

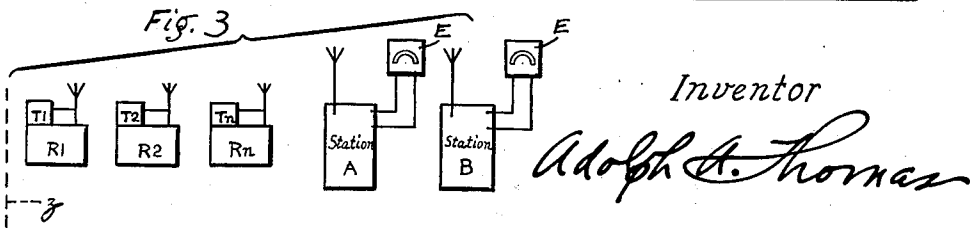
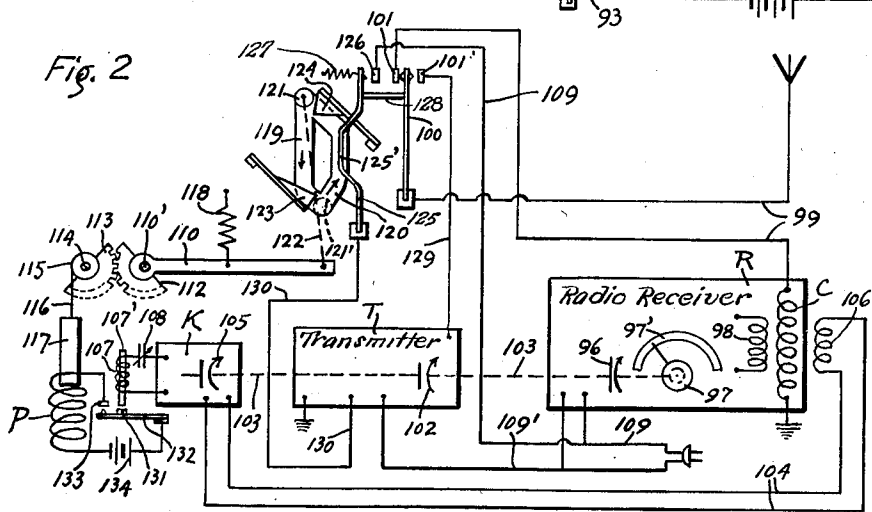
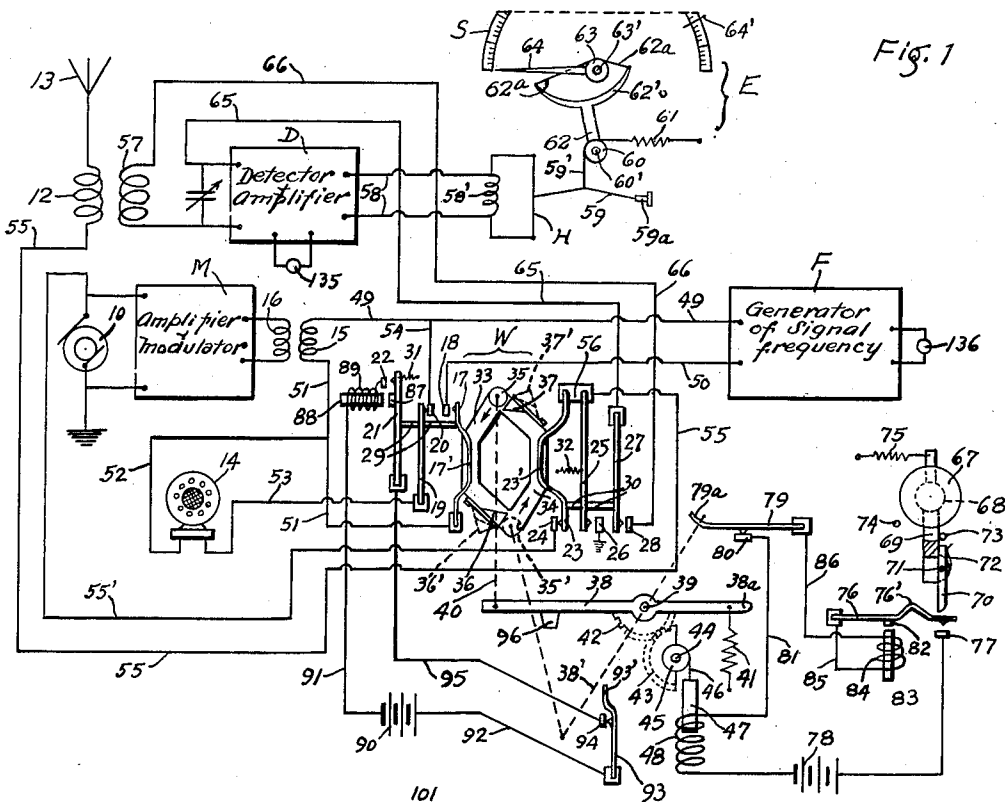
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A. A. THOMAS

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RADIO SYSTEM

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RADIO SYSTEM

Adolph A. Thomas, New York, N. Y., assignor to
Radio Corporation of America, a corporation of
Delaware

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2 Claims. (Cl. 235—52)

My invention relates to the art of radio broadcasting, and its object is to provide means for ascertaining the number of receivers tuned in on a given program. In this way the commercial sponsor of a broadcast program will have definite information on the public's attitude toward his program, and that, from the sponsor's viewpoint, is the most important thing about any piece of advertising broadcast. Herein lies the practical importance of my invention.

As everybody knows, radio advertising is highly expensive and its value to the advertiser depends upon the number of listeners-in. That is why station announcers so frequently urge their unseen audience to send in their opinions and suggestions concerning the program. Sometimes an advertiser offers a little gift to those who will write for it. However, it is a known fact that only a negligible percentage of listeners-in take the trouble to respond by mail or telephone, so that the number of communications received by a station in reference to a given broadcast furnishes no reliable basis for ascertaining the size of the invisible audience that heard the program.

It is the purpose of this invention to furnish a radio advertiser with accurate information regarding the number of receivers tuned in on his program, so that he can determine how well it is going with the public and to improve it if he finds that his audience is dwindling. In carrying out the principles of my invention, I provide each radio receiver with a device capable of transmitting a certain signal adapted to be received only by the station for which the receiver is in tune. These transmitting devices of the receivers are controlled entirely by the operator at the tuned-in station and without the knowledge of the listeners-in, so that no interference with the regular broadcast is possible. Detector mechanism at the broadcasting station receives a certain amount of electric energy from each operating transmitter, and the total energy thus received is indicated by a suitable instrument, whereby the approximate number of receivers tuned in on a given program can be ascertained. As the quality of a radio program is judged by the size of the audience, I may call my invention a radio program testing system.

The construction and operation of my invention will be understood from a description of the accompanying drawing, in which

Fig. 1 shows diagrammatically the apparatus at a broadcasting station for sending out certain signals to tuned-in receivers and receiving the response signals from such receivers;

Fig. 2 is a diagrammatic illustration of the mechanism associated with a radio receiver for receiving the special signal sent out by a tuned-in station and for transmitting the response signal to that station; and

Fig. 3 indicates in a diagrammatic way a plurality of broadcasting stations and a plurality of receivers, these stations and receivers being equipped with the special transmitting and receiving apparatus shown in Figs. 1 and 2.

Before describing the drawing I want to explain that I have made it as simple as possible for clearness. Such apparatus as is well known I have indicated merely in schematic outline, and only such parts of standard outfits used in broadcasting stations and radio receivers appear in the drawing as are necessary to describe my invention.

The various pieces of apparatus illustrated in Fig. 1 are parts of the operative equipment of a broadcasting station employing my invention and are placed in suitable locations. The transmitting antenna circuit is represented by a high-frequency generator 10, a tuning coil 12, an aerial 13, and combined amplifying and modulating mechanism M. The circuit of the broadcasting microphone 14 includes a coil 15 arranged in transformer relation to the modulating input coil 16 of mechanism AM, whereby the electric impulses produced by the microphone are imposed in amplified form upon the carrier frequency transmitted by the antenna 13. The above mentioned parts are standard equipment requiring no detailed description of structure and operation.

Switch mechanism W, conveniently located, comprises a plurality of switches represented by the pairs of contact members 17—18, 19—20, 21—22, 23—24, 25—26 and 27—28. The first member of each pair is a movable arm supported at one end, and the other member is a fixed contact arranged to be engaged by the free end of the arm for closing a circuit. The three switch arms 17—19—21 are mechanically connected by an insulating cross rod or pin 29, so that they always move in unison. Likewise, the three switch arms 23—25—27 are joined by an insulating connection 30 for simultaneous operation. The normal positions of the six switch arms are such that the four switches 17—18, 21—22, 25—26 and 27—28 are normally open, while the other two switches 19—20 and 23—24 are normally closed. The movable switch arms may be spring blades held in normal position by inherent tension, or I may use separate restoring springs 31 and 32, the first being connected to switch arm

21 and the other to switch arm 25. The contracting spring 31 normally holds the arm 19 against the fixed contact 20 and keeps the two connected arms 17 and 21 away from their respective contacts 18 and 22. The other coil spring 32 normally presses the switch arm 23 against the fixed contact 24, while the associated arms 25 and 27 are kept away from their respective contacts 26 and 28. The fixed contacts 20 and 24 also constitute stops for limiting the movement of the switch arms under the action of springs 31 and 32.

The various switches of mechanism W are mounted on a suitable insulating panel (not shown) which has a two-way groove consisting of a down passage 33 and an up or return passage 34. A switch-actuating roller 35 is arranged to operate in groove 33—34, the down movement of the roller being in passage 33 and the up movement in passage 34. This two-way travel of roller 35 is assured by spring latches 36 and 37, which normally extend into the end portions of passages 33 and 34 respectively, so that these latches are cammed out of the way by the roller at the end of its downward and upward movement. The cammed or inoperative positions of the latches 36 and 37 are indicated by the dotted outlines 36' and 37'. When the roller 35 is in normal position at the top of the groove, the latch 37 compels the roller to travel down through passage 33 till it reaches its lowest position 35' after camming the latch 36 out of the way. This latch now closes the passage 33 and compels the roller to travel up through the passage 34 till it reaches its normal position at the top of the groove after camming the latch 37 aside.

The roller 35 is actuated down and up the two-way groove 33—34 by a lever 38 pivoted at 39 intermediate its ends. One end of lever 38 is connected to roller 35 by a link 40, which is indicated by a dotted line so as not to obscure the drawing, it being understood that this line represents any practical connection between roller and lever. The top and bottom ends of groove 33—34 form stops for roller 35 and lever 38, which is normally held in uppermost position by a contracting coil spring 41. The lever 38 can be operated by hand like a pivoted switch arm, but I prefer to operate it electrically so as to insure uniformity of time at every operation for a reason that will become apparent later on. A half-gear 42 fixed on lever 38 around its pivot meshes with a half-gear 43 mounted on shaft 44, which also carries a pulley 45 connected by a cord or chain 46 to a magnetic core or plunger 47 of a solenoid coil 48. When this coil is energized, the plunger 47 is pulled down and rocks the lever 38 to position 38', whereby the roller 35 is carried down the angular passage 33 to position 35'. When the coil 48 is de-energized, the tensioned spring 41 returns the lever 38 to normal position and the roller 35 is carried up the angular passage 34 to the top of the groove.

The broadcasting station has a signal generator F of suitable construction adapted to produce a special signal of predetermined character or frequency. The signal generator F may be an alternator, a vacuum tube oscillator, an interrupter mechanism, or any other piece of apparatus designed to produce electric impulses of certain frequency or any kind of electric signal of such character as to be outside the regular broadcasting range. For the purposes of this description we may assume that the signal produced by generator F consists of electric oscilla-

tions of a specific frequency which does not interfere with the broadcasting operations of any station and which is adapted to control certain electric devices in radio receivers, as will be fully explained in connection with Fig. 2. So for the present I need only say that the signal frequency of generator F is impressed at the proper time upon the input coil 16 of the amplifier-modulator M. The output leads 49—50 of generator F are connected, respectively, to one side of coil 15 and to contact 18, which is normally open, as previously mentioned, so that the signal generator is normally in an inoperative condition and has no effect on the broadcasting of a program. The other side of coil 15 is connected by a conductor 51 to switch arm 17 and also to one side of the microphone 14 by a wire 52, which goes to conductor 51. The other side of microphone 14 is connected by a wire 53 to switch arm 19, which is normally closed, and the contact 20 is connected by a wire 54 to lead 49. The conductor 55 of the antenna circuit goes to the two switch arms 23 and 25, which are electrically connected at their supported ends by a metal piece 56. The conductor 55' of the antenna circuit goes to contact 23, and contact 26 is grounded so as to connect with the grounded end of the antenna circuit.

The antenna coil 12 has inductively associated therewith a coil 57, which is part of the tuned input circuit of an electronic detector-amplifier D. As will become clear from the description of Fig. 2, the function of mechanism D is to receive (and amplify if necessary) a certain response signal transmitted by every receiver in tune with the broadcasting station of Fig. 1. The output circuit 58 of the receiving mechanism D is energized in proportion to the total electric energy received by the input coil 57, and the resultant current in the output circuit operates a suitable measuring instrument indicated as a whole by E. As we are here dealing with high-frequency currents, the electric operative element of instrument E should be practically free of self-induction, and one type of such an instrument is a hot-wire ammeter, which I have shown diagrammatically in its essential parts. A fine wire H (usually of platinum, platinoid, or copper) is supported at its ends in taut condition and connected in the output circuit 58. The conductor H is connected at or near its center to one end of a strong thread or wire 59, which is secured at the other end to an adjustable support 59a. The filar member 59 is connected at the center to another thread or wire 59', which passes once or twice around a pulley 60 fixed on a rotary spindle 60'. The end of the filar element 59' is connected to a contracting coil spring 61, which holds the electric wire H and the filar connections 59—59' always taut. An arm 62 fixed on the spindle 60' terminates in a yoke 62' which carries a thin wire or strong thread 62a wound once or twice around a pulley 63 fixed on a spindle or arbor 63'. The filar connections 59' and 62a are always taut enough to operate their respective pulleys 60 and 63. A pointer 64 fixed on arbor 63' moves over a scale S marked off to indicate the numbers of tuned-in radio receivers or having equivalent notations. The adjustable support 59a for wire 59 may be a thumbscrew or the like for adjusting the pointer 64 to normal zero position.

The operation of measuring instrument E is like this: The electric energy passing through the output circuit 58 heats the tensioned wire

H, which thereby expands and causes the spring 61 to rotate the arm 62, and this rotates the pointer 64. Due to the amplifying connections between the pulley shaft 60' and the pointer shaft 63', the small movements of shaft 60' are transmitted to the pointer 64 in greatly increased ratio, so that a large indicating scale is possible. I have not attempted to show the transmission connections between wire H and pointer 64 with mathematical accuracy, as that detail lies within the skill of the instrument maker. It will be clear that the angle through which the pointer 64 is turned depends upon the elongation of wire H due to the heating effect of the current passing through it, and that heating effect is strictly proportional to the quantity or ampere value of the current. In other words, the movement of pointer 64 is governed by the amount of electric energy received in coil 57, and the amount of that energy, as will appear later, represents the number of receivers in tune for this particular station at a given moment.

The controlling wire H may be connected in series with the output conductors 58 to receive the full current flow, or it may be shunted across an inductance 58' of known value so that only a certain fraction of the total current traverses the wire H. The scale S is, of course, calibrated accordingly. The moving parts of instrument E can be made very light, so as to have minimum inertia and friction, and as the wire H has practically no self-induction, this instrument is well adapted for measuring high-frequency currents with accuracy. In some instances, depending upon the sensitivity of instrument E, it may not be necessary to interpose a current amplifier between the input coil 57 and the output circuit 58 of the detector mechanism D. The filar connections 59, 59' and 62a should be of a material substantially unaffected by temperature and atmospheric conditions. If only slight indications of pointer 64 are required (as distinguished from recording), the scale S may have a movable index member 64' pushed along by the tip of the pointer and adapted to remain in indicating position when the pointer returns to zero. This gives the observer time to read the scale at his convenience, even if the pointer is actuated only for a moment. On the other hand, the pointer 64 may have a recording tip for making marks on a properly graduated sheet or cylinder operated by clockwork, as is usual in recording instruments of various types. It is to be understood that, in the broader aspect of my invention, the instrument E represents any practical device operated or controlled by the amount of electric energy received in coil 57 at a given time and indicating or recording the equivalent of said energy in terms of the total number of receivers tuned in at that time.

The tuned input circuit of detector D includes two conductors 65-66, which are connected to the normally open switch members 27-28, so that this mechanism is normally in an inoperative condition and does not interfere with the broadcasting operation of the station. The movable switch arm 17 is shaped to have a central portion 17' projecting across the down passage 33, and the opposite switch arm 23 has a similar portion 23' projecting across the return passage 34. Consequently, the cam section 17' is engaged by roller 35 in its down movement, and when the roller moves up it engages the cam section 23'. The result is that during the down travel of roller 35 the normally open switches

17-18 and 21-22 are closed and the normally closed switch 19-20 is opened. As the roller 35 moves up through passage 34, it opens the normally closed switch 23-24 and closes the normally open switches 25-26 and 27-28. It is desirable to time the closed period of switch 17-18 which controls the signal generator F, and for that purpose I provide means for automatically holding the switch closed a predetermined period regardless of the length of time that the roller 35 engages the cam section 17' and independently of the manual control of coil 48. A simple arrangement for accomplishing that result comprises the following mechanism:

A rotary knob 67 (which represents any suitable finger piece) is mounted on a shaft 68 on which is fixed an arm 69 carrying a pivoted pawl 70. This pawl is pivoted at 71 to arm 69 and a light spring 72 normally holds the upper end of the pawl against the side of the arm. When the knob 67 is turned clockwise, the pawl 70 forms a rigid extension of arm 69, but during the return movement of the knob, the pawl is free to swing clockwise about its pivot 71. The rotary movements of knob 67 are limited by the fixed stops 73-74, and a contracting coil spring 75 normally holds the arm 69 against the stop 73. This spring also returns the knob to normal position when manually released. A switch arm 76 is normally held away from its contact 77 either by inherent tension or by a separate spring. A cam or hump 76' on switch arm 76 is in the path of pawl 70, so that the switch 76-77 is closed when the knob 67 is turned clockwise. During the return of knob 67, the end of pawl 70 rides idly over the hump 76' because the pawl is free to swing clockwise about its pivot 71.

For convenience of illustration I have shown a separate battery 78 as the source of current for the solenoid coil 48, but in actual practice this coil will be connected to the regular feed mains of the station. One side of battery 78 goes to coil 48 and the other side to switch contact 77. A movable switch arm 79 (which may be a spring finger) is normally in circuit-closing position against a fixed contact 80, which is connected by wire 81 to coil 48. The switch arm 76 carries an armature 82 arranged to be drawn to the fixed magnetic core 83 of coil 84, which is connected by wire 85 to switch arm 76 and by wire 86 to switch arm 79. According to these connections, the coils 48 and 84 are in series with the series switches 76-77 and 79-80. As the switch 76-77 is normally open, the coils 48 and 84 remain inert even though the switch 79-80 is closed. Therefore, when the knob 67 is turned right, the switch 76-77 is closed and the coils 48 and 84 are energized. As previously explained, the energized coil 48 operates the lever 38 to move the roller 35 down the passage 33, and the energized coil 84 holds the switch arm 76 in closed position independently of pawl 70. Consequently, the switch knob 67 can be released instantly after its operation, for the switch arm 76 will be held closed to keep the solenoid coil 48 energized.

The switch arm 21 carries an armature 87 arranged to be attracted by the magnetic core 88 of coil 89, which is in the circuit of battery 90, shown for convenience as a separate source of current. It will be understood that in actual practice the coil 89, like the coil 48, will be connected to the usual power system of the station. A conductor 91 connects one side of battery 90 to one side of coil 89, the other side of which goes to the switch contact 22. The other side

of battery 90 is connected by conductor 92 to a movable switch arm 93, which is normally held (as by inherent tension) against a fixed contact 94. A wire 95 connects the contact 94 with the movable switch arm 21. Since the two switches 21—22 and 93—94 are in series with coil 89, the latter remains deenergized as long as either switch is open. When the switch arm 21 is closed by the roller 35 engaging the cam section 17' of arm 17, the coil 89 is instantly energized and holds the three connected switch arms 17—19—21 in actuated position even after the roller is out of engagement with the cam section 17'.

The de-energizing of the electromagnetic coils 48, 84 and 89 is done automatically when the lever 38 reaches the position 38'—that is, when the roller 35 is in its lowest position 35' and is ready to return through passage 34. The lever 38 carries an insulating lug or projection 96 arranged to strike the free end 93' of switch arm 93 away from contact 94 when the lever 38 is in actuated position 38'. The opening of switch 93—94 de-energizes the coil 89, whereupon the three switch arms 17—19—21 instantly return to normal position. The cam-shaped end 19a of switch arm 19 is in the path of the end 38a of lever 38, which therefore opens the switch 79—80 simultaneously with switch 93—94. It is clear, then, that the switch 17—18 is held closed and the switch 19—20 held open for a predetermined period of time which is uniform in all repeated operations of the switch mechanism without regard to the manual release of switch knob 67. That is to say, whether this knob is released by the operator before or after the roller 35 reaches the position 35', the switches 17—18 and 19—20 remain closed and open, respectively, for the same uniform interval of time. This interval can be regulated by causing the lever 38 to travel downward at a predetermined rate of speed. Although the action of coil 48 is sudden, a suitable retarding arrangement (such as the well known dash-pot) can be attached to lever 38 to slow down its movements under the influence of coil 48 and spring 41. This will be understood without further description or illustration. The opening of switch 79—80 de-energizes the two coils 48 and 84, whereupon the spring 41 actuates the lever 38 back to normal position, thereby carrying the roller 35 up through passage 34, and at the same time the switch arm 76 moves to open position. The automatic reclosing of switches 79—80 and 93—94 by the return movement of lever 38 has no effect on coils 48, 84 and 89, because the switch arms 76 and 21 are open. I will now describe the operation of the system shown in Fig. 1. The circuit of the broadcasting microphone 14 is normally closed through conductor 53, closed switch 19—20, conductors 54 and 49, modulating coil 15, and back to the microphone through conductors 51 and 52. The electric impulses in coil 15 pass through the amplifier and modulator M, and are then imposed upon the transmitting antenna circuit in the usual way. While this broadcasting of a program is going on, the various switch arms of switch mechanism W are in the position shown in Fig. 1, so that the antenna circuit is closed through switch 23—24. The circuit of the signal generator F remains open because of the open switch 17—18, and the detector-amplifier mechanism D also remains inoperative on account of the open switch 27—28. In other words, the auxiliary signalling apparatus F and

receiving apparatus D do not interfere with the regular broadcasting operation of the station.

Let us now suppose it is desired to ascertain the number of radio receivers tuned in on the program that is being broadcast by the station. At a suitable moment (as during a pause in a number or in the interval between two numbers), the person in charge of this detail turns the knob 67 and the following events take place automatically: The solenoid coil 48 is energized and pulls down the lever 38, which causes the roller 35 to close the switch 17—18 and simultaneously open the adjacent switch 19—20, whereby the microphone 14 is cut out and the output circuit of signal generator F is closed through coil 15. As previously explained, the signal generator F operates to send electric impulses of predetermined frequency or character through the modulating coil 15, and this special signal is impressed upon the carrier frequency or wave of the station through the amplifier-modulator M. Thus, from the moment the roller 35 cams the switch arm 17 to closing position until it reaches the position 35' (an interval that need not be more than a second or two), the station is broadcasting a special signal, which I may call the search signal, adapted to be received only by those radio receivers that are tuned for this station at that time. When I describe Fig. 2, I will explain what the search signal does in a tuned receiver. I will now go on to describe what happens in Fig. 1 when the lever 38 reaches the end of its forward movement.

It will be recalled that when the roller 35 is in its lowermost position 35', the actuating lever 38 is in position 38' and opens the switch arms 79 and 93, whereby the solenoid coil 48 is de-energized and the switch arm 17 is opened to disconnect the signal generator F. As soon as coil 48 is cut out of circuit, the spring 41 rocks the lever 38 clockwise and the roller 35 travels up through passage 34 to open the switch arm 23 and close the adjacent switch arms 25 and 27. The high-frequency transmitting generator 10 is now cut out and the antenna circuit is closed through coil 12, conductor 55 and switch 25—26, this circuit now being a receiving circuit tuned to the carrier frequency of the station and adapted to receive the response signals transmitted by the tuned-in receivers. At the same time the correspondingly tuned input circuit including coil 57 of detector D is closed through switch 27—28, whereby the total electric energy received by mechanism D from the transmitters of all tuned-in receivers flows through the output or load circuit 58 and is registered or recorded in the instrument E, as previously explained.

Now we come to Fig. 2, which shows the apparatus associated with a household radio receiver for automatically sending a response to the search signal from a tuned-in station. The radio receiver R is of any approved make or design, having variable tuning means 96, a tuning knob 97, and a station dial 97'. The diagrammatic symbol 96 stands for the adjustable tuning elements found in all radio receivers. The inside mechanism of the receiver requires no illustration and description, since it is a matter of common knowledge in the radio field. So I have indicated only the antenna coil C and the input coil 98 of the receiver mechanism. The antenna circuit 99 is normally closed through switch arm 100 and contact 101, and it will be understood that the receiver is not operative for broadcast reception unless that switch is closed. 75

The receiver cabinet contains a small radio transmitter T (preferably of the vacuum tube type), which has variable tuning means indicated diagrammatically at 102 for adjusting the transmitter to a predetermined carrier frequency or wave length. As the construction and operation of radio transmitters are well understood, I need not go into further details about the transmitter T, except to say that it need not be of high power and long range, so that it may be a compact piece of apparatus easily housed in a radio cabinet of regular household size. In some cases it may be possible to use parts of the radio receiver mechanism for the transmitter T, but for convenience I have shown the latter as a separate device.

The adjustable reactance element 102 in transmitter T represents any practical means for varying the inductance of the transmitter circuit to vary the frequency of its oscillations, and the dotted line 103 indicates any suitable form of driving connection between the knob 97 and the tuning elements 96 and 102. That is to say, when the knob 97 (or whatever finger piece the receiver has) is adjusted to tune the receiver for a particular station, there is simultaneous adjustment of tuning element 96 in the receiver and of tuning element 102 in the transmitter T. In this way the transmitter T is always tuned to a carrier frequency which is different for each station, and that frequency is preferably the same as that of the station tuned in. The transmitter T is normally out of operation and does not interfere with the usual functions of receiver R. In fact, the person tuning the receiver need not (and perhaps will not) even know that transmitter T exists.

The radio receiver R also contains a signal-receiving device K, which has an input circuit 104 tunable to the required frequency by means of a variable reactance element 105, such as one or more adjustable condensers. The driving connection 103 extends to the tuning element 105, which is so constructed that the input circuit 104 of device K is always tuned to the carrier frequency of the station tuned in by the knob 97. It is clear, then, that the mere operation of knob 97 for tuning in a desired station automatically tunes the output circuit of transmitter T and the input circuit of the signal-receiving device K to the carrier frequency of that station. The input circuit 104 of signal receiver K includes a coil 106 inductively related to the antenna coil C of receiver R, and the variable tuning element 105 is also part of that circuit. The output circuit of signal receiver K includes a coil 107 and an adjustable reactance element 108, such as a condenser, for sharply tuning this circuit to the frequency of signal generator F at the station. It should be understood that the tuning element 108 is not adjustable by means of the tuning knob 97 on the receiver, but is adjusted once for all time to make the circuit of coil 107 resonant and responsive only to the signal of generator F. I am assuming here that this search signal is the same for all stations, but the input circuit 104 is resonant only to the carrier frequency of the particular station tuned in by the receiver R. Therefore, the signal-receiving device K is normally inoperative in its output circuit, even though the input circuit 104 is in tune with the carrier frequency of the selected station. Not until the input coil 106 receives the signal of generator F is the output coil 107 energized to carry out its intended function, as will presently be explained. If necessary, the signal receiver K contains a suitable current amplifier

between the input and output circuits, as will be understood without further description, since such amplifiers are well known. It should be noted that, although the signal receiver K is placed in receptive condition by the operator of radio receiver R for each tuned-in station, that device K is nevertheless under the exclusive control of the program tester at the broadcasting station.

The receiver R and transmitter T are electrically powered from the houselighting mains 109—109'. There is, of course, the usual on-off switch (not shown) on the radio cabinet, but the power switch connections for the transmitter T are controlled from the tuned-in station through the output coil 107 of device K. One practical form of such switch control is shown in Fig. 2 by way of example. A lever 110 pivoted at 110' has a half-gear 112 in mesh with a similar gear 113 which turns about a shaft 114. A pulley 115 on gear shaft 114 carries a cord or chain 116, which is attached to a magnetic plunger 117 arranged to move in a coil P. When this coil is energized, the plunger 117 is pulled down and rocks the lever 110 down through a certain angle. A contracting coil spring 118 automatically returns the lever 110 and all connected parts to normal position when the coil P is de-energized.

A suitable insulating panel in the radio cabinet has a two-way groove comprising a down passage 119 and an up or return passage 120. A roller 121 is mounted to travel in groove 119—120, and is connected to the free end of lever 110 by a link 122, which is indicated by a dotted line to prevent obscuring other parts of the drawing. The lower end of passage 119 is curved so that the roller 121 occupies the position 121' at the end of its downward travel. The two spring latches 123—124 associated with groove 119—120 compel the roller 121 to travel down through passage 119 and up through passage 120, as more fully explained for the similar latches 36—37 in Fig. 1. A movable switch arm 125 has a central portion 125' extending across the passage 120 in the path of the returning roller 121, so as to be actuated thereby into engagement with the adjacent contact 126. Either a spring 127 or the inherent tension of arm 125 normally holds the latter away from contact 126, so that the members 125—126 constitute a normally open switch. An insulating rod 128 mechanically connects the switch arms 100 and 125 so that they always move in unison. The spring 127 normally holds the arm 100 against its contact 101, which also forms a stop for the action of the spring. When the roller 121 moves the switch arm 125 against the contact 126, the switch arm 100 is at the same time moved away from contact 101 and into engagement with the opposite contact 101', which is connected by a wire 129 to the output or antenna circuit of transmitter T. The power main 109 goes to contact 126, while the other main 109 goes directly to the transmitter. A conductor 130 connects the other side of the transmitter's power circuit to switch arm 125. The insulating panel containing groove 119—120 may also be the support for the adjacent switches and the operating connections of roller 121.

The coil 107 in the resonant output circuit of the signal receiver K has a magnetic core 107' which, when the coil is energized, attracts an armature 131 mounted on a switch arm 132 supported at one end. The free end of this switch arm is adapted to engage a fixed contact 133, which is connected to one side of coil P. For con-

venience I have shown a separate storage battery 134 as the source of current for coil P, but in practice the circuit of this coil is connected to the houselighting leads 109—109', or to whatever source of electric energy the radio receiver R is connected. One terminal of battery 134 goes to coil P and the other to the switch arm 132, which is normally held open either by inherent tension or by a separate small spring. When the coil 107 is energized by the signal current of generator F, it closes the switch 132—133 and thus causes the solenoid coil P to be energized, whereby the switch lever 110 is actuated as previously described.

The operation of Fig. 2 in relation to Fig. 1 is like this: The radio receiver R is tuned in the regular way to any desired station, the grounded antenna circuit 99 being normally closed through switch 100—101 and the power circuit 109—109' being closed through the usual on-off switch of the receiver. The operation of tuning knob 97 automatically adjusts the elements 102 and 105 to tune the transmitter T and the input circuit 104 of signal receiver K to a predetermined frequency, which may be assumed to be the carrier frequency of the tuned-in station. However, this tuning of the mechanisms K and T has no operative effect at this time,—first, because the sharply tuned output circuit of coil 107 in device K can be energized only by the frequency or code characteristics of signal generator F, which is not now transmitting; and second, because the switch 125—126 of transmitter T is open, so that this mechanism remains inert.

Now we shall see what happens at the receiver when the search signal of generator F is transmitted from the tuned-in station during an interval when the broadcasting is silent. The signal oscillations of generator F (imposed upon the carrier wave of the station) pass through the antenna coil C of the tuned-in receiver R and therefore through the coils 98 and 106, which are inductively coupled to the antenna coil. However these signal oscillations may affect coil 98, they produce no effect in the receiver itself, which is not tuned to this special signal. The signal oscillations that enter the input circuit 104 of device K through coil 106 energize the tuned output coil 107, with the result that coil P is energized and operates the switch lever 110. It will be recalled that the signal generator F functions from the moment the switch arm 17 (Fig. 1) is closed by roller 35 until that roller is at the end of its downward movement in position 35'. During that same interval the roller 121 (Fig. 2) is pulled down to position 121', so that both rollers start their return movements at the same time. Therefore, while the roller 35 holds the switches 25—26 and 27—28 closed, the roller 121 holds the switches 125—126 and 100—101' closed, whereby the transmitter T is energized to transmit radio waves at the frequency of the tuned-in station, and these waves are received by the tuned antenna coil 12 of the station, which now operates as a receiver. Thus, the tuned input coil 47 of detector D is energized in proportion to the total amount of electric power radiated by the simultaneously operating transmitters T of all tuned-in receivers, and this electric load in coil 57 is translated by instrument E to indicate the number of receivers then listening to this particular station.

From the above it is apparent that the arrangement provides for the transmission of a search signal from the transmitter for a predetermined length of time and that the receiver when once

adjusted by the search signal transmits its tuning indication signal for a predetermined length of time. This feature of applicant's invention is very important since a device of the character described is of value only if the readings obtained give a somewhat true indication of the information desired. Without the timing mechanism it can be seen that during a reading period the number of receivers transmitting the particular signal may change due to the differences in timing of the length of the signal transmitted. Accordingly, the indicator would not give a true indication of the conditions. However, when all apparatus is equipped with a timing means it will be seen that a very accurate reading may be obtained throughout the test period due to the fact that the timing mechanisms force the transmission of the indicating signals throughout the test period.

The simplest kind of search signal to use for energizing the device K is one of mere frequency as distinguished from a telegraphic code signal, which would not only take longer to transmit but also require more complicated apparatus in device K. The signal of generator F may be of any frequency beyond the region of audibility and therefore outside the broadcasting range of any station. This makes the device K immune to any form of electric waves except those carrying the special signal of generator F. The operation of sending out the search signal and receiving the response signals need take only a second or so (perhaps even before the program tester lets go of the knob 67), so that the electric power consumed by this operation is negligible. For the information of the program tester, the detector D and signal generator F may have small signal lamps 135 and 136 associated therewith and automatically lighted when those devices are functioning. While it is possible to have a separate receiving antenna for coil 57, this would be an unnecessary complication, for the transmitting antenna of a station operates equally well as a receiving aerial with the proper switching connections.

In Fig. 3 I have indicated a plurality of stations broadcasting simultaneously and a plurality of receivers supposed to be tuned for different stations. If a group of receivers represented by R1 is in tune for station A, and another group of receivers Rn is tuned for station B at the same time, the search signal sent out by station A will affect only the transmitters T1 of receivers R1. Likewise, the search signal of station B will cause only the transmitters Tn of receivers Rn to operate, and this selective operation of the transmitters takes place even if several stations should happen to send out their search signals at the same time. Therefore the indicator or recorder E of each station is controlled only by the transmitters of those receivers that are tuned in on that station. When the same program is broadcast simultaneously by a number of stations, as in a coast-to-coast hookup, each station will receive the response signals of the receivers tuned to that station, and the total number of receivers listening to that program will be the sum of the figures indicated by the response instruments E of all the stations in the hookup. It is to be assumed that the readings of the response instruments in the subsidiary stations are immediately relayed (either manually or automatically) to the main station, which is thus able to give the desired information to the sponsor of the program at the conclusion of the

broadcast. If desired, the switch arms 76 of those stations that are in the same hookup can be closed simultaneously by clockwork at predetermined intervals. This will be clear without further illustration and description, since time-controlled switches are well known.

The transmitters T are of standardized design so as to radiate the same amount of power, and after being installed they are not to be tampered with. As these small transmitters are exclusively under station control, they are in effect part of the equipment of a duly licensed station, so that the owner of a radio receiver having such a transmitter combined therewith does not become an amateur radio operator requiring a license. The signal receivers K also are of standard design, so that the variable element 105 always tunes the input circuit 104 to the carrier frequency of the station tuned in by the receiver R. However, once the output circuit containing coil 107 has been tuned sharply to the adopted frequency of signal generator F, that circuit is sealed against tampering. This assumes that all broadcasting stations equipped with my invention have agreed to use the same frequency for their search signal, each station transmitting that special signal on its own carrier wave. Should certain stations decide among themselves to adopt a different search signal for each station, then the output circuit of device K would have to be tuned correspondingly for each station by connecting the variable reactance element 108 with the tuning shaft 103, as previously explained for the adjustable tuning elements 102 and 105. It may be possible to use certain parts and circuit connections of the radio receiver R for the device K, which is really a small receiver with an output circuit tuned exclusively for the signal of generator F.

Instead of marking the scale S of instrument E with figures representing the number of operating transmitters T (and therefore the number of listening receivers R), any other equivalent notations may be used,—as for instance, numbers indicating current values in amperes or milliamperes. The total ampere indication is then divided by a number representing the predetermined average amount of current received from each transmitter T, so that the quotient gives the approximate number of tuned-in receivers. If the amount of energy received by coil 57 from each transmitter T were exactly the same, the number of tuned-in receivers could be ascertained with mathematical exactitude. However, the transmitters T are necessarily located at different distances from any tuned-in station, and we know that the radiation field decreases with increase of distance. This means that the coil 57 will receive a greater amount of energy from a transmitter T located near the station than from one located far away. But it is sufficient for the practical purposes of this invention to adopt an average value for the energy received by coil 57 from each transmitter. This average current value is readily determined by experiment and is applicable to all stations. The procedure would be something like this:

A broadcasting station, like a newspaper, caters mainly to the inhabitants of the surrounding region. It is commonly known that radio receivers in any locality can get all the desired programs from a few stations nearby. Even in a nation-wide hookup for one program, a person will tune in on a nearby station for the best results. So we may fairly assume that each

broadcasting station gets most of its listeners from the surrounding territory, the extent of which depends upon the transmitting power of the station. Referring to Fig. 3, let us suppose that the zone served by station A extends to z, so that the receivers R1 are farthest from the station and the receivers R2 nearest to it, while the receivers R2 occupy a middle position. Experiments are conducted to determine the signal strength received by coil 57 of station A from a distant transmitter T1, from an intermediate transmitter T2, and from a near transmitter T3. After making a sufficient number of these experiments for each group of transmitters, an average value is obtained as representing the energy received by coil 57 from the transmitter of each tuned-in receiver, and that value is used for calibrating the instruments E. The indications thus obtained are sufficiently close for practical purposes, for the sponsor of a radio broadcast is satisfied to know the size of his unseen audience in round numbers.

By sending out the search signal at different points in a broadcast it is possible to get an idea of how the public is taking to the program. For example, if the instrument E shows a greater number of tuned-in receivers at the end of a program than at the beginning or the middle, this indicates an approval or liking of the program, and a reverse showing of the instrument would denote the public's disapproval of this program. My invention thus enables a radio advertiser not only to know the extent of his audience but also to get up a program that will secure for him the greatest number of listeners,—and that means the greatest number of possible or potential buyers of the advertised product. It is probably best to have an official record of the indications of instrument E, which is therefore preferably of the recording type.

I am aware that the transmitter T, the signal receiver K, and the associated switch-operating mechanism add to the cost of the radio receiver R, of which they are a part by being embodied in the same cabinet. However, this extra cost should not be borne by the purchaser of the radio receiver but by the broadcasting advertisers, who get the practical benefits of this invention. Let us say that several broadcasting companies have agreed to adopt this program testing system and have installed the necessary equipment. These companies will then arrange with one or more radio manufacturers to put out receivers embodying the additional apparatus needed for this purpose, and the extra cost of that apparatus is borne in the first instance by the broadcasters, so that the buyers of these specially equipped receivers pay no more than for an ordinary receiver. When a radio advertiser wants to know how many receivers are tuned in on his program, the broadcaster charges him an additional fee for this valuable information. In this way the manufacturing cost of this invention is ultimately paid for by the radio advertisers, as seems meet and fair.

Although I have shown and described certain specific apparatus and circuit connections, my invention is not limited to the details set forth, for its basic principles can be embodied in other ways without departing from the scope of the appended claims.

I claim as my invention:

1. In combination with a broadcasting station having means for transmitting at desired intervals a signal of certain frequency apart from the

broadcast program, a radio receiver, a normally inoperative radio transmitter associated with said receiver, said signal-transmitting means including switch mechanism for holding said means energized for a predetermined time interval, means at the receiver including an operable switch mechanism acting upon receipt of the station signal for rendering the receiver transmitter operative to transmit a characteristic signal during another predetermined time interval, means at the broadcasting station for receiving said characteristic signal, indicating means and means for applying the received characteristic signal to said indicating means.

2. The combination of a plurality of broadcasting stations each thereof having an electrical measuring device and means for transmitting a characteristic control signal apart from the broadcast program, operable means acting upon operation to hold the control signal transmitting means energized for a predetermined period of

time, a plurality of radio receivers each thereof being tunable to any one of said broadcasting stations and including means automatically settable upon receipt of the characteristic control signal from the station to which the receiver is tuned, to transmit for a certain predetermined time period a signal characterized to indicate the receipt of said characteristic control signal, means at each of said broadcasting stations for receiving the indication signals sent out by those receivers which are tuned to receive signals from the broadcasting station and means at each of said broadcasting stations for energizing said measuring device in accordance with the indication signals received whereby the measuring device at any one of the broadcasting stations gives an approximate indication of the number of receivers which are tuned to that station at the time of transmission of the control signal therefrom.

ADOLPH A. THOMAS.