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METHOD OF GENERATING CURRENTS FOR NON-SIGNALING PURPOSES

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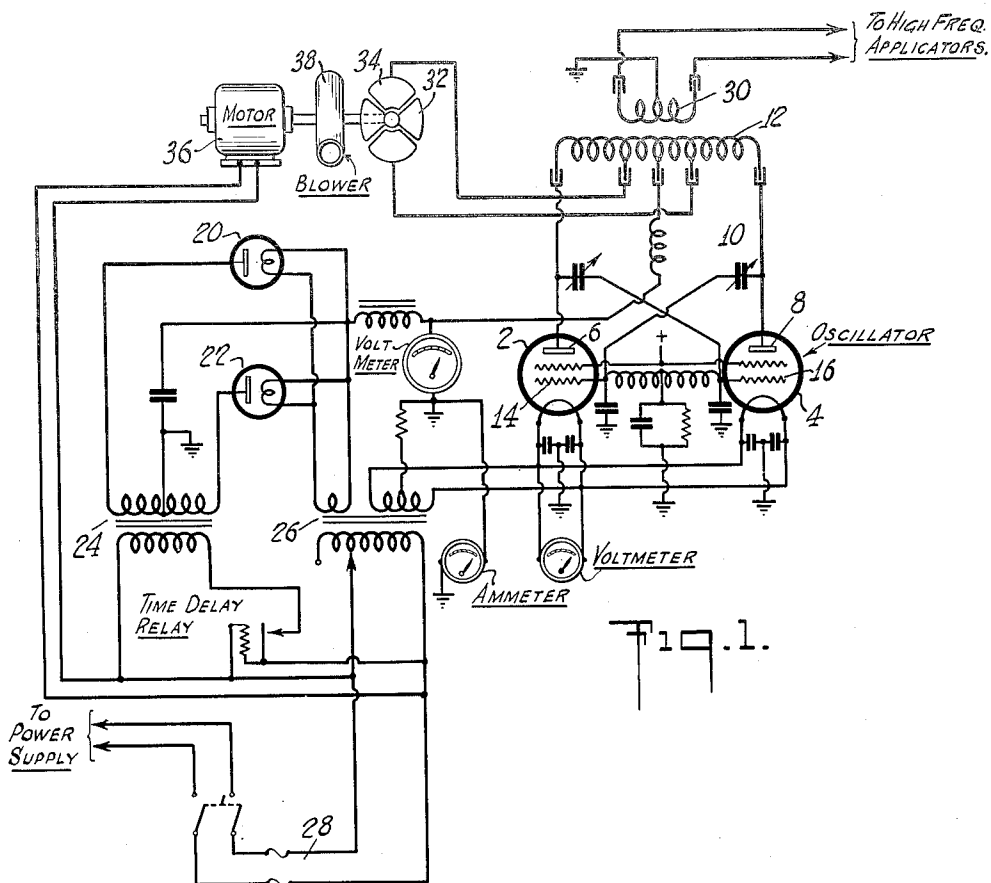
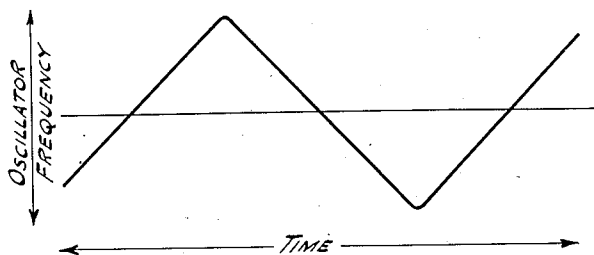


Fig. 2.



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METHOD OF GENERATING CURRENTS FOR
NONSIGNALING PURPOSESClarence W. Hansell, Port Jefferson, N. Y., as-
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4 Claims. (Cl. 250—36)

This application concerns new and improved methods of and means for generating currents for radio diathermy, radio heating, and other industrial radio-frequency applications.

In the operation of radio communications systems, particularly those associated with radio sound broadcasting and television and those operated on frequencies above 3 megacycles, interference from various sources of radio-frequency power are very common. One common source of interference arises from the operation of radio-frequency equipment used by physicians and others for the treatment of disease. The use of these types of equipment is commonly referred to as diathermy and depends for its effectiveness primarily upon internal heating of diseased parts through the use of high-frequency currents. Another common source of interference is due to radiation from radio-frequency equipment used for industrial heating purposes. For example, in the manufacture of vacuum devices which include metal parts, it is common practice to heat up the metal parts by means of high-frequency current induction for the purpose of driving out gases from the parts. Another application for high-frequency currents which is coming into general use involves surface heating of metal parts in combination with rapid cooling for the purpose of providing parts which have very hard surfaces but which are still relatively soft and resilient or malleable on the inside. This type of high-frequency equipment is used in hardening the bearing surfaces of crank shafts for automobiles and for similar purposes.

All of these radio-frequency devices used in the treatment of disease or for industrial purposes radiate radio-frequency power which can interfere with radio reception of broadcast programs or other communications signals. The interference normally appears as a beating effect between the carrier wave of a transmitter which is being received and the waves radiated from the diathermy or industrial heating equipment. Since most of the diathermy and industrial heating equipment has very poor frequency stability, it is a common occurrence for interfering radiations from it to drift about in communications frequency bands and to cause interference to a large number of circuits. One proposal for overcoming this difficulty has been that the Federal Communications Commission might set aside definite frequencies on which such equipment may be operated and that all of the equipment be required to include means for accurately stabilizing the frequencies at the correct values. One

objection to this solution is that the users of diathermy and industrial heating equipment often wish to adjust the operating frequency over a considerable range in order to obtain a control of the depth of heating and to control other effects in connection with application of the radio-frequency currents.

In accordance with the present invention, I propose to bring about a very great reduction in the maximum interfering effects of radio-frequency currents in diathermy and industrial applications by providing means for continuously varying the frequency of the radio-frequency currents over a relatively wide band of frequencies. When this is done interference to any particular communications circuit is reduced. If, for example, a particular communications circuit requires a total frequency band of 12,000 cycles corresponding to a maximum carrier modulation frequency of 6000 cycles, it is desirable that the interfering radiations pass through the whole frequency band of the communications circuit in a time interval which is small in comparison with one cycle of the highest modulation frequency. Then, the total energy which the interfering waves can cause in the circuits of the receiver is relatively small because of the small amount of time available to build up currents in the circuits. Even if the frequency does not vary this rapidly, the fact that the interference is continuously varying in frequency while the interfering carrier passes through the communications band very greatly reduces the total interfering energy on any one communications modulation frequency. Consequently, by the simple expedient of frequency modulating all diathermy and industrial radio-frequency heating equipment over a wide frequency band, I very greatly reduce the maximum interference they can cause in any one communications circuit. Moreover, by my method and means beat note interference is substantially limited. Especially is this true if the frequency swing is great enough and the mean frequency of operation is high enough.

Although a very large reduction in the maximum interference to any one communications circuit can be produced by sinusoidally modulating the frequency of the diathermy or industrial heating equipment, this is not the best wave form to employ because for portions of the modulation cycle the rate of frequency change passes through zero. As a consequence, maximum interfering effect would remain at the upper and lower limits of frequency swing where the rate of change of frequency is small. Rather than use sinusoidal

modulation of the sources of radio-frequency current, I propose to use sawtooth or straight line repeated modulation similar to that employed in the sweep circuits of cathode ray oscilloscopes and of the electron beam in the kinescopes of television circuits. There already exist in the art numerous means for producing sawtooth wave shapes and any of these means may be employed to obtain the frequency modulating current. Also, when the sawtooth currents are available, there are many means known in the art for causing the frequency of an oscillator to be modulated in accordance with these modulating currents.

Although my scheme of frequency modulating through a wide range radio equipment used in diathermy and industrial applications or other similar applications other than signaling will not eliminate the interference heretofore produced by such apparatus, it will reduce the maximum interference which can be produced in any narrow band communications channel. My invention is applicable to all such apparatus and is particularly applicable to portable apparatus of the nature described above. This is because the portable apparatus in many cases will not be used in shielded rooms and, therefore, when used in unshielded positions would, unless arranged in accordance with my invention, set up considerable interference in any adjacent signaling apparatus attempting to operate at nearly the same frequency.

Obviously, my invention is applicable to an extremely wide range of circuit arrangements and obviously I do not intend to limit the same to the apparatus described hereinafter since the same is used primarily for purposes of illustration, although the apparatus I have used is a preferred embodiment of radio-frequency equipment, other than signaling equipment, in which has been incorporated my invention.

The arrangement illustrated is particularly applicable to lightweight equipment such as might be moved from point to point. In the arrangement disclosed I employ small motor driven blowers for cooling the vacuum tubes and equipment and also for driving a rotary condenser element which serves as a means for frequency wobbling or modulating the high-frequency wave used in diathermy or industrial heating or in other similar apparatus. The rotary condenser may be in or of the circuit of the generator equipment and the blades of the rotor may be formed in a particular manner, as will be described more in detail hereinafter to accomplish the wobbling in the best manner.

In describing my invention reference will be made to the attached drawing where Figure 1 illustrates somewhat schematically an oscillation generator with a power supply source connected thereto and means for wobbling the frequency generated and for cooling the thermionic device used therein, and Figure 2 illustrates graphically the operation of my improved high frequency wave generator.

Referring to the drawing, tubes 2 and 4 have their anodes 6 and 8 connected in an alternating-current circuit 10 including the inductance 12. The grid electrodes 14 and 16 are cross-connected to the anodes 8 and 6 through adjustable condensers, as shown, so that feed-back potentials produce regeneration in the tubes and circuits. The tubes may be of any type. For purposes of illustration, they are shown as screen grid tubes. Anode potential for the tubes 6 and 8 is supplied

from a full wave rectifier including tubes 20 and 22 connected by transformers 24 and 26 to leads 28 which may be connected with any power supply. The rectifiers used here contain no unusual features and a detailed description thereof is not believed necessary. It is noted, however, that a time delay relay is included in a circuit of the rectifier in order to permit the filaments of the tubes thereof to warm up before full plate potential is developed in the rectifier circuit and applied between the anodes and cathodes of the tubes 2 and 4.

The inductance 12 is coupled to an inductance 30 which may supply high-frequency wave energy for diathermy purposes or for any industrial applications.

In order to wobble or modulate the frequency of the high-frequency power supplied to 30, I have provided a condenser comprising rotor plates 32 and stator plates 34, the stator plates being connected across a portion of the inductance 12 to form a part of the reactance in the oscillation generating and frequency determining circuit connected with the tubes 6 and 8. The rotor 32 is mounted on the shaft of a motor 36 which also drives the blower 38 used for tube and circuit cooling purposes.

As an example of the frequencies used, the oscillation generator including tubes 6 and 8 may operate at say 25 megacycles and the frequency generated may be varied by the rotary condenser 34 over a band width of 1,000,000 to 5,000,000 cycles. The generator may have a mean frequency of 25 megacycles and operate between 22.5 and 27.5 megacycles or any greater or lesser band.

The frequencies given above are merely examples of the frequencies to be used. It is important, however, that the range (total) through which the frequency of the current is deviated be large compared with the band width of communications receivers, such as broadcast receivers, or of the order of 5% to 30% of the mean frequency, whichever is larger. In other words, the amount of power left in the current within any communications frequency band with which it might interfere should be reduced by not less than 10 to 1 and preferably by more than 100 to 1.

To prevent bunching of side frequency energy, the reversal of direction of frequency swing or wobble should be as abrupt as can readily be accomplished.

If the blower motor runs at 1800 R. P. M. and a balanced two plate condenser rotor is used, then the fundamental modulation frequency will be 60 cycles per second. If, as an example, the frequency swing modulation wave is triangular in shape as shown in Figure 2 and the range of swing is 8,334,000 cycles, then the rate of change of frequency will be 1,000,000,000 cycles per second. It will take only $\frac{1}{100,000}$ of a second, or 10 microseconds, for the frequency to sweep through the pass band of a receiver when the receiver passband is 10,000 cycles wide. The frequency will fall within the passband of the receiver only $10,000 \div 1,000,000,000 = \frac{1}{100,000}$ of the total time. Therefore, the maximum interference in the receiver will be reduced in the ratio of about 100,000 to 1 in power or by 50 decibels. Obviously, in giving the above example, applicant does not intend to limit his invention to any frequencies such as those given because obviously it is applicable to all frequencies involved by diathermy and industrial radio applications known today.

The inductances 12 and 30 may be of the plug-in type to facilitate changing the operating frequency of the system.

What is claimed is:

1. The method of generating high frequency 5
radio currents for diathermy, heating and similar
non-signaling uses without producing substantial
interference in a predetermined communication
channel which includes the following steps, gen-
erating high frequency wave energy, shifting the 10
frequency of the generated wave energy back and
forth through a range of frequencies which in-
cludes the band of frequencies wherein the signals
used in said communication channel appear and
is at least twice as great as the frequency band 15
covered by the signals used in said communica-
tion channel and translating said generated and
frequency shifted wave energy to the point of uti-
lization whereby no substantial amount of dis-
turbance is caused by said generated and shifted 20
high frequency currents in said communication
channel.

2. The method of producing high frequency

radio currents for diathermy, heating and sim-
ilar non-signaling uses without producing sub-
stantial interference in a predetermined commu-
nication channel which includes the following
steps, generating high frequency wave energy,
shifting the frequency of the generated wave en-
ergy through a range of frequencies greater than
the range used in said communication channel
and at a rate sufficiently high so that the total
time during which the generated and shifted fre-
quency falls within the frequency spectrum used
by said channel is insufficient to cause a substan-
tial disturbance therein and translating the gen-
erated wave energy to the point of utilization.

3. A method as recited in claim 1 wherein the
frequency of the generated wave energy is shifted
linearly back and forth through said range of
frequencies.

4. A method as recited in claim 2 wherein the
frequency of the generated wave energy is shifted
linearly through said range.

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