Jan. 23, 1934. C. N. HICKMAN 1,944,238

TELEGRAPHONE

Filed April 15, 1931 2 Sheets-Sheet 1

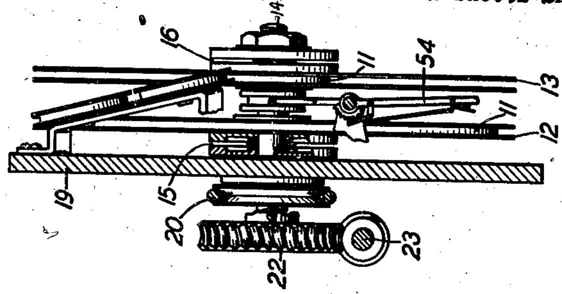

FIG. 2

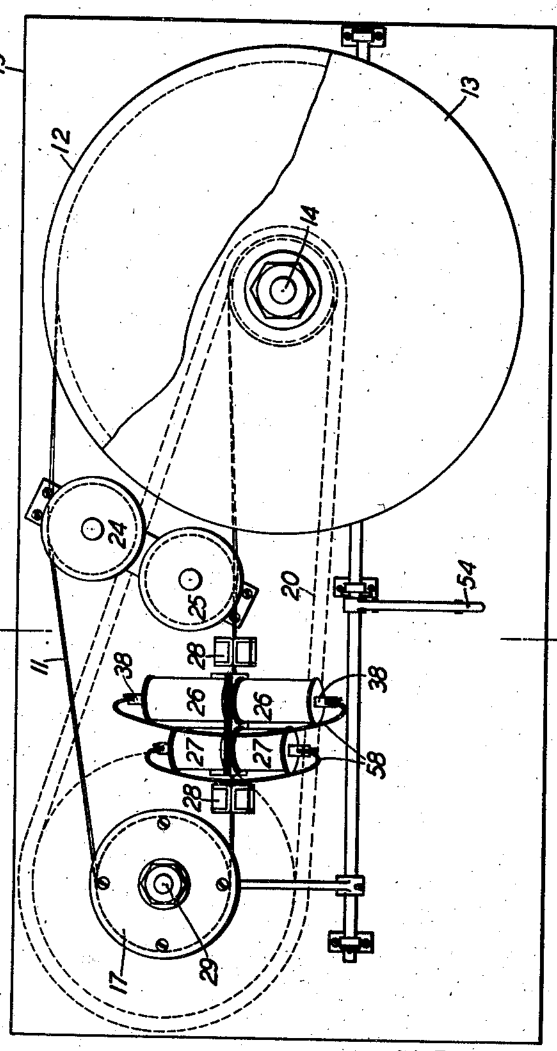

FIG. 1

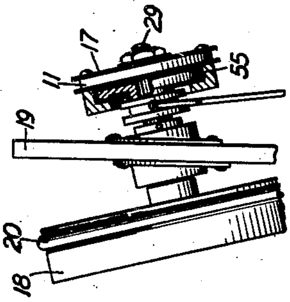

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FIG. 3

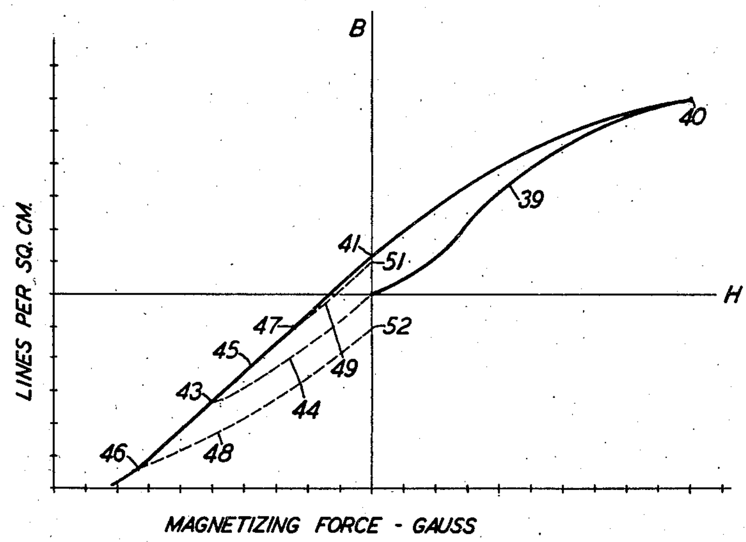
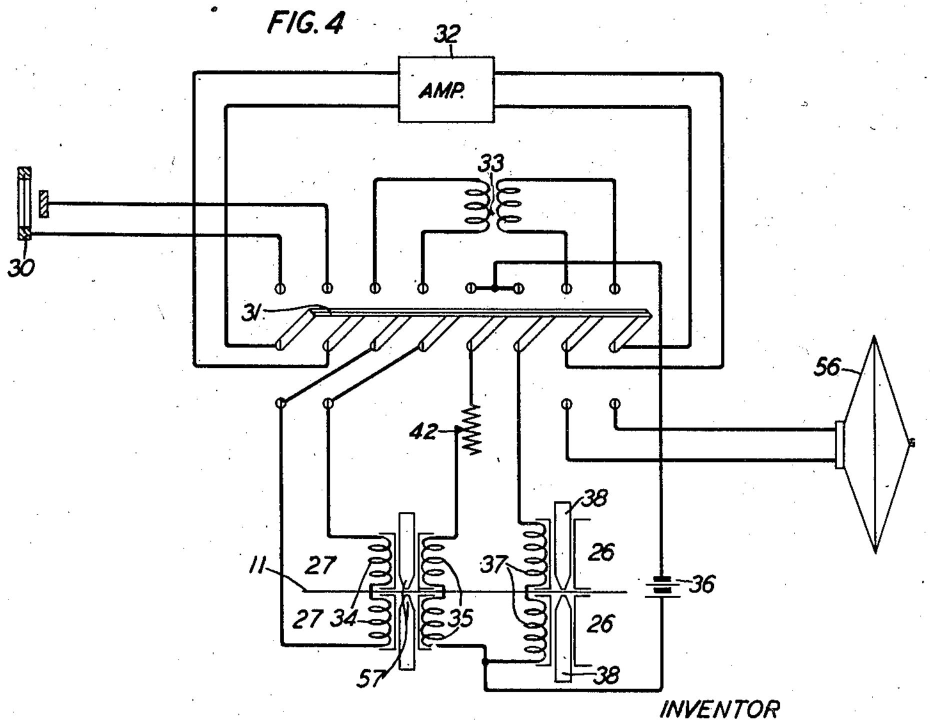


FIG. 4



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UNITED STATES PATENT OFFICE

1,944,238

TELEGRAPHONE

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Application April 15, 1931. Serial No. 530,167

6 Claims. (Cl. 179—100.2)

This invention relates to sound recording and reproducing systems and more particularly to telegraphones in which, as is well known, the signals are recorded by varying the magnetic condition of a moving magnetic body and are reproduced by causing such a magnetized member to vary the induction in a suitable translating device.

The object of the invention is to provide a novel method and apparatus of this kind and in general to improve the operation of such a recording and reproducing system.

While the telegraphone is an old and well known arrangement for recording and reproducing sound it has never been used commercially to an extent comparable to the use of phonographs or film recording. There are a number of reasons for this the most important of which are probably the inherent defects in the apparatus as heretofore proposed. In general the volume level of the reproduced signals of previous systems was low, the frequency range covered was very limited, the extraneous noise was objectionable and the distortion of the wave forms was often so great as to render the reproduction almost unintelligible. The linear velocity required for the record member, which was usually of wire, to obtain even these results was as much as six to ten feet per second so that the machine itself was exceedingly noisy and even somewhat dangerous in the event of breakage of the wire.

In one of its earliest forms a single recording magnet and a small rapidly moving wire were used and later when recording magnets were placed on opposite sides of the wire they were ordinarily spaced along the wire to set up longitudinal magnetization in it for it was believed that if they were directly opposed, a recording tape or wire of considerable thickness was necessary to be capable of retaining the record. In other words it was believed that the magnetic poles induced on opposite sides of the record material should be as far apart as practical to minimize the demagnetizing effect of the poles of opposite polarity on each other. In recording it was common practice to record on the normal magnetization curve of the record material by subjecting it simultaneously to a polarizing flux and a flux representing signals to be recorded.

In accordance with the general feature of this invention the record material is first very highly magnetized which incidentally erases any previous history. It is then demagnetized until the remnant is zero or in other words to a point such that if the demagnetizing force is removed the material is left in an entirely or very nearly totally demagnetized condition, and while still under the influence of this demagnetizing force, it is subjected to the flux representing the signals to be recorded. In this manner the remagnetizing of the material is carried out on the substantially straight portion of the hysteresis loop so that maximum variation in the magnetic condition of the completed record may be obtained with minimum distortion. Another important advantage in working about this particular point of the curve is found in the fact that for this point the noise in reproduction due to the condition of the record material is also a minimum.

An important feature of the invention is the method of recording at substantially constant flux whereby the higher frequencies are represented in the record by larger variation in magnetization than in systems proposed heretofore. This not only extends the range of higher frequencies which can be recorded without producing distortion from overloading in the low frequency portions of the record, but also increases the effective volume range of the system in that the higher frequencies are recorded at a much greater margin over the noise level which is ordinarily highest in this part of the range.

These and other features of the invention will be more clearly understood from the following detailed description and the accompanying drawings in which:

Figs. 1 and 2 show one form of a machine suitable for recording and reproducing sounds according to this invention;

Fig. 3 is a typical magnetization curve and a portion of a hysteresis loop for the recording material used; and

Fig. 4 is a schematic of a circuit for the arrangement of Fig. 1 whereby sounds are recorded and reproduced by the same machine.

Referring now to the drawings, particularly to Figs. 1 and 2, the mechanism for moving the record member will first be described. The machine has been designed particularly with a view to conserving space and involves a number of novel features which are more fully described and claimed in my copending application, Serial No. 530,168, filed April 15, 1931. The record member 11 is preferably a tape of any suitable magnetic material about .001 inch thick and .125 inch wide, the ends of which are secured to reels 12 and 13 respectively. To keep the machine small, these reels are rotatably mounted on the same drive shaft 14, and clutches 15 and 16 are provided to engage alternately so that either reel may be the feed reel or the take-up reel.

Since it is essential to good quality that the speed of any given part of the tape passing the magnet be the same for recording and reproducing and free from minor irregularities, the motion of the tape during both processes is controlled by the tape-wheel 17 which is positively driven by the pulley 18 on the other side of the frame 19 by the belt 20 from pulley 21 on the main shaft. The shaft is driven at a suitable speed through worm gearing 22 by a motor of which only the shaft 23 is shown.

To enable the tape to pass freely from one reel to the other the tape wheel is mounted on the frame 19 in an inclined position as shown, and similarly inclined guiding pulleys 24, 25 are provided between it and the reels 12 and 13. The pulley 18 is made large enough to serve also as a fly-wheel for damping out minor irregularities in speed or a separate fly-wheel may be provided as desired.

For recording, the lever 54 is moved to engage the friction clutch 15 and clutch 55 on the tape wheel shaft; the tape wheel pulls the tape between the magnets from right to left by friction with the tape-wheel 17 and is wound up on reel 12. At this time clutch 16 is disengaged so that tension on the tape unwinds it from the reel 13 against the slight friction of the reel on the shaft 14 which is turning in a clockwise direction as viewed in Fig. 1 and therefore prevents the tape from unwinding faster than required. Between guiding pulley 25 and tape-wheel 17 the polarizing magnets 26 and the recording magnets 27 are mounted and on either sides of these magnets are suitable damping pads 28 for damping out mechanical vibrations in the tape as it passes the magnets.

In Fig. 4 the sounds to be recorded are picked up by a transmitter 30 and with the switch 31 in the upper or recording position, the corresponding electrical variations will be transmitted to the amplifier 32, the output transformer 33 and finally to coils 34 of the magnets 27. These magnets also have depolarizing coils 35 through which circulates a current from battery 36. Similar coils 37 form the windings of the polarizing magnets 26. As the tape is moved from right to left as described above it is brought to a very high transverse magnetization by the flux set up in the pole pieces 38 of the magnets 26. In this way, the tape is magnetized along the normal magnetization curve 39 of Fig. 3 to some value such as 40 on the curve, but as it passes away from the tip of the pole pieces 38, the induction decreases to some value 41 according to the retentivity of the particular recording material used. While this would normally indicate a material of low retentivity, it should be remembered that this curve is plotted for the transverse magnetization of a tape which is only 1 mil thick.

Any previous history of the tape is now erased and it approaches magnet 27 in a uniform magnetic condition. As it passes the pole tips 57 of the magnets each element of the tape is successively subjected simultaneously to the flux set up by the current in both the coils 34 and 35. The pole pieces of magnets 26 and 27 are preferably held in proper relation to the tape by spring members 58 which equalize the pressure exerted on the opposite sides of it. The depolarizing coils 35 are arranged so that the flux set up by them is in the opposite direction through the tape to the polarizing flux set up by magnet 26. The value of the depolarizing current is adjusted by rheostat 42 so that with no current in coils 34 the tape will be completely demagnetized and remagnetized in the opposite sense to some point 43 on the curve, such that as the tape passes away from the magnet it returns along the curve 44 to zero. However, when the coils 34 are carrying alternating current representing sounds to be recorded, the condition of each element of the tape just as it leaves the pole tips will be represented by points along the curve 45 which lie between points such as 46 and 47, according to the magnitude and direction of the alternating signal flux in the coils 34. As the tape moves beyond the influence of the magnets 27, the induction in each element decreases along curves such as 48 and 49, all of which are in general parallel to curve 44 so that in its final state on the reel 12 the record is represented by variations in the magnetic condition of the tape, the limiting values of which are indicated by points 51 and 52 on the line of zero magnetizing force.

By recording these signals as variations in magnetization from the condition represented by point 43, which corresponds to the completely demagnetized condition of the tape, it is found that the surface noise during reproduction is much less than when the record is made on any other portion of the curve. While recording can be done about some point on the curve other than 43 it will be apparent that any signal variations which carry the induction above the point 41 will not leave any permanent record in the tape since the induction will automatically fall to the value at 41 as soon as the tape passes beyond the recording magnets. In other words, systems of this kind record only half waves of the signal or, at best, record the positive halves of the waves very imperfectly, whereas by the method of the present invention the entire signal is retained in the tape.

It has been stated above that the signals are recorded preferably at constant flux or constant current. By this expression, it is meant that sound waves of differing frequencies but of such intensity as to produce equal acoustic pressures on the sound pick-up device 30, will produce equal changes of flux in the recording magnets 27 and hence equal variations in the magnetization of the tape. In circuits commonly used heretofore, the increasing impedance of the recorder coils with frequency resulted in signal currents and hence recording flux which decreased with increasing frequency so that the higher frequencies were represented in the record by such small variations in magnetization that the noise level became comparable to the signals within the desired frequency range. In order to record at constant flux, the recorder circuit impedance must be substantially constant over the frequency range to be recorded. A well known but rather inefficient way of obtaining constant impedance in a circuit is to make the resistance very large as compared to the inductance. A very convenient and efficient way of approximating this condition is to correlate the impedances of the recorder coils 34 and the output circuit of the amplifier 32 so that they are matched at high frequencies. In this case the effect of the increasing inductive reactance of the coils is compensated by the increased power transfer as the signal frequencies approach the matching frequency. In the present invention, therefore, the variations in the magnetization of the record are substantially independent of frequency and hence the margin of the signal over the noise, which is greatest at high frequencies, is materially increased so that the effective range of the instrument is extended to frequencies which could not be recorded with previous systems.

When a record has been made according to the foregoing procedure the tape must, of course, be rewound before it can be reproduced so that in reproduction it passes the magnets in the same direction as in the recording process. The rewinding of the tape is preferably done at high speed to avoid unnecessary delay. The clutch lever 54 is moved inwardly to engage clutch 16 and at the same time to disengage clutch 55 between the tape-reel 17 and the fly-wheel pulley 18, so that the tape wheel turns freely on shaft 29. Under this condition the clutch 16 has little tendency to slip and the tape is quickly wound up on the reel 13. When this has been done the clutch lever is again moved to disengage clutch 16 and to engage clutches 15 and 55 and the tape is moved from right to left between the magnets under the control of the tape wheel as before. During reproduction, the switch 31 of Fig. 4 is closed downwardly so that a circuit is made from the coils 34 through amplifier 32 to the loud speaker 56. It will be noted that the polarizing coils 37 and the depolarizing coils 35 are then open-circuited. The movement of the magnetized tape between the pole tips 57 of the magnets 27 will produce alternating flux in the pole pieces which will generate in the coils 27, currents corresponding to the signals recorded.

While the variations in magnetization are constant with frequency, as explained above, it will be apparent that due to the longer wave lengths of the low frequencies the rate of change in flux in the pole pieces during reproduction will be less for the lower than for the higher frequencies and hence the lower frequencies would ordinarily be reproduced at less than the intensity of the original sounds. This may be corrected conveniently to a large extent by designing the amplifier to have a low input impedance so that it matches the coils 27 in the lower part of the range. The reproducing circuit is therefore relatively more efficient for low frequencies so that the output of the loud speaker 56 will be a good quality reproduction of the original sounds for all the frequencies recorded.

The general method described above will be found applicable to various recording arrangements and hence no attempt has been made to describe the preferred forms of magnet construction and other details which are fully covered in my copending application referred to above. It is of interest to note, however, that with a properly designed machine it has been found possible, according to this invention, to record and reproduce a large volume range and a greater frequency range at much lower noise level than with methods previously proposed and to accomplish these results with a record member moving at only 8'' per second, or even less, so that several hours of conversation can be recorded on a reel of moderate size.

What is claimed is:

1. In a telegraphone the method of recording signals in a magnetic material which consists in highly magnetizing the material, reducing the magnetization to a point about mid-way along the substantially straight portion of the hysteresis loop and subjecting the material in this state to alternating flux representing the signals to be recorded.

2. In a telegraphone the method of recording signals in a magnetic material at high intensity relative to the noise level which consists in highly magnetizing the material, reducing the magnetization to a point where the remnant in the absence of recorded signals is substantially zero and subjecting the material in this state to alternating flux representing the signals to be recorded.

3. In a telegraphone the method of recording signals in a magnetic material at high intensity and without substantial distortion which consists in highly magnetizing the material transversely, reducing the magnetization to a point where the remnant in the absence of recorded signals is substantially zero and subjecting the material in this state to alternating signal flux.

4. In a telegraphone the method of recording signals in a magnetic material which consists in bringing the material to a high transverse magnetization along the normal magnetization curve, reducing the magnetizing force to zero, applying sufficient negative magnetizing force to reduce the magnetization to the point at which if the negative magnetizing force is removed, the induction remaining in the material is substantially zero, and subjecting the material in this state to transverse magnetization in accordance with the signals to be recorded.

5. In a telegraphone system, a magnetizable body and means for moving the body with a substantially constant velocity, a polarizing magnet and a signal input circuit associated with the magnet having an impedance matching that of the magnet at a frequency near the upper limit of the range to be recorded.

6. In a telegraphone a thin magnetic tape and means for moving the tape at a suitable linear velocity, polarizing magnets and other magnetic members contacting opposite sides of the tape, and means for magnetizing the members simultaneously with an alternating signal flux substantially constant with the frequency for sounds of equal intensity, and with a depolarizing flux sufficient to reduce the magnetization to a point where the remnant in the absence of signal flux is substantially zero.

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