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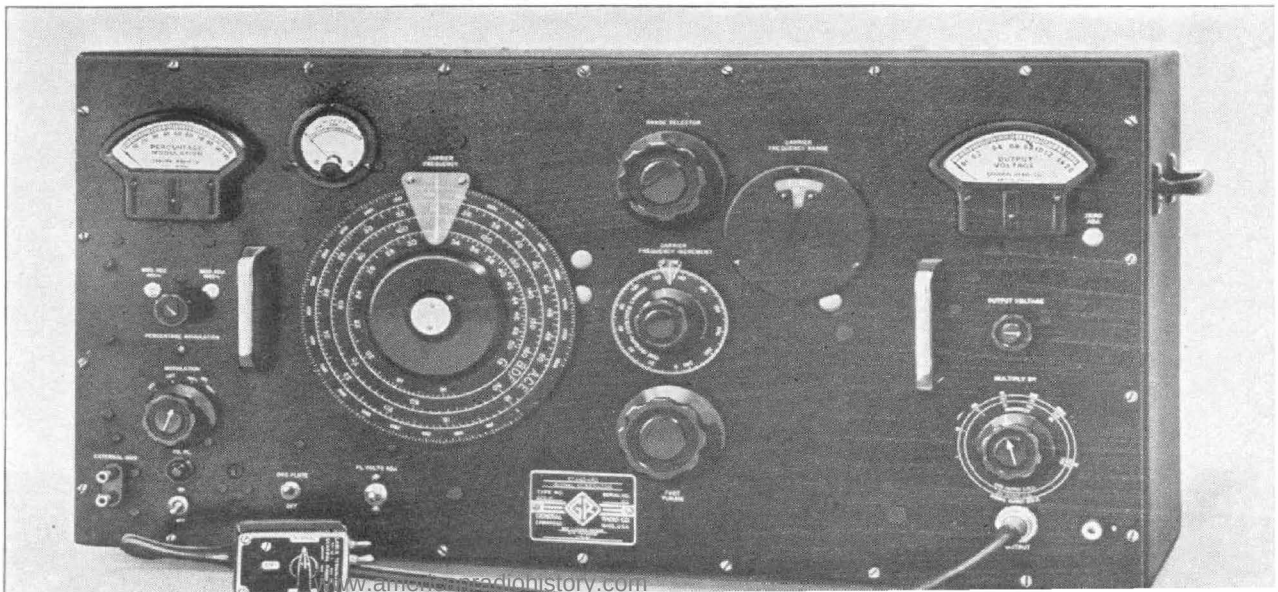
ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

Also IN THIS ISSUE

PROGRESS IN SIGNAL GENERATOR DESIGN

● **FOURTEEN YEARS IS A LONG TIME** in radio history. These years have seen the adoption by the industry of complete a-c operation, the single tuning control, the superheterodyne circuit, short-wave bands, the high-powered output stage, the dynamic loudspeaker, the diode detector, and the automatic volume control, not to mention the countless other refinements of circuit and design which have been added from year to year and which brought the pre-war home-type receiver to a point of perfection and low cost undreamed of fourteen years ago. Similar progress has been made in commercial, military, and communications equipment, including tremendously improved sensitivity with lower noise level and high selectivity. Such rapid development has been made possible only by the availability of suitable measuring instruments, which have allowed definite and accurate evaluation of the various factors involved in receiver performance. Exact measurements of receiver performance have eliminated the guesswork from receiver

FIGURE 1. Panel view of the TYPE 805-A Standard-Signal Generator.



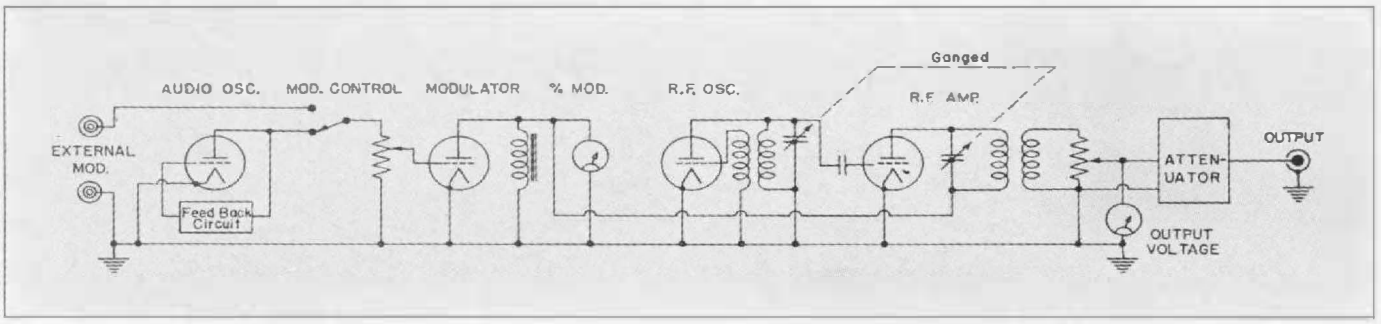


FIGURE 2. Elementary schematic circuit diagram of the TYPE 805-A Standard-Signal Generator.

design and resulted in a high degree of standardization and uniformity in the industry.

Just fourteen years ago the General Radio Company announced the TYPE 403 Standard-Signal Generator, the first commercial instrument of its type. To radio manufacturers, this early signal generator was the first commercially available means of measuring quantitatively the performance of their receivers. It was one of the first standardizing influences in an industry whose advertising claims were not exactly modest. To quote from the original announcement of the TYPE 403, "The inadequacy of such ratings as 'coast-to-coast reception every night' becomes apparent as the Barnum era passes."

In succeeding years the range, versatility, and accuracy of signal generators have been progressively improved, and models have been developed to meet definite requirements of frequency range, accuracy, etc. For some time, however, there has been a need for an amplitude modulated signal generator in the frequency range up to 50 megacycles, that would be suitable for testing all types of receivers, ranging from special military equipment to high-fidelity broadcast sets, and that could be sold at a reasonable price.

At the beginning of the war in Europe, one of America's largest receiver manufacturers asked the General Radio Company to undertake the design and manufacture of such an instrument. This was done, and a number of the new generators were in use in war production long before Pearl Harbor. A modification of this generator with further refinements is now available as the TYPE 805-A Standard-Signal Generator.

Since the generator was designed for use in the quantity production of receivers for the armed forces, it was necessary that high-quality performance be combined with ease of operation, ruggedness, and freedom from unnecessary frills. Modern design and quantity manufacturing have made it possible to price this instrument considerably below what has hitherto been considered normal for an instrument of this class.

Among the important features of this new generator are the following:

(1) Wide frequency range (16 kilocycles to 50 megacycles).

(2) High-ratio dial drive for accurate selectivity curves.

(3) Wide range of output voltage (0.1 microvolt to 2 volts).

(4) Constant impedance over entire output voltage range.

(5) Terminated cable to reduce reflection errors.

(6) Panel meters reading percentage modulation and output voltage directly and continuously.

(7) Degenerative modulating oscillator and modulator.

(8) High-level high-power modulation.

(9) Practical elimination of frequency modulation.

(10) Electronic voltage regulation of the power supply.

ELECTRICAL CIRCUIT

In order to provide the highest degree of performance with the simplest equipment, the signal generator is of the master-oscillator, power-amplifier type with a tuned output circuit. To eliminate frequency modulation without the use of a buffer stage, the oscillator runs at a relatively high-power level, nearly as high as the amplifier, and is coupled to the amplifier only very loosely. Amplitude modulation is accomplished in the plate circuit of the amplifier, thus providing high-quality modulation over the entire range of the instrument. Proper damping of the output circuit eliminates side-band cutting.

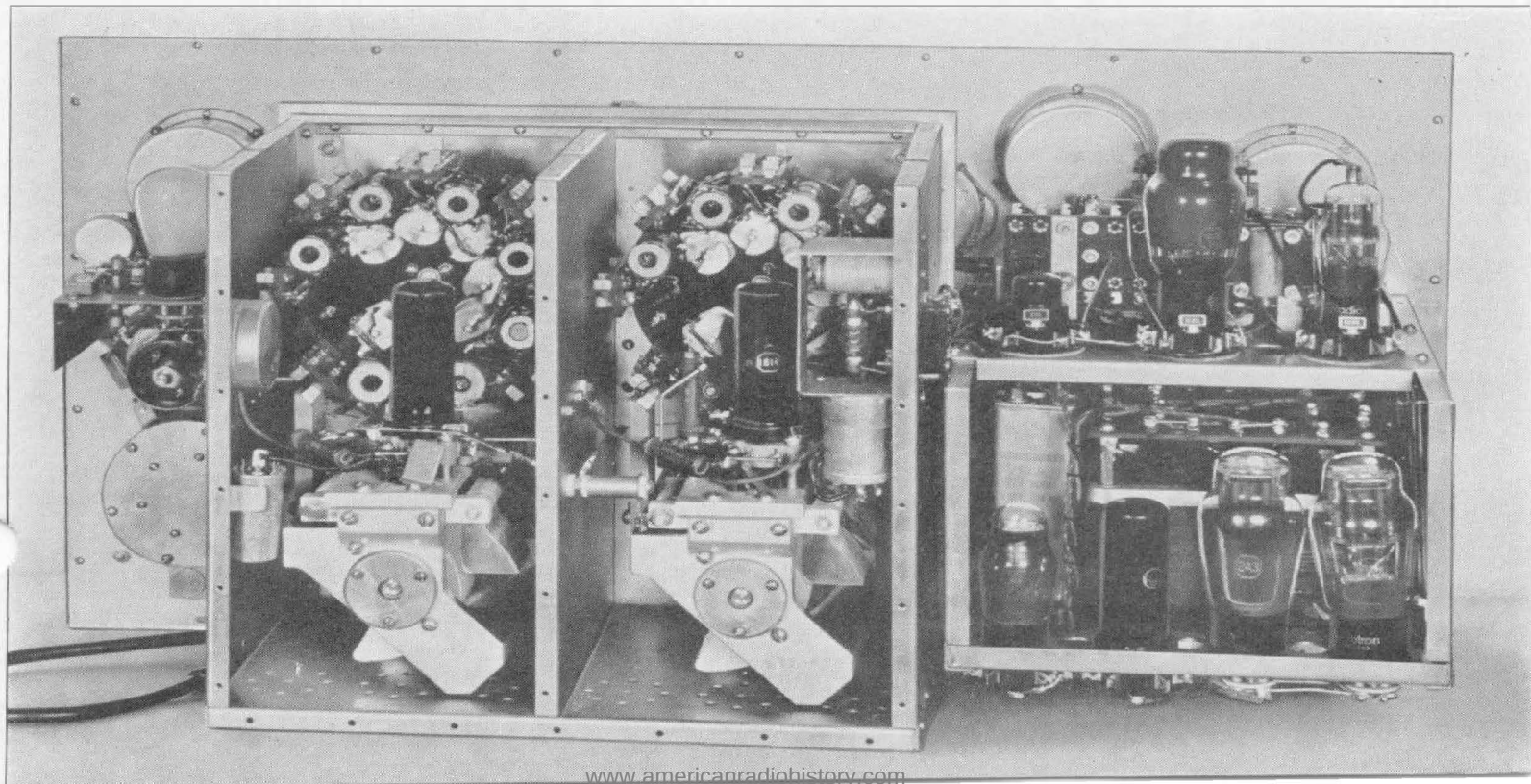
Figure 2 is a simplified block diagram showing the elemental operation of the circuit. In designing the generator, an attempt was made to keep everything as simple as was compatible with the desired performance. The generator, therefore, does not involve elaborate or new circuits, but rather represents a combination of sound engineering principles used to the best advantage.

TUNED CIRCUITS

Figure 3 shows a back view of the instrument with the shield removed. The oscillator and amplifier sections are identical except for a few minor differences. Each uses a type 1614 beam power tube, a condenser which provides a logarithmic frequency variation, and a coil turret.

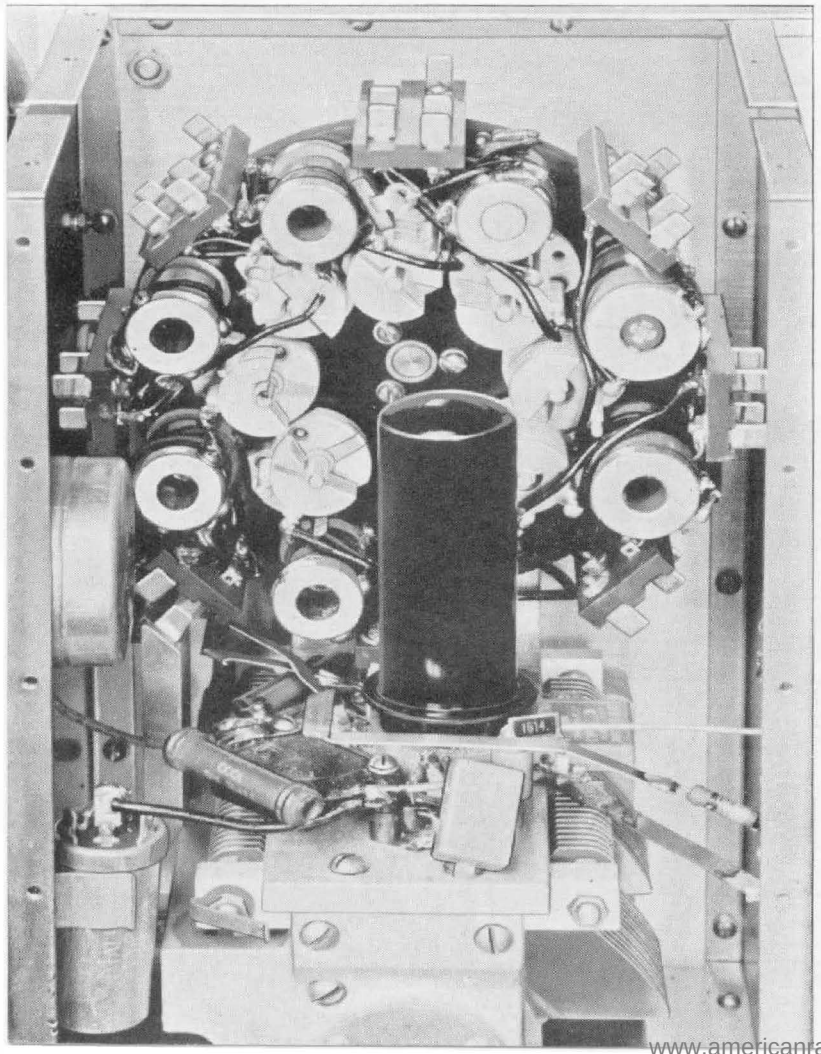
Associated with the coil for each range is an individual trimmer condenser and an adjustable iron-dust core, so that each range can be adjusted to track with a pre-engraved dial scale. One blank coil position is provided on each of the turrets so that an extra range can be added for any particular purpose.

FIGURE 3. Interior view of the signal generator.



All of the ranges excepting that for the highest frequency are direct multiples of lower-frequency ranges, so that a minimum number of dial scales is required. The total frequency range is covered on seven sets of coils. All frequencies are direct reading from the engraved panel dial, no calibration charts being necessary.

The two main tuning condensers have cast frames and ball bearings, and the plates are shaped to give a logarithmic frequency scale. These condensers are driven through a gear train which may be operated by either of two knobs. The first is used to change quickly from one point on the dial to another. The second provides a slow-motion reduction of 100 : 1 and allows frequency increments as small as 0.01% to be read directly.



MODULATION

The modulating oscillator is of the negative-feedback R-C type, providing good waveform and driving through an amplifier including a 6L6G tube in a degenerative circuit. Oscillator frequencies of 400 and 1000 cycles are provided, and provision is also made for modulating from an external source. The modulation is continuously variable from 0 up to 100% and for the broadcast and higher frequencies the characteristic is substantially flat from 50 cycles to 7000 cycles. Modulation at somewhat lower levels can be obtained at audio frequencies above and below these limits. The frequency modulation is so low as to be undetectable by ordinary means.

Percentage modulation is indicated directly by a vacuum-tube voltmeter connected to the output of the modulator. The plate voltages are held constant by an electronic, series-type regulator, utilizing two type 2A3 tubes controlled by a VR-150-30 regulator tube. This provides accuracy in the modulation calibration and also eliminates the effects of any fluctuations of line voltage within the range from 105 to 125 volts. Any power-line frequency from 40 to 60 cycles may be used, and the power transformer can also be reconnected for use on 210-250 volt lines.

OUTPUT CIRCUIT

The output circuit of the generator represents a considerable improvement over previous models. The tuned plate circuit of the amplifier feeds directly through a coupling coil to a constant-impedance type, Ayrton-Perry-wound volume control. The constant impedance feature eliminates any reaction of the

FIGURE 4. View of the coil assembly for one of the tuned circuits.

control on the r-f amplifier, but the output-voltage calibration does not depend upon this control, since the output voltage meter follows it in the circuit.

The output voltage is indicated directly on a panel meter having shaped pole pieces giving a semilogarithmic scale. This meter is driven by an average-type vacuum-tube voltmeter circuit which measures directly the input voltage to the step-by-step attenuator. In practice, then, the volume control is used to adjust this voltage, and the attenuator is calibrated as a multiplier. No slide-wire calibrations enter into the output reading whatsoever. Since the tube voltmeter circuit reads average voltage, it is unaffected by modulation and reads correctly whether or not the signal is modulated.

The step-by-step attenuator, enclosed in the cast "mousetrap" housing, is a further development of those used in the TYPES 603 and 605 Signal Generators and has seven steps, providing successive dividing factors of 10 : 1 in output voltage. For all settings of this attenuator the output impedance at the panel jack is 75 ohms. This matches the 75-ohm connecting cable, which is terminated in a resistance of 75 ohms, thus eliminating reflections and their consequent errors. The net output impedance at the termination unit is, accordingly, 37.5 ohms, and the panel meter reads directly in terms of the voltage across this impedance.

The terminating unit is also provided with a voltage divider for providing output impedances of 7.1 and 0.75 ohms, with 1/10 and 1/100 the normal output voltage, respectively. These low impedances are particularly useful in testing loop receivers. The terminating unit is also equipped with a standard IRE and RMA dummy antenna. The maximum output voltage available from the signal generator — 2 volts at 37.5 ohms — is sufficient for testing most high-level detector circuits and similar types of equipment. The minimum voltage, 0.1 microvolt, represents the best that the present state of the art requires. Leakage from the generator is kept well below this level.

MOUNTING

The complete signal generator is enclosed in a black wrinkle finish, steel cabinet, with full provision for proper ventilation and shielding. The modulation input terminals, power-supply leads, etc., are completely filtered.

OPERATING FEATURES

The advantages of the TYPE 805-A Standard-Signal Generator can only be appreciated through actual operation of

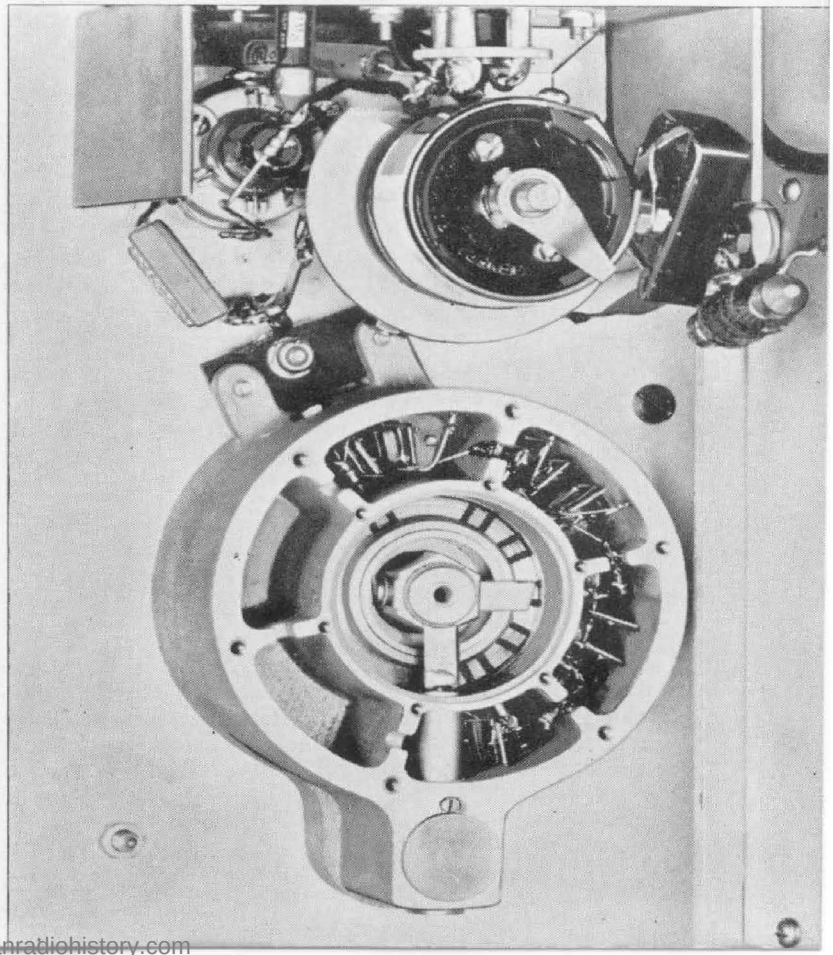


FIGURE 5. View of the attenuator with the cover of the multiplier housing removed. At the top is the Ayrton-Perry-wound output control.

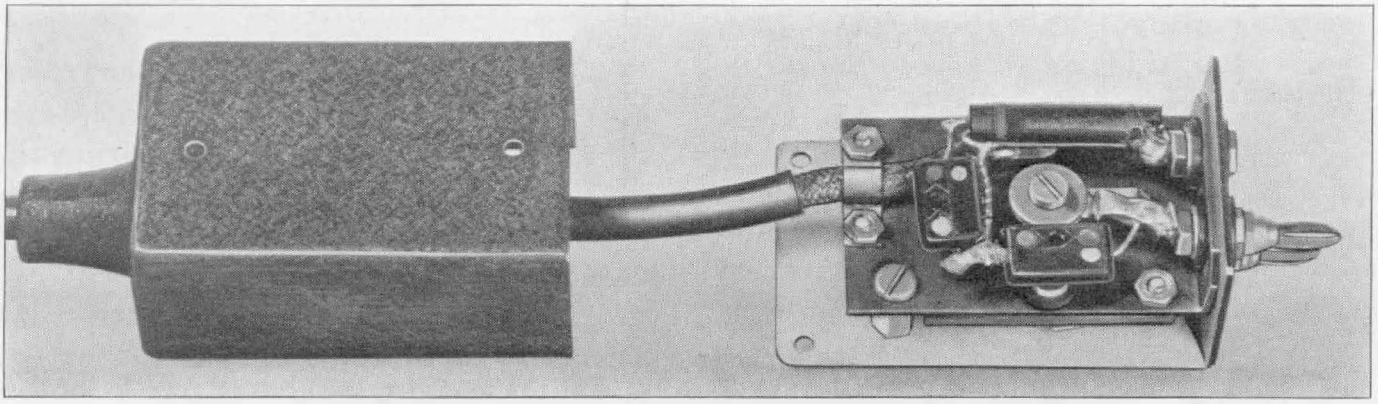


FIGURE 6. View of the cable terminating unit removed from its housing.

one of these units. The usual difficulties due to frequency modulation, cable errors, etc., are entirely absent for all practical measurements. The range switch is easily and quickly operated, the main frequency dial can be turned quickly to any desired point and increments measured with a high degree of accuracy, power-line fluctuations do not affect the operation of the generator, the percentage-modulation and output-voltage settings are continuously visible and direct reading, and the attenuator impedance does not change with setting. The modulation percentage and the output voltage do not change rapidly as the tuning is varied. While these generators are of a type which in pre-war days would be considered only for high-quality laboratory use, the strict requirements of war production have necessitated their use in a wide range of actual production work. In such applications, of course, ease and simplicity of operation are of prime importance.

— H. H. SCOTT

SPECIFICATIONS

Carrier Frequency Range: 16 kilocycles to 50 megacycles, covered in seven direct-reading ranges, as follows: 16 to 50 kc, 50 to 160 kc, 160 to 500 kc, 0.5 to 1.6 Mc, 1.6 to 5.0 Mc, 5.0 to 16 Mc, 16 to 50 Mc. A spare range position is provided so that a special set of coils can be installed if desired.

Frequency Calibration: Each range is direct reading to an accuracy of ±1% of the indicated frequency, except for the lowest frequency range, where the accuracy is 2%.

Incremental Frequency Dial: A slow-motion vernier drive dial is provided, by means of which frequency increments as small as 0.01% may be obtained.

Output Voltage Range: Continuously adjustable from 0.1 microvolt to 2 volts. The output voltage (at the termination of the 75-ohm output cable) is indicated by a panel meter and seven-point multiplier.

Output System: The output impedance at the panel jack is 75 ohms, resistive. A 75-ohm output cable is provided, together with a termination unit that furnishes constant output impedances of 37.5, 7.1, and 0.75 ohms. The calibration of the panel voltmeter-multiplier combination is in terms of the voltage across the 37.5-ohm output. When the 7.1 and 0.75-ohm positions are used, the indicated output voltage must be divided by 10 and 100, respectively. A standard dummy antenna output is also available at the termination unit.

Accuracy of Output Calibration:

Below 3 Mc	± 3%	±0.1 microvolt
3 to 10 Mc	± 5%	±0.2 microvolt
10 to 30 Mc	± 10%	±0.4 microvolt
30 to 50 Mc	± 20%	±0.8 microvolt

Modulation*: Continuously variable from 0 to 100%. The percentage of modulation is indicated by a panel meter to an accuracy of ±10% of the meter reading up to 80%.

Internal modulation is available at 400 cycles and 1000 cycles, accurate in frequency within ±5%.

The generator can be modulated by an external oscillator. Approximately 5 volts across 500,000 ohms are required for 80% modulation. The over-all modulation characteristic is flat

*By means of a minor modification, it is possible to modulate the instrument externally with signals having steep wave fronts.

within ±2 db from 50 cycles to 7000 cycles, at carrier frequencies above 0.5 megacycle.

Frequency Modulation: Negligible for all practical purposes.

Distortion and Noise Level: The envelope distortion at a modulation level of 80% is less than 5% at 1 Mc carrier frequency. Carrier noise level is at least 40 db below 80% modulation.

Stray Fields: Radio-frequency leakage fields are completely negligible with respect to the calibrated output voltage, at all levels down to 0.5 μv. At the higher frequencies, and for output settings below 0.5 μv, a very small amount of leakage may be detected within a few inches of the panel, but the 3-foot output cable allows the receiver under test to be kept well beyond this field.

Power Supply: The instrument operates from any 40 to 60 cycle, 115-volt (or 230-volt) line. An electronic voltage regulator compensates for line voltage fluctuations from 105 to 125 volts (or from 210 to 250 volts). A maximum input power of 180 watts is required.

Tubes: Supplied with instrument:

2 — type 1614	1 — type 6SF5
1 — type 6C8-G	1 — type VR-150-30
1 — type 6L6-G	1 — type 955
1 — type 5T4	1 — type 6H6
2 — type 2A3	1 — Sylvania Ballast Lamp No. 2

Accessories Supplied: Seven-foot line connector cord, spare pilot lamps and fuses, shielded output cable and termination unit, and one TYPE 274-M Plug.

Mounting: The panel is black crackle finished and the cabinet is black wrinkle finish.

Dimensions: (Height) 16 x (width) 33 x (depth) 12 inches, over-all.

Net Weight: 120 pounds, approximately.

Type		*Code Word*	*Price*
805-A†*	Standard-Signal Generator.....	LEPER	$850.00

†This instrument is licensed under patents of the American Telephone and Telegraph Company solely for utilization in research, investigation, measurement, testing, instruction, and development work in pure and applied science.

*Although this signal generator has not been publicly announced before, many are already in service, mainly as the result of word-of-mouth information passed along from one user to another. A large number of orders are on our books awaiting shipment, so deliveries of new orders at the present time are necessarily delayed. Users who are going to need the instrument are urged to apply the best possible priority rating to their orders because under present conditions shipment on priority ratings lower than AA-1 are very uncertain.

ORDERS FOR REPLACEMENT PARTS

● **IN ORDER TO ASSIST CUSTOMERS** who service their own General Radio instruments, we maintain a small stock of replacement parts for most major instruments. Replacement parts are just as scarce as new instruments. Therefore, if this stock of replacement parts is to be of maximum service to industry, it is necessary that each customer order only enough for his immediate needs. Over-ordering only prevents some other user from getting badly-needed replacements.

Many replacements are of standard manufacture. Among these are vacuum tubes, pilot lamps, and fuses. Whenever possible, these should be purchased locally, because our stock is limited and is earmarked for use in new instruments. Where tubes are critical and must be selected, they should, of course, be ordered from us.

Replacement output cables and interconnecting cables can no longer be supplied, because of the shortage of rubber and copper. When cables fail, attach the old end fittings to whatever substitute conductors you can get to do the job adequately. If the end fittings are damaged or missing, we can supply replacements.

For the same reason, we are no longer able to supply replacement power cord-and-plug assemblies for our instruments. If your power cord fails, replace it with any of the types available on the market. The male plug is readily obtainable, but the small female plug may be difficult to

obtain locally. A satisfactory replacement is the type 2173 manufactured by the General Electric Company, Bridgeport, Connecticut.

Our stock of replacement batteries is exhausted, and no more can be obtained. If the correct type cannot be obtained locally, substitutes must be used. While some instruments can be operated satisfactorily from external batteries, without any particular precautions, in others the problem is complicated by the necessity for complete shielding of the power supply. We hope to have more on this subject in a forthcoming issue of the *Experimenter*.

Electrical indicating instruments (meters) are hard to get. New production of the instrument manufacturers is practically all allocated to new war equipment. Repairs, however, can still be handled in a few weeks, and we urge that damaged meters be returned to us for repair.

We hope that our customers will cooperate with us in keeping their replacement part orders within reasonable figures. At present, every order is checked against our serial-number records and orders for excessive quantities are necessarily reduced or refused. Only in this way can replacements be supplied to all who need them with a minimum delay.

— H. H. Dawes

SELL US YOUR UNUSED PARTS

● **WHEN GENERAL RADIO** circuit components such as Variacs, rheostats, decade resistors, and decade condensers are built into another manufacturer's equipment, knobs or dials are sometimes removed by the manufacturer and replaced by items which conform to his standard design. We can use these General Radio parts. They are built of scarce materials. If you have accumulated surplus parts in this way, return them to us and credit will be allowed, provided of course that the parts are in good condition. Please write our Service Department for shipping instructions and credit allowances.

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