

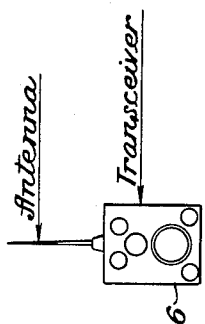
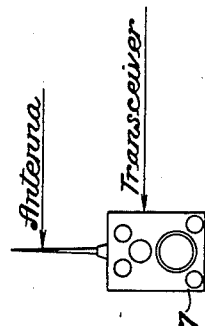
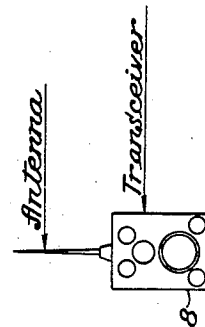
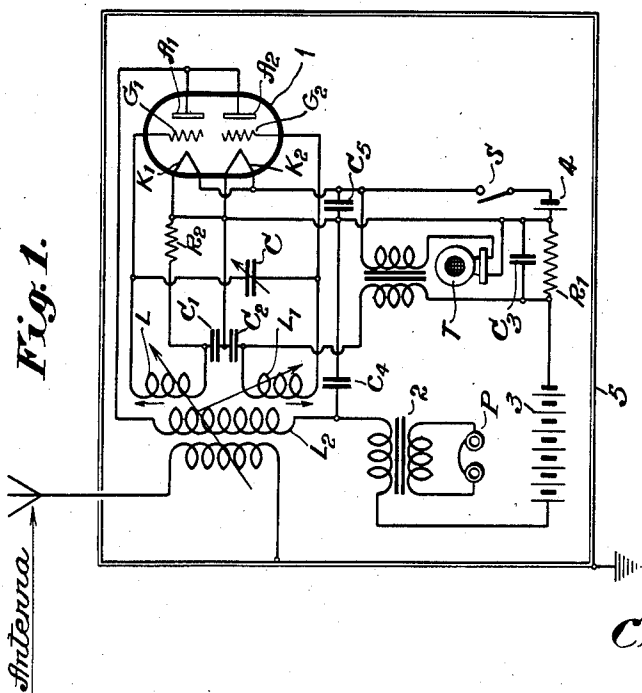
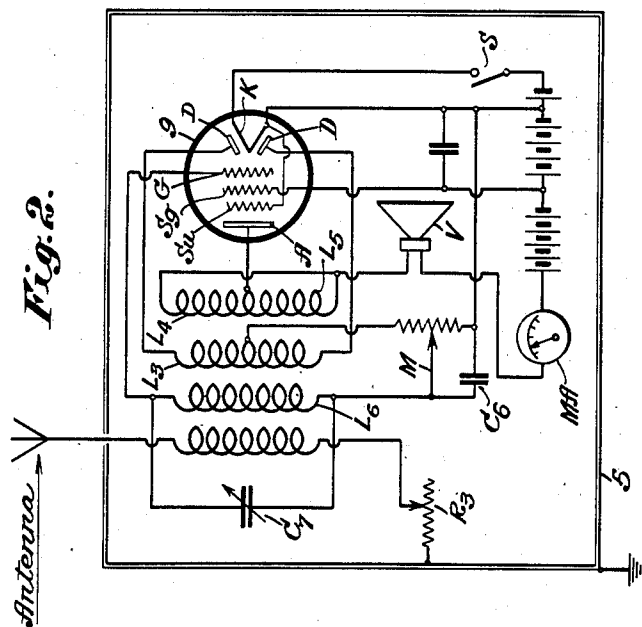
June 1, 1943.

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2,320,428

OSCILLATING AMPLIFIER AND DETECTING SYSTEM

Filed April 30, 1941



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2,320,428

OSCILLATING AMPLIFIER AND DETECTING SYSTEM

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Application April 30, 1941, Serial No. 391,117

11 Claims. (Cl. 250—15)

This invention is designed to provide a communication instrument which may serve as a transmitter, a receiver, and/or a signal repeater for the transmission, reception and relaying of amplitude modulated waves.

The apparatus of the invention may be used alternatively to transmit or receive waves without the need of switching devices, and also while receiving to repeat or relay signals received from a remote transmitting station. In one aspect, the invention concerns improvements in communication systems for relaying waves from one point to the other. A particular application of the invention is to the radio relaying of amplitude modulated waves from one spaced point to another.

By means of the present invention, simultaneous communication may be provided between a plurality of transceiver stations, so that any number of persons may talk and be heard by all the others. Thus, a round table discussion or communication may be carried on between persons a considerable distance apart. The term "transceiver" is used to designate a single piece of apparatus which can be used both to transmit and receive signal waves.

In carrying out the invention, each transceiver station employs a regenerative and feebly oscillating vacuum tube amplifier which is adjusted to be synchronized or locked in step by electromagnetic power received from one or more other stations. The oscillations of the feebly oscillating vacuum tube circuit of the invention are made to remain small in amplitude as long as the feedback is barely sufficient to maintain oscillations. By increasing the feedback, the amplitude of oscillation will also increase, but for each value of feedback the amplitude will be stable. The point of stability is that at which the effective negative alternating current resistance of the tube balances the positive resistance of the associated circuits. The negative resistance of the tube under the conditions specified tends to decrease with increasing amplitude of oscillations. With such an arrangement, the power received by the oscillating amplifier from a remote station will increase the amplitude of oscillation and, if the received power is amplitude modulated, the strength of oscillations of the oscillating amplifier will also be modulated.

By so adjusting the oscillating amplifier of the invention that its total effective resistance is close to zero for a wide range of oscillation amplitudes, it is possible to modulate the oscillations with a very small amount of received

power. As an example, let us assume that the oscillating amplifier with no input energy applied thereto holds a relative amplitude of oscillation of 25%, which is only a partial maximum amplitude. By adding input energy from an unmodulated transmitter carrier received from a remote station, to a desired degree, we can thus increase the amplitude of oscillations to, say, 50%. If the received carrier has been modulated 100% at the distant station, the oscillations will vary in accordance with the modulation from 25% to 75%. This range of variation in amplitude of oscillation may represent enormously greater energy variation than the variation in input or control energy. Furthermore, since the vacuum tube circuit oscillates at partial maximum amplitude, the effective oscillator resistance is nearly zero, a fact which results in relatively great frequency selectivity, so that interference and noise may be greatly reduced without resorting to the expedient represented by the superheterodyne receiver. If the strength of the received power increases, the effective resistance of the oscillator automatically increases, thus tending to hold more nearly constant output from the device acting as a receiver. The selectivity decreases as the received power increases, but this is not very objectionable because less selectivity is required to receive strong signals satisfactorily.

A more detailed description of the invention follows in conjunction with the drawing, wherein Figs. 1 and 2 illustrate diagrammatically two different embodiments of the present invention, and Fig. 3 illustrates schematically a radio relaying system including a plurality of radio transceiver and repeater stations in accordance with the circuits of Fig. 1 or 2.

Referring to Fig. 1 in more detail, there is shown a radio receiver and repeater system comprising a vacuum tube 1 having within a single evacuated envelope a pair of electrode structures, one including a cathode K₁, a grid G₁, and an anode A₁, while the other includes a cathode K₂, a grid G₂, and an anode A₂. Although both of these electrode structures are shown contained within a single envelope, and may form a tube such as is known in the trade by the designation RCA G-7AB, it will be understood that, if desired, individual vacuum tubes may be employed for the individual electrode structures. Coupled to the grids G₁ and G₂ to supply opposite instantaneous potentials thereto, there is provided a tank circuit comprising a variable condenser C and a pair of inductance coils L, L₁, the latter

being coupled together through by-pass condensers C_1 , C_2 . The anodes are connected together in parallel and to a feedback coil L_2 , and then through one winding of an audio frequency transformer 2 to the positive terminal of a suitable source of supply (here shown as a battery 3). A suitable energy collector or pick-up device, such as an antenna is shown inductively coupled to the feedback coil L_2 , the latter being coupled to the coils L , L_1 for impressing the power received over the antenna upon the grids in opposed phase. Suitable means (not shown) is provided for varying the degree of coupling between the various coils, as by moving the antenna coil and also coil L_2 closer or further away from the coils L and L_1 . A resistor R_2 serves to supply suitable grid bias to the grid G_1 , while a resistor R_1 in the anode current circuit of the lower electrode structure serves to supply a desired bias to the grid G_2 . Condensers C_3 , C_4 and C_5 are suitable radio frequency by-pass condensers. A microphone T , connected across the cathode leads, as shown, serves to modulate the amplitude of the oscillations of the oscillating amplifier 1. A switch S functions to close the circuit of the cathode battery 4 through the cathodes, in order to heat the same when it is desired to condition the transceiver station for operation. A shield 5 serves as a ground or surface of zero alternating current potential and surrounds the entire apparatus. The condensers C_1 and C_3 serve not only as radio frequency by-pass condensers but also as by-pass condensers for the modulation frequencies. By making condenser C_3 large enough to by-pass audio currents, we are thus assured that the resistance drop across R_1 is determined only by the carrier current and will not follow modulation frequency currents. The condensers C_1 and C_3 are so chosen that they delay the time response of the circuit such that the automatic grid biasing arrangement does not suppress modulation, in a manner which will appear in more detail hereinafter. Condenser C_2 is of such value that it by-passes radio frequency currents but not audio frequency currents delivered from the microphone T through its coupling transformer.

The control grids G_1 , G_2 of the two electrode structures are unequally biased, the grid G_1 being biased by grid leak action from rectified current flowing through resistance R_2 , while the other control grid G_2 is biased by anode current flowing through resistance R_1 . In the arrangement of this figure, it should be noted that one electrode structure assists oscillation; namely, G_1 , K_1 , A_1 , while the other electrode structure opposes oscillation; namely, G_2 , K_2 , A_2 . Or, putting it in other words, the first electrode structure provides a regenerative action, while the second electrode structure provides degenerative action. The resistors R_1 and R_2 have such values that when there is insufficient feedback to produce oscillations, the electrode structure K_1 , G_1 , A_1 has substantially zero negative bias on its control grid G_1 relative to the cathode, while the electrode structure K_2 , G_2 , A_2 has sufficient negative bias on its control grid G_2 to cut off or greatly reduce its anode current. If now, the regeneration feedback from the anodes to the grid circuits is increased by an adjustment of the couplings between the coils L , L_1 and L_2 , in order to start and build up the strength of oscillations, rectified grid current will flow in the grid leak R_2 , thus increasing the effective bias on the grid G_1 . This increasing grid bias on G_1 , will de-

crease the amplification and the anode current of the electrode structure K_1 , G_1 , A_1 , thus tending to decrease the voltage drop in resistance R_1 and therefore decrease the bias on the grid G_2 , as a consequence of which the amplification and the current through the electrode structure K_2 , G_2 , A_2 will increase. Since the grids are supplied with oscillation grid potentials of opposed phase, while the anodes are connected in parallel, the shifts in grid bias in the two electrode structures toward equality, as the amplitude of oscillations increases, results in a stable partial amplitude of oscillation for any amount of regeneration. Putting it in other words, as the oscillations amplitude in the tank circuit L , L_1 , C increases, the regenerative power of the electrode structure K_1 , G_1 , A_1 decreases, while the degenerative power of the electrode structure K_2 , G_2 , A_2 increases. Thus, the oscillation can only approach but never reach such an amplitude that the regenerative and degenerative feedbacks become equal, since in that condition the combination of the two electrode structures would have no sustaining action on the oscillation. Therefore, as the regeneration feedback coupling from coil L_2 to coils L , L_1 is increased by manual adjustment, the amplification of the combined electrode structures automatically changes to oppose increase in oscillation strength and there is no instability in the amplitude of oscillation. Unlike ordinary vacuum tube oscillators, the type of oscillating amplifier shown in Fig. 1 may be chosen to operate at any desired percentage of maximum oscillation amplitude. The antenna serves to radiate a portion of the oscillation power and also to receive power from other oscillators. The earphones P in circuit with the audio frequency transformer 2 is responsive to changes in anode current in the oscillator. The microphone telephone transmitter T serves to modulate the grid bias potential of any desired one of the control grids of the vacuum tube, here shown by way of example as control grid G_2 . If desired, the earphones P can be replaced by an electroacoustic transducer unit which combines the functions of a phone receiver and microphone in which case the microphone T can be eliminated.

If the antenna is lightly coupled to the oscillating amplifier 1 and is carrying current picked up from another oscillator, and the circuits associated with the tube of Fig. 1 are varied in tuning from the frequency of the current picked up, a point will first be reached where a beat note will be heard in the phone receiver P just as would be the case with any self-oscillating heterodyne detector. The tuning of the circuit C , L , L_1 is adjusted by means of variable condenser C to bring the beat note to zero and the coupling to the antenna is then increased, as a result of which, the local oscillations are locked in step with the incoming oscillations. If the received current has been amplitude modulated at the remote station, the degree of coupling between the antenna and the oscillator and the amount of regeneration, if such control is provided, are adjusted so that an adequate amplitude of response to the modulation is heard in the earphones P . The modulated received currents will cause an increase in the strength of oscillations of the oscillating amplifier and cause it to be amplitude modulated in response to the modulations of the received current. The oscillator of Fig. 1 will thus radiate signal modulations over its antenna in accordance with the received sig-

nal modulations and of the same frequency as the received carrier, in this way functioning as a repeater or relay station.

It should be noted that as the received current becomes stronger the amplitude of oscillation of the oscillator will become greater, but, at the same time, the effective oscillating circuit resistance of the oscillator will increase automatically, thereby tending to reduce the increase in oscillation strength. The resistances R_1 and R_2 with their effective shunt condenser capacities C_1 , C_3 across them, automatically bias the two control grids in a manner tending to oppose the increase of amplitude of oscillation due to the helping current coupled in from the antenna. However, this response in bias is rather slow compared to the modulation frequencies and does not greatly oppose modulation of the strength of oscillations but acts as a carrier current operated automatic volume control. It is contemplated that the modulation frequencies be audio frequencies, although super audible modulation might also be employed, including superaudible sub-carrier modulation. The grid bias in each electrode structure changes relatively little in response to modulation, with the result that the strength of oscillation is relatively sensitive to amplitude modulations of the received current. Therefore, any amplitude modulations of the received current will be heard in the earphones P.

If the attendant speaks into the microphone transmitter T, this will cause a modulation of the amplitude of oscillations, and will result in the transmission or radiation of modulated radio waves from the antenna. If the distant oscillator unit is of the same kind as the local oscillator or transceiver unit shown in Fig. 1, a two-way conversation may be carried on between the two transceiver stations. We may thus have two synchronous transceivers, each capable of modulating the other by virtue of the radiation coupling between them and each provided with means to produce or to receive modulations. It will be evident that even in the absence of modulation, the radiation from the stations will affect each other to increase the amplitude of oscillations of each, and the amount of this change in amplitude will be further increased or decreased by the modulations.

Fig. 3 illustrates a radio relaying system wherein three or more transceiver stations 6, 7, 8 are employed operating at exactly the same frequency, by means of which the attendants at all stations are able to hear the conversation of any one attendant, and each attendant is able to speak to all the others. In the arrangement of Fig. 3, any one or more of the stations can function merely as automatic signal repeaters for the others, while any of them may, in addition, function as a transmitter and a receiver. Transceiver 7 of Fig. 3, if desired, may function merely as a repeater between the two stations 6 and 8. By varying the length of the antenna of Fig. 1, the attendant can vary the coupling between his station and the adjacent spaced oscillator station, and thus limit the distance of communication between adjacent stations to little more than that actually needed for communication.

Fig. 2 illustrates another type of transceiver and repeater which may be employed, in accordance with the invention, in a relay system or otherwise. The feebly oscillating amplifier of this figure is composed of a pentode vacuum tube 9 having a pair of diode elements coupled to the

cathode, as shown. Tube 9 may, if desired, comprise an RCA G-7AF type, although it will be understood that any other suitable vacuum tube may be employed which combines the functions of a pentode amplifier and a double diode rectifier, or separate tubes for accomplishing similar purposes may be used. The elements of the tube include an anode A, the suppressor grid S_u , a screen grid S_g , a grid G, a cathode K, and a pair of diode elements D, D. The diode elements are coupled together through a coil L_3 to the center of which there is connected a grid bias resistor R. The anode is coupled to the mid-point of a pair of coils L_4 , L_5 arranged in electrically parallel relation but wound in opposite directions. Although a single coil could replace both of these coils, it is preferred to employ the arrangement shown in the drawing in order to obviate any possible unbalance. The resonant circuit which is coupled between the grid G and the cathode K is composed of a variable condenser C_7 arranged in parallel with a coil L_6 , this coil being coupled to the antenna coil as well as to the coil L_3 . With such an arrangement, a portion of the oscillation energy is rectified in the double diode rectifiers D, D and used to bias the control electrode G of the tube. By suitably setting the tap M on the resistor R, the control electrode bias may be placed at any desired point on its control characteristic, for which reason there is no limitation due to need for grid rectification as would be the case if self-bias of the grid were employed. The coils are so arranged that the voltage impressed on each diode D by the halves of the winding L_3 and induced therein from the anode coils L_4 , L_5 is in excess of the voltage impressed on the control grid from the same anode coils due to step-up transformer action. The potentiometer R provides another way of controlling the ratio of oscillation amplitude to control grid bias, in order to maintain any desired partial oscillation amplitude for the unmodulated carrier condition. The variable resistor R_3 shown in series with the antenna may be used to adjust the system to be effective for different operating distances within a limited range. Here also, as in Fig. 1, the length of the antenna can be varied to vary the coupling between the local transceiver station and a distant station with which it is in communication. The milliammeter MA in series with the anode circuit serves to assist in obtaining a good operating adjustment.

The transceiver repeater of Fig. 2 also has an automatic bias arrangement for the purpose of obtaining stable oscillations of partial maximum amplitude. When the amplitude increases due to an incoming signal, the bias on the grid G will automatically increase due to the increased IR drop through resistor R, caused by increased rectification of the diodes, as a result of which the sensitivity of the device is automatically adjusted in accordance with the strength of the received signal. The condenser C_6 is a by-pass condenser, both for radio and modulation frequencies, and serves to prevent grid bias response at the modulation frequencies. In Fig. 2 the function of the receiver speaker and the microphone transmitter have been combined within a single electroacoustic transducer unit V which performs both functions in one piece of apparatus. With such an arrangement the attendant may speak into the unit and also hear a reply to his conversation from the same device.

It should be understood, of course, that the

system of the invention is not limited to a radio circuit employing the ether as a communication medium, since, if desired, the transceiver stations can employ wire lines as the communication medium, in which case the antenna may be replaced by any suitable pick-up and transmitting device. Similarly, the invention is applicable to supersonic and submarine signalling systems, in which the water functions as the medium of communication between the stations, and is useful for military purposes.

The transceivers of the invention can be operated on any desired frequency band depending upon the purpose for which it is employed. The choice of frequency is likely to depend upon the needs of other services. In general, it is believed that frequencies above 30 megacycles would be used and preferred, for the reason that at very low frequencies the equipment might tend to become too selective for satisfactory phone modulation. It should be understood, however, that the system of the invention is not limited to any particular frequency of operation.

What is claimed is:

1. In a relaying system, a repeater comprising a transceiver including an electron discharge device oscillator whose amplitude of oscillations is responsive to the amplitude of received waves at the same frequency, said oscillator comprising a regenerative structure and a degenerative structure having circuits associated therewith for causing the regenerative power to decrease and the degenerative power to increase with an increase in the amplitude of oscillations.

2. In a communication system, a transceiver and signal repeater comprising an oscillator of stable oscillations at partial maximum amplitude, said oscillator including a regenerative electrode structure and a degenerative electrode structure, a signal pick-up and radiating device coupling said oscillator to a communication medium, and means in circuit with said oscillator for automatically increasing the sum of its positive and negative resistances when a signal carrier current of increasing strength at the same frequency as the oscillation frequency is delivered to the oscillator.

3. In a relay system, a repeater of amplitude modulated power comprising an oscillator producing oscillations of a frequency equal to the frequency of the received power and having means responsive to the amplitude of the received power for controlling the amplitude of oscillation, said means including a regenerative electrode structure and a degenerative electrode structure, a grid condenser and a grid leak for supplying bias to said regenerative electrode structure, and a resistor in the space current path of said regenerative structure for supplying bias to said degenerative structure.

4. A transceiver and repeater comprising an oscillator having a pair of electrode structures each having anode, cathode and control electrodes, a resonant circuit common to both structures connected to the control electrodes to apply instantaneously opposed potentials thereto, a feedback coil in the common anode circuit of both structures and coupled to said resonant circuit, means for operating said structures along different portions of their control electrode potential-anode current characteristics, and means for amplitude modulating and demodulating the oscillations produced by said oscillator.

5. A transceiver and repeater comprising an oscillator having a pair of electrode structures

each having anode, cathode and control electrodes, a resonant circuit common to both structures connected to the control electrodes to apply instantaneously opposed potentials thereto, a feedback coil in the common anode circuit of both structures and coupled to said resonant circuit, means for operating said structures along different portions of their control electrode potential-anode current characteristics, and means for modulating and demodulating the oscillations produced by said oscillator.

6. In a communication system, a transceiver and signal repeater comprising an oscillator of stable oscillations at partial maximum amplitude, said oscillator including a regenerative electrode structure and a degenerative electrode structure, a signal pick-up and radiating device coupling said oscillator to a communication medium, including means for adjusting the degree of coupling between said signal pick-up and said oscillator, and means in circuit with said oscillator for automatically increasing the sum of its positive and negative resistances when a signal carrier current of increasing strength at the same frequency as the oscillation frequency is delivered to the oscillator.

7. In a communication system, a transceiver and signal repeater comprising an oscillator of stable oscillations at partial maximum amplitude, said oscillator including a regenerative electrode structure and a degenerative electrode structure, a signal pick-up and radiating device coupling said oscillator to a communication medium, including means for adjusting the efficiency of the transfer of energy between the communication medium and said oscillator, and means in circuit with said oscillator for automatically increasing the sum of its positive and negative resistances when a signal carrier current of increasing strength at the same frequency as the oscillation frequency is delivered to the oscillator, said means including a resistor in the space current path of said regenerative structure for supplying bias to said degenerative structure.

8. In a relay system, a plurality of geographically spaced units greater than two, each unit comprising a regenerative oscillating amplifier for generating stable oscillations at partial maximum amplitude of the same frequency as the other units and having coupled thereto a single antenna for receiving waves from one unit in the system and for transmitting waves to another unit in the system, the frequency of each unit being adapted to lock in synchronism with incoming waves, said units being so disposed that each unit receives from at least one other unit incoming waves of sufficient strength to produce said synchronism, whereby all of said units are maintained in synchronous oscillation, and means for modulating the oscillations of one unit and means at at least one other unit for indicating modulation of waves incoming thereto.

9. In a radio relaying system, a plurality of geographically spaced units greater than two, each of said units comprising a regenerative oscillating amplifier for generating oscillations at partial maximum amplitude of the same frequency as the other units and having coupled thereto a single antenna for receiving waves from one unit in the system and for transmitting waves to another unit in the system, the frequency of each unit being adapted to lock in synchronism with incoming waves, said units being so disposed that each unit receives from at least one other unit incoming waves of sufficient strength to produce

synchronism, whereby all of said units are maintained in synchronous oscillation, two of said units being too far apart to synchronize each other in the absence of the third unit, but each of said two units being close enough to said third unit to provide oscillations of sufficient strength to assume synchronism with said third unit and thereby with each other, means at each unit for modulating and means at each unit for indicating modulation of the received signal.

10. In a relay system, a plurality of geographically spaced units greater than two, each having an oscillator for generating oscillations of the same frequency as the other units, the frequency of each unit being adapted to lock in synchronism with incoming waves, each oscillator comprising a regenerative structure and a degenerative structure and means for causing the regenerative power to decrease and the degenerative power to increase with an increase in the amplitude of oscillations, said units being so disposed that each unit receives from at least one other unit incoming waves of sufficient strength to produce said

synchronism, whereby all of said units are maintained in synchronous oscillation, and means for modulating the oscillations of one unit and means at at least one other unit for indicating modulation of waves incoming thereto.

11. In a relay system, a plurality of geographically spaced units greater than two, each comprising a regenerative oscillating amplifier for generating oscillations at partial maximum amplitude of the same frequency as the other units and having coupled thereto a single antenna for receiving waves from one unit in the system and for transmitting waves to another unit in the system, the frequency of each unit being adapted to lock in synchronism with incoming waves, said units being so disposed that each unit receives from at least one other unit incoming waves of sufficient strength to produce said synchronism, whereby all of said units are maintained in synchronous oscillation, and means at each unit for modulating the oscillations and for indicating the modulation of waves incoming thereto.

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