation effect to the loudspeaker R2, the rheostat elements 37 connected to the coil 72 of all the playback heads, except the playback head P1, are connected to serially combine their output and impress it on playback channel lead 46-B; and the rheostat elements 37 connected to the coil 73 of all playback heads, except the playback heads P1, P2, P3, are connected to additively impress their output on the playback channel lead 46-C leading to the playback amplifier PB-3. Each playback amplifier PB-1 to PB-3 may be provided with a suitable tone control arrangement TC and an attenuation con-

trol arrangement AC, so as to permit amplification and adjustment of the characteristics of the amplified output impressed on the loudspeakers so as to produce the desired acoustic effect.

Instead of using an arrangement of the type described in Fig. 2 for operating a plurality of different reverberation channels for supplying artificial acoustic treatment to a room, the different reverberation channels may be used, for instance, for supplying one type of reverberation characteristic to the voice of a singer, the other to the music of the orchestra, another to the choir, in lieu of three separate reverberation channels, as described in Fig. 1.

Fig. 3 illustrates diagrammatically an arrangement using different reverberation channels REA, REB, REC operating with a single endless magnetic tape 32 for supplying different reverberation effects to different groups of loudspeakers R1, R2, R3 used, for instance, for giving to a room, such as shown in Fig. 2, the desired acoustic treatment, the arrangement of Fig. 3 operating in the same way as that in Fig. 2, except that each reverberation equipment REA, REB, REC is equipped with a recording head and a full complement of playback heads, such as described in connection with Fig. 1, for independently producing any desired reverberation effect or other time delay effects with a single endless magnetic tape recording system.

When using arrangements, such as shown in Figs. 2 and 3, for supplying artificial acoustic treatment to a room, the distances between the playback heads are so arranged as to operate the different loudspeakers or sound reproducers with a time delay relatively to the source corresponding to the time required for the sound to travel from the source to the location of the loudspeakers. However, in many cases, for instance, if special sound effects are desired, the sound delay supplied by the magnetic recording arrangement may be made greater than the actual time required for the sound to travel from the source to the particular part of the room. It is thus possible to give a room artificial acoustical enlargement.

Although for ideal conditions, the room should be practically sound dead, it will not be necessary in practice. Thus, if the room has a relatively small reverberation time, the acoustic effects added by time delay recording arrangements described in connection with Figs. 2 and 3 may be only used to add acoustic liveliness or other desired acoustic characteristics to a room.

An endless magnetic tape recording device of the type designed in accordance with the principles of the invention to operate as a time delay medium, in the way described in connection with Figs. 1 to 3, is also ideal for supervising the transmission of messages, for instance, broadcasts, to prevent dissemination of improper information, such as of war secrets during news broadcasts in wartime. An arrangement of such type exemplifying one form of the invention is shown in Fig. 4.

A source of signal energy, such as a microphone MC, delivers its output to an amplifier IA, the output of which, instead of being impressed directly on a modulator and radio broadcast transmitter TR, is supplied to a recording head 4—R of an endless magnetic recording arrangement shown in the form of an endless magnetic tape 31 driven at uniform

speed in clockwise direction, for instance, in the way described in connection with Fig. 1.

The signal recorded on each element of the moving endless tape remains thereon until, after a full operating cycle of the endless tape, it reaches a playback head 4—P, the output coil of which is connected to the modulator and radio broadcast transmitter TR, so as to bring about the broadcast of the message from the microphone in the same way as if it had been directly supplied to the radio broadcast transmitter. An obliterating head 4—O, shown in the form of a permanent magnet, is placed between the recording head 4—R and the adjacent main pickup head 4—P, so that each element reaching the recording head is ready to receive a new recording.

The equipment for supervising or censoring the transmitted message is shown as consisting of two censoring stations CA, CB, although more stations may be provided. Each censoring station is provided with a set of four push button switches K, L1, L2, L3, and with headphones 81, a signaling lamp 82 and auxiliary switching elements for performing the various operations as explained hereinafter.

Upon actuating the push button L1 of each station, the headphones 81 of the station are connected to an output lead 83 from the amplifier LA, so as to enable the censor to listen to the transmitted message as it is being recorded on the endless magnetic tape 31 for subsequent transmission, after the time delay determined by the recording length of the magnetic tape, for instance, one minute, to the radio broadcast transmitter TR. Upon releasing the push button L1, and actuating the push button L2, the censor at each station may connect his headphones to the output lead of a playback amplifier AM—1 upon which is impressed the output of a playback head located on an intermediate portion of the tape so as to enable the censor, if, after listening to the transmitted message, he realizes that it contains objectionable matter, to pickup the starting phrase of the message so as to enable him to cancel the entire objectionable message before it can be transmitted from the main playback head 4—P to the radio broadcast transmitter TR.

After having thus picked up the starting phrase of the objectionable message, the censor has merely to release the push button L2, and by actuating push button L3, connect his headphones 81 to the output lead from amplifier AM—2 which amplifies the output of a third playback head 4—P3 placed a distance ahead of the main playback head 4—P, and as soon as he hears the initial phrase of the objectionable message, he has merely to push button K which completes a circuit sending an obliterating current to the obliterating head 4—O3 placed ahead of the playback head 4—P, thereby cancelling the message recorded on the tape and preventing its transmission when the elements of the tape on which it was recorded pass through the main playback head 4—P.

In order to make such censoring system effective, at least two censoring stations, such as indicated at CA, CB, must be provided so that while one censor traces an objectionable message and attends to its being cancelled, the other censor may attend to the censoring of the further part of the matter that is being broadcast. Under normal transmission of a broad-

cast, only one censor has to watch the transmission of the broadcast.

In order to indicate to the censor that it is his duty to listen in, the signaling lamp of the proper station, for instance, station A in the case shown, is lighted by a circuit completed through the contact of a stepping switch 86 having an operating coil 87, which, upon energization, advances the contact of the stepping switch one step, thereby cutting out the signal lamp of station A and lighting up the signal lamp of station B, indicating to the censor of the latter station that it is his duty to watch the transmitted message by closing his push button switch L1.

With this arrangement, censor A, whose signaling lamp 82 is lighted and has his push button L1 operated to listen to the transmitted message, on noticing that the message contains objectionable matter, merely releases the push button L1 and actuates the push button L2, which immediately connects his headphones to the intermediate playback head 4-P2 for enabling him to pick up the starting phrase of the objectionable message. On closing his push button switch L2, the censor at station A also completes a circuit including the normally closed contacts of the two auxiliary relays 88, 89 to the operating coil of the stepping switch, thereby advancing it to the next step in which his own signal lamp 82 is extinguished and the signal lamp 82 of the other censor is lighted up, whereupon the censor B actuates his push button switch connecting his own headphones to the amplifier IA for watching the transmitted message.

In the meantime, the censor at station A, upon having picked up the beginning phase of the objectionable message, is releasing his push button L2 and actuating his push button L3 so as to connect his head phone to the playback head 4-P3 and be ready to cancel the message as soon as he hears the initial phrase of the message in question, whereupon he actuates his cancelling button K for sending an obliterating current to the obliterating head 4-O3.

In order to prevent accidental obliteration of a message that is being transmitted, the obliterating push button switches K are normally locked by a locking relay 91 which is actuated to release the obliterating switch only while the cancelling push button L3 of one or the other of the two stations is actuated to cancel the message, thereby completing a circuit to the operating coil of the locking relay 91. A foolproof censoring system, which prevents interference with the transmitted message, but enables tracing of an objectionable part of the message while its transmission is delayed, and its obliteration before it is transmitted, is thus made possible.

Obviously, a larger number of message tracing playback heads, such as 4-P2 may be provided for enabling the censor to pick up different parts of the message which are stored in the endless tape, while they are being advanced from the recording head 4-R, during the time interval of the full endless tape recording cycle, to the point where they are picked up by the playback head 4-P for delivery to the radio broadcast transmitter TR.

The endless magnetic recording devices of the type described in my copending application Serial No. 197,851, filed March 24, 1938, which will issue as Patent 2,224,854, and described therein in connection with Figs. 1, 5, 10 and 19, and which have

proved successful in actual operation, lend themselves for utilization as a time delay medium for supplying artificial reverberation and for similar applications constituting the subject matter of the present application. In Figs. 5 and 6 is shown one form of arrangement for utilizing a magnetic recording device of the type described in connection with Figs. 8 to 10 of my copending application Serial No. 197,851 as a time delay recording equipment supplying artificial reverberation, in the way described in connection with Fig. 1, for instance.

Inside a suitable casing, not shown, is mounted a rectangular frame structure 5-0 consisting of a front frame 5-1 and a similar rear frame 5-2 formed of metallic angle bars reinforced by corner braces and suitably held together by cross bars or struts. In the corners of the rectangular frame are mounted four cylindrical guide rollers 5-6 having bearings journaled on stationary shafts supported in the corner braces of the frame structure.

A long endless magnetic carrier in the form of a magnetic tape 5-13 is wound over the four guide rollers in the form of a helix, a suitably guided cross loop completing the endless tape. The frame with the four rollers forms thus a spool-like structure on which the endless tape may be readily wound. One of the guide rollers is driven through a belt by a motor, not shown, suitably supported within the frame structure so as to impart through the frictional driving engagement between the motor-driven roller with the portions of the tape helix engaging its surface a uniform speed to the helix along the guide rollers. Suitable comb bars maintain the helices in their proper position along the rollers.

In order to make it possible to place a large number of magnetic recording and playback heads along a portion of the endless tape, the spool-like frame structure has mounted on one side thereof, on arms 5-21 suitably secured to one side of the frame structure, an elongated supporting bar 5-25, shown as having a T-shaped cross section, and an elongated slot 5-26 is formed in the forwardly facing portion of the bar 5-25 so as to enable adjustable mounting thereon of a series of magnetic heads 5-27.

The magnetic heads are preferably of the type described in connection with Figs. 34 to 42 of my copending application Serial No. 340,030, filed June 12, 1940, and as indicated in the drawing, each magnetic head consists of two halves placed on opposite sides of the magnetic tape 5-13 and held in position by a bracket 5-28 which is adjustably clamped to the front face of the supporting bar 5-25 by a bolt extending through the elongated slot 5-26 thereof. The location of the individual magnetic heads and their relative spacing may be readily adjusted along the supporting bar 5-25.

On the upper and lower ends of the supporting bar 5-25 are journaled two aligning rollers 5-31 for guiding one loop brought outwardly from the loop helix guided on the rollers 5-6 so as to pass through the succession of magnetic heads 5-27 mounted on the bar 5-25, an auxiliary cross-over roller 5-32, suitably mounted on a bracket extending from the upright mounting bar 5-25, leading the helix loop passing through the magnetic head from its position on the frame rollers 5-26 to its path of motion between the aligning rollers 5-31.

By using magnetic heads of the type shown in Figs. 41 and 42 of the above application Serial No.

340,030, so that the coils in the pole pieces of successively arrayed heads placed in adjacent rows overlap each other, using one set of heads for cooperating with one portion of the tape and the other set of heads for cooperating with an adjacent portion of the tape, so as to utilize a single tape with two recording tracks, it is possible to playback a recorded signal with shorter time delay intervals between successive playbacks, such arrangement requiring, of course, a recording head for each playback track. The foregoing, of course, applies to an endless tape driving arrangement, while the arrangement shown in Figs. 41 and 42 is intended to illustrate an oscillatory tape drive. The foregoing principles are also applicable for an arrangement in which more than two adjacent recording tracks are provided on a single endless tape.

For the sake of illustration, Fig. 5 illustrates a series of playback heads P1, P2, etc. to P14, which are utilized for supplying artificial reverberation in the arrangement of Fig. 1, mounted successively adjacent to each other on the supporting bar 5-25 and enclosed in a magnetic shield 5-35, a recording head R and an obliterating head O being mounted ahead of the first playback head P1 outside the shield enclosing the playback heads. An additional playback head is also shown mounted ahead of the obliterating head so as to permit utilization of the device shown as a censoring equipment. There is also secured to the mounting bar 5-25 ahead of the magnetic recording and playback heads a switch structure 5-51 which is utilized for automatically cutting out the operation of the playback heads each time the soldering junction passes them, in the way explained hereinabove.

As shown in Fig. 6, any required number of guide bars 5-25 with sets of magnetic heads mounted thereon in the way shown in Fig. 5, may be suitably mounted along one side of the spool-like guide roller structure 5-1, 5-2 for guiding different loops of the endless tape helix 5-13 over different sets of magnetic heads, thus enabling the operation of a device, such as shown in Figs. 5 and 6, with different reverberation channels or in the way described in connection with the various applications described in connection with Figs. 1 to 4.

In order to support the individual guide bars 5-25 of the magnetic heads in the different locations along one side of the frame structure, two angle bars 5-41, for instance, may be detachably secured to the side surfaces of the front and rear frames 5-1, 5-2 of the spool-like roller structures, and the mounting arms 5-21 for carrying the guide bars 5-25 are suitably secured, as by bolts, to the two cross arms 5-41.

In Figs. 7 and 8 is shown the construction of the switch mechanism 5-51, of the type shown at 51 in Figs. 1 to 4, for performing the controlling operation which automatically cuts off the output of the playback heads when the soldering point passes through them, or for performing any other desired signaling operation in conjunction with the operation of an endless magnetic tape recording arrangement.

On forwardly projecting wall portions 5-52 of a supporting block 5-50, the back side of which is suitably clamped to the front face of the guide bar 5-25, are revolvably mounted two grooved guide rollers 5-53 aligned so as to provide a guiding support for the tape 5-13 as it moves upwardly towards the magnetic heads in the way shown in Fig. 5, two spring arms 5-54

serving to yieldably retain the tape 5-13 within the groove of the rollers as it is being impelled at a uniform speed toward the magnetic head. An additional biasing spring 5-55 urges the tape 5-13 to engage with its opposite edge the side walls of the two rollers 5-53 along which it is guided.

The control switch 51 for performing the control operations described in connection with Fig. 1, is shown in the form of a commercially available unit, such as sold under the name Micro-switch, and designed, for instance, in the way described in Patent 1,780,758, to release the contact from its open position shown to the closed position, if its operating arm 5-56 pivotally mounted on a bracket extending from the switch casing releases the operating pin 5-57 of the switch to the outward position under the biasing action of the flexed spring contact of the switch 51.

The free end of the operating arm 5-56 is provided with a bracket on which is pivotally mounted a grooved roller 5-58 engaging the facing edge of the tape so as to ride thereon as the tape is being impelled, and keep the switch operating pin 5-37 in its inward position in which it holds the switch contact 51 open, and to release the switch 51 so as to close during a short instant while the depression 5-39 formed along the edge of the tape moves past the roller 5-58.

Various other switching arrangements may be used to perform in a similar or analogous manner for automatically performing control operations in response to an automatic actuation by a signal element, such as a depression formed on the tape, so as to synchronize a control operation with a predetermined selected position of the endless tape as it is being continuously impelled.

In the guide and driving arrangement for an endless magnetic recording tape described above, the magnetic tape is guided and driven at a uniform speed along a helix coiled around the outer surfaces of a plurality of spaced guide rollers, one of the guide rollers having frictional driving engagement with loop portions of the helix being driven by external forces for impelling the tape helix past the magnetic transducing means, such as the recording and playback heads, for recording and reproducing sound, at least one guide roller being frictionally driven by the moving tape helix and having sufficient mass so as to exert on the tape helix inertia reaction forces which suppress fluttering of the tape helix and maintain it at substantially uniform speed.

In addition, the spacing of the guide rollers is designed in the way described in my aforesaid application Serial No. 197,851, filed March 24, 1938, which will issue as Patent 2,224,854, so that the spacing between the guide rollers is sufficiently large and the effective guide roller surfaces engaged by the tape helix are sufficiently small to permit lateral slippage of the tape portions of the helix over the roller surfaces while they are impelled along the path of the helix.

In addition, the effective length of the helix portions frictionally engaged with the guide roller surfaces is made sufficiently small and the effective length of the free helix portions extending between the spaced guide rollers is made sufficiently large as to permit limited slippage of the tape helix portions over the guide roller surfaces while maintaining sufficient effective frictional driving engagement with the revolving

roller surfaces to assure uniform speed along its helical path.

Furthermore, the effective length of the helix portions frictionally engaged with the guide roller surfaces are so proportioned in relation to the effective length of the free helix portions, and the inertia of the guide roller masses frictionally driven by the tape helix are designed to be sufficiently large as to permit limited slippage of the tape portions over the guide roller surfaces while being kept in sufficiently effective frictional engagement therewith for maintaining uniform speed of the tape along the helix.

Furthermore, the frame for supporting the guide rollers is arranged to form a spool-like structure permitting winding of the endless tape helix around the outer roller surfaces when it is being joined into an endless tape, and the interior space of the spool juncture may be readily designed as a support for the driving motor mechanism and the amplifier means associated with the operation of the endless magnetic tape recording system.

In Figs. 9 to 14 is shown an endless magnetic tape recording device designed in accordance with the principles disclosed in connection with Figs. 1, 5, 13 and 27 of my copending application Serial No. 197,851, but embodying various desirable improvements thereover, exemplifying various other features of the invention. Inside a casing, not shown, for the sake of clarity, is mounted a rectangular frame structure consisting of a front frame 9-1, and a rear frame 9-2 of metallic angle bars reinforced at the corners by brace plates 9-3, 9-4, 9-5, 9-6 and held together by cross bars or plates 9-7, 9-8, 9-9, the latter being clamped to the intermediate angle bars 9-11 secured between the side members of the front frame 9-1 and the rear frame 9-2, in the way shown in Figs. 9 and 10.

In the form shown, two cylindrical guide rollers 9-21 are revolvably mounted on shafts 9-22, the ends of which are supported by the corner braces 9-3, 9-4 shown in the lower part of the frame structure, and two pairs of additional rollers 9-23, 9-24 are similarly revolvably mounted on shafts suitably held by the corner brace plates 9-5, 9-6 on the opposite part of the frame structure. A long endless magnetic tape 9-31 is wound in the form of a helix, first as an inner helix layer, for instance, by starting on the left sides of the rollers, as shown in Fig. 9, and winding it from the left to the right around the two pairs of rollers 9-21, 9-23, and then back from the right side of the rollers, as shown in Fig. 9, in the same direction, but on the two pairs of rollers 9-21 and 9-24, back to the left end of the rollers, shown in Fig. 9, to a point where the end of the outer helix joins the starting point of the inner helix, so as to form a continuous endless tape. Two layers of tape are thus wound on the lower pair of rollers 9-21, and one layer of tape is wound on each of the other two pair of rollers 9-23, 9-24.

In order to guide the successive loops of the endless tape 9-31 along the helices so formed, comb-like bars 9-32 are mounted in front of a few of the guide rollers, for instance, in front of the guide roller 9-21 held by the brace plate 9-3, and the guide roller 9-23 held by the brace plate 9-5 in a diametrically opposite corner of the frame structure, so that if the tape is impelled in clockwise direction, each loop of the two tape helices will be retained in its proper

operating position relatively to the other loops forming part of the endless tape.

An electric driving motor 9-34 has its vibration absorbing bracket structure 9-35 mounted on the cross plate 9-7 of the spool-like frame structure so formed, and a driving pulley mounted on one end of the motor shaft drives through a rope belt 9-36 one of the guide rollers 9-23 so as to impart to the tape a uniform motion, in clockwise direction, for instance, as indicated by the arrow.

In the design of such endless magnetic recording tape guide and driving arrangement, the following considerations are important: If the driving arrangement is to be used for synthetic reverberation, it is of utmost importance to eliminate even traces of flutter due to irregularities of the motor speed or any other causes, because if even slight changes of the momentary tape speed occur, the signal will be picked up by the different playback heads with a varying phase shift giving uncontrollable differences in pitch. Since the signal reproduced by the reverberation playback heads is combined with the original signal, such differences in pitch would bring about a modulation effect causing undesirable disturbance of the artificial reverberation supplied by such recording arrangement.

By using an endless rope belt 9-36, of the type employed in dental drives, and winding the belt in the form of a plurality of loops so as to be guided in suitable grooves formed on the motor pulley and corresponding grooves formed in the periphery of the motor driven guide roller 9-23, such belt may be operated with sufficiently small tension per belt loop as to take up in the belt any fluctuations of the motor speed without transmitting them to the motor driven roller 9-23. Such driving arrangement is also of great advantage because it reduces the belt tension and wear and also reduces the friction losses. As a result, a smaller motor may be used and the remanent mechanical noises inherently present in any mechanical drive is brought down to a very low level.

As shown in Figs. 10 and 14, the correct tension of the belt 9-36 is maintained by a cross-over pulley 9-37 journaled on the end of an arm 9-38 which is pivotally mounted on a bracket extending from the motor, a suitable biasing spring 9-36 serving to supply the pressure with which the cross-over roller 9-37 maintains the cross-over loop of the endless belt 9-36 at the desired tension. The end grooves of the motor pulley of the motor driven guide roller 9-23 are sufficiently wider than the grooves over which the other loops of the endless belt 9-36 are wound so as to enable the cross-over loop to be guided from the point where it leaves the motor pulley to the point where it enters the starting point of the belt helix on the motor driven guide roller 9-23. One of the loops of the rope belt 9-36, which is not used for transmitting the driving force to the guide roller 9-23, is utilized as the cross-over loop.

In order to secure the full effectiveness of such drive in suppressing even traces of flutter, the magnetic heads are arranged to engage with their pole pieces one or more loops of the inner tape helix layer guided over the guide rollers 9-23 so as to impart to the inner tape helix the tension required for maintaining its loop portions that pass over the guide rollers 9-21, 9-23 in good frictional driving engagement therewith.

In order to assure long foolproof operation

without requiring servicing of the moving parts, the guide rollers are revolvably mounted on their shafts 9—22 by ball bearings 9—42 in the way shown in Fig. 12. Compared to sleeve bearings, ball bearings have the great advantage that they operate with less noise than sleeve bearings, a factor which is very important in such magnetic tape drives, for instance, when used as a reverberation medium in the studio where the sound to which the reverberation is applied originates. The ball bearings are interposed between the shaft and the rollers so that the shaft remains stationary while the roller revolves in the way shown in Fig. 12.

The ends of the shaft 9—22 are supported by a resilient member, for instance, Neoprene, in the way shown in Fig. 12, in order to assure that any remanent mechanical vibration imparted to the shaft is not transmitted to the frame structure 9—1, 9—2 having a large sound radiating area from which noise should be kept away. In order to reduce the noise, the surface of the guide rollers 9—21, 9—23, 9—24 is made of non-metallic sound-absorbing material. Since such non-metallic sound-absorbing material is usually an electrical insulator, it will accumulate in the course of operation electric charges due to friction with the tape, and such charges, if accumulated until they reach a potential sufficient to spark over to the frame structure, will induce electric noise effects in the playback circuits associated with the recording and playback equipment. This disturbing effect is eliminated by providing, as shown in Fig. 12, a sliding metallic contact member 9—45, supported by the metallic frame structure and pressing against the metallic portion associated with the shaft, such as the inner ball race of the ball bearings 9—42.

It has been found that the guide bars, such as shown at 9—32 for guiding the loops of the helices in their positions along the rollers, may cause a disturbing high pitched noise caused by the mechanical vibrations of the comb teeth, as the tape loops which they keep apart move past them.

Fig. 11 illustrates a comb guide bar arrangement 9—31 for the tape helices which was found to be highly efficient in properly guiding the loops of the tape helices, without causing any noise. As shown, a bar 9—31 of suitable non-magnetic material, such as brass, for instance, holds in suitable grooves or holes formed therein tooth members 9—51 in the form of pins or tooth-shaped sheet metal portions projecting between and separating adjacent loops of the helix, two strips of felt 9—52, 9—53 being held in position on the teeth so as to confine the loops of the tape and the projecting teeth portions between them, and suppress any vibrations of the same.

The two felt strips 9—52, 9—53 are held suitably clamped, for instance, by an overlying bar 9—54, likewise of non-magnetic material, which is suitably attached to the comb bar 9—31, for instance, by screws, as shown in Fig. 11. This arrangement of the guide bars not only suppresses vibrations of the tape and of the guide bar teeth, but also automatically cleans the tape. In addition, it distributes the tension of the tape uniformly over its individual loops.

Obviously, an endless magnetic tape guide and drive arrangement of the type shown in Fig. 10 may be, of course, made to operate with a larger or smaller number of such rollers. For instance, the endless tape may be wound in a similar way

in the form of two helix layers over only one roller 9—21 and one roller 9—23 and one roller 9—24, the three rollers being supported on two frame members, such as two side members of the frame structure 9—1, 9—2 interconnected by a cross plate 9—8, in the way shown. Such endless magnetic tape driving arrangement may be used in the various applications outlined in my prior application Serial No. 197,851, filed March 24, 1938, which will issue as Patent 2,224,854, and it is desired that the specification of said applications, together with its drawings, should be considered as a part of the present application.

The endless tape guide and drive arrangement shown in Figs. 9 to 14 is particularly suited for use as a time delay medium for supplying artificial reverberation or other acoustic effects requiring the operation of the magnetic tape with several sets of magnetic recording and playback heads arranged in different magnetic tape portions.

As shown in Figs. 9, 10 and 13, the frame structure 9—1, 9—2 also serves as a support for three additional rollers 9—61, 9—62 mounted in a way similar to the other guide rollers in three corners of the frame structure. Any number of loops of a continuous endless tape guided and driven on the inner rollers 9—21, 9—23, 9—24 may be led from their position on the inner rollers so as to move over the outer rollers 9—61, 9—62, for instance, the 1st, the 11th, the 31st loop of the inner helix or similar loops of the outer helix may be guided out of their inner position to the position along the outer rollers 9—61, 9—62.

In the arrangement shown in Figs. 9 and 10, two loops 9—63A, 9—63B are shown guided from their position along the inner helix moving over the two pairs of rollers 9—21, 9—23 so as to move over the outer rollers 9—61, 9—62 and return to their positions in the inner helix, suitable gaps being provided when winding the loops of the outer helix around the rollers 9—24 for permitting the loops 9—63A, 9—63B to be led from their position on the inner helix to their position on the outer rollers 9—61, 9—62.

As shown in Figs. 9 and 10, angle metal cross bars 9—71 are suitably secured to the brace plates of the two frames 9—1, 9—2 so as to provide mounting supports for guide bars 9—72, 9—73 on which any desired array of magnetic heads may be mounted for cooperation with the tape loops 9—63A, 9—63B passing thereover.

As shown in Figs. 9 and 10, channel members are used for the guide bars 9—72, 9—73 and an elongated slit 9—74 is provided in each guide bar permitting adjustable mounting thereon of the brackets 5—28 of the magnetic heads, as by screws 9—75, and nuts, in the way shown. A magnetic shield 5—35 for enclosing the magnetic heads, as in the arrangement of Fig. 5, is likewise arranged for detachable mounting on the guide bars 9—71, 9—73.

To secure maximum effectiveness in suppressing flutter, in a tape driving arrangement of the type shown in Figs. 9 and 10, the magnetic heads should be placed on a tape loop portion which has to traverse at least one of the tape driven guide rollers, such as 9—21, 9—24 before it reaches the motor driven roller. Thus, in the arrangement shown in Figs. 1 and 2, the portion of each tape portion 9—31 leaving the magnetic heads located on an outer loop guided over the

outer rollers 9-61, 9-62, has to pass over at least four tape driven rollers 9-21, 9-24 along the outer helix and the two tape driven rollers 9-21 along the inner helix before coming into driving engagement with the surface of the motor driven roller 9-23. One of the driving belt loops which does not transmit the driving force is used as a cross-over loop, and the belt idler roller 9-37 urges this cross-over loop in outward direction so as to enable the cross-over roller to guide the cross-over loop from the point of the motor pulley where it leaves the end of the belt helix to the point on the roller where the belt helix starts, without interfering with the other loops of the belt 9-36.

The use of the roller arrangement of the type shown in Figs. 9 and 10 makes it possible to separate the convolutions of one or more outer tape helix layers guided over the outer guide rollers 9-24 from the inner tape helix guided over the rollers 9-23 over the major portion of its length without requiring much more room for guiding a very long endless tape, since only a relatively short portion of the loops of the inner tape helix has superimposed thereon portions of the tape helix wound around it. This is not objectionable because the overall length of the tape is made sufficiently long and so related to the frictional engagement of the tape loops of the inner tape helix layer with the driving rollers as to leave in the outer tape helix sufficient slack to assure that no portion of the outer tape helix is under excessive tension and moves loosely over the inner tape helix.

A larger number of additional helix layers may be wound in pairs over the outer helix layer engaging the rollers 9-24, one layer of each pair of outer helices being wound around the spool-like structure formed by the rollers 9-24, 9-21, in the same direction as the inner helix layer shown in Fig. 13, and then back in the direction of the outer helix layer, the end of the outermost layer of the last pair being joined to the end of the inner helix layer wound around the rollers 9-23, 9-21. By employing the construction of the type shown in the drawing, a great length of endless tape can be guided and driven with a small spool-like tape guiding and driving structure. The size of the guide rollers is determined by the tape thickness. It is important that the curvature of the rollers shall be large enough to assure that the bending to which the tape is subjected in passing thereover does not impose on it stresses that effect its magnetic properties. Thus, a magnetic tape of tungsten steel having a thickness of three thousandths of an inch operates satisfactorily when guided over rollers having a diameter between 2½ and 3 inches. When using thinner tapes, for instance, having a thickness of the order of one thousandth of an inch, rollers having a diameter of as low as one inch are satisfactory.

The tension of the tape may be adjusted by the provision of an adjustable mounting support for one of the tape guide rollers. In the arrangement of Figs. 9 and 10, the two ends of the tape roller shaft 9-22 on which the tape roller 9-21 revolves is adjustably supported on the two corner frame brace plates 9-3 by providing them with elongated holes 9-46 in which the shaft bushings 9-43 may be moved to increase or decrease the tension of the endless tape loops, and after adjustment, the flange of each bushing 9-46 is clamped to the clamping ring on the other side of the brace plate 9-3, so as to hold

the guide roller in the adjusted position, in the way shown in detail in Fig. 12.

If two layers of magnetic recording tape are permitted to remain in engagement with each other and are subjected to excessive pressure, a fraction of the magnetic energy of a recorded signal stored in one tape will be impressed on the adjacent tape layer resulting in undesirable echo effects when reproducing the original record. By adjusting the tape in the way described above, such undesirable effects may be eliminated.

As pointed out hereinafter, when a magnetic tape machine of the type described herein is used as a time delay device, for instance, for producing reverberation effects, the undesirable echo effects described above are of no significance because only the portion of the tape which is engaged by the magnetic heads mounted immediately following the recording head is utilized for performing the operation.

In special applications where it is essential to suppress even the slightest traces of undesirable echo effects, the outer tape layers extending over the rollers 9-21 on which the inner as well as the outer helix layers are guided, may be separated by the teeth of the guide combs over adjacent guide roller surface portions so that one tape layer does not engage another. However, if provisions are made to assure that the loops of the innermost tape helix wound around the inner rollers 9-31 are held sufficiently tensioned to maintain the driving engagement of its loops with the motor driven rollers, sufficient slack may be provided as to assure that at all times the outer tape helix layer is sufficiently loose to positively eliminate any traces of undesirable echo effects. With such arrangement, any required number of outer helix layers may be wound and operated over the first outer helix provided the outer tapes have sufficient slack as to enable them to slide freely along their path without being subjected to excessive pressure.

According to the invention, the pole pieces of the magnetic heads, which are used for recording and reproducing the signal, are utilized to exert sufficient friction on the inner tape helix as to maintain it in the required operating tension. The magnetic heads may be supported in the space of the inner helix as described in my prior applications. However, in many cases, such as in time delay machines used for reverberation, where a large number of magnetic heads have to be employed, it is desirable to mount the heads so that they are accessible on the exterior of the supporting structure. According to the invention, one or more loops of the inner tape helix layer are brought out and guided in the space beyond the outer tape helix so as to make it possible to guide such outwardly brought tape helix through magnetic heads mounted in such space.

As shown in the arrangement of Figs. 9, 10 and 13, a suitable number of loops of the inner helix are brought out through gaps left in the outer helix layer and guided over the outer guide rollers so as to guide two sides of each loop along the periphery of the frame structure through a plurality of magnetic heads mounted along them, and thus maintain the inner helix at the proper tension, while leaving the outer helix layers sufficiently loose as to permit them to slide past each other.

Since a large number of magnetic heads placed along these helices automatically subject the inner helix to a substantial friction, the loops

of the outer helix will be automatically maintained in the desired loose tension condition. Since the pole pieces which are maintained in frictional engagement with the tape exert a substantial frictional force on the moving tape, it is important to assure that the frictional forces do not impose an excessive strain on the tape because such excessive strain impairs and deteriorates the magnetic properties of the material. These considerations are of great importance in machines in which a large number of magnetic heads have to be placed close to each other to produce an effect such as required in a reverberation machine.

A distinct feature of the invention resides in mounting two or more groups of magnetic heads on different sections of an endless magnetic tape which are separated by sections that are maintained in frictional engagement with the guide roller structure so as to limit the maximum tension imparted on a section of the tape by the frictional forces of the pole pieces and distribute the tension on a large section of the endless tape.

For best operating results, it is desirable to give the guide rollers, over which the endless tape helix is guided, a uniformly cylindrical surface, and then mount them parallel to each other. In order to assure freedom from mechanical noise, the guide rollers should be dynamically balanced.

The spool-like tape guide and driving structure shown in Figs. 9 and 10 is arranged so as to make it easy to wind thereon any desired number of tape helix layers. Since the supporting bars 9-71 on which the guide bars 9-72, 9-73 with the magnetic heads 5-27 are mounted, may be readily removed by unscrewing their clamping bolts, and the outer rollers 9-24, 9-61, 9-62 are readily dismantled by unclamping the mounting bushings 9-43 which hold their shafts in position, the first inner helix layer may be wound on the inner rollers 9-21, 9-23 of the spool-like structure, and after then mounting in place the additional rollers 9-24, any required number of outer helix layers may be wound thereon, back and forth, care being taken to bring the end of the last loop to the starting point of the first loop, so that they may be joined to form an endless tape. A similar procedure is followed if one roller of each of the three pairs of rollers 9-21, 9-23, 9-24 is used in a spool-like tape guide and driving structure of the type shown in Figs. 9 and 10.

The novel features of the invention relating to the censoring or supervising systems described above in connection with Fig. 4 to illustrate exemplifications of the present invention, are not claimed herein, but in my copending application Serial No. 495,801, filed July 21, 1943 as a continuation-in-part of the present application.

The principles of the invention explained in connection with specific exemplifications thereof will suggest to those skilled in the art many other applications and modifications of the same. It is accordingly desired that the appended claims be construed broadly, and that they shall not be limited to the specific details shown and described in connection with exemplifications thereof.

I claim:

1. In a signal transmission system, a long endless signal recording and reproducing carrier, signal transducing means cooperating with said

signal carrier for recording or reproducing a signal record while said carrier moves past said transducing means, said transducing means including at least two recording elements and an array of signal reproducing elements arranged so as to reproduce a signal recorded on one portion of said moving carrier with a predetermined sequence of different time delays, and at least two reproducing channels having different operating characteristics supplied by said array of reproducing elements, said carrier having at least two sections, one part of said array of reproducing elements being arranged to cooperate with one of said sections and another part of said array of reproducing elements being arranged to cooperate with another of said sections, each of said sections having a signal recording element, the output of at least two of the signal reproducing elements of two of said carrier sections being impressed on each of at least two of said reproducing channels.

2. In a signal transmission system, a long endless signal recording and reproducing carrier, signal transducing means cooperating with said signal carrier for recording or reproducing a signal record while said carrier moves past said transducing means, said transducing means including at least two recording elements and an array of signal reproducing elements arranged so as to reproduce a signal recorded on one portion of said moving carrier with a predetermined sequence of different time delays, and at least two reproducing channels having different operating characteristics supplied by said array of reproducing elements, said carrier having at least two sections, one part of said array of reproducing elements being arranged to cooperate with one of said sections and another part of said array of reproducing elements being arranged to cooperate with another of said sections, each of said sections having a signal recording element, the output of at least two signal reproducing elements of one carrier sections being impressed on one of said reproducing channels and the output of at least two reproducing elements of another section being impressed on the other of said channels.

3. In a signal transmission system, a long endless signal recording and reproducing carrier, signal transducing means cooperating with said signal carrier for recording or reproducing a signal record while said carrier moves past said transducing means, said transducing means including at least two signal recording elements and an array of signal reproducing elements arranged so as to reproduce a signal recorded on one portion of said moving carrier with a predetermined sequence of different time delays, and at least one reproducing channel supplied by said array of reproducing elements, said carrier having at least two sections, one part of said array of reproducing elements being arranged to cooperate with one of said sections and another part of said array of reproducing elements being arranged to cooperate with another of said sections, each of said sections having a signal recording element, the signal recording elements and the reproducing elements associated with said sections being correlated, combined and interconnected so as to deliver an output of the same characteristics as an output derived from an array of reproducing elements cooperating with a single recording element and a single section of said carrier.

4. In a signal transmission system, a long end-

less magnetic signal recording and reproducing carrier, signal transducing means cooperating with said signal carrier for magnetically recording or reproducing a signal record while said carrier moves past said transducing means; said transducing means including an array of signal reproducing elements arranged so as to reproduce a signal recorded on said moving carrier with a predetermined sequence of different time delays, and at least one reproducing channel supplied by said array of reproducing elements, said signal carrier having a discontinuity causing a disturbance in the output of said array of reproducing elements, and control means including a control element forming part of said carrier for momentarily rendering ineffective the reproducing elements affected by said discontinuity without introducing into said reproducing channel a substantial disturbance.

5. In a signal transmission system, a long endless signal recording and reproducing carrier, signal transducing means cooperating with said signal carrier for recording or reproducing a signal record while said carrier moves past said transducing means, said transducing means including an array of signal reproducing elements arranged so as to reproduce a signal recorded on said moving carrier with a predetermined sequence of different time delays, and at least one reproducing channel supplied by said array of reproducing elements, said signal carrier having a discontinuity causing a disturbance in the output of said array of reproducing elements, and control means including a control element forming part of said carrier for momentarily rendering ineffective the reproducing elements affected by said discontinuity without introducing into said reproducing channel a substantial disturbance.

6. In a signal transmission system: a signal translating channel including an endless signal recording and reproducing carrier, and signal transducing means cooperating with said signal carrier for recording or reproducing a signal while said carrier moves past said transducing means; said transducing means including a signal reproducing element arranged to reproduce a signal recorded on said moving carrier with a predetermined modified characteristic and to transmit the reproduced signal through said signal translating channel; a source of signal waves; means for impressing signals from said source on said signal translating channel so that they are transmitted therethrough; and means for combining the signals from said source with the signals transmitted through said signal translating channel; a portion of said signal carrier having a discontinuity causing a disturbance in the reproduced signal; and means synchronized with the operation of said signal carrier for disabling in a predetermined manner said signal translating channel so as to reduce the effectiveness of the disturbance caused by said discontinuity.

7. In an artificial reverberation apparatus, signal input means, signal output means, a direct signal channel between said signal input means and said signal output means, an indirect signal channel including signal delay means having a discontinuity interconnected between said signal input means and said signal output means, and means operated by said discontinuity for breaking said indirect signal channel.

8. In an artificial reverberation apparatus, first electro-mechanical transducer means, second electro-mechanical transducer means, a first

signal channel between said first and said second transducer means for transmitting a signal from the first transducer means to the second transducer means, a second signal channel including time delay means interconnected between said first and said second transducer means for transmitting said signal with a predetermined time delay, said second signal channel having a discontinuity, and means controlled by said discontinuity for momentarily breaking the said second signal channel.

9. In an artificial reverberation apparatus, a plurality of electro-mechanical transducer means, a plurality of signal channel means connecting said electro-mechanical transducer means and each channel adapted to transmit a signal therebetween, signal time delay means associated with some only of said signal channel means, said signal time delay means comprising a movable magnetic signal carrier, recording means for recording a signal on said magnetic signal carrier, and reproducing means controlled by the recorded signal on the said magnetic signal carrier for reproducing said signal with a time delay, said magnetic signal carrier having a discontinuity which adversely affects the quality of the reproduced signal, and means synchronized with the passing of the said discontinuity through the reproducing means for reducing the volume of the said reproduced signal during the time that the said adversely affected signal is apt to be objectionable.

10. In an arrangement for magnetically recording and reproducing signal waves, an endless magnetic tape signal reproducing carrier, magnetic transducing means cooperating with said carrier for recording or reproducing a signal while said carrier moves past said transducing means, guide means including at least two revolvably mounted elongated guide rollers for guiding one portion of said carrier as a helix layer wound around the outer surfaces of said two rollers, and at least one additional revolvably mounted elongated guide roller for guiding on its outer surfaces and the outer surface of one of said two guide rollers another portion of said carrier as at least one outer helix layer surrounding said inner helix layer so that each element of said carrier is continuously moved from the inner helix layer to the outer helix layer, one of said first mentioned guide rollers having frictional driving engagement with portions of said helix layer and being driven by external forces for impelling said carrier past said transducing means, at least one other of said first mentioned guide rollers being frictionally driven by portions of said helix layer and having sufficient mass for exerting on said helix layer inertia reaction forces effective in substantially suppressing fluttering and maintaining said carrier at substantially uniform speed.

11. An arrangement as defined by claim 10, having means for applying forces to portions of the tape moving along the inner helix layer so as to maintain frictional driving engagement between tape portions of the inner helix layer and surface portions of said guide rollers, while maintaining the elements of the endless tape surrounding the inner helix layer in loose condition so as to substantially prevent the introduction of forces tending to bring about excessive forces between portions of the endless tape surrounding the inner helix layer and tape portions underlying such surrounding tape portions.

12. In a signal transmission system, a long

endless signal recording and reproducing carrier, signal transducing means cooperating with said signal carrier for recording or reproducing a signal record while said carrier moves past said transducing means, said transducing means including at least two recording elements and an array of signal reproducing elements arranged so as to reproduce a signal recorded on one portion of said moving carrier with a predetermined sequence of different time delays, and at least two reproducing channels having different operating characteristics supplied by said array of reproducing elements, said carrier having at least two sections, one part of said array of reproducing elements being arranged to cooperate with one of said sections and another part of said array of reproducing elements being arranged to cooperate with another of said sections, each of said sections having a signal recording element, the output of at least two of the signal reproducing elements of two of said carrier sections being impressed on each of at least two of said reproducing channels, the signal recording elements and the reproducing elements associated with said sections being correlated, combined and interconnected so as to deliver an output of the same characteristics as an output derived from an array of reproducing elements cooperating with a single recording element and a single section of said carrier.

13. In a signal transmission system, a long endless signal recording and reproducing carrier, signal transducing means cooperating with said signal carrier for recording or reproducing a signal record while said carrier moves past said transducing means, said transducing means including at least two recording elements and an array of signal reproducing elements arranged so as to reproduce a signal recorded on one portion of said moving carrier with a predetermined sequence of different time delays, and at least two reproducing channels having different operating characteristics supplied by said array of reproducing elements, said carrier having at least two sections, one part of said array of reproducing elements being arranged to cooperate with one of said sections and another part of said array of reproducing elements being arranged to cooperate with another of said sections, each of said sections having a signal recording element, the output of at least two signal reproducing elements of one carrier section being impressed on one of said reproducing channels and the output of at least two reproducing elements of another section being impressed on the other of said channels, the signal recording elements and the reproducing elements associated with said sections being correlated, combined and interconnected so as to deliver an output of the same characteristics as an output derived from an array of reproducing elements cooperating with a single recording element and a single section of said carrier.

14. In an apparatus which records a signal and reproduces it with time delay, signal input means, signal output means, a first signal channel interconnected between said signal input means and said signal output means, a second signal channel interconnected between said signal input means and said signal output means, said second signal channel including signal delay means having a periodically effective discontinuity which affects said signal, and means operating in synchronism with the periodic effect of

said discontinuity for modifying in a predetermined manner the operating conditions of said second signal channel.

15. In an artificial reverberation apparatus, signal input means, signal output means, a first signal channel interconnected between said signal input means and said signal output means, a second signal channel interconnected between said signal input means and said signal output means, said second signal channel including signal delay means comprising an endless magnetic tape driven at a substantially constant rate of speed and means for magnetically recording the signal on the tape and reproducing it therefrom with a time delay, said magnetic tape having a tape joint which periodically affects the signal in the said second signal channel as said joint passes the signal reproducing means, and means synchronized with the passing of the tape joint through the reproducing means for altering the volume of the signal in the said second signal channel to reduce the effect of the said tape joint on the signal transmitted through said second signal channel to said signal output means.

16. In an apparatus which records a signal and reproduces the signal with time delay, an endless signal carrier loop, at least one recording head associated with said endless carrier loop for recording signals on said loop, signal input means connected to said recording head, at least one reproducing head associated with said endless carrier loop for reproducing signals recorded thereon, signal output means connected to said reproducing head, means for driving said endless carrier loop past said reproducing head, said signal carrier loop having a discontinuity which periodically causes a discontinuity in the output signal reproduced by said reproducing head as said loop discontinuity passes said reproducing head, and means synchronized with said periodic action of said discontinuity for altering the output signal to reduce the effect of said discontinuity.

17. In a signal transmission system having signal input means, signal output means and a signal channel interconnected between said signal input means and said signal output means: said signal channel comprising an endless magnetic carrier for magnetically recording and reproducing signals thereon; signal transducing means associated with selected portions of said signal carrier for recording or reproducing a signal sequence while said carrier moves past said transducing means; means for driving said carrier so that it continuously moves past said transducing means; means operative to connect said signal input means to said transducing means for recording on said signal carrier a signal sequence which is to be transmitted through said signal channel; means operative to connect said transducing means to said signal output means for reproducing from said carrier said signal sequence and supplying it to said signal output means; said signal carrier having a discontinuity which periodically causes a discontinuity in the signal sequence reproduced by said transducing means and supplied to said output means; and means synchronized with the periodic action of said discontinuity for altering the level of the signal sequence reproduced from said signal carrier and supplied to said output means so as to reduce the effect of said discontinuity.

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