

Oct. 27, 1942.

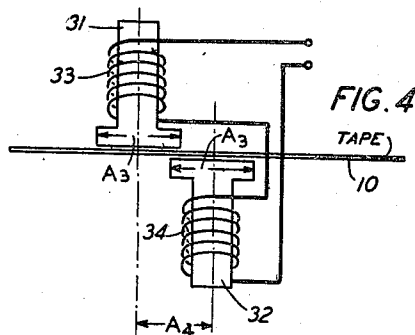
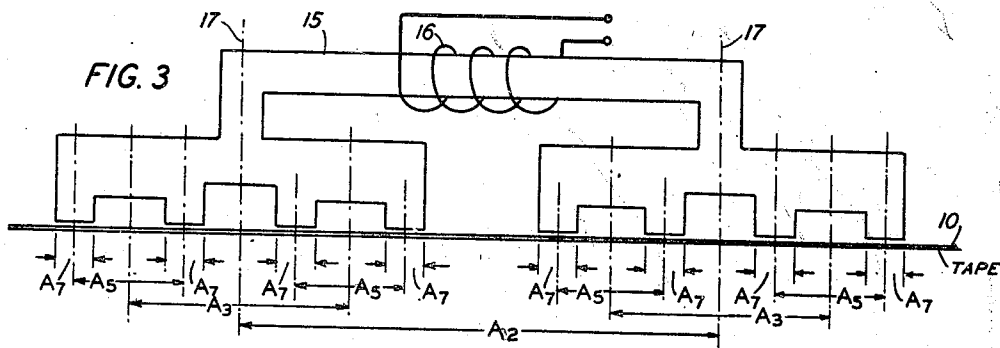
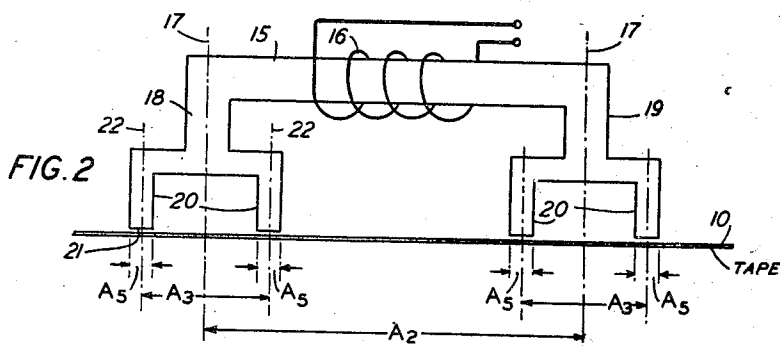
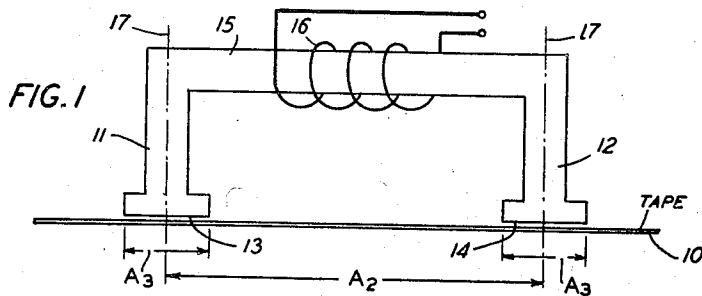
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2,300,320

DEVICE FOR REPRODUCING TONE FREQUENCIES

Filed May 27, 1941

2 Sheets-Sheet 1



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FIG. 5

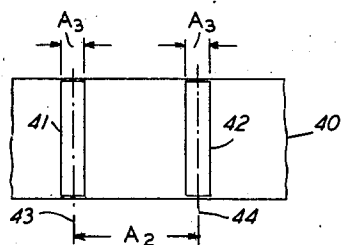


FIG. 6

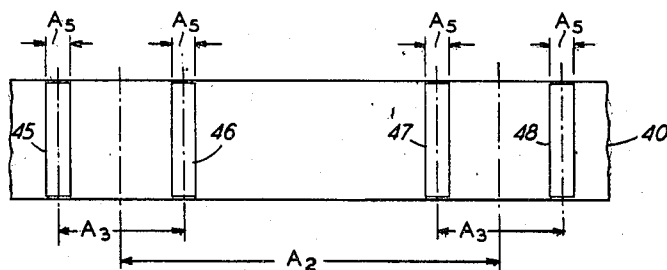
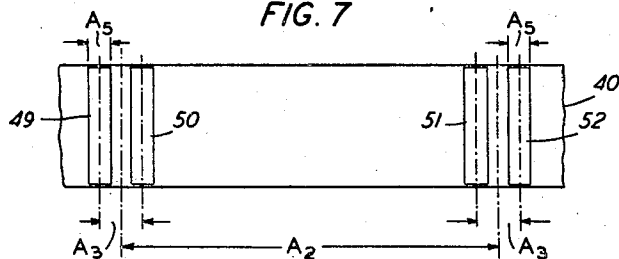


FIG. 7



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DEVICE FOR REPRODUCING TONE
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Application May 27, 1941, Serial No. 395,341

6 Claims. (Cl. 179-100.2)

This invention relates to the reproduction of tone frequencies and the object of the invention is to reproduce substantially pure tones from records of the tone and its harmonics.

As explained in Patent 2,144,344 granted to Hickman January 24, 1939, it is difficult to record single frequencies without at the same time recording harmonics at levels high enough to be objectionable in cases where a substantially pure tone is required. The Hickman patent also discloses that the even order harmonics in a magnetic record of a tone frequency may be suppressed by proper spacing of the reproducing pole-pieces along the record member.

In accordance with this invention, odd as well as even harmonics are suppressed by a proper proportioning of both the dimensions and spacing of the pole-pieces or other translating devices. Each pole face is subdivided and proportioned to suppress the higher order, odd harmonics such as the fifth and the subdivided pole faces may be resubdivided to any extent necessary in a given case until the lowest harmonic reproduced is beyond the frequency range of interest or until the frequency interval between the fundamental and the first harmonic reproduced is sufficient to make its elimination by filtering a relatively easy matter.

It will be understood that the principles of the invention are not limited to magnetic reproducing systems but that they are equally applicable, for example, to the design of the slots of an optical reproducing system or the pick-up plates of an electrostatic system.

The invention will be more clearly understood from the following detailed description and the accompanying drawings, in which:

Fig. 1 is a pole-piece assembly for eliminating all even harmonics, the third harmonic and all its multiples in a longitudinally magnetized system;

Fig. 2 shows the pole-pieces subdivided to eliminate the fifth harmonic and its multiples in addition to those suppressed by the structure of Fig. 1;

Fig. 3 shows a further subdivision for suppressing the seventh harmonic and its multiples;

Fig. 4 is a pole-piece assembly for a transversely magnetized record; and

Figs. 5 to 7 show the application of the invention to the design of aperture plates for an optical record or the pick-up plates of an electrostatic reproducing system.

In Fig. 1 the pole-pieces 11 and 12 have faces 13 and 14 which are spaced along the surface of

the member 10 containing a record of the tone frequency to be reproduced and these pole-pieces are joined by a low reluctance yoke 15 which mounts a coil 16 in which the tone frequency voltage is generated as the record member moves past the pole faces. The spacing A2 between the center lines of the pole faces is made equal to $\lambda/2$ where λ is the wave-length in the record of the tone frequency to be reproduced. There is, however, always a full wave-length of the second harmonic between these center lines and assuming for the moment that the dimension A3 approaches zero, it will be evident that the magnetization in the elements of the record which are opposite the pole faces will always be equal and that there is, therefore, no magnetomotive force to set up a flux in the yoke at the second harmonic frequency. This will also be true, of course, for all multiples of this frequency so that all even order harmonics of the tone such as the fourth, sixth and eighth harmonics are suppressed by the choice of pole-piece spacing.

Increasing the pole face dimensions A3 will not affect this suppressing action as long as they are increased symmetrically about the center lines 17, 17 for the magnetomotive force at each element of one pole face is at every instant opposed by an equal force at the corresponding element of the other pole face. If the width of the pole faces A3 is made equal to $\lambda/3$, each pole face will be influenced at all times by a full wave-length in the record of the third harmonic and hence this harmonic and all its multiples will be suppressed.

It will be also seen that if for any reason the dimensions $A2=\lambda/2$ and $A3=\lambda/3$ are undesirable or impractical they may be made equal to any desired odd multiple of $\lambda/2$ or $\lambda/3$ as the case may be. Obviously no even multiples which result in a spacing of λ or its multiples can be used for in that case the desired fundamental tone would be suppressed.

If it is desired to suppress the fifth harmonic and its multiples also this may be done without affecting the suppression of the lower harmonics by a structure of the type shown in Fig. 2. In this case the pole-pieces 18, 19 are subdivided into furcations 20 of a width in direction of the record travel of A5 which may be $\lambda/5$ or any multiple thereof which will not suppress the fundamental tone. The pole faces 21 of each of these furcations will suppress the fifth harmonic and all its multiples. The center lines 22 of the furcations are spaced apart a distance $A3=\lambda/3$ or a suitable multiple and symmetrically disposed with respect to the center lines 17 of the pole-pieces and the

lines 17 are spaced a distance A2 which in this case must be at least $3\lambda/2$ to provide the necessary mechanical clearances. Due to the symmetry of this structure the even harmonics and the third and its multiples will be suppressed for the reasons given in connection with the discussion of Fig. 1 and in addition each of the faces 21 will extend over at least one full wave-length of the fifth harmonic thereby suppressing it and all its multiples.

While the structure of Fig. 2 will reproduce higher harmonics such as the seventh, eleventh and thirteenth these will ordinarily be relatively very small and more easily eliminated by filtering, if necessary, than by resorting to the more complicated structures required to suppress them. However, it will be clear from the foregoing discussion that the furcations 20 may be subdivided in which case the subdivisions would be disposed about centers A5 apart and the faces of the subdivisions would each extend along the record a distance $A7=\lambda/7$ or a suitable multiple thereof to suppress the seventh harmonic as shown in Fig. 3.

In the general case the n th harmonic is suppressed by pole extensions having a dimension of $A\eta=K\lambda/\eta$ where λ is the wave-length of the fundamental tone as before and K is any whole number other than η or its multiples and is ordinarily as small as practical to avoid an unnecessarily bulky unit.

This method of suppressing undesired harmonics is particularly advantageous as compared with the use of filters alone in cases where a single tone record is operated at different speeds to vary the pitch of the reproduced tone. If filters alone were used in such a case either a number of fixed networks would be required or it would be necessary to provide a very complicated and expensive variable frequency filter. By eliminating a number of the lower harmonics in accordance with this invention, the frequency interval between the tone and the lowest harmonic reproduced may be made large enough to permit the use of only a single, simple, fixed network while operating the record at widely different speeds.

When it is desired to reproduce a pure tone from a transversely recorded record this may be done by means of a structure of the general type shown in Fig. 4. The axes of the pole-pieces 31, 32 are displaced by an amount $A4=\lambda/4$ or an odd multiple of this distance instead of being accurately aligned as in the ordinary transverse system. The pole face dimension $A3=\lambda/3$ and the coils 33, 34 are connected in the usual manner, namely, series aiding when the flux is flowing toward the tape in one pole-piece and away from the tape in the other. Due to the displacement of the axes of the pole-pieces the flux emerging from each pole-piece will return very largely by way of the leakage path so that the flux in each pole-piece varies substantially independently of the other. Since the pole faces are each equal to the wave-length of the third harmonic, this frequently and its multiple are suppressed as before. The fundamental will be reproduced though at somewhat lower level than if the pole-pieces were aligned but the even order harmonics will produce fluxes in the same direction with respect to the record in both pole-pieces and the corresponding voltages in the coils 33 and 34 will be opposed and balanced out. Here, too, if desired, the pole faces may be subdivided to suppress harmonics of higher orders.

For harmonic suppression in an optical reproducing system of the usual type comprising a light source, a photo-electric cell and film record, the single slit aperture plate would be replaced by one having a plurality of slits of the proper widths and spacings to suppress the undesired harmonics in accordance with the general principles already explained.

As is well understood in the art, a single slit suppresses a frequency having a wave-length on the film equal to the width of the slit. It will also be clear from the foregoing discussion that a plurality of slits in the path of the reproducing light beam will also suppress all harmonics for which the increased light transmission through one slit or combination of slits at any instant is nullified by a corresponding decrease in transmission through another slit or combination of slits.

In Fig. 5 as applied to an optical system 41 and 42 are slits in the aperture plate interposed between the light source and the record 40 with the length of the slits extending transversely of the record as shown. If the axes 43 and 44 of the slits are spaced a distance A2 which is an odd multiple of the quarter wave-length of the fundamental tone such, for example, $3\lambda/4$ all even order harmonics are suppressed and the third harmonic and its multiples are suppressed by making the width A3 of each slit equal to $\lambda/3$ or any suitable odd multiple thereof.

In Figs. 6 and 7 the slits 45 to 48 and 49 to 52 are each of a width $A5=\lambda/5$ to suppress the fifth harmonic and its multiples. In Fig. 6

$$A2=3\lambda/4=3(\lambda)/2(2)$$

to suppress even order harmonics and

$$A3=\lambda/2=3(\lambda)/2(3)$$

to suppress the third harmonic and its multiples. Alternately as shown in Fig. 7, A2 may be equal to $\lambda/2=3(\lambda)/2(3)$ for suppressing the third harmonic and A3 may be equal to $\lambda/4=1(\lambda)/2(2)$ to suppress the even order harmonics. It will be understood, of course, that where necessary or desirable suitable multiples of the dimensions given may be used.

As applied to an electrostatic reproducing system involving a plurality of parallel-connected pick-up plates the dimensions given in Figs. 5 to 7 for the slits in optical systems will apply to the corresponding dimensions of the plates.

In applying the principles of the invention to the design of pole-pieces for a magnetic reproducing system, it should be noted that the dimensions given for the pole-pieces and spacings are based on the assumption that they are so large compared with the air-gap between the pole-faces and the record and that the permeability of the yoke is so high that no appreciable spreading of the flux occurs. When this is not the case it will be necessary to make the dimensions slightly less than the values given to compensate for the increase in effective pole-face area caused by the spreading of the flux. The exact values can be determined empirically for each case and small unbalances existing with a structure only approximately correct can be reduced by adjusting the air-gap between the pole faces and the record. Somewhat analogous considerations apply when the invention is applied to tone reproducing systems of other types.

What is claimed is:

1. A translating device for reproducing tone frequencies from a record member containing a

record of the tone and its harmonics, comprising reproducing elements having axes spaced apart a distance substantially equal to an odd multiple of one-half the wave-length in the member of the tone frequency, each having a dimension substantially equal to an odd multiple of one-third of said wave-length in the direction in which the device is adapted to extend along the member.

2. A translating device for reproducing tone frequencies from a record member containing a record of the tone and its harmonics, comprising a plurality of translating elements having axes spaced along the member such a distance as to suppress one harmonic of the tone and its multiples, each element having a dimension along the record such as to suppress another harmonic of the tone and its multiple.

3. A translating device for reproducing tone frequencies from a record member containing a record of the tone and its harmonics, comprising two translating elements substantially symmetrically disposed about the axes spaced along the member such a distance as to suppress one harmonic of the tone and its multiples, each element having furcations substantially symmetrically disposed about the axes spaced to suppress another harmonic and its multiples and each furcation having a dimension along the record member substantially equal to the wave-length in the member of still another harmonic of the tone frequency.

4. A translating device for reproducing tone frequencies from a record member containing a record of the tone and its harmonics, two translating elements symmetrically disposed about the axes each element having a pair of furcations on each side of the axis of the element, said pairs

of furcations being symmetrically spaced with respect to the axis and each furcation having a dimension along the record member equal to a wave-length in the member of a harmonic of the tone frequency.

5. A telegraphone magnet for reproducing tone frequencies from a record member containing a longitudinally magnetized record of a tone frequency and its harmonics comprising a pair of pole-pieces, a low reluctance yoke joining the pole-pieces and a coil on the yoke, said pole-pieces having axes spaced apart a distance equal to the wave length in the member of a harmonic of the tone frequency and pole faces symmetrically disposed about the axis and having a dimension in the plane of the axes equal to the wave-length in the member of another harmonic of the tone frequency.

6. A telegraphone magnet for reproducing tone frequencies from a record member containing a longitudinally magnetized record of a tone frequency and its harmonics comprising a pair of pole-pieces, a low reluctance yoke joining the pole-pieces and a coil on the yoke, said pole-pieces having axes spaced apart a distance equal to the wave-length in the member of a harmonic of the tone frequency, furcations on each pole-piece having axes symmetrically disposed about the axis of the pole-piece and spaced apart a distance equal to the wave-length in the record member of another harmonic of the tone frequency and a pole face on each furcation having a pole face width equal to the wave-length in the record member of a third harmonic of the tone frequency.

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