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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

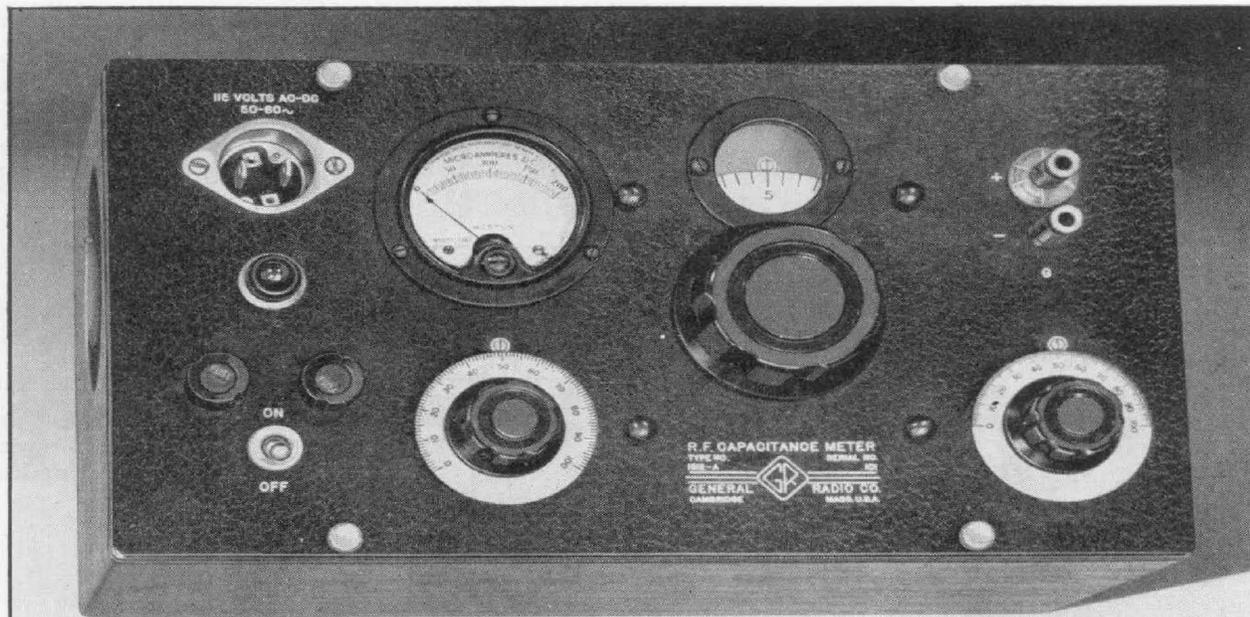
A COMPACT RADIO-FREQUENCY CAPACITANCE MEASURING INSTRUMENT

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● **THE TYPE 1612-A** Radio-Frequency Capacitance Meter is a device for conveniently measuring capacitance of magnitudes usually encountered in radio-frequency applications, where the accuracy required is not extreme, and where the dissipation factor of the capacitance to be measured is reasonably low at one mega-

cycle. This instrument is complete in itself and requires no auxiliary equipment except a source of 115-volt power. The operation is extremely simple, the capacitance value being read from a calibrated dial after it has been set to give the proper visual indication on a panel meter. In addition to indicating capacitance values, the capacitance

Figure 1. Panel view of the R-F Capacitance Meter.



meter provides a relative indication of losses in the capacitance measured. An interesting application of this feature is in the intercomparing of losses in dielectric samples at the operating frequency of one megacycle.

The capacitance range is covered in two parts, zero to 80 micromicrofarads and zero to 1200 micromicrofarads. The ranges are calibrated in separate 180-degree sectors of the dial and range switching is accomplished automatically as the dial is rotated. Thus any ambiguity is avoided in capacitance indications since only one scale at a time appears under the dial indicator. The capacitance scale distribution is nearly logarithmic so that accuracy and readability are maintained down to low capacitance values.

The functional diagram illustrates the principles of operation. The instrument consists simply of a one megacycle oscillator whose output is loosely coupled to a resonant detector circuit. The resonance indicator includes a crystal rectifier and a d-c microammeter loosely coupled to a resonant circuit by means of a small pickup coil.

Measurement is made by a substitution method in which the capacitance of a calibrated condenser is reduced to re-establish resonance after an unknown capacitance is placed across the terminals. Resonance is indicated by maximum deflection of the microammeter.

In the instrument, the calibrated capacitor is a straight-line-capacitance

variable capacitor, carrying the capacitance dial, in series with a fixed padding capacitor. The relative magnitudes are so chosen that the capacitance change with dial rotation of the combination is small near the maximum capacitance end of the variable capacitor (minimum capacitance on dial) and much larger at the minimum capacitance end (maximum capacitance on dial). Thus, as the dial is rotated, the effective capacitance removed varies slowly at first, increasing in rate with angular rotation. The resulting capacitance scale approaches a logarithmic variation with angle for the low capacitance range.

An extension of the series padder principle is used to obtain the high capacitance range. In this case an additional padding condenser is switched in series with the unknown terminals. Thus incremental changes of capacitance in the unknown present decreasing capacitance changes to the resonant detector circuit as the value of the unknown capacitance increases. The net effect is an increased angular spreading of the low capacitance end of this range with respect to the high end.

In order to permit the angular rotation of the dial required to operate the range switch, the dial is provided with separate zeros for the two ranges. A panel trimmer permits standardizing the circuit at zero capacitance and can be used to balance out the capacitance of leads that might be used to connect the unknown capacitance. Approximately 5

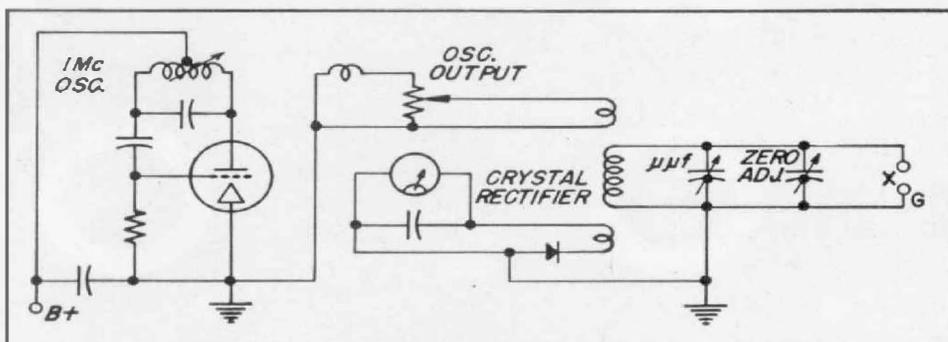


Figure 2. Elementary schematic circuit diagram of the R-F Capacitance Meter.



micromicrofarads of external capacitance can be balanced out on the low range and 120 micromicrofarads on the high range.

Once the circuit has been standardized at the zero point, any capacitance can be easily measured by connecting it, turning the dial to point of maximum indication on the microammeter, and reading the capacitance value from the calibrated dial. Re-standardization of the zero for successive measurements of capacitance on the same range is not required if the zero of the panel trimmer is not disturbed between measurements. If the unknown capacitances are connected directly to the terminals of the instrument, the zero settings of the trimmer are coincident for the two ranges and, therefore, no attention to zero standardization is required in going from one range to the other.

For production testing of a number of capacitors of the same type, a test jig can be devised for facilitating connections.

On the low capacitance range, losses in the unknown capacitance show up on the indicating meter as a lower indication at resonance with the unknown connected than at the zero-standardization resonance. The difference in resonant peak indications is a function of the shunt conductance in the unknown and consequently is a relative indication of the losses at a given value of capacitance. An oscillator output control permits setting the meter to full scale during the zero-standardization process in order to provide a reference for loss comparisons. This indication of losses is intended only for rough intercomparisons and not for precise measurements.

If the terminals of the instrument are provided with two electrodes between which can be placed dielectric samples,

intercomparison of the losses can be made. The oscillator output control should be set so that the microammeter gives a full-scale indication at resonance before a sample is placed between the electrodes. A setting of the capacitance dial should be found on the low range where resonance can be obtained with the various samples in place by merely changing the position of one of the electrodes on the sample. The amount the microammeter indication differs from the full-scale value at resonance, with a sample in place, is an index of the losses in that particular sample. These intercomparisons should be made at the same capacitance setting because the indication depends upon shunt conductance rather than upon dissipation factor.

The oscillator used in the 1612-A uses a pentode section of a type 117N7GT tube, connected as a triode in a simple Hartley circuit. The oscillating frequency is preset to one megacycle by means of an adjustable powdered iron core in the oscillator coil. The type 117N7GT also contains a rectifier section which is used to supply power through an *R-C* filter to the plate of the oscillator section from a 115-volt a-c supply. The instrument can also be operated from a 115-volt d-c supply provided the power plug is inserted to give the proper polarity. This is simply determined by reversing the power plug if the instrument fails to function. The heater in the 117N7GT is supplied directly from the 115-volt supply.

The oscillator circuit is not connected by any conducting path to the metal panel or chassis so that the use of a transformerless power supply places absolutely no limitation on the use of the instrument.

— W. F. BYERS



SPECIFICATIONS

Capacitance Range: 0 to 1200 $\mu\mu\text{f}$ in two ranges—0 to 80 $\mu\mu\text{f}$ and 0 to 1200 $\mu\mu\text{f}$. Ranges are switched automatically as capacitance dial is rotated.

Capacitance Accuracy: Low Range: From 0 to 50 $\mu\mu\text{f}$, $\pm(3\% + 0.3 \mu\mu\text{f})$. Between 50 and 80 $\mu\mu\text{f}$, $\pm 6\%$. High Range: From 0 to 1200 $\mu\mu\text{f}$, $\pm(3\% + 5 \mu\mu\text{f})$.

Dielectric Losses: Relative meter indications with different dielectric samples give a comparative measure of dielectric loss.

Oscillator Frequency: 1 megacycle $\pm 1\%$ adjusted at factory. Frequency can be readjusted if necessary by means of a movable dust core.

Resonance Indicator: A 1N34 crystal rectifier is used with a microammeter to indicate resonance.

Tube: A 117N7-GT tube is used in the oscillator circuit, and is supplied.

Power Supply: 115 volts, 50 to 60 cycles, ac or dc.

Power Input: 12 watts at 115 volts, ac; 11 watts at 115 volts, dc.

Dimensions: (Length) 12 x (height) 6 $\frac{5}{8}$ x (depth) 7 $\frac{1}{2}$ inches, over-all.

Net Weight: 11 pounds, 10 ounces.

Type	Code Word	Price
1612-A R-F Capacitance Meter.....	AFTER	\$155.00

INEXPENSIVE, BASIC INSTRUMENTS FOR THE LABORATORY

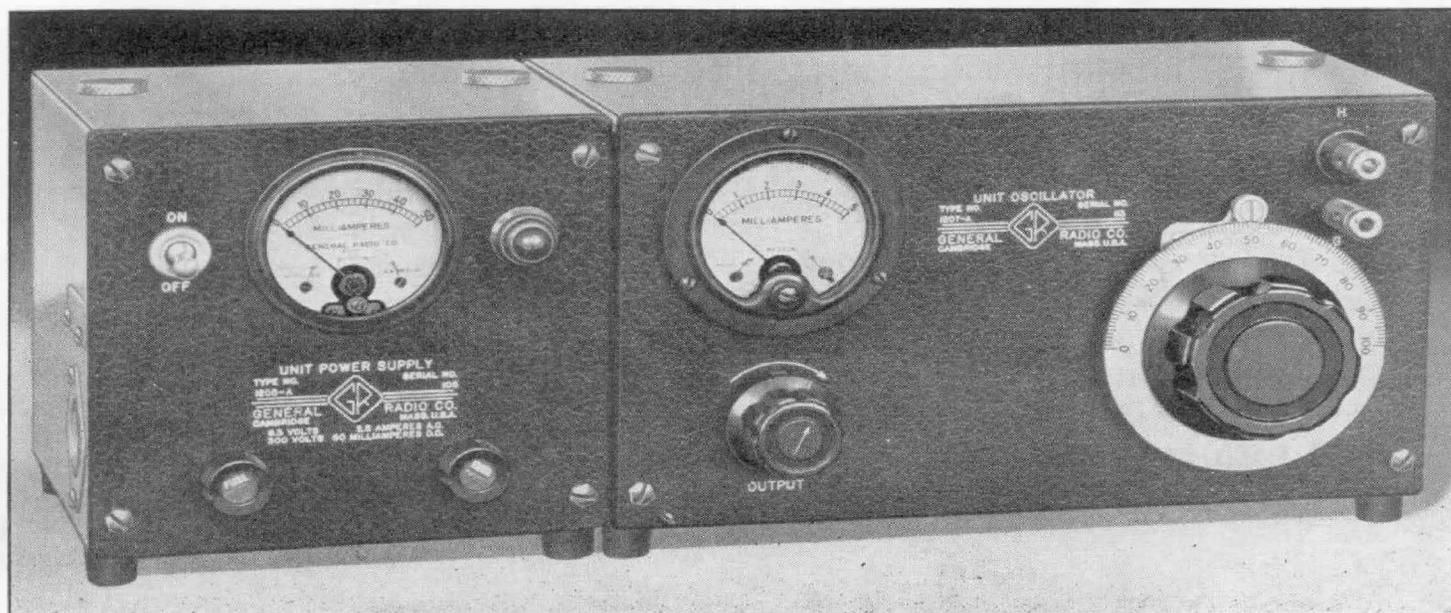
Believing that there exists a need for simple, wide-range, basic laboratory tools at low cost, the General Radio Company has developed a series of unit instruments, designed to be versatile in application and lower in price than any heretofore available.

Three units are now available; others will be added in the future. The three currently available instruments, which can collectively be purchased for a total of \$316, include (1) a 3-watt amplifier

covering the frequency range from 20 c to 200 kc, whose gain is adjustable from 0 to 45 db; (2) an oscillator operating over the range from 400 c to 80 Mc, and delivering $\frac{1}{2}$ watt up to 5 Mc; and (3) a compact a-c power supply that plugs into either the oscillator or the amplifier. Each unit can be purchased separately, if desired.

Such instruments have many applications in the laboratory. They supplement more expensive equipment in the large

Figure 1. View of the Type 1205-A Power Supply and the Type 1207-A Oscillator plugged together.





organization and fill a basic need in the small laboratory whose budget is limited. A particularly important field of application is in the college laboratory, where the cost of providing several oscillators and amplifiers for student use is often prohibitive. The low cost of each of these units permits several to be purchased at the same price that would be paid for a single, more elaborate instrument.

A further advantage for the undergraduate laboratory lies in the fact that the wiring in these instruments is open and accessible, permitting the student to modify the circuit in many ways and to study the effect of such modification on circuit performance. Laboratory practice can thus be closely correlated with theory and the student's understanding of the circuit operation greatly enhanced.

DESCRIPTION OF THE UNITS

1. TYPE 1206-A UNIT AMPLIFIER

The unit amplifier measures $10\frac{1}{4} \times 5\frac{3}{8} \times 6\frac{1}{2}$ inches, over-all. Plug terminals on the end, as shown in Figure 2, directly engage a jack in the power supply. Hence it is small, compact, and easily handled by laboratory personnel. Input and output terminals are on the front panel. Its performance, as detailed in the specifications below, is completely adequate

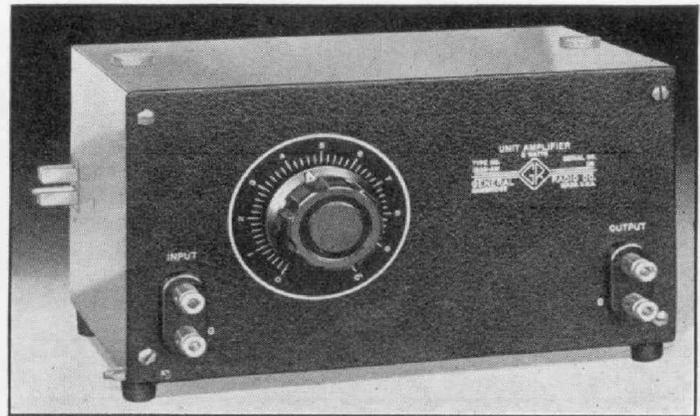


Figure 2. Panel view of the Type 1206-A Amplifier, showing, at the left, the plug that engages a socket in the power supply.

for most laboratory uses, and considerably better than might be expected from its size and price.

The amplifier covers both audio and supersonic frequencies. Its 45-db gain is sufficient for use in the detector circuits of impedance bridges, and its maximum output of 3 watts is adequate for driving low-power laboratory devices.

The circuit uses two triode direct-coupled voltage-amplifier stages and a resistance-capacitance-coupled output stage. Cathode degeneration is employed on the input stage and additional degeneration is provided between the last two stages. As a result, the gain stability is excellent, distortion is low, and the phase-shift characteristic is good.

SPECIFICATIONS

Voltage Gain: Continuously adjustable from 0 to 45 decibels.

Load Impedance: 7500 ohms optimum. Blocking capacitor is 1 μ f.

Maximum Output: 3 watts (150 volts) into 7500 ohms can be obtained with less than 5% distortion.

Input Impedance: The input resistance is 200,000 ohms. Blocking capacitor is 0.05 μ f.

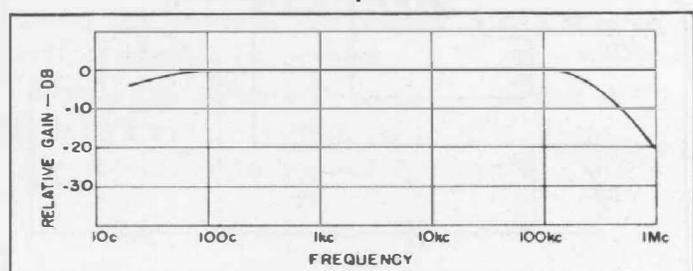
Frequency Response: Essentially constant from 100 cycles to 100 kc. Response drops 6 db per octave above 200 kc. Response at 20 c is down 6 db.

Tubes: One 6SN7-GT and one 6V6-GT are supplied.

Terminals: Jack-top binding posts on $\frac{3}{4}$ -inch spacing.

Distortion: The distortion when delivering 1 watt into a load of 7500 ohms is less than 2% at frequencies above 100 cycles. At lower frequencies the distortion increases, but is less than 3% at

Figure 3. Frequency characteristic of the Type 1206-A Amplifier.



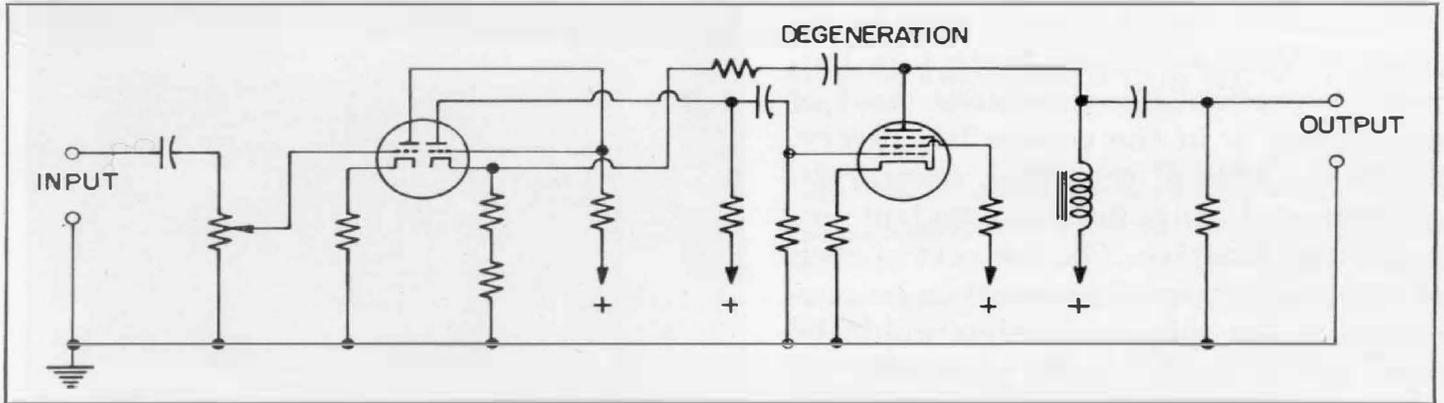


Figure 4. Elementary schematic circuit diagram of the Type 1206-A Amplifier.

50 cycles. At an output of 3 watts, total distortion is under 5% above 100 cycles.

A-C Hum: The 60-cycle hum level in the output is about 125 millivolts.

Power Supply: The TYPE 1205-A Unit Power Supply plugs directly into the amplifier.

Dimensions: (Width) 10¼ x (height) 5⅞ x (depth) 6½ inches over-all.

Net Weight: 8¾ pounds.

Type	Code Word	Price
1206-A Unit Amplifier.....	ARBOR	\$65.00

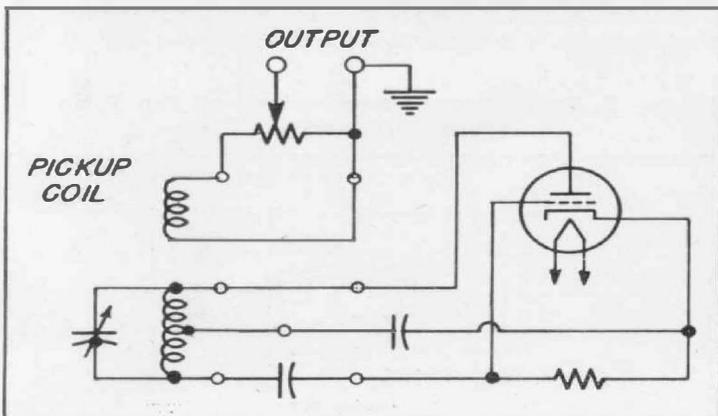
Licensed under Patent of the American Telephone and Telegraph Co.

2. TYPE 1207-A UNIT OSCILLATOR

Wide frequency range and adequate output were the design objectives for this oscillator. Its ability to produce a test signal at frequencies ranging from 400 cycles to 80 megacycles makes it a most useful laboratory instrument. It fills the need for a simple, wide-range signal source for measurement and testing, without expensive refinements, but quickly adaptable to a variety of uses.

The shielding is adequate for bridge measurements at audio frequencies. At radio frequencies, for bridge and resonant-circuit measurements, additional external shielding must be provided by the user.

Figure 5. Elementary schematic circuit diagram of the Type 1207-A Oscillator.



A conventional Hartley circuit is used in this oscillator. Seven plug-in coils are available, which collectively cover a continuous frequency range from 70 kc to 80 Mc. Plug-in coil forms are available and can be used to meet special requirements. Three plug-in tuning units are available to operate at fixed frequencies of 400, 1000, and 20,000 cycles, respectively. Jacks across the tuned circuit permit extending the range of any coil by plugging in external capacitors or inductors, so that the entire range from 100 cycles to 100 megacycles can be covered.

The output circuit is coupled inductively to the tuned circuit, and the output is controlled by a voltage divider. The oscillator plugs directly into the TYPE 1205-A Unit Power Supply.

In addition to the various plug-in coils and tuning units listed below, note that a blank coil form with plugs and case is furnished and that others are available, so that a coil for any particular frequency or range of frequencies can be wound by the user.



SPECIFICATIONS

Frequency Range: Seven plug-in coils are available to cover the range from 70 kc to 80 Mc, and a plug-in coil form, also available, may be wound to meet special requirements. Three plug-in tuning units are listed to provide within $\pm 2\%$ fixed audio frequencies at 400, 1000, and 20,000 cycles. Coils, coil forms, and plug-in units must be ordered separately (see price list).

Frequency Control: With the seven tunable coils, continuous frequency adjustment is provided by a variable air capacitor, having a uniform scale from 0 to 100.

The audio frequency tuning units are inductor-capacitor combinations, and the internal variable air capacitor has little effect on the frequency. The frequency can be changed, however, by connecting a suitable capacitor or inductor to the jacks provided.

Frequency Stability: The frequency stability is adequate for most laboratory applications, except those involving highly selective tuned circuits. Variations of load impedance cause some shift in frequency.

Output Impedance: Approximately 75 ohms at full output for the coils (70 kc to 80 Mc) and 750 ohms for the tuning units (400, 1000, and 20,000 cycles). A 2000-ohm voltage divider at the output terminals provides an output control.

Output Power: At least 0.5 watt into a matched load up to 5 Mc, and 10 milliwatts at 80 Mc.

Modulation: Jacks are provided for connecting a modulating audio source in series with oscillator plate supply. The oscillator can be amplitude modulated to 50% from 0.5 to 15 Mc. The maximum modulating frequency is 10 kc over this carrier range. The modulating audio oscillator must be capable of delivering about 115 volts to yield 50% modulation.

Terminals: Jack-top binding posts with standard $\frac{3}{4}$ -inch spacing are provided for the output connection.

Power Supply: The TYPE 1205-A Unit Power Supply plugs directly into the oscillator.

Tube: One 6C4 is used and is supplied.

Accessories Supplied: One plug-in coil form with case; multipoint connector; one shorting bar, 274-SB.

Accessories Available: Tuning units, coils, and coil storage rack are listed in price list below.

Dimensions: 1207-A: (Width) 10 x (height) $5\frac{1}{8}$ x (depth) $6\frac{5}{8}$ inches over-all.

P1, P2, and P3: $4\frac{1}{4}$ x $2\frac{1}{2}$ x 3 inches each over-all.

P4, P5, P6, P7, P8, P9, and P10: $2\frac{3}{8}$ inches diameter x $3\frac{1}{2}$ inches over-all.

Net Weight: Coils: 5 oz. each; Tuning Units: (P1, $1\frac{3}{4}$ lbs.) (P2, $1\frac{1}{4}$ lbs.) (P3, $1\frac{1}{2}$ lbs.); 1207-A: $5\frac{1}{4}$ lbs.

Type		Code Word	Price
1207-A	Unit Oscillator.....	ARGON	\$73.00
1207-P1	Tuning Unit, 400 c.....	ARGONSAWAY	19.50
1207-P2	Tuning Unit, 1 kc.....	ARGONSAFIT	17.50
1207-P3	Tuning Unit, 20 kc.....	ARGONSAPIS	16.50
1207-P4	Coll, 70 kc to 180 kc.....	ARGONSALOE	9.00
1207-P5	Coll, 180 kc to 500 kc.....	ARGONSABLE	9.00
1207-P6	Coll, 0.5 Mc to 1.5 Mc.....	ARGONSACRE	9.00
1207-P7	Coll, 1.5 Mc to 5 Mc.....	ARGONSANTY	9.00
1207-P8	Coll, 5 Mc to 15 Mc.....	ARGONSARTY	9.00
1207-P9	Coll, 15 Mc to 50 Mc.....	ARGONSAQUA	9.00
1207-P10	Coll, 50 Mc to 80 Mc.....	ARGONSAYAH	9.00
1207-P11	Extra coil form with case and plug-in base.	ARGONSAXLE	6.50

3. TYPE 1205-A UNIT POWER SUPPLY

This power pack is designed primarily for use with the TYPE 1206-A Unit Amplifier and the TYPE 1207-A Unit Oscillator. Connections to the oscillator or amplifier are made through multipoint connectors mounted in the ends of the instruments. When so assembled, the

combination of units is very compact, occupying a minimum of bench space. The power supply can also be used separately as a general-purpose source of heater and plate power for other electronic equipment, for which purpose a mating plug is furnished.

Fuses are accessible from the panel. A pilot light is provided, as is a milliammeter to indicate output current.



SPECIFICATIONS

Output Voltages: 6.3 volts, ac, at 2.5 amperes, maximum. Approximately 300 volts, dc, at 50 milliamperes maximum. No-load voltage is about 390 volts. No regulation is provided.

Approximate Hum Level: 0.8 volt at 300 volts and 50 milliamperes, 60 cycles.

Input Power Supply: 115 (or 230) volts, 50 to 60 cycles.

Input Power: Approximately 12 watts, no load; approximately 50 watts, full load.

Rectifier Tube: One 6X5-GT/G which is supplied.

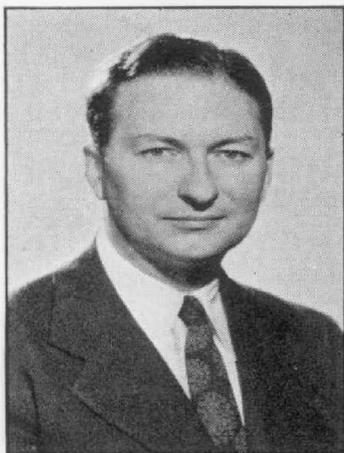
Output Terminals: A standard multipoint connector is arranged for plugging directly into either the TYPE 1206-A Unit Amplifier or the TYPE 1207-A Unit Oscillator. A mating plug is provided for use with other equipment, and a line connector cord is supplied.

Dimensions: (Width) 5 5/8 x (height) 5 7/8 x (depth) 5 7/8 inches over-all.

Net Weight: 6 3/4 lbs.

Type	Code Word	Price
1205-A Unit Power Supply.....	APPLY	\$55.00

MISCELLANY



Frank D. Lewis



Donald B. Sinclair

HONORS—Awarded, to Donald B. Sinclair, Assistant Chief Engineer, and to Frank D. Lewis, Engineer, the President's Certificate of Merit for outstanding services. Dr. Sinclair's certificate was awarded for his work in the Counter-measures Division and the Guided Missiles Division of the NDRC, Mr. Lewis's for his work in the field of international liaison with the NDRC, OSRD, and as Expert Consultant to the Secretary of War.

PAPERS — "Problems Relating to Research Personnel in Industrial Laboratories," by H. B. Richmond, Chairman of the Board, at the Conference on Research Administration, at Pennsylvania State College, September 14.

—"Catalog Design and Distribution," by A. E. Thiessen, Vice-President for Sales, at the Mid-Year Meeting of the Scientific Apparatus Makers' Association, French Lick, Indiana, October 12.

RECENT VISITORS to our plant and laboratories—Dr. Pierre Marie of Societe Sadir-Carpentier, Paris; Mr. Jacques Franeau, Faculte Polytechnique, Mons, Belgium; Mr. L. Webster, Chief Radio Engineer, and Mr. A. Birrell, Assistant Radio Engineer, G.P.O., Victoria, South Africa; and Mr. R. S. Medlock, of George Kent, Ltd., Sutton, Bedfordshire, England.

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