The GENERAL RADIO EXPERIMENTER

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ELECTRICAL COMMUNICATIONS TECHNIQUE AND ITS APPLICATIONS IN ALLIED FIELDS

WIDE-RANGE TRANSFORMERS

BASED on original designs of the engineers of Wired Radio, Inc.,* the General Radio Company has developed a new line of transformers characterized by their extremely wide frequency range.

The characteristics of these three transformers are shown in Figure 1, Figure 2, and Figure 3. The TYPE 741-G Line-to-Grid Transformer has a flat frequency response within 2 decibels from 35 to 225,000 cycles. It will be noted from an examination of the curve that the characteristic does not deviate from a linear response anywhere below 200,000 cycles except for gradual falling off of the low frequency response below 100 cycles.

The TYPE 741-J Interstage Transformer is flat within 2 decibels from 70 to slightly over 200,000 cycles. This curve was taken with the transformer operating from the plates of 56-type tubes operating in push-pull and into the grids of the tubes in the following stage connected in push-pull. The same characteristic would be obtained when operating from tubes or any other balanced impedance of the order of 10,000 ohms. When operating from lower impedances than this, the low frequency characteristic is improved correspondingly. As might be expected, a uniform wide frequency response with these transformers is most difficult of achievement when the impedances between which they work are highest.

The TYPE 741-P Tube-to-Line Transformer has a flat frequency response from less than 20 cycles to about 200,000 cycles. The input circuit in this case is a pair of 56-type tubes in push-pull, and the terminating impedance 500 ohms, resistive.

Many uses for such transformers are immediately suggested. With the cathode-ray tube available as an accurate oscillograph, voltmeter, or

* Mr. R. D. Duncan, Chief Engineer, Mr. H. R. Butler, Engineer, Wired Radio, Inc., Ampere, New Jersey. Patent No. 1,983,657; December 11, 1934.

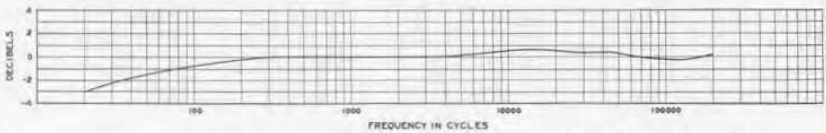


FIGURE 1. Frequency characteristic TYPE 741-G Line-to-Grid Transformer. Voltage step-up ratio 1 : 6.4

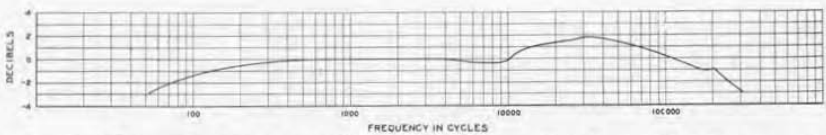


FIGURE 2. Frequency characteristic TYPE 741-J Interstage Transformer. Voltage ratio 1 : 1

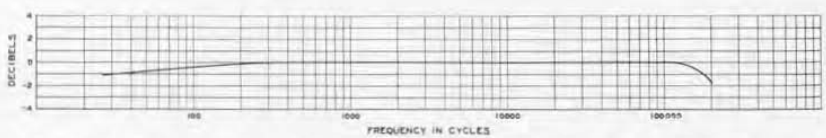


FIGURE 3. Frequency characteristic TYPE 741-P Plate-to-Line Transformer. Voltage step-down ratio 6.35 : 1

ammeter for the high-frequency ranges, the investigation of superaudible or low radio-frequency phenomena is greatly facilitated by the use of these transformers in amplifiers for the operation of cathode-ray tubes.

These transformers faithfully reproduce without attenuation all the frequencies of a wide frequency spectrum. With more and more interest constantly developing in high-quality sound reproduction, these transformers fill an important need in wide-range audio systems.

In experimental television applications, an acceptable picture can be transmitted over a 200,000-cycle band width. This band is frequently adequate for fair pictures and particularly for experimental investigation. Many other applications will suggest themselves to engineers and experimenters carrying on investigations which require the amplification of a wide band of frequencies including the audio spectrum.

A high-permeability nickel-iron alloy is used for the core material. Similar alloys have been considerably used for core material where their high permeability is helpful in obtaining wide frequency-response transformers. It, however, has one characteristic which makes it necessary to handle it carefully in the usual vacuum-tube circuits — that is, that magnetic saturation of the core occurs at very low values of ampere-turns. One of the important reasons

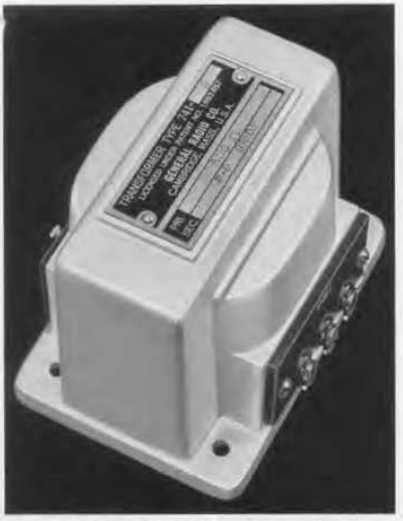


FIGURE 4. TYPE 741-G Transformer. The same size cast-aluminum case is used for all three models

why these wide-range transformers must be used in push-pull circuits is to cancel any direct current flowing in the plate circuits of tubes from which the transformers are operated. A current unbalance between tubes of 1 or 2 milliamperes will not affect the magnetic characteristics, but it is essential that the unbalance plate current does not exceed this value.

The principal feature of these new transformers and that which requires much attention in their design is the structure of the coil and the core so that leakage reactance and distributed capacitance are reduced to the lowest possible values. The question of the electrical balance between the various sections of the winding is important, and that is a second reason why it is necessary, in order to obtain the best possible frequency characteristic, that the transformers be worked in balanced or push-pull circuits.

As described above, three standard models are now available:

(1) TYPE 741-G, 500-600-ohm line to push-pull grids

(2) TYPE 741-J, interstage push-pull plates to push-pull grids

(3) TYPE 741-P, push-pull plates to 500-600-ohm line.

One of the completed transformers is illustrated in Figure 4. All models are housed in cast-aluminum cases. The cases provide excellent shielding for frequencies above 1000 cycles and are particularly useful in reducing inductive feed-back which may cause "singing." The cases are also excellent shields against other high-frequency disturbances such as the usual laboratory noises caused by circuit breakers, switches, etc., all of which are bothersome, particularly when a wide frequency range is being used. Cast iron is a somewhat more effective shield at 40-180 cycles than is aluminum. Such cases can be provided on special order, but generally it has been found that power-line hum interference is less serious than that produced by other sources.

—ARTHUR E. THIESSEN

Type	*Code Word*	*Use*	*Net Weight*	*Price*
741-G	WIDTRANANT	L to G	2½ pounds	$22.50
741-J	WIDTRANBOY	Interstage	2½ pounds	22.50
741-P	WIDTRANCAT	P to L	2½ pounds	22.50

BEAT-FREQUENCY OSCILLATORS

Among the new instruments recently announced is a beat-frequency oscillator (TYPE 713) which replaces the TYPE 513. The development of new types of tubes has made possible an oscillator of improved characteristics. The outstanding characteristic of the new oscillator is its power output, two watts, combined with excellent waveform. The power, adequate for all usual laboratory needs without amplification, has, we believe, never before been available in a laboratory oscillator.

The design of an oscillator of this beat-frequency type always presents many problems. In the following article Mr. Arguimbau, the designer, describes some of the interesting features of the new instrument.

THE general characteristics of beat-frequency oscillators are well known. The outputs of two oscillators of high frequency are mixed in a modulator, and the difference frequency, after being filtered, is amplified and used as a source of alternating current. The system has two important advantages: the difference frequency can be controlled over a wide range by a single control without the use of large inductors and condensers and the output is approximately constant as the frequency is varied. On the other hand, certain drawbacks of such a system will appear upon examination. Among the troublesome factors which have contributed to make the beat-frequency oscillator one of the most difficult of design problems are: distortion introduced by the detectors, the presence of miscellaneous high-frequency products in the output, and the difficulty of getting a 10-cycle output when a change of 0.1% in the oscillator frequency makes a change of 200 cycles in the output.

As has been pointed out, the frequency stability of both oscillators is of primary importance in the design, since the output frequency is necessarily far less stable than that of the component oscillators, and yet stability of the output frequency is an essential characteristic of the instrument.

One of the chief difficulties which have been experienced in making stable oscillators has been the flow of grid current in the oscillator circuit. While circuits can be made stable where grid current is present by properly arranging the tuned circuit, the use of a pentode circuit which is entirely free from grid current has so simplified the problem that frequency stability becomes purely a question of the mechanical permanence of the circuit as influenced by temperature and aging.

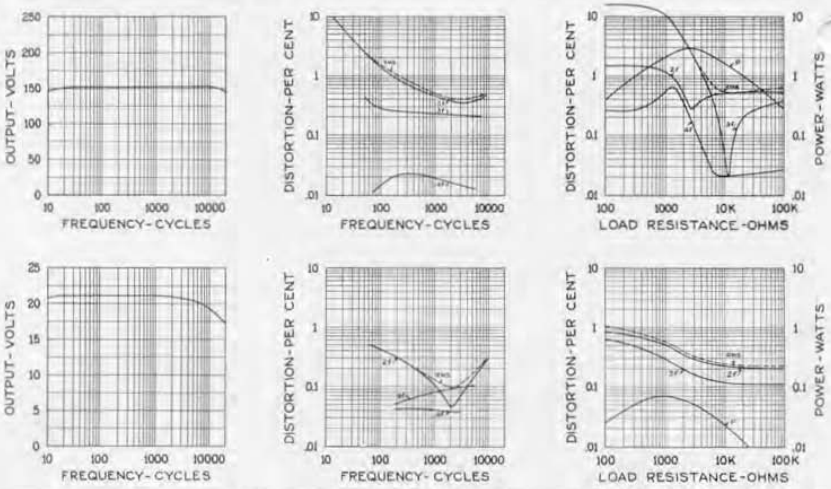
To reduce temperature variation, the two tuned circuits have been symmetrically placed and mounted on a heavy aluminum slab which is thermally insulated from all heated portions of the circuit, including the oscillator tubes themselves, reducing the temperature variations

The TYPE 713-A Beat-Frequency Oscillator. A new a-c operated oscillator with undistorted output of 2 watts. The frequency range is 10 cycles to 16,000 cycles.

due to heating within the oscillator to a somewhat lower order than normal room temperature fluctuations.

In addition to having a stable frequency, the oscillator should be of good waveform. Two superimposed waves of nearly equal frequency can be thought of as the vector sum of two signals differing in phase at the angular velocity of the difference frequency. The envelope generated by this is similar to the result of a connecting rod motion and contains a large second harmonic.

The use of a balanced push-pull detector circuit eliminates this second harmonic, and from this point on the problem is a routine matter of amplifier, filter, and transformer design. The filter and transformer arrangement has been made of substantially uniform gain from 10 cycles to 20,000 cycles. It was found impossible to pass the full 10-cycle output of two watts through any transformer of practical size without serious distortion. Partly for this reason a switch has been provided so that the input to the detector can be reduced and with it the level throughout the instrument. At the reduced output level, the distortion remains at less than 1% down to 10 cycles. While no measuring arrangements were available for accurate tests, the waveform as viewed on a



Performance characteristic of a typical TYPE 713-A Beat-Frequency Oscillator. The upper set of curves represents normal output conditions; the lower group conditions at 1/10 normal output. A considerable improvement of waveform at low frequencies will be noted under the latter conditions

cathode-ray oscillograph when beating against another oscillator appears sinusoidal at 2 cycles.

The push-pull detector circuit has the additional advantage of decreasing the coupling between the two oscillator circuits. The currents from the parallel branch divide equally through the coils of the grid-to-grid (variable) oscillator so that the resultant coupling is balanced to zero. The buffer stage in the parallel branch has been added to isolate the detector plate current of the fixed oscillator frequency (along with its second harmonic) which flows in this branch from the output. The detector balance along with the reduced coupling on the low output range makes interaction between the oscillators very small.

The power frequency components have been kept to about 1% on the low output range, to 0.1% on the high range. Most of this hum is introduced by the filaments of the last stage and the amplitude control must, therefore, be at the output of the final high-level stage. Otherwise, amplitude would be decreased without decrease in hum, *i.e.*, with increase in hum percentage. Realizing this situation, it was felt that for a general-purpose instrument it would be best to use a grounded output circuit. For most measuring purposes such a circuit is much less likely to cause trouble than a balanced circuit. In case the instrument is to be used in a carefully balanced circuit, a transformer is ordinarily necessary.

Many psychological laboratories have used an "incremental pitch" condenser* in conjunction with the

* A. E. Thiessen, April-May, 1933, General Radio *Experimenter*, Vol. VII, Nos. 11 and 12.

TYPE 613-B d-c operated beat oscillator for tone tests. This type of condenser with direct-reading scale of ±50 cycles has been included on the TYPE 713-A Oscillator. This dial permits resonance curves to be taken as well as permitting the auditory tests. Additional use has been made of this dial by engraving a line at least every 100 cycles on the main scale, thereby effectively providing a calibration point *for every cycle throughout the scale*. This does not mean that the oscillator should be used as a frequency standard, but the added feature should prove useful if it is desired to duplicate settings accurately.

— L. B. ARGUIMBAU

The TYPE 713-A Oscillator is licensed under patents of the American Telephone and Telegraph Company

NETWORKS AT REDUCED PRICES

THE following attenuation networks (one each) are available at a large price reduction.

They have been used for demonstration and display but are in perfect condition.

Type	*Range*	*Impedance*	*Section*
329-K	55 db steps of 0.5	6000 ohms	H
329-N	22 db steps of 0.2	600 ohms	Bal. H
329-R	22 db steps of 0.2	6000 ohms	H
329-P	22 db steps of 0.2	6000 ohms	Bal. H
429-R	22 db steps of 0.2	6000 ohms	T

Price—all types **$50.00**

VOLUME CONTROLS

A FEW of the TYPE 552 Master Gain Controls (discontinued) are still available (former price $28.00). All are L sections. Range 30 db in 1.5-db steps.

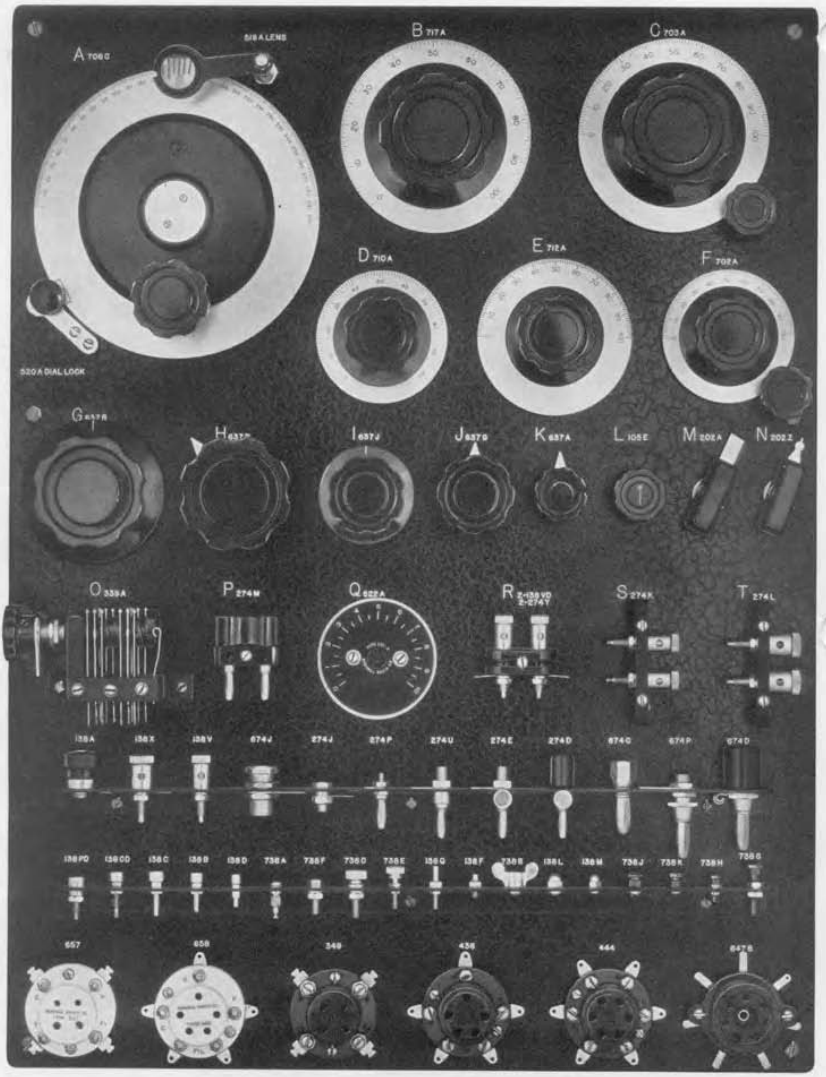
Type	*Impedance*
552-LA	50 ohms
552-LB	200 ohms
552-LC	500 ohms

Price—all types **$10.00**

ERRATA NOTICE
TYPE 200-CUH VARIAC

WE regret that the curves showing the ratings for the TYPES 200-CUH Variacs shown in the April *Experimenter* were in error, showing a considerably higher rating at the ends of the winding than can be relied upon in practice.

The flat portions of Curves A and B should be at 2.5 amperes instead of 3.5 amperes as shown, and the flat portion of Curve C should be 2.0 amperes between 0 and 150 volts instead of 3.5 amperes as shown.



PARTS AND ACCESSORIES — A full-size reproduction of the parts and accessories panel illustrated above, approximately 19½ x 28 inches in size, is available for free distribution to engineers and draftsmen interested in securing a copy. Since all of the parts appear in full scale, this condensed parts catalog is of considerable assistance to persons having to design equipment. To secure a reproduction of the parts and accessories panel, readers of the *Experimenter* should ask for a copy of Form 339-B

GENERAL RADIO COMPANY
30 State Street - Cambridge A, Massachusetts

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