Feb. 18, 1958 J. H. TREVITT 2,824,245

SIGNAL GENERATING APPARATUS

Filed Jan. 16, 1956

Fig. 1.

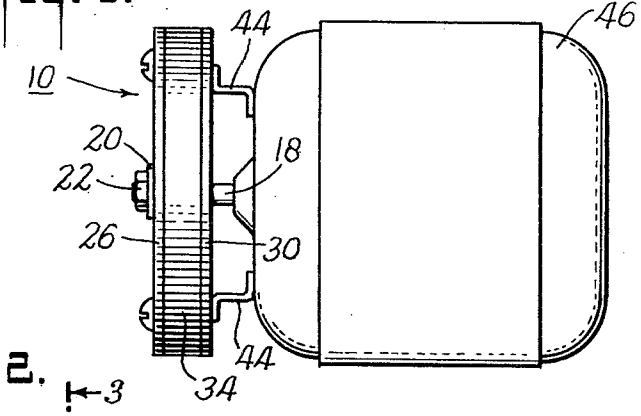


Fig. 2.

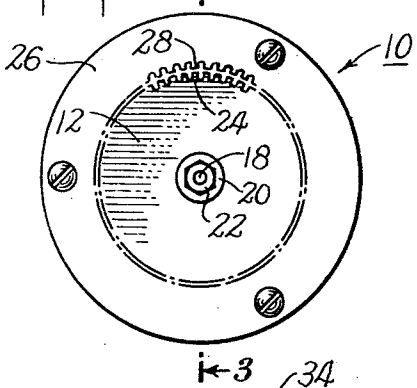


Fig. 3.

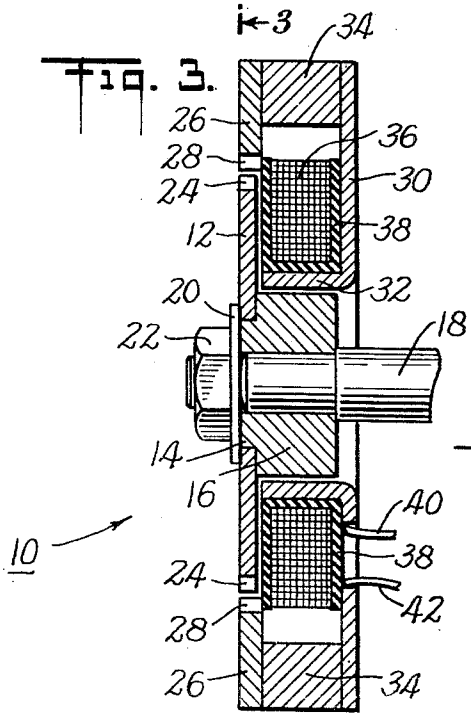


Fig. 4.

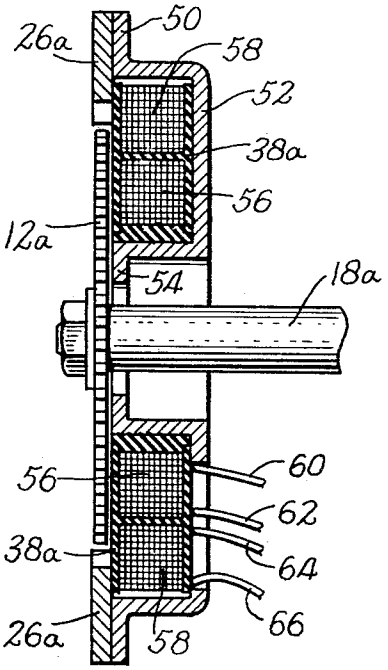
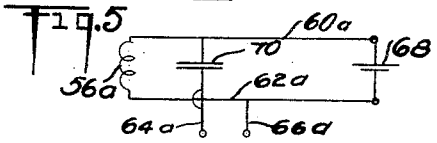


Fig. 5



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SIGNAL GENERATING APPARATUS

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1 Claim. (Cl. 310—168)

This invention relates to signal generators of the rotating electro-mechanical type. More particularly, this invention relates to such apparatus for producing an electrical tone signal in the audio-frequency range.

Many different types of tone generators have been proposed heretofore and some have found extensive use in a variety of fields, as for example in conjunction with testing of electrical equipment. However, there has been a problem in providing suitable tone generators for use with communication systems, e. g. to feed a warning signal to a telephone receiver when the conversation is being recorded. For such applications, the tone generator should (1) be stable in frequency, (2) be capable of operating continuously for long periods of time without maintenance service, (3) be adapted to provide an output signal of substantial power, (4) be compact and inexpensive to manufacture, (5) reduce to a minimum any stray magnetic field which might interfere with neighboring circuits, and (6) have an output impedance that is high relative to the communication line impedance to avoid loading down this line. Although many types of tone generators, including vacuum tube oscillators, have been tried for such purposes, none of these attempts has produced a fully satisfactory solution to the problem.

Accordingly, it is an object of the present invention to provide signal generating apparatus of the type set forth that is superior to such apparatus used heretofore. It is a further object of this invention to provide such apparatus that is capable of meeting the stringent requirements applicable to tone generating equipment to be employed with communication systems.

In a preferred embodiment of this invention, to be described hereinbelow in more detail, there is provided a rotatable wheel the periphery of which is formed with a relatively large number of spaced-apart teeth. This wheel is constructed of magnetic material and is rotated at essentially constant speed within a concentric annular ring of magnetic material, having corresponding teeth formed in its inner wall immediately adjacent the wheel teeth. Magnetic flux is produced across the air-gap existing between these two sets of teeth in such a manner that the changing reluctance of this air-gap due to the relative movement between the two sets of teeth causes a periodic variation in the strength of the magnetic flux with the frequency of variation being determined by the rotational velocity of the wheel. The periodic variation in flux strength is converted to an electrical output signal by inductive coil means.

Other objects, aspects and advantages of this invention will be in part apparent from, and in part pointed out in, the following description considered together with the accompanying drawings, in which:

Figure 1 is a plan view of the tone generator secured to an electric drive motor;

Figure 2 is a front view of the tone generator showing the toothed wheel and the concentric toothed stator ring;

Figure 3 is an enlarged vertical section of the tone generator taken along line 3—3 of Fig. 2;

Figure 4 is a vertical section of a modified form of tone generator; and

Figure 5 is a circuit diagram showing a modified coil arrangement.

Referring first to Figures 2 and 3, the tone generator generally indicated at **10** includes a relatively thin, flat wheel **12** seated on a flange **14** forming part of a collar **16** mounted on one end of a rotatable shaft **18**. The right hand face (Figure 3) of the collar abuts a shoulder formed in the shaft, and the collar and tone wheel are secured by a washer **20** and a nut **22** threaded onto a stem projecting out from the left hand end of the shaft. The wheel and the collar are constructed of magnetic material such as iron, and the periphery of the wheel is formed with a relatively large number of uniformly spaced-apart teeth **24**.

Surrounding the toothed wheel **12** is an outer flat stator ring **26** of magnetic material, having its interior surface formed with a number of uniformly spaced-apart teeth **28**. The wheel and the stator ring have the same number of teeth so that, as the wheel is rotated through one full revolution, both sets of teeth exactly line up (as shown) a number of times equal to the number of teeth in either set.

The rear wall (to the right as viewed in Figure 3) of the tone generator comprises a ring-shaped plate **30** of magnetic material formed with an inwardly extending flange **32**. Positioned between the stator ring **26** and the rear plate **30** is a permanent magnet ring **34**, which is secured in position by any conventional means (not shown). The flange of the rear plate closely surrounds the collar **16** forming an air-gap therebetween of relatively large area and correspondingly low reluctance.

With this arrangement, the permanent magnet **34** produces flux around a closed magnetic circuit which may be traced from the stator ring **26**, across the air-gap between the two sets of teeth **24** and **28**, inwardly and radially along the tone wheel **12**, longitudinally through the collar **16**, outwardly across the circular air-gap to the rear plate flange **32**, and through the rear plate **30** back to the magnet ring **34**. As the tone wheel rotates, the magnetic reluctance between the two sets of teeth **24** and **28** varies periodically from a maximum to a minimum; that is, when opposing teeth are lined up, the reluctance is at a minimum, and when the teeth are fully misaligned the reluctance is maximum. Accordingly, rotation of the wheel will provide a periodic variation in the strength of the flux passing through the magnetic circuit referred to above.

Secured within the interior of the tone generator casing is a coil **36** supported by an insulating coil bobbin **38**, the turns of the coil being wound in solenoid fashion generally concentric with the shaft **18**. Since the magnetic circuit described above links this coil, the periodic variations in flux strength induce in the coil an alternating electrical voltage which is coupled as an output signal through two lead wires **40** and **42** to a load (not shown), e. g. a telephone line. The intimate enclosure of the coil by the low-reluctance magnetic circuit elements assures relative freedom from stray magnetic field interference with nearby equipment or circuits.

One important advantage of the structure described is that the total flux passing around the coil structure is spread evenly throughout the entire rotating wheel at all times, i. e. the wheel in this arrangement provides a large number of parallel flux paths each fanning out radially from the wheel center and each having a corresponding air-gap between opposing teeth on the wheel and the stator ring. This construction minimizes leakage flux, and the tone generator is highly efficient so that large ampli-

tude output signals may be produced with a compact device, e. g. comparatively thin and small magnetic members can adequately carry the required flux density without difficulty. Furthermore, the output signal has sufficient power that a load such as a telephone line can be energized directly from the tone generator without employing amplification as used heretofore.

It may particularly be noted that end play in shaft 18 will have no substantial effect on the generator output signal. This is partly because the spacing of the two air gaps in the magnetic circuit is not affected by longitudinal movement of the shaft, and also partly because the tone wheel thickness is slightly less than the stator ring thickness. This latter feature also makes it possible to apply less stringent manufacturing tolerances and thus simplifies fabrication of the generator. Additionally, the tone wheel may be slightly off-center with respect to the stator ring without greatly affecting the output signal, since the average air gap always remain substantially the same; and this further simplifies the fabrication problem.

Referring now to Figure 1, the rear plate 30 is secured by brackets 44 to the outer housing of an electric motor 46. The shaft 18 is integral with the rotor shaft of this motor so that the motor bearings may support the rotating tone wheel without the need for additional bearings in the tone generator 10. The motor and the tone generator thus may be supplied as an independent and complete unit adapted for ready installation.

In operation, the motor 46 spins the tone wheel 12 at a substantially constant rotational velocity, and the strength of the magnetic flux linking the coil 36 changes at a rate determined by the number of wheel teeth 24 and the wheel velocity. In a preferred embodiment of the present invention, the frequency of the electrical output signal was 1400 C. P. S. Further, although the teeth may be relatively sharp-edged, the output signal produced thereby has been found to be nearly sinusoidal, due to the inductance of the electric circuit which is particularly noticeable when higher audio frequencies are being generated.

Figure 4 shows a modified tone generator arrangement. Here the stator ring 26*a* is fastened, as by means of machine screws (not shown), to the outer flange 50 of an annular casing 52. This casing is formed of magnetic material and concentrically encircles the shaft 18*a*. The casing also includes an inner flange 54 which is apertured to permit free rotation of the shaft, and is formed with a flat face immediately adjacent the flat inner face of the tone wheel 12*a*.

Positioned within the interior of the casing 52 are two concentric coils 56 and 58 supported by an insulating bobbin 38*a*. The turns of these coils are wound in solenoid fashion generally concentric with the shaft 18*a*. The lead wires 60 and 62 of the inner coil 56 extend through a hole in the casing wall and are connected to a source of regulated direct current (not shown), and in a known manner the flow of this current produces magnetic flux linking the coil.

The casing 52, the stator ring 26*a*, and the wheel 12*a* form a closed magnetic circuit encircling the inner coil 56 and within which the flux produced by this coil is essentially confined. The flux passes across the air-gap between the casing inner flange 54 and the wheel, which gap should be as small as possible commensurate with providing free rotation of the wheel, and the flux also passes across the toothed air-gap between the wheel and the stator ring. As in the Figure 3 embodiment, rotation of the wheel causes a periodic variation in the reluctance of this latter air-gap, which correspondingly varies the flux intensity in the closed magnetic circuit. Since this circuit also links the outer coil 58, the periodic variations in flux strength induce in this coil an alternating electrical voltage which is coupled by two output leads 64 and 66 to the load (not shown).

For some applications, it may be preferable to use a single coil both for producing the magnetic flux and for detecting the variations in flux intensity due to rotation of the wheel. For this purpose, the single coil may be connected directly to the source of direct current but coupled to the load through a D.-C. blocking capacitor. This arrangement is shown in Figure 5, wherein the single coil 56*a* is connected by a pair of wires 60*a* and 62*a* to a source of direct current 68. An output lead wire 64*a* is coupled to one side of the coil 56*a* through a D.-C. blocking capacitor 70, while the other output lead wire 66*a* is connected directly to the other side of the coil.

Although specific preferred embodiments of the invention have been set forth in detail, it is desired to emphasize that these are not intended to be exhaustive or necessarily limitative; on the contrary, the showing herein is for the purpose of illustrating the invention and thus to enable others skilled in the art to adapt the invention in such ways as meet the requirements of particular applications, it being understood that various modifications may be made without departing from the scope of the invention as limited by the prior art.

I claim:

Tone generating apparatus comprising, in combination, a wheel of magnetic material, the peripheral surface of said wheel being notched with a plurality of uniformly spaced-apart and sharp-edged teeth, a ring of magnetic material encircling said wheel, the inner surface of said ring being correspondingly notched with a plurality of uniformly spaced-apart and sharp-edged teeth, the number of teeth on said wheel and said ring being identical, an electric motor for driving said wheel relative to said ring, a housing surrounding said motor, a rotor shaft for said motor having one end thereof extending out through said housing, means for securing said shaft to the center of said wheel, an annular casing of magnetic material, said casing being mounted coaxially with said shaft between said wheel and said motor housing, said casing being open on the side thereof remote from said motor housing, a first flange formed on the outer periphery of said casing and lying in a plane perpendicular to the axis of said shaft, said first flange being secured to one side of said ring in tight intimate contact therewith, a second flange formed on the inner edge of said casing, said second flange lying in said plane and being spaced a small distance away from the adjacent side of said wheel to form an air-gap therebetween, a pair of brackets secured to the outer surface of said motor housing and fastened at their remote ends to said annular casing to hold said casing and said ring in fixed position relative to said wheel, an annular coil mounted within said casing, a first pair of lead wires for said coil, said lead wires being connected directly to a source of direct current so as to produce unidirectional flux through the magnetic circuit formed by said casing and said ring and said wheel, and a second pair of lead wires, said second pair of wires being coupled to said first pair of wires through a D.-C. blocking capacitor and arranged to transmit to a load the alternating-current signal developed in said coil by the changes in intensity of said flux resulting from rotation of said wheel relative to said ring.

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