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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

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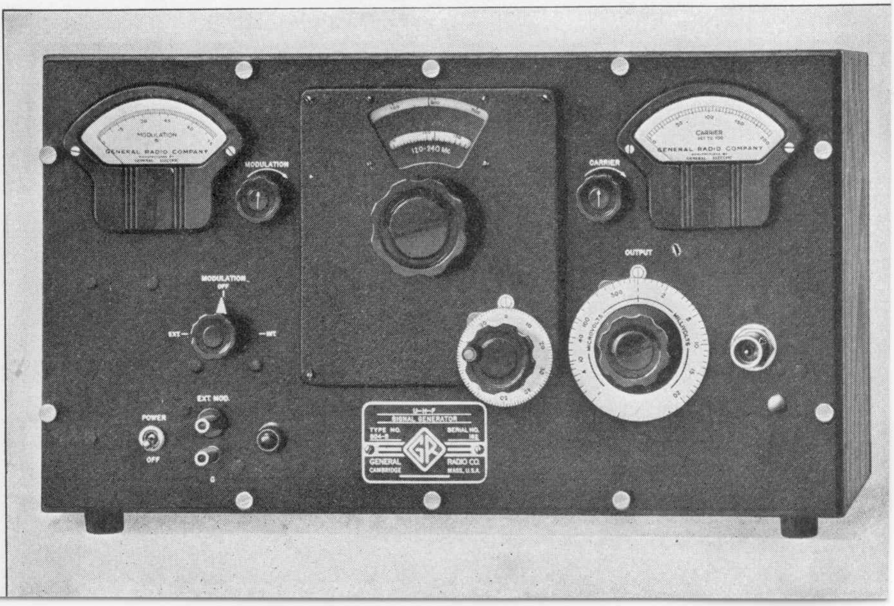
AN IMPROVED ULTRA-HIGH-FREQUENCY SIGNAL GENERATOR

● THE NEED CONTINUES TO INCREASE in communication and allied research for an accurately known source of radio-frequency voltages in the frequency range extending upward from 10 megacycles. In the General Radio *Experimenter* for November, 1939, the Type 804-A U-H-F Signal Generator was announced. This instrument furnished a test signal at frequencies up to 330 Mc. The new Type 804-B U-H-F Signal Generator employs the same basic design as the older instrument, but incorporates a number of refinements and improvements.

To meet the requirements of most users, a signal generator must

Figure 1. Panel view of the Type 804-B U-H-F Signal Generator. The knob in the center controls the band-change switch, and the dial below it, the tuning condenser. The output control is at the lower right.



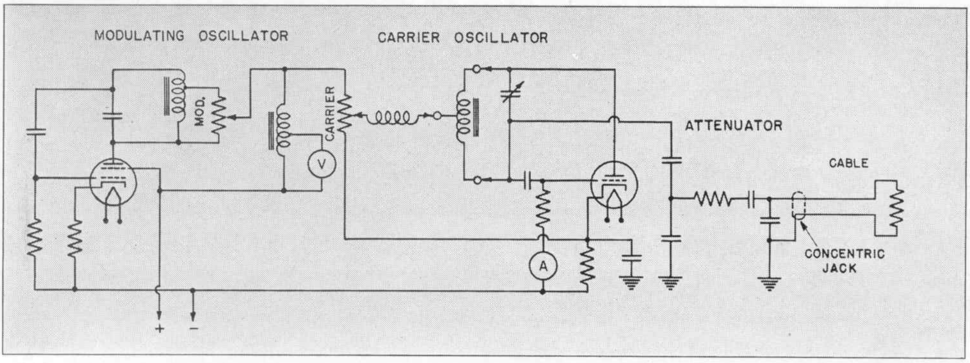


FIGURE 2. Schematic circuit diagram of TYPE 804-B U-H-F Signal Generator. The a-c power supply is not shown.

combine a wide frequency range with the ability to be set easily and accurately. The frequency range of the TYPE 804-B U-H-F Signal Generator extends from 7.5 to 330 megacycles in five overlapping ranges. The five corresponding scales on the main frequency dial are direct reading. The desired range is selected at will by an ingenious coil-switching mechanism, which brings the proper coil into position immediately above the variable tuning condenser and associated 955-type oscillator tube. The range selector is designed to bring the proper direct-reading frequency scale into view through the window in the protective dial housing. The scales not being used are masked, thus doing away with the confusion of multiple scales simultaneously in view. Each frequency range is carefully aligned with the direct-reading frequency scale so that the frequency can be set to well within 2% of the desired value.

The five coils for the five overlapping frequency ranges are fastened to a mycalex disc, which is rotated by the range selector. Mycalex is used because it has very low loss at radio frequencies. At each coil position, silver contacts on the disc engage silver brushes on the condenser frame, as the particular coil is moved into operating position. Lead length between the coil and the condenser is a minimum. A sixth position is provided on the range switch with a blank plug-in form, which can be wound by the user to cover frequency bands in or below the normal range of the signal generator, or to provide band spread over a limited frequency range.

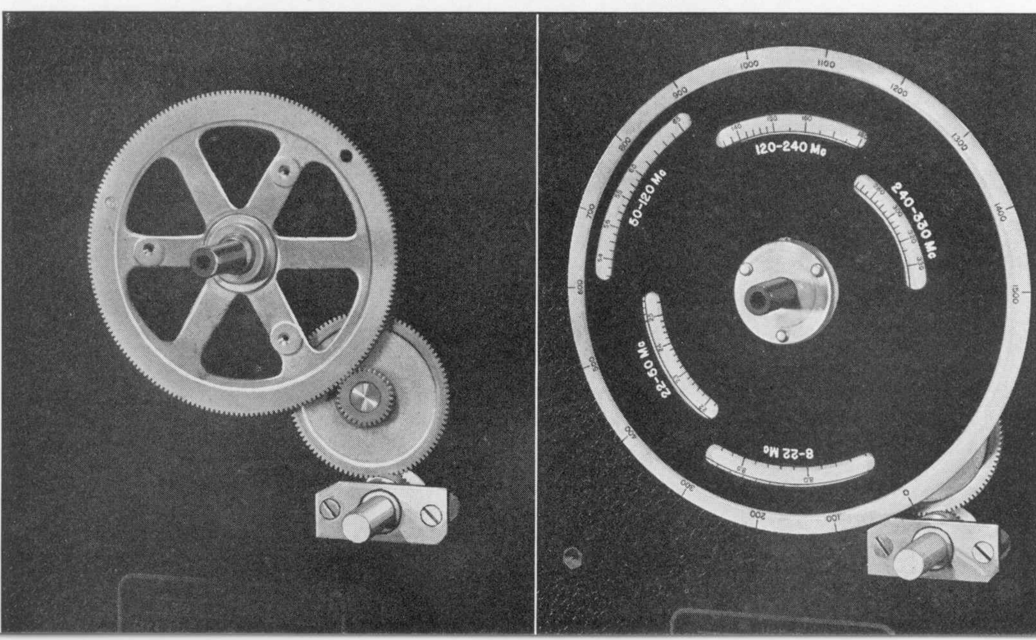
Over each range, the frequency is controlled by a worm-driven variable air condenser. The vernier dial has 100 divisions and requires 15 turns to cover each frequency range. The tuning condenser therefore has 1500 scale divisions for each range, making possible a precision of setting to better than 0.1%. The carrier oscillator uses a Hartley circuit in conventional arrangement.

Radio-frequency leakage in the TYPE 804-B U-H-F Signal Generator has been reduced to a minimum and is not noticeable with receivers that are now available. The design of the new instrument is such that there are no openings or windows in the panel or cabinet to allow a small amount of radio frequency field to "spray" out. Complete shielding of the two cases of the panel voltmeters has effectively prevented leakage through the meters. Direct-reading, protected frequency scales have been obtained without allowing appreciable leakage to occur.

The output voltage is continuously variable from 1 microvolt to 20 millivolts up to 100 megacycles. Above this frequency, the maximum output is somewhat less than 20 millivolts. The attenuator dial is calibrated in microvolts and millivolts, and is direct reading when the oscillator amplitude is adjusted to a standard value as indicated by the carrier-level grid-current meter. The attenuator dial controls a capacitive attenuator. A step-down gear reduction is provided for ease in adjusting to the desired output voltage. Adjusting screws, set at the factory, allow the output voltage to conform accurately to the dial calibration over the entire scale of the attenuator dial. The capacitance of the attenuator is variable between 0 and 15 $\mu\mu$f in each of two sections, forming a capacitive voltage divider. Regardless of setting, the attenuator presents a constant capacitance to the oscillator circuit so that the carrier frequency does not change with adjustment of the attenuator control.

The voltage from the attenuator is impressed across a 100 $\mu\mu$f condenser. The output voltage is obtained from this condenser through a series resistor of 75 ohms, and is made available at the concentric shielded jack at the right-hand side of the panel. A three-foot concentric shielded output lead, having a characteristic impedance of 75 ohms and fitting the shielded jack, is furnished with the signal generator. The calibration of the attenuator dial is the actual open-circuit voltage at the output jack. Above 30 megacycles the voltage at the far end of the output cable is very nearly equal to that at the output jack. Below 30 megacycles a correction factor for the voltage at the far end of the cable must be applied. A plot of this correction is included in the instruction book. Above 30 megacycles a 10:1 shielded attenuator can be used with the output cable to

FIGURE 3. Two views of the frequency-control drive mechanism partially disassembled. In the left-hand view are shown the gears through which the direct-reading frequency dial is driven from the worm shaft of the condenser. The dial attaches directly to the large gear. At the right, the dial and mask are shown assembled. The bakelite shaft concentric with the large gear drives both the coil switch and the mask for the frequency scales.



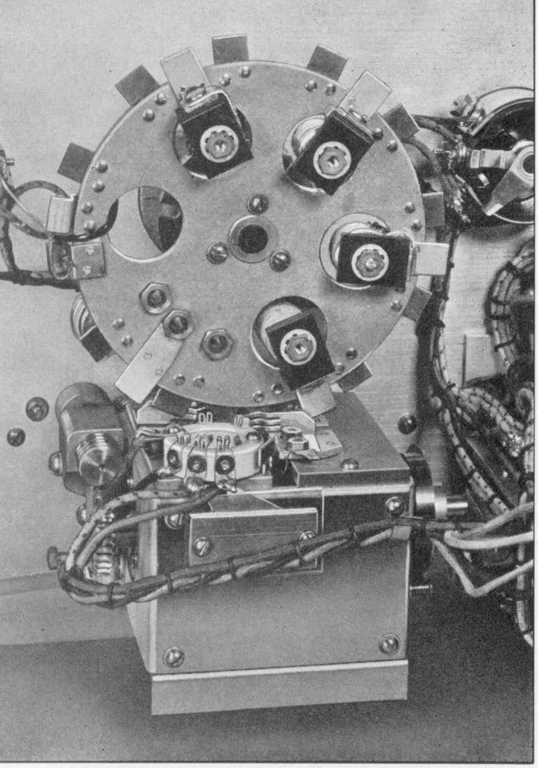


FIGURE 4. Rear view of the coil switching mechanism. A positive wiping contact between silver-plated surfaces is obtained. Leads are made short and direct in order to keep residual inductance and capacitance low.

reduce the indicated output voltage by a factor of ten.

The TYPE 804-B U-H-F Signal Generator will furnish either an amplitude-modulated or an unmodulated output signal. The type of modulation desired is controlled by a three-position panel switch; one position for an unmodulated signal, the second for a 400-cycle modulated signal from an internal oscillator, and the third for modulation from an external source. The modulation is adjustable up to 60%. The percentage-modulation indicator on the panel measures the a-c modulating voltage which is inserted in series with the d-c plate supply of the oscillator tube. As the latter voltage is maintained constant by voltage regulation, the indicating meter can be calibrated directly in percentage modulation, since the modulating voltage is proportional to the percentage of modulation.

When it is desired to employ external modulation, the internal modulation oscillator tube is used as an amplifier. The input impedance for external modulation is 0.25 megohm. Approximately seven volts across the input terminals are required for 50% modulation. The modulation characteristic is flat within ±2 db from 100 to 20,000 cycles per second.

The TYPE 804-B U-H-F Signal Generator operates from the a-c line, 105 to 125 volts, 42 to 60 cycles. A voltage regulator circuit eliminates difficulties due to fluctuating line voltage. Provision is made for altering the connections to the primary of the power transformer so that the instrument can be used on 210 to 250 volt lines. Adequate radio-frequency filtering is provided in the power supply to prevent leakage back into the power line.

— MYRON T. SMITH

SPECIFICATIONS

Carrier Frequency Range: 7.5–330 Mc in five ranges — 7.5–22, 22–50, 50–120, 120–240, 240–330 Mc.

Frequency Calibration: Direct reading within 2%.

Output Voltage Range: 1 microvolt to 20 millivolts for 7.5–100 Mc; 1 microvolt to 10 millivolts for 100–330 Mc.

Output System: Output is obtained across a 75Ω cable.

Modulation: The generator is amplitude modulated. Continuously adjustable 0–60%. Internal: 400 cycles ±5%. External: Flat within 2 db from 100 to 20,000 cycles. Seven volts are required for 50% modulation. The input impedance is 0.25 megohm. Frequency modulation is present, particularly at the higher frequencies. For testing selective receivers, therefore, it is recommended that the generator be used unmodulated.

Stray Fields: Stray fields will not be noticeable with receivers of poorer sensitivity than 1 microvolt.

Power Supply: 105–125 (or 210–250) volts, 40–60 cycles, 25 watts.

Tubes: 955, 6G6G, 6X5G, VR150.

Accessories Supplied: Three-foot output cable, 75-ohm impedance. Six-foot cable for a-c line connection. One blank coil form for additional frequency range. One terminal unit 774-YA-1. One external attenuator 774-X-1.

Mounting: Black crackle aluminum panel, walnut cabinet, hinged cover.

Dimensions: (Length) 19½ x (depth) 9 x (height) 11⅝ inches.

Net Weight: 32 pounds.

Type		*Code Word*	*Price*
804-B	. . . .	DENSE	$350.00

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.

Type 804-B U-H-F Signal Generator is not in stock at present, and nearly all units now in production have already been reserved for customers. After the few remaining units are sold, deliveries cannot be made before next June.

BROADCAST FREQUENCY REALLOCATION

● **BROADCAST ENGINEERS** are urged to place their orders *now* for new frequency monitor crystals required by the frequency reallocation plan effective March 29.

The Type 376-L Quartz Plate is recommended for use in all approved GR monitors. The special price effective until March 29 is $65.00. Send $35.00 with your order, which will be shipped COD for the balance unless credit has been established. If cash for the full amount is sent in advance, we prepay postage.

SERVICE DEPARTMENT NOTES

RETURNING INSTRUMENTS FOR REPAIR

● **WHEN GENERAL RADIO** instruments are returned to the Service Department for repair or reconditioning, the time consumed in handling the job can be held to a minimum if the procedure outlined here is followed.

Before returning an instrument to our factory for any reason whatever, a letter giving *complete* information about its operation should be sent to the Service Department. It is essential that both the type and serial numbers be given so that our records may be checked and the history noted. In many instances, if the instrument is not operating properly, it is possible to diagnose the trouble from the information supplied, and to correct it by furnishing a new part such as a tube, resistor, inductor, or capacitor.

If it is necessary that the instrument be returned to the factory, the Service Department will so advise the owner and will furnish complete shipping instructions.

When an instrument is to be returned for reconditioning and recalibration, which may require a week to ten days to complete, it is sometimes possible to speed the work if a letter is written requesting us to proceed at once upon receipt of the instrument and a confirming purchase order is then sent within a few days. This procedure should be followed only in an emergency, as it is easier for all concerned when packing and shipping instructions are supplied by the Service Department. Because of possible damage from excessive handling in transit, we do not recommend shipment via freight or overland trucking, but prefer railway express or parcel post, depending upon the size and weight of the instrument.

The letter or purchase order authorizing necessary work to an instrument should always be mailed so as to arrive before the shipment. A packing slip referring to the letter or purchase order should be enclosed in the shipment. If this is not done, serious delays will result, as in some cases we would have no way of knowing by whom the instrument was shipped.

In accordance with the procedure of purchasing divisions, some of our customers request a quotation to cover the cost of reconditioning equipment. It is our practice to submit an estimate based on records of previous charges for equipment of the same type and age. This estimate is not a definite quotation, but is the form of minimum and maximum prices.

We have found it necessary to follow this plan rather than to test a returned instrument completely and to quote an exact charge, which would inevitably be in excess of what the customer expected because of the excess laboratory time required. As an example, let us consider the return of a Type 736-A Wave Analyzer about two years old. A charge between $45.00 and $60.00 would be quoted to cover complete reconditioning and recalibration, guaranteed for one year. However, if this instrument were sent to our laboratory for test to determine the extent of necessary reconditioning and recalibration, at least eight hours would be spent before an exact quotation could be made. Following acceptance of the quotation by the customer, repairs would be made in the shop, after which the eight hours' laboratory test time would have to be duplicated. In such instances, costs may be almost 50% greater than that compared with an amount quoted between minimum and maximum prices.

The following table can be used to estimate the approximate charge for an instrument, not obsolete, that requires normal reconditioning and recalibration.

List Price	*Maximum Reconditioning Charge % of List Price*
Up to $100	25
$100 to 200	20
200 to 400	15
400 up	10

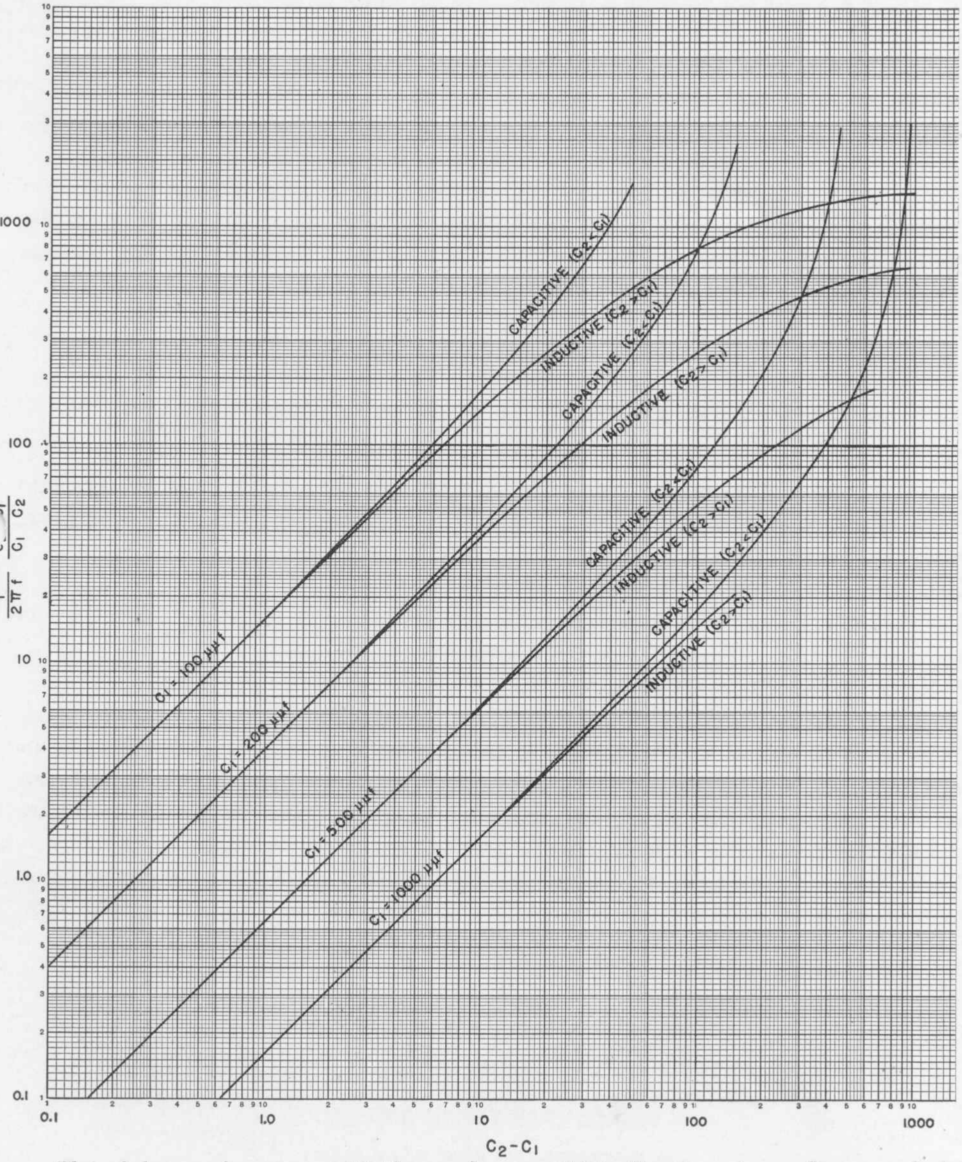
The use of this table will often avoid delays by giving the customer's purchasing division an idea of the approximate cost. If, upon inspection of a returned instrument, it is found that the cost of reconditioning will be in excess of normal charges, the customer is advised the maximum cost, and no work is done until a reply is received.

The procedure that is followed in reconditioning a returned instrument is to clean it thoroughly; check and resolder any connections that may have weakened; replace or repair any component part that has become worn, deteriorated, or damaged; tighten all assembly and mounting screws; clean the panel and polish the cabinet.

It is then sent to the laboratory for final test and recalibration. The instrument must pass the same test as a new instrument. If an obsolete type, it is tested under the specifications that were used when it passed through the laboratory originally. Because of the careful and complete reconditioning in our shop and accurate testing in our laboratory, we are able to guarantee an instrument for one year, which guarantee is identical to that which applied to it when it was originally sold. — H. H. Dawes

A CHART FOR USE WITH THE TYPE 516-C RADIO-FREQUENCY BRIDGE

● **FOR ACCURACY** and flexibility, measurements with the TYPE 516-C Radio-Frequency Bridge are ordinarily made with a series-condenser substitution. A fixed condenser of the appropriate capacitance is first placed across



Plot of change of reactance of bridge condenser at 1 Mc. For the series-condenser method this is equal to the unknown reactance. For use at other frequencies, divide by the frequency in megacycles. If the unknown reactance is inductive, C_2 is greater than C_1; if the unknown reactance is capacitive, C_2 is less than C_1.

the UNKNOWN terminals and the bridge balanced, giving a capacitance reading C_1. The unknown impedance to be measured is then connected in series with the auxiliary fixed condenser and the bridge rebalanced, yielding a capacitance setting C_2.

The reactance of the unknown impedance is calculated from the expression

$$X_X = \frac{1}{2\pi f}\left(\frac{C_2 - C_1}{C_2 C_1}\right)$$

Where many measurements are to be made, these calculations are tedious, so that the use of a chart for determining X_X saves considerable time. The reactance X_X can be plotted against the capacitance difference $C_2 - C_1$, using C_1 as a parameter.

Since only a few fixed condensers are necessary for covering all ordinary conditions of measurement, only a few curves need be plotted. The condensers ordinarily used with the bridge are TYPE 505 Mica Units having capacitances of 100, 200, 500, and 1000 $\mu\mu$f. Using these values, the curves on the preceding page have been plotted.

We shall be glad to send an enlarged copy of this chart to any user of the TYPE 516-C Radio-Frequency Bridge who requests it.

USING THE VARIAC AT LOW FREQUENCIES

● **IN THE ARTICLE** bearing this title, which appeared in the December, 1940, issue, the current ratings for TYPE 200-CUH and TYPE 200-CMH Variacs are incorrectly listed. Rated current for these units is 2 amperes, and maximum current 2.5 amperes.

THE General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in communication-frequency measurement and control problems. When sending requests for subscriptions and address-change notices, please supply the following information: name, company name, company address, type of business company is engaged in, and title or position of individual.

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