

July 2, 1940.

C. W. LA PIERRE

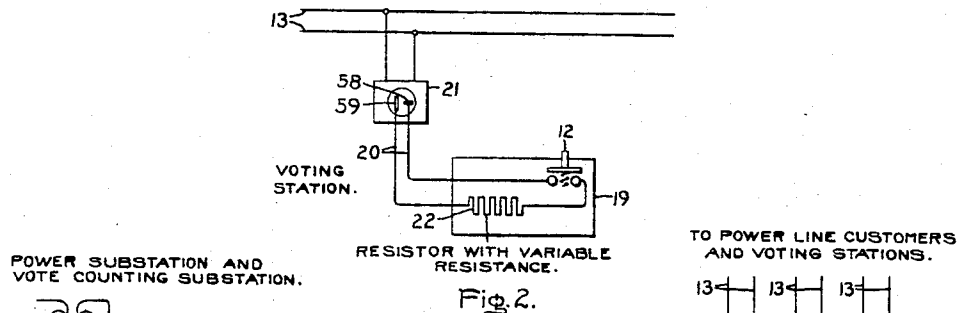
2,206,702

RADIO VOTING

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4 Sheets-Sheet 1

Fig. 1.



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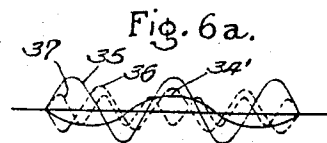
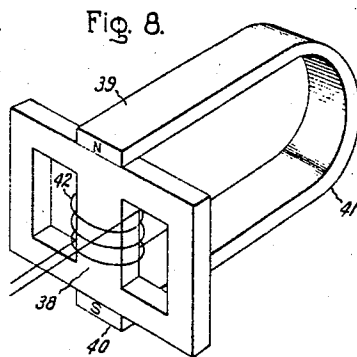
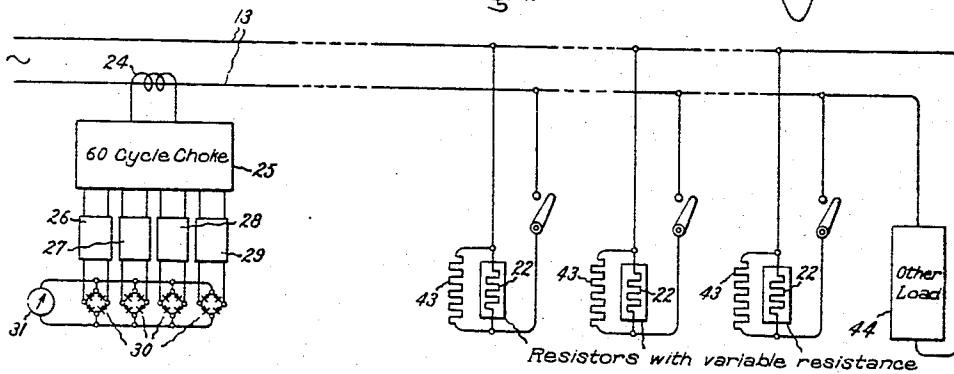
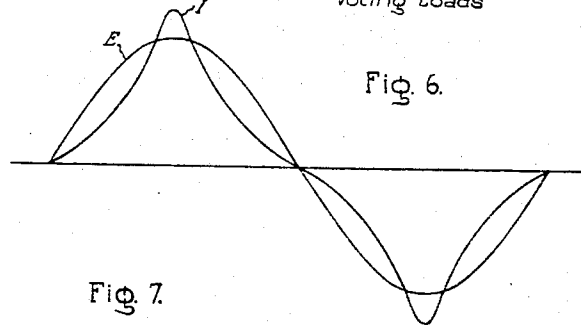
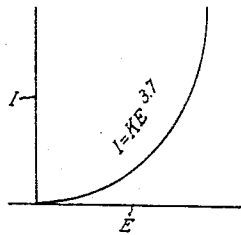
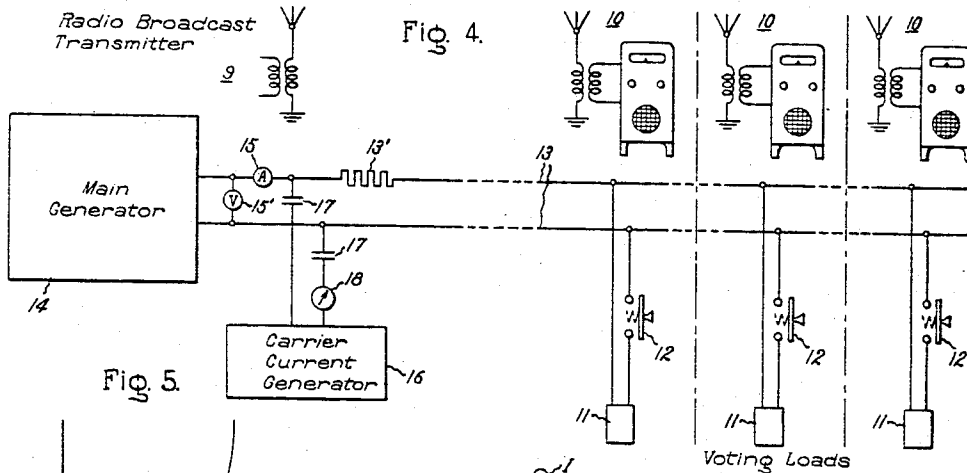
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2,206,702

RADIO VOTING

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4 Sheets-Sheet 2



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RADIO VOTING

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4 Sheets-Sheet 3

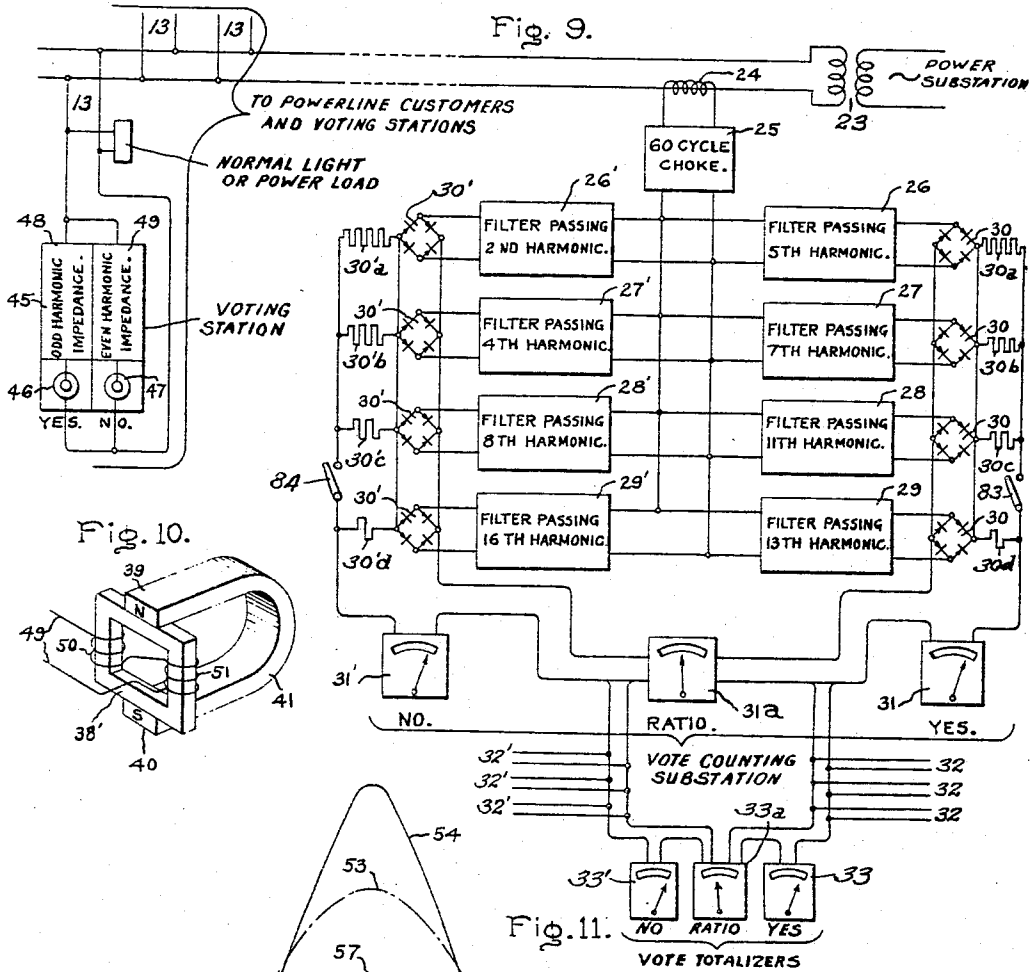
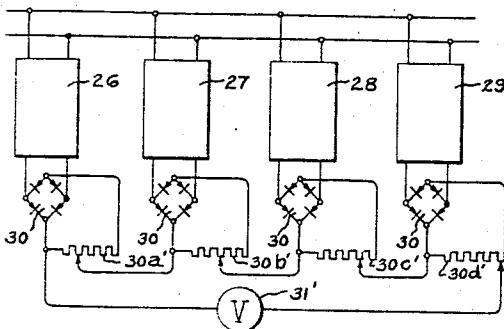


Fig. 12.



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July 2, 1940.

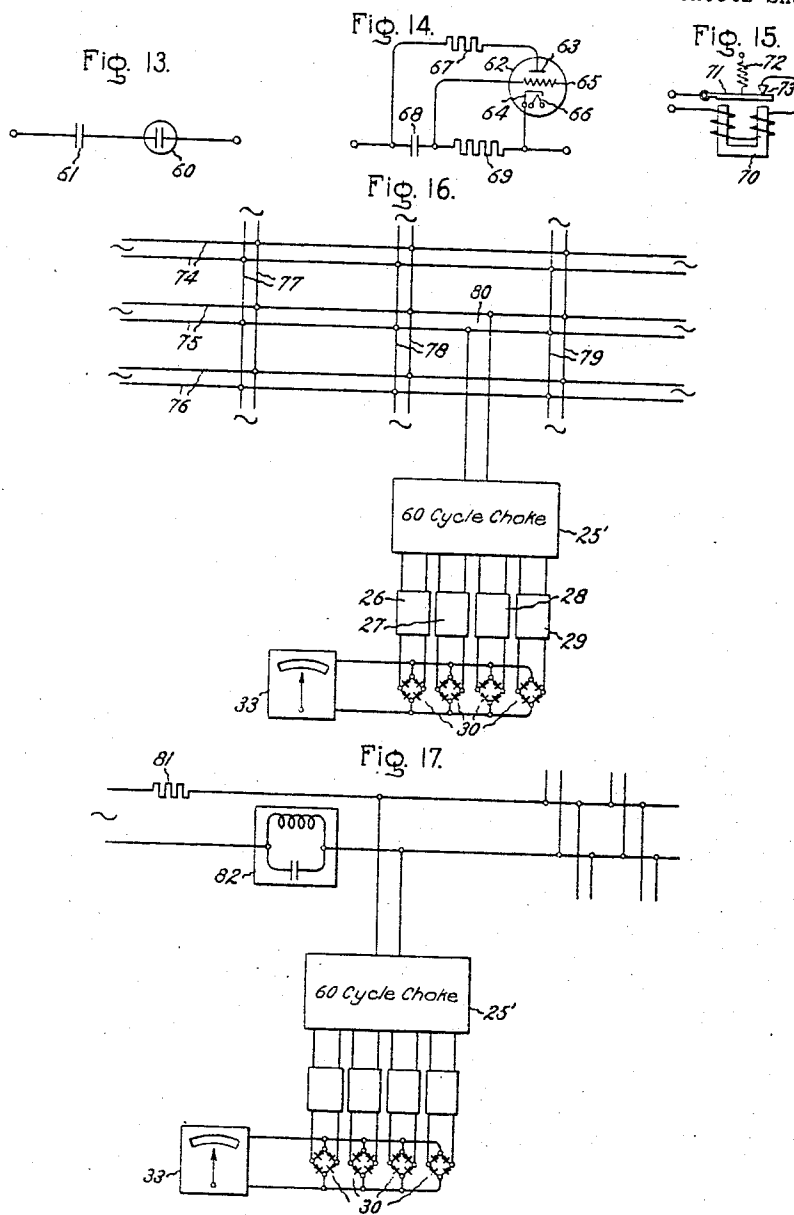
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RADIO VOTING

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,206,702

RADIO VOTING

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Application February 27, 1936, Serial No. 65,998

14 Claims. (Cl. 235-52)

My invention relates to methods and apparatus for counting and concerns arrangements particularly useful in connection with radio broadcasting for conducting elections among broadcast listeners.

My invention has for its principal object to provide means for utilizing existing facilities, such as electric light and power or telephone lines, for counting indications or collecting votes.

Another object of the invention is to provide a method and apparatus of such simplicity that the general public can readily be educated to make proper use of the voting system and to cooperate in providing expressions of popular opinion.

Still another object is to obtain relatively accurate and definite indications, not only of the ratio or the number of votes cast for one proposition in proportion to the number of votes cast for another proposition, but also an indication of the actual number of votes cast.

Other and further objects and advantages will become apparent as the description proceeds.

In accordance with my invention in its preferred form, I provide the broadcast listeners or members of a broadcast audience, including television audiences, with impedances or loads to be connected to a suitable network of electrical conductors when a signal is given. The network is supplied with current by a suitable source and a suitable current-responsive or voltage-responsive device is provided at the supply end of the network in order to measure the effect of impedances connected to the network in order to determine the number of impedances connected to the network by the broadcast listeners and the number of votes so cast by them.

As a large proportion of the broadcast listeners is served by electric light and power circuits and by telephone circuits, either of such existing facilities is employed as the electrical network for collecting the votes. Any possibility of interference between the vote collecting and other functions of the network may be minimized or avoided by causing the impedances to draw alternating currents of a predetermined frequency or frequencies and measuring network effects at only a selected frequency or group of frequencies.

The invention will more readily be understood from the following detailed description when considered in connection with the accompanying drawings and those features of the invention which are believed to be novel and patentable will be pointed out in the claims appended here-

to. In the drawings, Fig. 1 is a schematic diagram representing a voting station or the apparatus at the broadcast listener's end of an electrical supply circuit in accordance with one embodiment of the invention; Fig. 2 is a schematic circuit diagram representing the apparatus for collecting and totalizing the votes expressed at voting stations of the type shown in Fig. 1; Fig. 3 is a graph explaining the principle of operation of an embodiment of the invention used in connection with electric light and power distribution circuits; Fig. 4 is a schematic diagram representing another embodiment of the invention; Figs. 5, 6 and 6a are graphs explaining the operation of the embodiment of Fig. 2; Fig. 7 is a schematic diagram of an arrangement for counting objects or events; Fig. 8 is a perspective view of a modified form of variable impedance device for use with my apparatus; Fig. 9 is a schematic diagram of an arrangement for recording affirmative and negative votes simultaneously; Fig. 10 represents an even harmonic impedance; Fig. 11 is a graph explaining the operation of the apparatus of Fig. 9; Fig. 12 is a circuit diagram of a modification of a portion of the apparatus of Fig. 2; Figs. 13, 14, and 15 are schematic diagrams of various forms of variable impedance loads to be used in voting stations; Fig. 16 is a circuit diagram explaining the use of my invention on complicated networks; and Fig. 17 is a circuit diagram of an arrangement for making the harmonic voltage level of a system more responsive to harmonic currents drawn from the system.

In order to bring out the principle of operation of my invention more clearly, an elementary form of vote-counting system will first be described.

As illustrated in Fig. 4, local voting loads 11 having normally open push button switches 12 are provided at the premises of the telephone subscribers or electric light and power customers having radio-receiving sets 10 for receiving broadcasts from a transmitter 9. The voting loads 11 are adapted to be connected to an electrical circuit 13 by the switches 12 and the electrical circuit 13 is supplied by a main generator 14, the form of which, of course, will depend upon whether the circuit 13 is a power distribution line or a telephone circuit. A suitable instrument, such as an ammeter 15 or a voltmeter 15', for example, may be provided for measuring the current drawn by the voting loads 11 or measuring the effect of current being drawn through an impedance 13'. If desired, the in-

strument 15 or 15' may be calibrated in terms of the number of voting loads connected. The local loads 11 may take the form of simple resistances. Of course, the impedances of the voting loads 11 will be made substantially equal in order that the current indicated by the ammeter 15 will provide an effect proportional to the number of push button switches 12 which have been depressed. If desired, the exact impedances of loads located at different distances from the generator 14 may be adjusted to different values to correct for voltage drop in the line 13. A vote among radio broadcast listeners is obtained by requesting all the listeners desiring to vote in a certain way to press their push button switches 12 at a predetermined signal.

Although the principal form of broadcasting at present in use is radio broadcasting, it will be understood that this method of counting or voting is not dependent upon the type of broadcasting system employed. The apparatus need not in any way be connected to the apparatus of the broadcasting system. However, if desired, the same conductors may be utilized when the vote-counting system is employed in connection with broadcast programs transmitted over telephone circuits; over power circuits, for example, by carrier currents or "wired radio"; or in connection with broadcast programs or communications transmitted over special circuits.

If ordinary resistance loads are employed, it will be necessary to differentiate between the currents normally flowing through the ammeter 15 as a result of the normal load on the circuit 13 and those produced by the voting loads 11. Counting may be accomplished by noting the increase in current at the instant when a signal to connect the loads 11 is given. When utilizing alternating current power lines as the electrical distribution network, the accuracy of the differentiation between normal current and current produced by the voting loads may be increased by making the voting loads highly reactive with inductance or capacity and utilizing at 15 a current-responsive device affected only by quadrature or reactive component currents, e. g., such as that disclosed on page 3, right-hand column, line 24 et seq., of Patent No. 2,017,703 granted to William H. Pratt.

Even greater ease of distinction between normal load currents and the currents produced by the voting loads 11 may be obtained if the arrangement is such that currents of an unusual frequency or group of frequencies are drawn by the voting loads 11 or imposed on the power system by the voting loads and only currents of a selected frequency or frequencies are measured to determine the number of votes counted. For example, a carrier-current generator 16 may be provided, which is coupled to the electrical circuit 13 in some suitable manner as by a capacitive coupling arrangement represented schematically by the condensers 17. In this case, the generator 16 will be arranged to produce currents of a frequency not normally occurring or occurring in only inconsequential amounts in the telephone or power circuits 13 and the voting loads 11 will be in the form of impedances tuned to the frequency of the carrier current generator 16.

When using the carrier current system, the vote will be measured by reading the increase in carrier current excitation, the rise in harmonic voltage or by reading the current flowing in the carrier current generator, for example, by means of the ammeter 18.

Another embodiment of the invention which avoids the expense of providing the carrier current generator 16 or tuned voting loads consists in providing voting boxes containing current-distorting impedances in connection with an alternating-current electric light and power network. At each voting station, as illustrated in Fig. 1, there is provided a voting box 19 having a flexible appliance cord 20 adapted to be plugged into the usual base receptacle 21, which, in turn, is permanently connected to conductors 13 supplying the customer with electric light and power. The voting box 19 contains an impedance 22 having a variable volt-ampere characteristic and a push button 12 arranged to connect the impedance 22 to the power circuit 13 when depressed by a broadcast listener.

My invention is not limited to the use of a particular type of impedance 22 but satisfactory results may be obtained by utilizing for this purpose a resistor composed of a material having a variable resistance ampere characteristic, for example, a material of the type disclosed in Letters Patent of the United States to Carl B. McEachron, assigned to General Electric Company, No. 1,822,742, granted September 8, 1931, for Discharge devices and resistance material. The resistance employed may be a mixture of silicon carbide and carbon with a suitable binder, or silicon carbide mixed with other conducting materials, such as tungsten, molybdenum, or the like. It will be understood, however, that any suitable material having a variable resistance ampere characteristic may be employed, preferably one in which the resistance falls with increase in current. It will be understood also that my invention is not limited to the use of variable resistance material but includes the use of any variable impedance device, such as a saturable core inductance, for example, or an electron discharge device or an ionization discharge device, or a mechanically varying impedance like a signalling buzzer.

At the substation of the electric power company supplying the circuits 13, there is also provided a vote-counting substation, as shown in Fig. 2. The vote-counting substation contains a device responsive to voltage or current variations produced by the voting loads 11 or 19. For example, in series with the secondary winding 23 of the substation power transformer for supplying the various customers' circuits 13, there may be connected a current transformer 24. The output terminals of the transformer 24 are connected to a 60-cycle choke 25 or a filter adapted to pass only alternating currents of some other frequency than 60 cycles. It will be understood that the usual 60 cycle power circuit is assumed and that, in case of a power circuit having some other frequency, the choke 25 will be arranged to block the fundamental frequency of the circuit. One or more, preferably a plurality of filters, each tuned to pass only one of various odd harmonics of the fundamental frequency other than the third or multiples of the third are connected to the output side of the choke 25. For example, I may provide a fifth harmonic filter 26, a seventh harmonic filter 27, an eleventh harmonic filter 28, and a thirteenth harmonic filter 29. Owing to the fact that there is a tendency for the third harmonic to become appreciable in certain types of power circuits, it may often be preferable to avoid using the third harmonic and its multiples in connection with the voting system.

Suitable alternating-current responsive devices are connected to the output sides of the filters. If desired, the outputs may be combined in one instrument. To this end, the output sides of the filters 26 to 29, inclusive, are connected to rectifiers 30 which may conveniently be in the form of full-wave bridge-type copper-oxide rectifiers and the direct-current sides of the rectifiers 30 are connected in parallel. The rectifiers 30 energize a direct-current instrument 31, which is calibrated to count the votes reported over the power lines 13 supplied by the substation transformer 23. It may be desirable to weight the effects of the various harmonics by inserting resistors 30a, b, c, and d in the connections of the rectifiers 30 to the circuit of the instrument 31 or by designing the filters 26—29 to accomplish the same effect. The higher harmonics are ordinarily less in value and the resistors 30a, b, c, d are so chosen as to make the effect of each harmonic about the same in the instrument 31.

Since even harmonics seldom occur on alternating-current systems, it may be helpful under certain circumstances to provide voting loads 19 especially adapted to draw even harmonic currents and to include filters passing selected even harmonics in the group energized by the 60 cycle choke 25. As will be understood by those skilled in the art, saturable reactors with permanently magnetized cores or with windings fed with direct current may be employed to draw even harmonics. A suitable impedance for drawing even harmonics is illustrated in Fig. 8. A core 38 of saturable magnetic material is mounted between the polar extremities 39 and 40 of a permanent magnet 41. A winding 42 is carried by the core 38, and the parts are so proportioned that, with rated alternating voltage applied to the winding 42, the core 38 tends to saturate or alternate half cycles of the applied voltage.

In the case of an extensive electric power system having a plurality of substations, pilot wires 32 are brought from the various vote-counting substations and connected in parallel (in case harmonic currents rather than voltages are measured) to a direct-current instrument 33 which serves as a vote totalizer since it measures the sum of the currents flowing in the substation vote counters 31 and thereby adds together the effects produced in the filter-rectifier systems of the respective vote counting substations. Although I have shown pilot wires in the form of continuations of the output circuits of rectifiers 30, it will be understood that any desired arrangement may be employed for totalizing the votes recorded in the various vote counters 31.

The manner of operation of the counting system illustrated in Figs. 1 and 2 will readily be understood from a consideration of the characteristics of the usual alternating-current power system. Such an alternating-current power system has, in addition to the fundamental frequency current, a harmonic current made up of practically all higher harmonics of the fundamental. The magnitude of each harmonic depends somewhat on which harmonic it is. For example, the various harmonics may run about as follows on a particular system, the percent of the average load current being

	Per cent
5th harmonic	1.8
7th harmonic	.51
11th harmonic	.24
13th harmonic	.16

In Fig. 3, the average load current is represented by the curve 34 and the fifth, seventh, and eleventh harmonics, respectively, are represented by the curves 35, 36, and 37, respectively. It will be observed that the curve 34 is substantially sinusoidal. The amplitudes of the curves 35, 36, and 37 have been exaggerated for the sake of clarity in the drawings. On a given system, the harmonic currents are fairly constant over a considerable period of time and are substantially independent of load changes as they arise mainly from the transformer and other pieces of apparatus which are more or less permanently connected to the system. Of particular importance is the fact that the harmonic current on the system is relatively small and fairly constant although the fundamental frequency current may fluctuate within wide limits as the system load varies.

Since the resistance of the resistors 22 decrease with an increase in current, the current therein tends to increase more rapidly than the voltage applied. As a result, even with a sinusoidal applied voltage, the current is distorted in wave shape and various harmonics are introduced in the load current.

The reason for the distortion in wave shape will be apparent upon consideration of the nature of the material composing the resistor 22. As explained in the McEachron Patent No. 1,822,742, hereinbefore mentioned, by suitable variation in composition and manufacturing procedure, certain resistance-ampere characteristics may be obtained. In the example given on page 4, line 81, et seq., of the McEachron patent, a resistance material is obtained satisfying the equation

$$RI^3=C$$

where

R is the resistance in ohms

I is the current in amperes

C is a constant

From Ohm's law

$$R = \frac{E}{I}$$

where E is the E. M. F. in volts.

The first equation may, therefore, be written:

$$I = KE^{\frac{1}{1-35}} = KE^{3.7}$$

where K is another constant.

The last equation is represented graphically in Fig. 5. In Fig. 6, the curve E represents a sinusoidal voltage wave. By utilizing the curve of Fig. 5 to plot a current wave corresponding to the voltage wave E of Fig. 6, one obtains the highly distorted peaked symmetrical current wave I representing currents flowing in the resistor 22. As is well known, such a wave may be resolved into a sine wave of fundamental frequency and various sine waves of relatively large amplitude with odd harmonic frequencies. Such a wave shape, therefore, characterizes an alternating current wave having large components of odd harmonic frequencies. Figure 6a illustrates some of the harmonic currents of which the current wave I of Figure 6 is composed. There may be a triple frequency current 34' and there may be various other harmonic currents 70 such as the 5th harmonic 35, the 7th harmonic 36, and the 11th harmonic 37, depending in magnitude and phase relationship upon the type and design of current distorting impedances employed. However, for the sake of clarity and

owing to space limitations the curves of Fig. 6a are not shown to scale.

In case saturable reactors or inductances are employed as the voting loads 19 of Fig. 1 highly distorted waves containing accentuated harmonics will be produced somewhat similar in nature to those produced by using the variable resistance material just described. During each half-cycle of the alternating current the core of a saturable core inductance will become increasingly saturated decreasing the back E. M. F. and giving rise to a peaked current wave somewhat like that of Fig. 6.

As the normal harmonic load current in the system is relatively small and fairly constant, it will be seen that relatively small harmonic current need be drawn by the voting boxes 19 or imposed in the system by the voting boxes in order to obtain vote-indicating currents which are of appreciable value in comparison with the normal harmonic currents. The number of voting boxes 19 connected to the system by means of push buttons 12 in response to a request for a vote may be determined by measuring the increase in value of any harmonic of the fundamental frequency of the power circuit. By selecting the fifth, seventh, eleventh, and thirteenth harmonics and measuring the sum of these or weighting them according to their usual relative values, as illustrated in Fig. 2, greater sensitivity is obtained and the definiteness and the accuracy of the count are also increased.

It will be understood that a vote on any question may be obtained from broadcast listeners by asking all listeners in favor of a given proposition to press their push buttons 12 upon a given signal, then asking all listeners in favor of a second proposition to press their push buttons upon a second signal, and so on, if there are more than two possible alternative propositions until all have been voted upon. The sum of the votes cast for all propositions may be used as an indication of the total number of broadcast listeners. This result may, of course, be checked by asking all listeners to press their push buttons at once to obtain a count of the listeners. Ordinarily, only one voting box will be supplied to the owner of each radio receiver so that the results will be representative of the desires of the owners of the radio receivers or their empowered representatives.

While I have described my invention in connection with voting, it will be understood that my invention is not limited to counting votes and includes counting not only responses from persons but also counting objects, simultaneously occurring events, or actions of a machine and the like. I have used the phrase "counting units" in the claims to refer to any of these counting operations. If a central station company desires to count the number of electric range elements 43 connected to its system at any one time, it may connect a variable resistance device 22 in parallel with each of the electric range elements 43, as shown in Fig. 7, so that whenever a range element is turned on, a distorted current is drawn from the system 13. The sum of harmonics is measured by means of the filter circuit system with the instrument 31, as in Fig. 3, to determine the number of variable resistance devices 22 and, consequently, the number of range elements 43 connected to the system. The result is thus unaffected by the size of any other load 44 which may be connected to the system 13.

In Fig. 9, I have illustrated an arrangement

for counting the affirmative and negative votes simultaneously or for counting two different units. Each voting station includes a double voting box 45 with "yes" and "no" push buttons 46 and 47. Impedances 48 and 49, having two different characteristics or drawing two different types of current or two different frequencies or groups of frequencies, are provided in association with the push buttons 46 and 47, respectively. For example, the impedance 48 may be one of the type disclosed in Fig. 1, distorting the current to produce odd harmonics, and the impedance 49 may be one of the type disclosed in Fig. 10, distorting the current to produce even harmonics. Instruments are provided at the vote counting station for independently measuring even harmonics and measuring odd harmonics.

The impedance 49 is somewhat similar to that shown in Fig. 8 but has the center leg of the magnetic core 38 omitted and has its winding split into two parts, 50 and 51, on the outer legs so wound that they tend to produce flux in opposite directions in the core 38' but act together with respect to the magnet 41. In this way, the even harmonic impedance is accentuated as the winding parts 50 and 51 both act upon a saturated core during one half cycle and upon an unsaturated core during the other half cycle of the alternating-current wave. Likewise, the fundamental and odd harmonic impedance is made substantially zero as the winding parts act in opposition so that odd harmonic currents are not introduced into the system 13 by the impedance 49.

As the impedance 49 is an unsymmetrically saturated reactor, it has unsymmetrical impedance and current waves, indicative of the presence of even harmonics. The action of the impedance 49 in introducing even harmonic currents and avoiding odd harmonic currents is shown in Fig. 11. The curve 53 represents a true sine wave, and curve 54 represents the current which would be drawn by one part 50, alone, of a direct-current saturated reactor connected across an alternating-current line. The arrow 55 represents the direction of the unidirectional magnetomotive force of the permanent magnet 41. Since the alternating current tends to increase the saturation of the core 38' during positive half cycles, the induced or counter electromotive force and the impedance of the coil 50 necessarily become less the greater the current. Likewise, during negative half cycles, the alternating current tends to decrease the saturation of the core 38' and the induced or counter electromotive force and the impedance of the coil become greater the greater the current. Since the impedance varies in this way whenever the applied voltage is substantially sinusoidal, it is only natural that the current wave 54 should become more peaked than a true sine wave during positive half cycles and that it should become flatter than a true sine wave during negative half cycles. It can be shown that such a wave may be resolved into a fundamental frequency wave and a plurality of odd and even harmonics of which only the fifth, 56, and the second, 57, are shown, by way of example, to avoid confusion in the drawing. Connecting the winding parts 50 and 51 in opposition will eliminate the fundamental and odd harmonic components from the impedance of the device 49 since the odd harmonics 56 are 180 degrees out of phase during positive and negative half cycles of

the reference wave 53, as seen from Fig. 11. The even harmonics 57, however, have the same phase position during positive and negative half cycles and, therefore, connecting the winding parts 50 and 51 in opposition merely cumulates the even harmonics.

In the arrangement of Fig. 9, I provide, at the vote-counting station, the apparatus shown in Fig. 2 for measuring the odd harmonics, and also corresponding apparatus for measuring the even harmonics. The filters 26', 27', 28', and 29' are added, which allow only the 2nd, 4th, 8th, and 16th harmonics, respectively, to pass. These harmonics are rectified by the rectifiers 30' and measured by the instrument 31'. If desired, an additional instrument 31a of the ratio type may be connected with its windings in the circuits of the instruments 31 and 31' in order to indicate the relative strengths of the "yes" and "no" votes. The switches 83 and 84 are normally closed in order that the combined and if desired weighted effects of the various odd and even harmonics, respectively, may be measured as previously explained. However, in case it should be desired to utilize only one odd harmonic, such as the 13th, as originally explained, or one even harmonic, such as the 16th, the switches 83 or 84 may be left open. It will be understood, however, that the switches 83 and 84 are shown only for purposes of illustration and that my invention is not limited to any particular switch arrangement or to an interchangeable arrangement. As previously explained, in cases where it is desired to do so, the apparatus may be permanently constructed such as to utilize only one of the harmonics.

In the installations employing voting boxes producing even harmonics, it is important to have all the voting boxes plugged into the electric distribution circuit with the same polarity, that is, the same relationships between the poles of the magnets 41 (Fig. 8) and the connections of the windings 42 to the conductors 13 (Fig. 1) in order that voting currents drawn by different voting boxes will not cancel. The proper polarity may be insured after it has been initially determined at a given outlet by providing the base receptacle 21 and the corresponding plug with dissimilarly shaped or placed contact blades 58 and 59 so that the cord 20 will always be plugged in the same way, a plug and receptacle arrangement which is now standard in many communities.

Examples of additional forms of harmonic generators for use as voting loads in place of the variable resistance elements 22 of Fig. 1 are illustrated in Figs. 13, 14, and 15. Fig. 13 illustrates the use of an ionization discharge device. A neon glow tube 60 alone may be used, or the tube 60 may have a condenser 61 connected in series with it to make the harmonics more pronounced.

Fig. 14 illustrates a harmonic generator controlled by electronic discharge. A gaseous or vapor discharge device 62 is provided having an anode 63, a cathode 64, a control electrode 65, and, if the cathode 64 is of the indirectly heated type, a filamentary heater 66, energized by a source of current not shown. A resistor 67 is connected in the anode lead. In order that the discharge device 62 will conduct only during portions of the positive voltage half cycles and have a very irregular current wave shape, a phase-splitting circuit is provided for the control electrode. The phase-splitting circuit may consist

of a condenser 68 connected between the positive terminal of the resistor 67 and the control electrode 65, and a resistor 69 connected between the control electrode 65 and the cathode 64.

The unit of Fig. 15 generates harmonic current by producing current interruptions mechanically. It consists of a buzzer having an electromagnet 70, an armature 71 adapted to be attracted by the magnet 70 but biased away from the magnet 70 by a spring 72, and a pair of contacts 73 for breaking the circuit through the winding 70 whenever the armature 71 is attracted.

In Fig. 12, I have shown a modified arrangement for combining and weighing the outputs of the rectifiers 30, shown in Fig. 2. In the arrangement of Fig. 12, the rectifiers 30 are connected in their output sides to potentiometers 30a', 30b', 30c', and 30d'. The taps of the potentiometers are set to collect voltages having the desired ratios to the output voltages of the rectifiers 30 and the potentiometer output voltages act in series on the voltmeter 31'.

The readings of the instruments 31 and 33 in Fig. 2 and of the instrument 31' in Fig. 12 are indicative of the magnitudes of the harmonic currents in the systems or weighted combinations of these harmonic currents. However, it will be apparent that my invention is not limited to actually measuring the current or using measuring arrangements corresponding to ammeters but includes determining the variation in any characteristics of the system resulting from variations in the harmonic currents. For example, the appearance of harmonic currents will cause a variation in the harmonic voltage level of the electric distribution system and, in the appended claims, I aim to include systems with voltage-measuring apparatus by the words "means responsive to current," and I aim to include measuring harmonic voltages by the conception "measuring the effect of harmonic currents."

In the case of very complicated grid or network systems, such as that in New York city where each load point may receive power from many different sources by various conductors connected to different supply points, it may be very difficult to measure the harmonic current without resorting to the use of a very large number of current-measuring devices and totalizing their indications. However, in such a case, the harmonic voltage may readily be measured on a suitable point of the system.

In Fig. 16 is shown a portion of a low-tension network consisting of portions of conductors 74 to 79 which are connected together at the points where they cross and are connected at the ends and at intermediate points (not shown) to sources of low-tension current. The usual light commercial and domestic power and lighting loads (not shown) are tapped off the conductors 74 to 79 all along their lengths, and voting boxes (not shown) such as the voting boxes 19 of Fig. 1 are also tapped off the conductors 74 to 79 whenever a radio receiver is in use. A vote-counting station is connected to the network at the point 80 and is quite similar to the apparatus of Fig. 2, consisting of a 60-cycle choke 25' connected directly across the line at 80 and the harmonic-passing filters 26, 27, 28, and 29 supplying the instrument 33 through the rectifiers 30.

Some impedance is inherent in the conductors 74 to 79 of the network and, when the harmonic currents are drawn through portions of this impedance, the harmonic voltage drops in the im-

pedance will give rise to harmonic voltages which are transmitted over the conductors to the point 80 and measured by the instrument 33. Owing to the wide diversification and great extent of such a network, any inequality in system impedance in different portions of the system will be balanced out and the instrument 33 may be calibrated to read in terms of the number of voting boxes connected to the network in response to a request for a vote by radio listeners.

The measurement of harmonic voltage level is particularly advantageous in the case of complicated networks but may be carried out also in the case of simple branching or tree-type networks in which all the conductors are fed from a small number of lines or only a single line. In such a case, if the inherent impedance of the system is very low, a linear impedance may be inserted, such as a resistor 81, or the harmonic voltage may be accentuated by connecting in series with the line a filter 82 tuned to one of the harmonics measured by the instrument 33 or tuned broadly to the 5, 7, 11, and 13 harmonics e. g., so as to introduce a high impedance in the line for such harmonic or harmonics and cause a wide fluctuation in harmonic voltage when the voting boxes are connected to the system.

I have herein shown and particularly described certain embodiments of my invention and certain methods of operation embraced therein for the purpose of explaining its principle and showing its application but it will be obvious to those skilled in the art that many modifications and variations are possible and I aim, therefore, to cover all such modifications and variations as fall within the scope of my invention which is defined in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A method of obtaining a count which comprises causing even harmonic currents substantially equal in value to be drawn from points in an electrical distribution circuit equal in number to the units to be counted and measuring the even harmonic current drawn from a power source supplying the electric distribution circuit, said total harmonic current being dependent upon the number of points from which said substantially equal harmonic currents are drawn.

2. A method of counting responses from persons served by an electrical conductor system which comprises having each person desiring to make a response draw from the system a current having an even harmonic frequency different from any frequency at which currents normally flow in substantial amounts and measuring at such even harmonic frequency the change in harmonic voltage level of the conductor system.

3. Counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of impedances adapted to be connected to the system when a count is to be made and to impose on said system even harmonic alternating current, means for connecting as many of said impedances to said conductor system as there are units to be counted, and means responsive to the change in magnitude of even harmonic current drawn from the system.

4. Counting apparatus comprising, in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of current-distorting impedances adapted to produce fifth, seventh, eleventh and

thirteenth harmonics in an appreciable amount relative to fundamental frequencies, means for connecting as many of said impedances to said conductor system as there are units to be counted, and means responsive to the change in magnitude of currents drawn from said system at frequencies which are the fifth, seventh, eleventh, and thirteenth harmonics of the fundamental frequency of the source.

5. Counting apparatus comprising in combination with an electric conductor system supplied by an alternating-current electric source, a plurality of non-inductive resistors of a character adapted to impose on said system in appreciable amount alternating current having a frequency higher than the frequency of said electric source, means for connecting as many of said resistors to said conductor system as there are units to be counted, and means responsive to the change in magnitude of current imposed on the system by said resistors at said higher frequency.

6. Counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of resistance devices having the characteristic of decreasing in resistance with increase in applied voltage, means for connecting as many of said resistance devices to said conductor system as there are units to be counted, and means responsive to the change in magnitude of current drawn from the system by said resistance devices at a higher frequency than the fundamental frequency of the source.

7. Counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of resistors including silicon carbide and carbon in their composition, means for connecting as many of said resistors to said conductor system as there are units to be counted, and means responsive to the change in magnitude of current drawn from the system by said resistors at a higher frequency than the fundamental frequency of the source.

8. Counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of unsymmetrically saturable reactors adapted to be connected to the system when a count is to be made, means for connecting as many of said reactors to said conductor system as there are units to be counted, and means responsive to the change in magnitude of current drawn from the system at a frequency which is an even harmonic of the frequency of the source.

9. Selective counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of impedances adapted to impose on said system alternating current having a given frequency higher than the frequency of said electric source, a plurality of impedances adapted to impose on said system alternating current having a frequency higher than the frequency of said electric source and different from said first mentioned higher frequency, means for connecting as many of said first mentioned impedances to said conductor system as there are units of one type to be counted, means for connecting as many of said second mentioned impedances to said conductor system as there are units of a second type to be counted, means selectively responsive to the change in magnitude of current of said first mentioned higher frequency imposed on the system, means selectively

responsive to the change in magnitude of current of said second mentioned higher frequency imposed on the system and means for comparing the effects of said responsive means.

- 5 10. Selective counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of impedances adapted to impose on said system alternating current having
10 a frequency which is an odd harmonic of the frequency of said electric source, a plurality of impedances adapted to impose on said system alternating current having a frequency which is an even harmonic of the frequency of said
15 electric source, means for connecting as many of said first mentioned impedances to said conductor system as there are units of one type to be counted, means for connecting as many of said second mentioned impedances to said con-
20 ductor system as there are units of the second type to be counted, means selectively responsive to the change in magnitude of current of said odd harmonic frequency imposed on the system, means selectively responsive to the change in
25 magnitude of current of said even harmonic frequency imposed on the system and means for comparing the effects of said responsive means.

11. Selective counting apparatus comprising in combination with an electrical conductor system
30 supplied by an alternating-current electric source, a plurality of variable impedances with symmetrical characteristic wave shapes, a plurality of variable impedances with unsymmetrical characteristic wave shapes, means for connecting as
35 many of said first mentioned impedances to said conductor system as there are units of one type to be counted, means for connecting as many of said second mentioned impedances to said conductor system as there are units of a second
40 type to be counted, means selectively responsive to the change in magnitude of the current imposed on said system with a frequency which is an odd harmonic of the frequency of said source, means responsive to the change in magnitude
45 of current imposed on the system with a frequency which is an even harmonic of the frequency of said source and means for comparing the effects of said responsive means.

12. Counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of impedances adapted to impose on said system alternating currents having frequencies higher than the frequency of said electric

source, means for connecting as many of said impedances to said conductor system as there are units to be counted, a plurality of filtering devices connected to said electric conductor system, each adapted to pass only a frequency higher than the fundamental frequency of said alternating-current source, the selected frequencies of said filtering devices being different, a current-responsive device connected to said filtering devices, and means for increasing the proportionate effect on said current-responsive device of the frequencies at which weaker currents are drawn.

13. Counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of impedances adapted to impose on said system alternating currents having frequencies higher than the frequency of said electric source, means for connecting as many of said
20 impedances to said conductor system as there are units to be counted, a plurality of filtering devices connected to said electric conductor system, each having output terminals and being adapted to pass only a frequency higher than
25 the fundamental frequency of said alternating-current electric source, the selected frequencies of said filtering devices being different, a plurality of rectifiers, each connected to the output terminals of one of said filtering devices, and a
30 direct-current responsive instrument connected to said rectifiers.

14. Counting apparatus comprising in combination with an electrical conductor system supplied by an alternating-current electric source, a plurality of impedances adapted to impose on said system alternating currents having frequencies higher than the frequency of said electric source, means for connecting as many of said
40 impedances to said conductor system as there are units to be counted, a plurality of filtering devices connected to said electric conductor system, each filtering device having output terminals and being adapted to pass only a frequency higher than the fundamental frequency of said
45 alternating-current electric source, the selected frequencies of said filtering devices being different, a plurality of rectifiers, each connected to the output terminals of one of said filtering devices, a direct-current responsive instrument connected to said rectifiers, and means for increasing the proportionate effect of the frequencies at which the currents are weaker.

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