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H. J. SCHRADER

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MODULATION MEASURING SYSTEM

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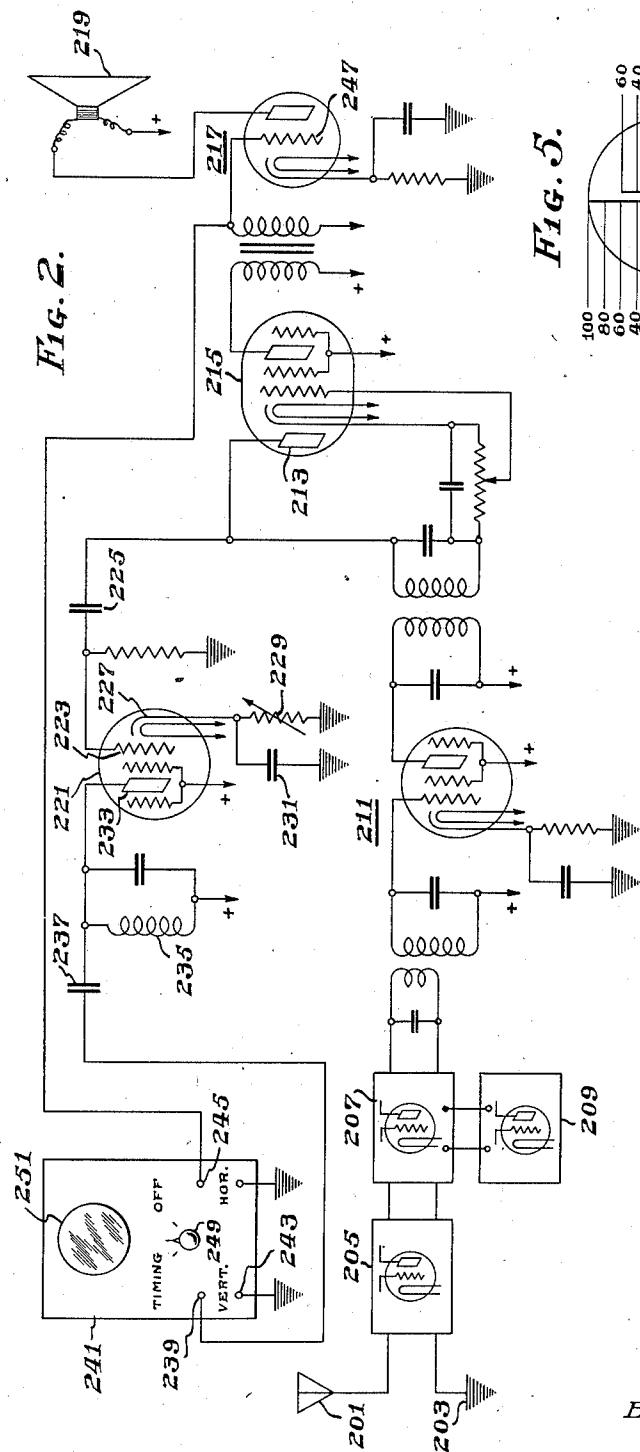


**Fig. 5.**

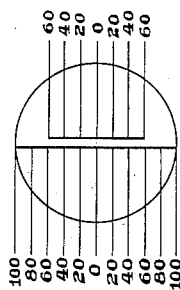


**Fig. 4.**

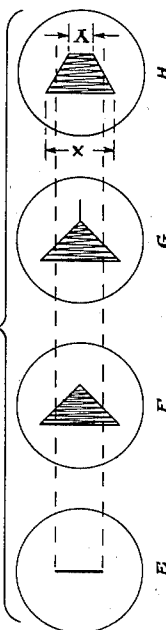
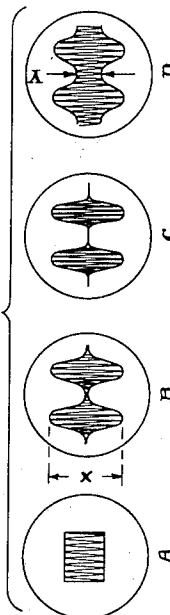


**Fig. 3.**



INVENTOR  
*Harold J. Schrader*  
 BY *R. Goldsborough*  
 ATTORNEY

## UNITED STATES PATENT OFFICE

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## MODULATION MEASURING SYSTEM

Harold J. Schrader, Haddon Heights, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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3 Claims. (Cl. 179-171)

My invention relates to modulation monitoring systems. Specifically my invention is a system for determining the character and percentage of modulation of a radio transmitter at a point remote from the transmitter.

for an oscillograph for determining percentage modulation.

In Figure 1, a cathode ray tube 1 having a fluorescent screen 3 is provided with a pair of vertical deflecting plates 5-6, and a pair of horizontal deflecting plates 7-8. The illustration shows the pair of horizontal plates in perspective. The second horizontal deflecting plate 8 is partly hidden by the nearer plate 7 which is parallel to it and it is grounded. The vertical and horizontal plates are located at right angles to each other. A unipotential cathode 9, energized by the heater 11, emits cathode rays, or electrons, which are illustrated as the dash line 13. The emission from the cathode is regulated by a control electrode 15 and by an accelerating electrode 17. The cathode ray is focused on the screen by a suitable electrode 19 or by a focusing field. The potentials applied to the various electrodes will be described later.

A pair of input terminals 21-23 for vertical deflection are connected to the input of a thermionic amplifier 25 through a capacitor 27 and an attenuator 29. The output of the amplifier is coupled through a capacitor 31 to the vertical deflecting plate 5. The cathode 33 is self-biased by a resistor 35 which is bypassed by a capacitor 37. The screen grid 39 is connected to a positive potential point on a source of power. The anode 41 is likewise connected to the positive potential point through a resistor 43 and an inductor 45.

A second pair of terminals 47-49 for horizontal deflection are connected respectively to a contact 51 of a double pole double throw switch and to ground. One of the movable blades 53 of the switch is connected through a capacitor 55 to the horizontal deflecting plate 8. The other movable blade 56 of the switch is connected through a capacitor 57 to one terminal of an attenuator 59 which is grounded at its other terminal. The adjustable contact of the attenuator is connected to the control grid 61 of an amplifier 63. The cathode of the amplifier is grounded through a self biasing resistor 65 which is bypassed by a capacitor 67. The screen grid 69 is connected to a positive point on the direct current power source. The anode 71 is connected to a fixed contact 73 of the double pole double throw switch and through a resistor 75 and inductor 77 to a positive potential point on the power source.

The linear horizontal timing is accomplished by the use of a saw tooth oscillator. I prefer a gas tube, such as an RCA Type 855, for the saw tooth oscillator. The grid electrode 79 of the gas tube 81 is grounded. The anode 83 is connected

I am aware that it is old to measure the percentage modulation of a modulated carrier current at the transmitting station. It would be highly desirable to visibly determine the percentage modulation of modulated carrier currents at points remote from the transmitters of said carriers. If a simple practical system could be devised, the Federal Government could continuously exercise its supervisory authority and observe whether radio stations were fully utilizing their allotted power by fully modulating their carriers. Likewise, if the stations are sending poorly modulated or defectively modulated carriers, such transmission could be quickly detected. In a similar manner the station managers could occasionally observe the operation of their own stations when they are at remote points. A few receiving systems, in accordance with my invention, could monitor the transmission of a large number of amateur transmitters. The cathode ray oscillograph which is embodied in this invention is described in the co-pending application of William F. Diehl and Harold J. Schrader, Serial No. 759,498, filed December 28, 1934, and entitled Oscillographs, which is assigned to the same assignee as this instant application.

One of the objects of my invention is to provide means for determining the modulation characteristics of a radio transmitter at a point remote from the transmitter.

Another object is to provide means for determining the percentage of modulation of a modulated carrier at a point distant from the transmitter.

A further object is to provide means for amplifying modulated carrier currents and for applying the amplified currents to a cathode ray oscillograph.

Additional objects will appear in the accompanying drawings and specification.

In the accompanying drawings Figure 1 is a schematic diagram of a cathode ray oscillograph.

Figure 2 is a schematic diagram of a receiving system embodying one form of my invention.

Figure 3 is an illustration of one form of pattern appearing on the cathode ray oscillograph of Figure 2.

Figure 4 is an illustration of a second form of cathode ray oscillograph pattern, and

Figure 5 is an illustration of a suitable scale

to a positive potential point on the power supply through a variable resistor 85. The anode is also connected through a variable capacitor 87 to a negative potential point on the power supply, and the cathode 89 is connected to this same negative point, which is grounded. The saw tooth type of oscillation which is generated by a gas tube and circuit of the character described is dependent upon the time required to charge and discharge the capacity in the anode circuit. A detailed description is not necessary as this type of oscillator is well known to those skilled in the art.

The power supply for the cathode ray oscillograph will now be described. A transformer 91 has its primary 93 connected to a source of alternating current. A plurality of secondaries are arranged to energize the heaters of the several thermionic tubes. The secondary connections from top to bottom are as follows: the first winding 95 is connected to the heater 97 of the saw tooth oscillator 81. The second winding 99 energizes the heaters of the thermionic amplifier tubes 25, 63. The third winding energizes the heater for the cathode 9 of the cathode ray tube 1. The fourth winding 103 energizes the filament of the high voltage rectifier 105. The fifth winding 107 provides the high voltage for the rectifiers 105, 109. The sixth winding energizes the filament of the full wave rectifier 109.

The rectified output from the high voltage rectifier 105 charges a smoothing out capacitor 111. The capacitor 111 is shunted by resistors 113, 115, 117, 119, 121 and 123. An adjustable connection on the first of these resistors 113 varies the negative potential applied to the control grid electrode 15 of the cathode ray tube 1, and hence the intensity of the cathode ray. An adjustable connection on the second of these resistors 115, varies the positive potential on the second grid electrode 17 of the cathode ray tube 1 and thus the focussing of the cathode ray. The third resistor 117 and fourth resistor 119 are connected in parallel. An adjustable connection on third resistor 117 connects through the resistance and capacity network 125 to the horizontal deflecting plate 7 and applies voltages which permit adjustment of the position of the horizontal deflections. An adjustable connection on the fourth resistor 119 is connected through the resistance and capacity network 127 to the vertical deflecting plate 5, and applies voltages which permit adjustment of the position of the vertical deflections.

The output of the full wave rectifier 109 is connected to a filter network comprising capacitors 129—131 and an inductor 133. An appropriate potentiometer comprising resistors 121, 123, 135 and 137, is shunted across the output of the filter. The junction between the resistor 137 and the inductor 133 is the point of highest positive potential. Connections are made from this point to the anode circuits of the oscillator tube 81 and the two amplifiers 25—63. The positive potential supplied from the junction of resistors 135—137 may be further filtered by a capacitor 139 and connected to the screen grids of the two amplifier tubes. The potential supplied from the junction of resistors 121 and 123 is filtered by capacitor 141 and is connected to the cathode of the oscillator. The cathode 9 of the cathode ray tube 1 is connected to its heater 11 and the heater in turn is connected to the junction of the first and second resistors 113—115 in the high voltage supply circuit. The above described apparatus and circuit completes the cathode ray tube circuit,

per se. I shall next describe one embodiment of my invention in a complete system.

In Figure 2 a superheterodyne receiver is schematically illustrated. A receiver of that type is so well known to those skilled in the art that a detailed description is not necessary. My invention is not limited to this particular type of receiver but may be applied to any conventional high gain receiving system. An antenna 201 and a ground 203 are connected to a radio frequency amplifier 205. The amplifier is connected to a first detector or mixing tube 207. Oscillatory currents from a local oscillator 209 are fed into the mixing tube 207. The resulting currents are of intermediate frequency and are amplified by the intermediate frequency amplifier 211 which may consist of a plurality of stages. A diode second detector 213 may be connected to the output of the intermediate amplifier. The detector output may be amplified by an audio stage 215, which may be further amplified by a second audio frequency amplifier 217. The output currents from the second audio amplifier are fed to a loud speaker 219 or the like. The system thus far described is a conventional superheterodyne receiver in which batteries and power sources have been omitted for sake of simplicity.

An intermediate frequency amplifier 221 has its control grid 223 connected by a capacitor 225 to the input circuit of the second detector. The cathode 227 is self biased by a variable resistor 229 which is bypassed by a capacitor 231. The anode 233 is connected to a resonant circuit 235. A capacitor 237 connects the resonant anode circuit 235 to the high potential terminal 239 of the vertical deflector terminals of the cathode ray oscillograph 241 which is illustrated in detail in Figure 1. The remaining terminal 243 of the vertical deflector terminals is grounded. The high potential terminal 245 of the horizontal deflector terminals is connected to the grid electrode 247 of the second audio amplifier 217. The switch 249 on the oscillograph corresponds to the double throw double pole switch of Figure 1. When the switch 249 is thrown to position "off" it corresponds to the movable blades 53—56, in Figure 1 contacting the fixed points 51, 70. In this position the impulses from the saw tooth oscillator 81 are not impressed on the amplifier tube 61, and the audio frequency currents are impressed on the horizontal deflecting plate 8 of the cathode ray tube 1. At the same time currents of intermediate frequency flowing in the amplifier are impressed on the vertical deflecting plate 5 of the cathode ray tube. When the switch 249 is thrown to the "timing" position the saw tooth generator 81 is connected to the amplifier 63 and the connection to the grid electrode of the audio amplifier 217 is opened. This position corresponds to blades 53, 56 connecting fixed contacts 73—74 of the double pole double throw switch of Figure 1. The circular opening 251 corresponds to the fluorescent screen 3 of the cathode ray tube 1.

I shall now describe the operation of the system and the different patterns which may be obtained on the fluorescent screen 251 of the oscillograph. The receiving system is carefully tuned to the carrier to avoid overloading or distortion. The carrier is converted to intermediate frequency and amplified by the intermediate amplifier and by the auxiliary amplifier 221. The detector, audio amplifiers and loudspeakers perform their usual functions. If the switch 249 is placed in the "timing" position, the saw tooth shape impulses

will deflect the beam linearly across the horizontal scale. The carrier currents will deflect the beam at intermediate frequency along the vertical scale. The resultant pattern will be a rectangle similar to A of Figure 3. If the carrier is modulated, the audio frequency envelop will appear as illustrated in B, C, or D of Figure 3. The vertical deflections are proportional to the voltages impressed on the deflecting plates. By measuring the relative heights of the modulations in the envelope, the percentage modulation may be determined in accordance with the equation:

$$\text{Percentage modulation} = \frac{x-y}{x+y} \times 100$$

It is practical to detect over-modulation; i. e., modulation in excess of 100%. In the event of over-modulation the "valleys" of the modulation pattern run together and show a sharp bright horizontal line as illustrated in C of Figure 3. Under-modulation is characterized by the "valleys" being shallow and not cut deeply into the carrier as illustrated in Figure 3 D. The several patterns illustrated represent a single modulating frequency. If the modulation is sinusoidal, any distortion will be apparent in the shape of the curve. If the carrier is being modulated with an audio current of several frequencies, such as speech or music, the pattern will be complexed. Ordinarily the patterns will travel across the screen making it necessary to measure the relative amplitudes of the peaks and valleys by a quick reference scale.

One convenient type of scale is shown in Figure 5. The scale to the left may be used to measure the peaks and the scale to the right may be used to determine the depth of the valleys. In using this scale, the observations may be simplified by centering the unmodulated carrier on the zero line.

When the switch 249 is placed in the "off" position the horizontal deflections caused by the saw tooth impulses are eliminated because the saw tooth generator is disconnected. In its place the amplifier audio frequency currents from amplifier 217 are impressed on the horizontal deflecting plates. The characteristic patterns are now of trapezoidal shape during modulation, and a single vertical line during periods of no modulation. These patterns are illustrated in Figure 4 E, F, G and H. Percentage modulation is determined as described in connection with Figure 3. Over-modulation is shown by a single bright horizontal line trailing out after the pattern. This is shown in G of Figure 4. If a single modulation frequency is impressed on the carrier with less than 100% modulation, the pattern will be a trapezoid. If the modulation is 100%, the pattern will be a triangle. Any distortion will be apparent in the pattern.

If the receiving system cuts side bands, distortion

will be shown which is not caused by the transmitter. This is avoided by the use of a high fidelity receiver. The first detector must not be overloaded. Those skilled in the art are thoroughly familiar with the design of high fidelity receivers which are suitable for embodiment with my invention. Various modifications within the scope of my invention will occur to those skilled in the art. The arrangements shown are merely by way of example and are not to limit my invention except as required by the prior art and the appended claims.

I claim as my invention:

1. A system for measuring percentage modulation including in combination, means for receiving modulated carrier frequency currents, means for creating a local oscillatory current, means for combining said carrier and local oscillatory currents to form currents of intermediate frequency, an intermediate frequency responsive device, means for amplifying intermediate frequency currents, means for detecting said intermediate frequency currents, means for amplifying said detected currents, a cathode ray tube including an emissive cathode, vertical and horizontal deflecting means, connections from one of said deflecting means to said intermediate frequency amplifying means, connections from the other of said means to the means for amplifying said detected currents, and a scale traversed by said cathode ray and arranged to indicate percentage modulation.

2. A system for determining the percentage of modulation of a high frequency current including means responsive to high frequency currents means for amplifying said high frequency currents, means for detecting said high frequency currents, means for amplifying said detected currents, a cathode ray tube including cathode, vertical and horizontal deflecting means, a generator of impulses of saw tooth shape, means for impressing said impulses on one of said deflecting means, connections from the other of said deflecting means to said high frequency amplifying means, and a scale traversed by said cathode ray and arranged to indicate percentage modulation.

3. The method of determining the relative modulation of a radio frequency carrier at a point remote from the origin of said carrier which comprises, amplifying, and demodulating said carrier; instantaneously forming a graph representing said modulated radio frequency carrier in which the abscissa corresponds to substantially linear time intervals, and the ordinate corresponds to modulation of said carrier, and determining the percentage of modulation from the relative heights along the ordinate of said graph.

HAROLD J. SCHRADER.