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THE MEGACYCLE METER
By Jerry B. Minter

Summary of:
"Pulse Time Modulation" by Fred C. Wallace
"A Radio Man's Scenic Moments" by Joseph A. Waldschmitt

THE RADIO CLUB OF AMERICA

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Volume 24 MARCH, 1947 No. 3

THE MEGACYCLE METER

By

Jerry B. Minter*

Presented before the Radio Club, May 9, 1947

The Model 59 is basically a grid-dip meter. Such instruments have been used by radio amateurs, and others for many years. This commercial instrument is rather carefully designed, however, to eliminate some of the shortcomings of the home-made models which have been used from time to time and described in the literature. In the first place, the Model 59 is a balanced type oscillator. That is, the tuning capacitor is balanced to ground and the Colpitts type circuit is arranged so that the neutral point of the oscillator is exactly at the mid-point of the oscillator inductance. It will be seen later that this permits one to obtain pure magnetic coupling or pure electrostatic coupling to a circuit under examination.

The instrument can be thought of as a dynamic wavemeter, since unlike ordinary wavemeters, it

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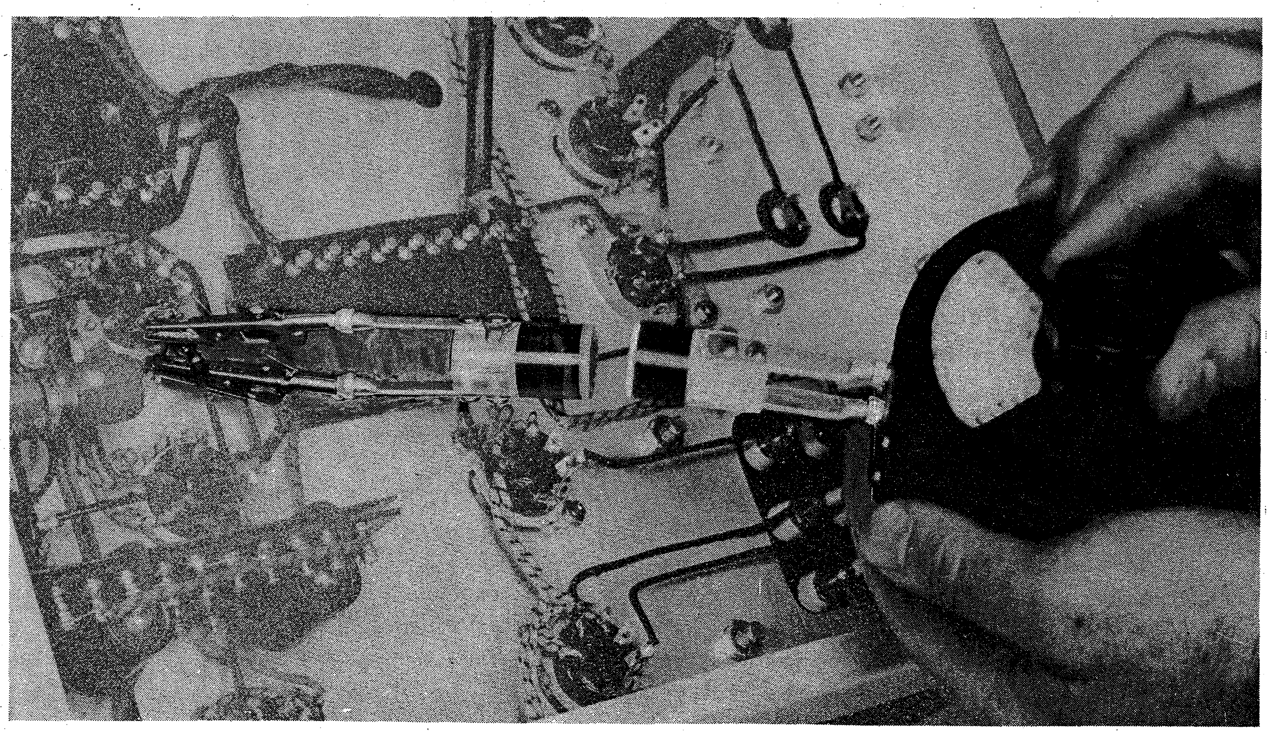


Note: Use of the Mueller #60CS Clips (illustrated) will add about one mmfd to the minimum circuit capacitance of the coil; therefore one mmfd should be subtracted from that value read opposite the resonant frequency of the chart.

Figure 1 - MEASUREMENT OF CAPACITANCE

supplies its own power; it therefore is capable of measuring the resonant frequency of tuned circuits which are passive in themselves. Of course, it will also measure the resonant frequency of oscillating circuits. For additional convenience a phone jack is provided for audible detection of resonance in addition to the meter in the grid circuit.

The Model 59 covers the frequency range of 2.2 to 400 mc. It is as basic to the High Frequency Art as the volt-ohmmeter and the soldering iron. It can be used to measure not only frequency but also capacity, inductance, mutual inductance and Q.

To measure capacitance, one of the unused coils is connected with suitable clips across the unknown capacitor, and the resonant frequency of the combination is then measured. (See Fig. 1). A set of charts permits direct reading of capacitance from zero to 1,000 micromicrofarads. It is necessary to obtain one extra coil for the range from 10 to 50 mmf, since this is the capacitance range of the internal tuning capacitor of the 59. The accuracy of capacitance measurement is of the order of 5% or better, depending upon the care taken in connecting to the capacitor and determining resonant frequency.

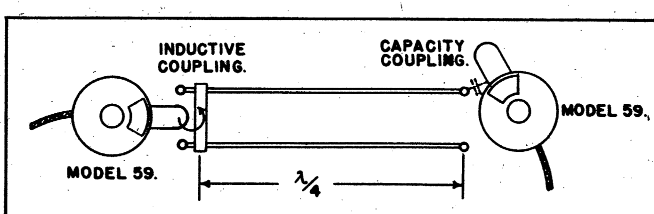
Likewise, it is easy to measure unknown inductance coils by connecting them across a known capacitor, and determining the resonant frequency of the combination. Mutual inductance can be determined in a similar manner by first connecting the coils, aiding and then bucking, and then calculated by using the well known formula for mutual inductance.

In order to measure Q, accurately, a suitable vacuum tube voltmeter should be used to indicate resonance of the unknown circuit and the 70% response point. Of course, a relative indication of Q can be obtained by merely noting how sharp the dip in grid current is and comparing that with other grid current indications. For example:- a very high Q circuit will give a very sharp indication of grid current, in fact, it may pull the oscillator completely out of oscillation. Whereas a very low Q circuit, one with a Q of 5 or 10, perhaps, will yield a broad indication of resonance. In other words, the circuit does not couple readily to the Model 59, and therefore does not give a large sharply defined dip of grid-current. Therefore it is possible to get a qualitative measure of the Q with the 59 alone.

So far, I've been dealing with the basic applications of the Model 59, those involving the measurement of frequency, inductance, capacitance, etc. The instrument also has many applications in the field of antenna measurements. You can measure not only the natural resonant frequency of simple antenna, but you can also take into account the proximity effect of parasitic reflectors on resonant frequency. Thus it is possible to adjust accurately an antenna structure to a particular frequency by use of the Model 59.

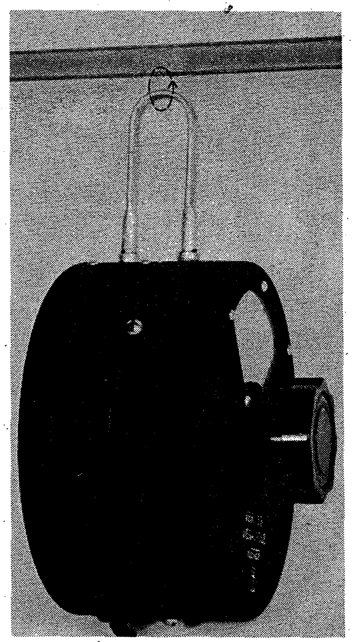
A very pretty demonstration of the magnetic field about an antenna can be made with the Model 59. The direction of the current flow and hence the direction of the magnetic field as well as location of maxima and minima can be shown by moving the exploring coil along the antenna and determining where the maximum current absorption occurs and where the maximum voltage occurs. If it desired to measure an antenna accurately, it is always well to couple to the current maxima, which in the case of a half-wave antenna means at the center rather than at the ends. Coupling at the ends, (see Fig. 2), tends to detune the antenna to some extent; it is therefore better to measure a 1/4 wave section at its second harmonic or half-wave resonance frequency by shorting out the 1/4 wave section at its far end because of end effects. Of course, in many cases for matching stubs, the frequency need not be known so accurately.

It is possible to couple to transmission lines to determine whether they are properly matched to eliminate standing wave errors. (see



Note: Inductive coupling may be more convenient for low-Q stubs.
Capacity coupling is quite satisfactory for Hi-Q stubs.
On co-axial stubs, a noticeable dip may be obtained by inductive coupling to the shorted end of single braid co-axial stubs in the 100 to 400 mc frequency range. This occurs because of the imperfect shielding action of the outer braid conductor at these higher frequencies.

Figure 2 - COUPLING TO QUARTER-WAVE STUBS



Note: 1. Orient for maximum inductive coupling (on "DIODE"), with power applied to line;
2. Move linearly along line for a distance of one quarter wave or more while maintaining constant spacing.

FIGURE 3 - CHECKING FOR STANDING WAVES ON TRANSMISSION LINES

Fig. 3). All these measurements can be made in the oscillating condition with the Model 59 supplying the required power. Therefore, it is not necessary to drive the antenna from a transmitter and radiate a strong interfering signal to make these measurements.

It is possible to get a quantitive measure of harmonic reduction by means of the 59 coupled to a transmitter antenna. This application is fully described in the instruction book.

The Model 59 has many applications in the field of transmitters. It can be used to determine the location of parasitic oscillations in audio modulators. Frequently these oscillations occur in the range from 30 to 150 megacycles, beyond the limits of the average oscilloscope. The Model 59, when used as an oscillating detector, with a pair of headphones, can be used to locate the maximum current and its direction and thus trace out the path of the parasitic. It can, therefore, be used to determine when the parasitic has been completely eliminated under actual modulation conditions.

The 59 can also be used to line up the master oscillator, tune up the buffer-amplifier stages, and the final power amplifier.

In some high frequency transmitters, such as are used for taxi-cab radio, a great many harmonic amplifier stages are employed, and it is difficult to determine to which harmonic some of these amplifiers are tuned without the aid of an instrument such as the Model 59.

It is possible to tune up most stages without even having the power applied to the transmitter! This is important in transmitters employing high voltage and results in a considerable improvement in safety during experimental work and tuning of the transmitter.

It is easy to neutralize an amplifier stage with the Model 59. There are two basic methods of neutralization; one is called "reaction method" which involves the coupling to the grid circuit, and adjusting the neutralizing capacitor for minimum reaction of the plate tank tuning on grid circuit tuning. This can be done without any power being applied to the stage whatsoever; the second involves the application of drive power to the grid, but no plate voltage to the amplifier stage and is called the "transmission method" of neutralization. This involves coupling to the plate tank and adjusting the neutralization capacitor for minimum transmission at the desired frequency. Both of these methods are carefully described and diagrammed in the instruction book.

Frequently, parasitics are encountered in the r.f. stages of the transmitter. These can be located, provided they do not exceed the upper frequency limit of 400 megacycles.

The Model 59 has numerous applications in receiver design and alignment. It is possible to adjust and track the high frequency, r.f. antenna, and oscillator circuits without having power applied to the receiver. In many cases involving grid mixing of the oscillator, a certain amount of dragging of oscillator frequency occurs due to misadjustment of the mixer input circuit. With the conventional method of using a standard signal generator, this condition is rather difficult to overcome and sometimes the mixer circuit is badly mistuned through false interpretation of the maximizing of conversion gain. With the Model 59 the correct tuning range is first set up on the mixer circuit, and then on the oscillator circuit. Next the coupling between the two can be adjusted for optimum conversion gain after power is applied. Thus, the two opposing effects of resonance and local oscillator injection are separated into two adjustments thru the use of the Model 59.

It is frequently necessary to include trap and rejection circuits for the elimination of IF interference, FM image responses and other undesirable responses in television receivers. These traps can be readily adjusted with the aid of the Model 59. It is sometimes desirable to incorporate a hi-pass filter to eliminate undesired IF responses; such a hi-pass filter can be readily adjusted by the Model 59. The adjustment of such a filter is described in detail in the instruction book.

Of course the intermediate frequency circuits in a receiver can be checked for correct tuning. The Model 59 is particularly useful for the adjustment of stagger-tuned circuits, which are becoming increasingly popular in television receivers. The i.f. trap circuits can also be readily tuned with the Model 59.

In the design of video detector circuits it is desirable to use a low pass filter between the video detector and the first video amplifier. This low pass filter can be adjusted by means of the Model 59.

Of course the video peaking coils between the video stage and the kinescope grid can also be adjusted with the Model 59. There are many cases where it is desired to measure small capacitors in the video stages between the range of 5 and 15 mmf. The use of one of the unused oscillator coils and a pair of short clips to measure this capacity, as previously mentioned, is very convenient, since it is not necessary to carry a large capacitance bridge over to the chassis under study. Nor is there a lead length problem, since the coil can be clipped directly into place in the circuit. Also it is possible to measure this capacity, in most cases, without unsoldering load resistors and other components, as is necessary if a low frequency capacitance bridge is used.

In an FM receiver or in the FM sound portion of a television receiver, the Model 59 can be used to adjust the center frequency or crossover of a discriminator. It can also be used to adjust carrier difference detection type discriminators which are becoming more popular in some of the cheaper television sets.

There are many other applications in the field of high frequency receivers. Some receivers, such as those used in the taxi-cab service in the range from 150 to 165 megacycles, employ band pass type harmonic amplifiers for their crystals, so that substantially no retuning of the receiver is necessary in order to change crystal frequency. These band-pass circuits can be easily adjusted by use of the 59 in determining their natural resonant frequency. If they are slightly over coupled, two resonant dips will be noted on the Model 59. If they're undercoupled, of course only one resonant dip will be found.

In receivers and other high frequency equipment, parasitic circuits can cause considerable trouble, since they create dead spots in the tuning range by the process of absorbing energy in a manner similar to a trap. By overcoupling they may actually drag the circuit and make it difficult, if not impossible, to cover a desired tuning range. These undesired parasitic resonant circuits are frequently present in the mechanical structure of the assembly. Latch bars of push button switches may resonate because they are large compared to wave length. Mechanical support members such as bearing supports, shafts and other structural members, which are not normally thought of as being electrical parts of a circuit, may become resonant and cause considerable trouble. The 59 can be used to determine not only the direction of current flow, but also the maximum current flow or the maximum voltage standing wave points. Obviously, if the circuit can be open-circuited at the current maximum, a substantial reduction in the parasitic should result. If the circuit can be shorted or loaded at the voltage maximum point, the parasitic can also be eliminated.

The technique of using a Model 59 for locating a parasitic can be illustrated by exploring the field around a simple 1/2 wave or 1/4 wave antenna in space and thus demonstrating the ease with which the Model 59 can plot the field.

There are many miscellaneous applications of an instrument like the Model 59. It can be used as a signal source for point to point trouble checking in a VHF receiver: by locating it at some distance from the antenna input, a signal can be introduced in a small loop in the antenna input circuit, and point to point checks made between the antenna, the r.f. stage, and the i.f. stages in turn. Preceding stages can be disabled by pulling the tubes out of their sockets or by removing the plate voltage.

The Model 59 can also be used as a beat marker for marking sweep generator displays on an oscilloscope. There are a good many types of sweep generators without a suitable marker. The beat type marker which results when the Model 59 is coupled in loosely to the input of the broad band amplifier under sweep alignment is quite convenient. It can be made more pronounced and sharply defined by restricting the band width of the oscilloscope by means of a simple RC low pass filter. Sometimes broad band oscilloscopes may be used simply because they are used for other applications on the same project. A broad band width of 1 or 2 megacycles will produce a broad beat marker and thus obscure, or make it difficult, to determine the frequency accurately. The amplitude of the marker can be controlled by varying the coupling between the Model 59 and the input of the system under test.

The Model 59 has been carefully designed to assure long and faithful service. There are a number of refinements which have been added to the original laboratory models; such as, a small trimmer to permit replacement of the 955 r.f. oscillator tube and readjustment of the tuning dial to exact tracking of the scale. All the Model 59's are individually calibrated in frequency, and tho the frequency is guaranteed to 2%, it is actually held to much closer limits than this in production. All of the coils are held to close limits even though the dials are individually calibrated. Thus it is possible to buy a replacement coil and not have a serious error in the frequency calibration of the dial.

The instrument has provision for modulation, so that a 120 cycle ripple from the power supply can be applied for internal modulation. External modulation can be applied, if desired. This is sometimes convenient for identifying the signal when checking the beats from a harmonic oscillator.

Of course it has been previously pointed out that headphones can be used to indicate resonance by a sharp click in the case of a passive circuit, as contrasted with a dip of grid current on the meter. There will be an audible beat note in the headphones when beating to an oscillating circuit as compared to a rise, dip and then a rise again in grid current. The headphones can also be used with the instrument in a non-oscillating or a diode condition. This may be useful for monitoring for the presence of parasitics in a system.

In the construction of the instrument, every effort has been made to use the highest quality of component parts, so that no difficulty should be experienced with the failure of components, other than an occasional vacuum tube.

We hope in the near future to make available a small battery pack for use with the instrument in the field. This would be particularly useful in examining antennas on aircraft and up on towers or locations where it may be inconvenient to obtain 110 ac power, or detrimental to the antenna under investigation. This battery pack will increase the utility of the instrument.

We also anticipate the possibility of making both a low frequency and a high frequency tuning head. These heads could be purchased separately, and thus, increase the utility of the instrument to those people interested in that part of the frequency spectrum.

The flexibility of the Model 59 is almost unlimited. The field of applications has been scarcely scratched.

A RADIO MAN'S SCENIC MOMENTS

By

Joseph A. Waldschmitt*

EDITOR'S NOTE: Following is a summary of a Paper presented by Mr. Waldschmitt to the Radio Club of America, New York City on April 11, 1947.

A very interesting account of his many experiences during the war installing and maintaining radio equipment was presented. As his duties took him to all parts of the world, he illustrated his talk with a collection of colored slides of pictures taken in Labrador, Baffin Land, Greenland, China, Burma, India and the United States.

* Engineer with E.C. Page, Consulting Radio Engineers of Washington, D.C.

PULSE TIME MODULATION

By

Fred C. Wallace*

EDITOR'S NOTE: Following is a summary of a Paper presented by Mr. Wallace to the Radio Club of America, New York City on March 14, 1947.

A sound motion picture describing a 24 channel microwave system was shown followed by a description of the methods used to time modulate and demodulate the signalling pulses. The results obtained in communication service were explained.

* Supervising Engineer, General Technical Service, Federal Communications Lab., Inc.

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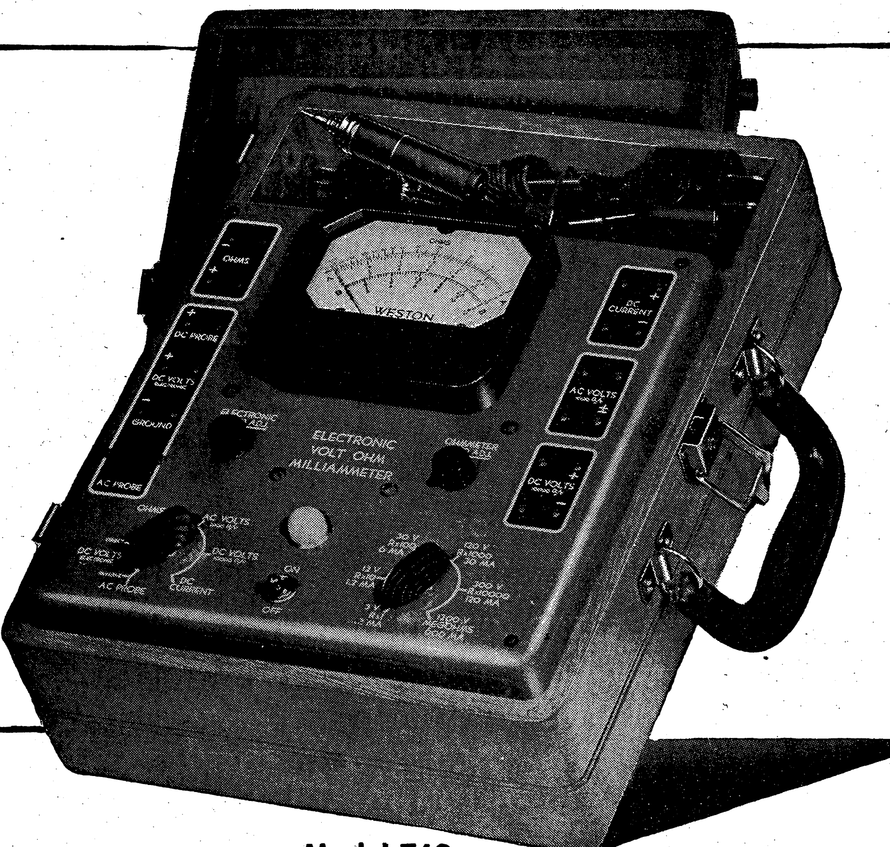

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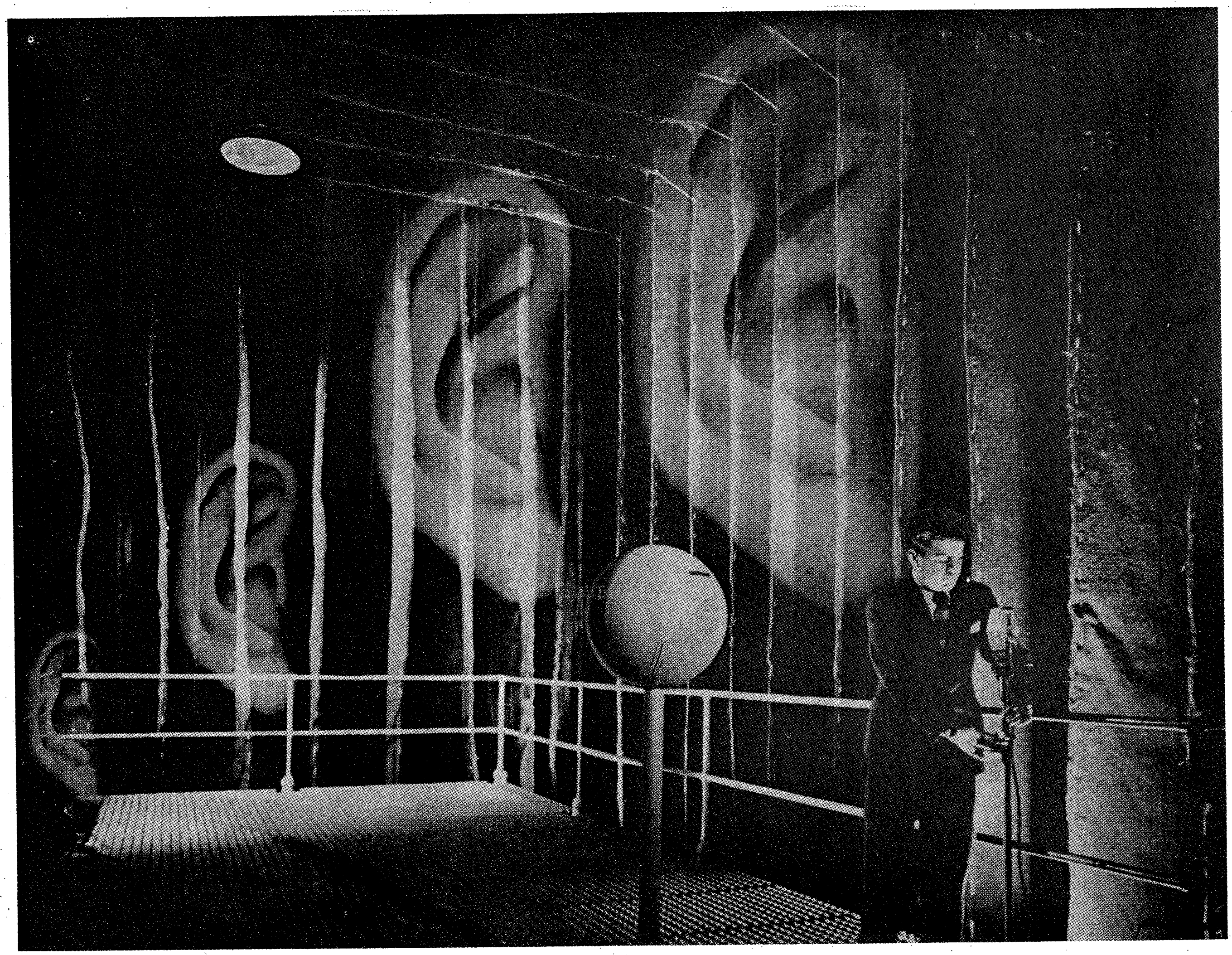

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