New Radio Devices of Fixed Precision

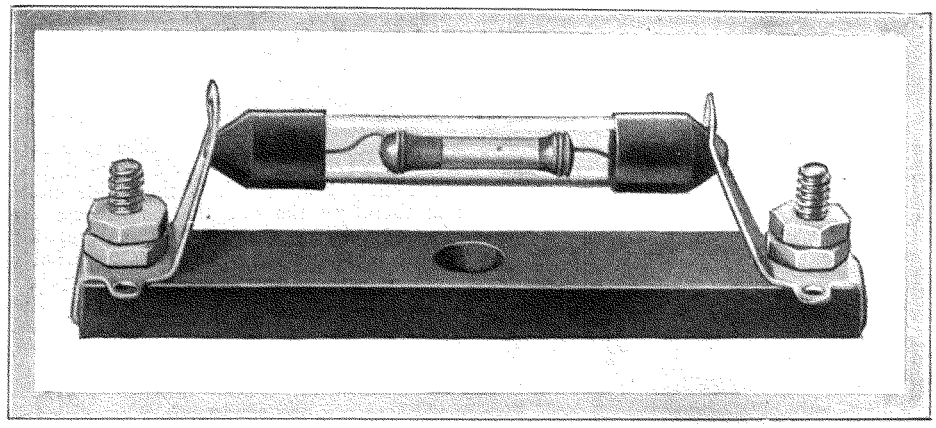
In addition to packing the parts of a radio receiving set into two vacuum tubes, Dr. Siegmund Loewe has constructed tiny apparatus which is hermetically sealed, and therefore does not vary, to measure wave-frequencies with an error less than a hundredth of one per cent.

NOT only has Dr. Loewe devoted a great deal of time to the development of his new vacuum tube, but he has turned his attention to other phases of radio as well. In this article are described two more of his inventions that will be instrumental in furthering the science to which he has devoted such a great portion of his life.

A NEW FIXED RESISTANCE

The resistances, mentioned elsewhere in connection with the coupling of the amplifiers, are also made separately. The external tube is of the same size as the grid leaks and resistances, with which the American radio fan is familiar, and so fits the holders, such as are used in this country. The outside glass tubes are evacuated, so that there can be no variation in the resistance value, due to changes in atmospheric conditions as previously mentioned.

These resistances can be used in any place where fixed resistances are required; and, due to their construction, there is little chance that the values will change. These resistances can carry a continuous load of 0.1 watt and will stand a peak load of 0.5 watt.



Another of Dr. Loewe's radio developments, a new type of high resistance. The small glass tube suspended in the larger one is covered with a metallic film, which acts as the resistance element.

A TUBE FOR MEASURING WAVE-LENGTHS

In previous issues of RADIO NEWS there have been various articles concerning "piezo-electric" crystals and the nature of their vibrations. For instance, quartz in the form of a rod may be made to vibrate mechanically at a very high frequency under the influence of an alternating electrical field; if this frequency corresponds to one of the elastic natural frequencies of the crystal.

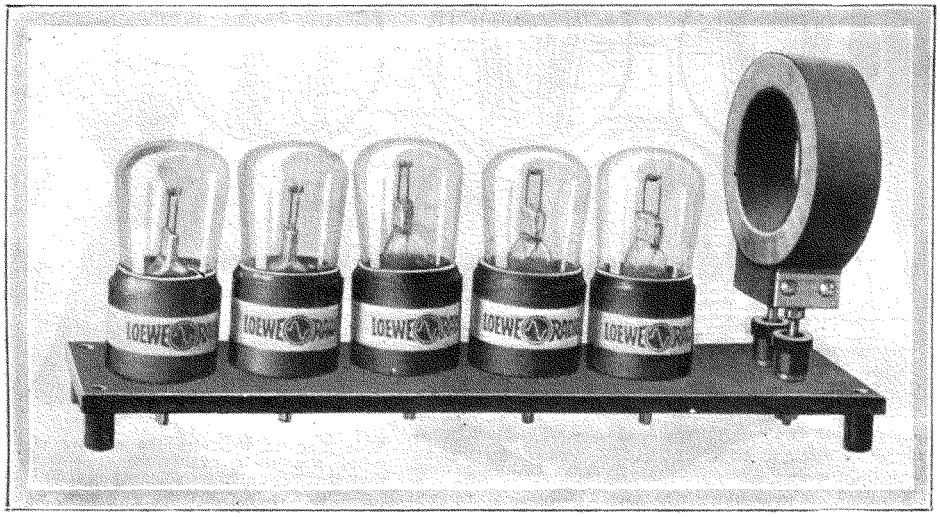
This effect is obtained by placing a specially-formed quartz rod between two condenser plates of an electrically-oscillating circuit. The occurrance of resonance between the electric and elastic oscillations may be found by measuring the current strength in the oscillating circuit; a sudden decrease of the current occurring just before the resonant point is reached. It has been discovered that the elastic oscillation of the quartz crystal, which takes place in the condition of resonance, may be made visible by a luminous effect. This effect is obtained by placing the two condenser plates together, with the quartz crystal between them, in a glass tube and evacuating this to a pressure in the neighborhood of 10 or 15 mm. of mercury. The condenser plates are connected to the external circuit by means of lead-in wires, which are run through the prongs in the base of the tube.

One of the quartz-crystal tubes for the measurement of the frequency of radio-frequency currents.

The alternating electrical field of such an oscillating circuit will cause, by reason of the electrical polarization of the quartz rod, alternating deformations in the latter. These, in the condition of resonance, will have the effect of generating the elastic oscillations. The deformations due to these oscillations will give rise to secondary alternating voltages upon the quartz rod, which bring the rarified gas contained in the tube to luminescence.

The resonance is extremely sharp and therefore the luminous effect may be adjusted down to one hundredth of one per cent. (.0001) of the wave-length. By the proper choice of the condenser plates and the degree of vacuum, the discharge is made to occur throughout the discharge space. A quartz resonator of this type affords a very accurate indicator for the measurement of wave-lengths. One of the accompanying illustrations shows a quartz resonator tube, which is filled with a special gaseous mixture, including helium and neon.

Extraordinary accuracy of wave-length measurements can be obtained with this instrument. Although the frequency may be easily calculated from the given wave-length, there will be some uncertainty because of possible errors in computing the exact velocity of light. For this reason these tubes are calibrated so that they will give readings in frequencies instead of wave-lengths, thus making them independent of the velocity of light.



The coil on the right is for coupling the wave-meter to the oscillating circuit to be measured.

ELECTRICAL MEASUREMENTS

By means of indirect methods, capacities and inductances may be measured very exactly by means of these resonators. Since the calibrated quartz crystal is placed within an evacuated glass tube, the measuring instrument can be regarded as absolutely unvarying, so long as the quartz and the glass tube remain uninjured. Since it has been found practically impossible to detect any influence of the variations in temperature, these "frequency standards" can be regarded as being entirely independent of the temperature.

The resonators will respond, if excited by a potential as low as thirty volts; but only in case the exciting current has a frequency (within 1/100 of 1 per cent.) identical with the resonance frequency of the quartz crystal. On account of the low potential used, the

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strain imposed upon the quartz is reduced to a minimum; and the life of these resonators is, therefore, practically unlimited. In the case of higher voltage the cell will also become luminescent, this phenomenon being due solely to a glimmering discharge between the electrodes. By means of an interposed oscillatory circuit, which is tuned approximately for the proper wave-length, it is easy to tune the transmitting station exactly to its prescribed wave. First the coupling is made somewhat closer and a preliminary tuning is made by means of the glimmering effect. If the coupling is made looser, the "luminescence" property of the quartz will be obtained; which takes place only in case the tuning is accurate within a frequency limit less than that specified above.

A bank of five of these resonators (one of which is calibrated exactly to the required frequency, two others to frequencies slightly above, and the remaining two to frequencies slightly below the prescribed frequency) may easily be used in the determination of the exact frequency of a transmitter or oscillator. The condenser controlling the frequency of oscillations is slowly varied until the outside tubes become luminescent. The condenser is varied, more slowly still, until only the middle tube, which is the one having the exact frequency desired, is luminescent. This indicates that the oscillatory circuit is at the same frequency as that to which the middle tube is calibrated.

This brief description of Dr. Loewe's new apparatus will give the reader a rough idea of just how important these inventions are. The possibilities that the new vacuum tubes afford are also limitless; for it is entirely within the realms of possibility that sometime we shall have entire radio sets within a comparatively small space instead of the cumbersome boxes and cabinets such as we know today. Even now, with the detector and amplifier tube in its present state of development, the space needed in the cabinet of a portable receiver has been much reduced, due to the elimination of two vacuum tubes.

As for the quartz-crystal frequency resonator, this, too, is an important step forward. Broadcast stations, and also receiving sets, can now be tuned to an accuracy hitherto unobtainable; and at the same time these tubes act as a danger signal when there is a variation from the assigned wave-length of the station.

addendum from *Radio News for September, 1926*

Tubes Within Tubes

IN the July, 1926, issue of RADIO NEWS, appeared an article by G. C. B. Rowe entitled "Tubes Within Tubes." In that article we neglected to state that the vacuum tube described, containing in addition to the thermionic elements a complete resistance-capacity-coupling system, is the result of work done by Dr. Sigmund Loewe, on the thermionic elements, and by Baron Von Ardenne, on the circuit arrangement. This work was done in the Loewe laboratories in Berlin.

In the same issue an article entitled "New Radio Devices of Fixed Precision," describes a quartz resonator used for accurately determining and measuring radio frequencies. The original idea of the luminous quartz, as employed in this device, is due to Prof. Giebe and Dr. Adolph Schiebe, both of the German Bureau of Standards. These scientists worked in conjunction with the laboratories of the Loewe Radio Co. of Berlin, in the development of the resonator.