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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

NEW UNIT INSTRUMENTS POWER SUPPLIES — MODULATOR

Also IN THIS ISSUE

● **GENERAL RADIO UNIT INSTRUMENTS** are laboratory-grade instruments designed to sell at moderate prices. Their design is based on two fundamental concepts. The first of these is that functions common to several instruments, such as power supply, or modulator, should not be re-embodied in each assembly but should be isolated and packaged separately in individual units. The second is that each unit should be simple, electrically and mechanically. These units plug into one another, connect to one another, or are used with one another to form assemblies and systems for specific purposes.

Simplification of design has been a constant objective in the development, and standardized design has been adapted wherever it has seemed to offer possibilities of economy. At the same time, no concessions have been made in electrical characteristics, and the instruments offer high-grade performance as well as simple, compact, and rugged construction.

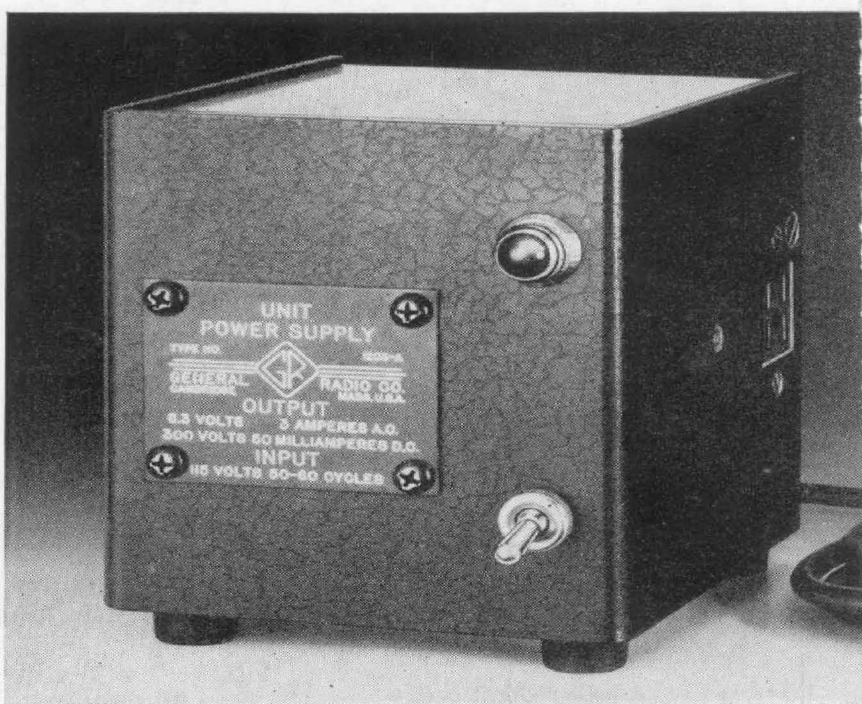

Figure 1. Panel view of the Type 1203-A Unit Power Supply.

Two unit oscillators, the TYPE 1208-A (50-500 Mc) and the TYPE 1209-A (250-920 Mc), were described in an earlier issue[1] of the *Experimenter*. This article describes two new power supplies and a simple two-frequency audio oscillator that can be used to modulate the u-h-f and v-h-f oscillators. It is planned to supplement these unit instruments with several others, which will be made available in the near future.

TYPE 1203-A UNIT POWER SUPPLY

The basic Unit Power Supply is the TYPE 1203-A, which supersedes the TYPE 1205-A. The new unit, which is designed to supply plate and cathode heater power to the unit oscillators and other unit instruments, is improved both electrically and mechanically over the older model. Supplying 50 milliamperes at 300 volts and 3 amperes at 6.3 volts, this unit is also useful as a general-purpose laboratory supply for low-power equipment. Unit instruments plug into the multipoint connector on one side of the assembly, and a mating plug is furnished for making connections to other equipment.

[1]Eduard Karplus, "V-H-F and U-H-F Unit Oscillators," *General Radio Experimenter*, Vol. XXIV, No. 12, May, 1950, pp. 7-11.

The mechanical design features of this power supply, which are also common to the other two instruments, have been developed to reduce the cost of construction.

The cabinet, shown in Figure 1, consists of two U-shaped aluminum pieces, one forming the front panel and the two ends, and the other the top, bottom, and back. The first piece is grooved at top and bottom to accommodate the second piece, which slides in the grooves. It is held in place by pinching the two sides of the first piece together with two screws and a tie-bar. Two sizes, the one housing the power supply illustrated, which is approximately a five-inch cube, and the other having a panel twice as wide, have been found sufficient to house the unit instruments so far developed.

Figure 2 shows the general internal construction. The clamps for the transformer have been bent up out of sheet aluminum, and the lower clamp extended to form the shelf on which are mounted the filter condensers and rectifier. The transformer terminal board carries the transformer terminals and the line fuses. The sandwich formed by the transformer assembly is complete in itself, comprising all electrical components but the pilot light, line switch, and Jones plug. It mounts on the panel with four screws.

It will be noticed from Figure 1 that a photo-etched nameplate carries all the instrument information. Since no serial number is included, there is no need for

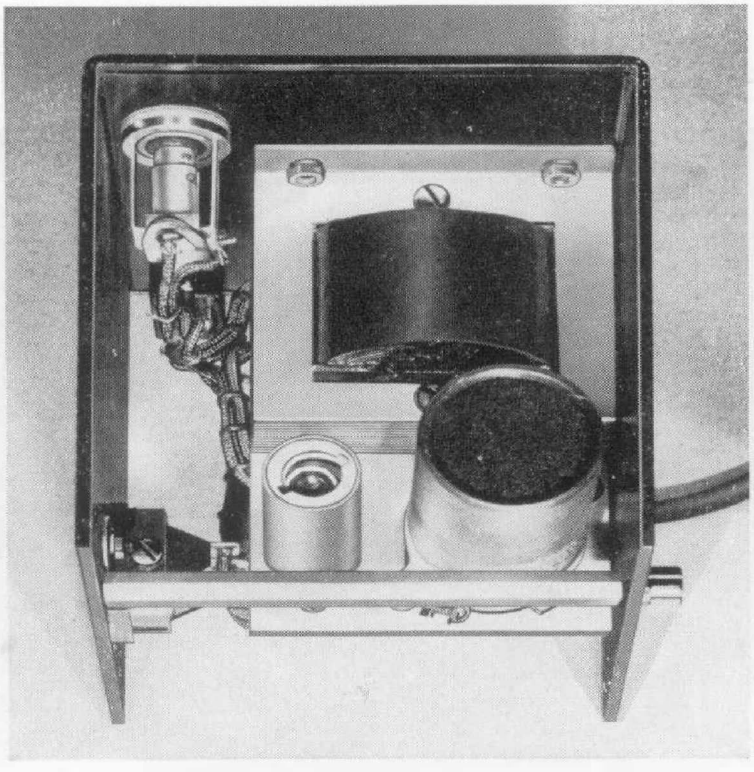

Figure 2. Top interior view of the Type 1203-A Unit Power Supply.

additional engraving, and substantial saving is effected at the same time that a maximum amount of information is presented. The nameplates used are made with square corners, so that they can be sheared out in various rectangular shapes without special punches, and the number of holes in them and the number of hole sizes are reduced to a minimum.

This power supply is small, convenient, and inexpensive. The construction is well adapted to get rid of heat by conduction to the panel, and the unit can supply 20 watts of heater power and 15 watts of plate power despite its small size.

SPECIFICATIONS

Output Voltages: 6.3 volts ac, nominal; 3 amperes maximum; 300 volts dc, 50 milliamperes maximum. No-load voltage is about 410 volts.

Hum Level: About 250 millivolts at 300 volts and 50 milliamperes d-c output.

Input: 115 volts, 50 to 60 cycles; 50 watts full load. A line-connector cord is permanently attached to the instrument.

Rectifier: One 6X4-type supplied.

Output Terminals: A standard multipoint connector is mounted on the side of the unit.

Accessories Supplied: A mating multipoint connector for connecting the power supply to other equipment; a 10-32 screw with wing nut for permanently attaching the power supply to other unit instruments. Also spare fuses.

Mounting: Black-crackle-finish panel and sides. Aluminum cover finished in clear lacquer.

Dimensions: (Width) 5 x (height) 5¾ x (depth) 6¼ inches, overall, not including power cord.

Net Weight: 5 pounds.

Type		*Code Word*	*Price*
1203-A	**Unit Power Supply**	ALIVE	**$47.50**

TYPE 1204-B UNIT VARIABLE POWER SUPPLY

This power supply is intended primarily for general-purpose use, where it is desirable to have a means of varying the output voltage.

As shown in Figure 3, the same general construction is used as in the Type 1203-A, but a meter has been added, the power output has been increased, and the high-voltage d-c output has been made continuously adjustable.

Since this power supply will be used extensively for experimental work in which convenience of attaching wires is important, binding posts on the front panel have been added in parallel with the Jones plug connections. These are grouped at the left of the panel with all controls requiring identification. The output control knob at the right needs no legend, since its setting controls the

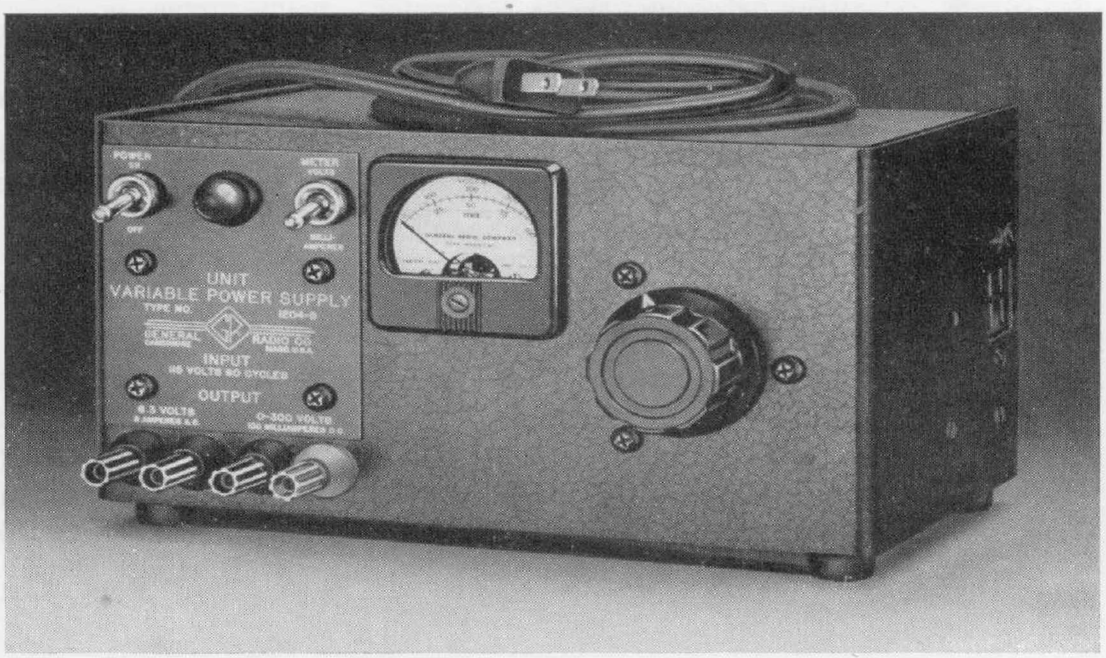

Figure 3. Panel view of the Type 1204-B Unit Variable Power Supply.

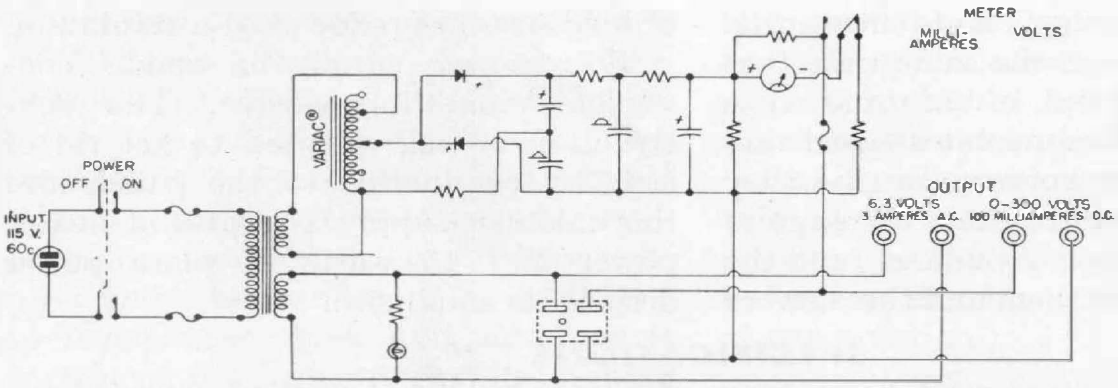

Figure 4. Circuit diagram of the Type 1204-B Unit Variable Power Supply.

meter reading, and its function is therefore obvious. The meter can be switched with the toggle switch to read either current or voltage.

A feature of the design of this power supply is the Variac®, which controls the a-c voltage to be rectified. It is used because it provides a continuous control to zero volts and because, being an autotransformer, it maintains a low source impedance at all settings. Since there is but one transformer in the instrument, and the Variac® used is a standard, 115-volt stock model, a novel circuit arrangement is used to provide a constant voltage of 6.3 volts ac and a continuously variable voltage of zero to 300 volts dc. This circuit is shown in Figure 4.

The power transformer isolates the output voltages from the line, furnishes the 6.3-volt heater supply, and provides a voltage for the Variac® augmented to about 17% above line voltage. The particular Variac® used will withstand this voltage, plus or minus 10%, at 60 cycles without excessive magnetization current, and will produce an output voltage adjustable between zero and 158 volts. A voltage-doubler rectifier circuit is used to produce the desired d-c output voltage.

SPECIFICATIONS

Output Voltages: 6.3 volts ac, nominal; 3 amperes maximum. The d-c output voltage is adjustable from zero to 300 volts with a maximum load of 100 milliamperes. No-load maximum, 400 volts.

Meter: A panel meter indicates the d-c output voltage and current.

Hum Level: About 250 millivolts at 300 volts, 100 milliamperes d-c load; about 150 millivolts at 350 volts, 50 milliamperes d-c load.

Input: 115 volts at 60 cycles; 75 watts at full output load. A line-connector cord is permanently attached to the instrument.

Rectifier: Two selenium rectifiers used in a voltage doubling circuit.

Output Terminals: Insulated binding posts on panel and a standard multipoint connector on the side of the instrument.

Accessories Supplied: Spare fuses; a mating multipoint connector.

Mounting: Black-crackle-finish panel and sides. Aluminum cover finished in clear lacquer.

Dimensions: (Width) 9⅞ x (height) 5¾ x (depth) 6¼ inches, not including power cord.

Net Weight: 9¾ pounds.

Type		*Code Word*	*Price*
1204-B	**Unit Variable Power Supply....................**	AGATE	**$85.00**

U. S. Patent No. 2,009,013.

TYPE 1214-A UNIT OSCILLATOR

This simple two-frequency oscillator (400 and 1000 cycles), shown in Figure 5, is useful as a modulating source for high-frequency oscillators such as the Type 1208-A and the Type 1209-A and as a general-purpose laboratory source for bridge measurements.

It will furnish approximately 0.2 watt to a balanced or unbalanced 8000-ohm load at less than 2% distortion.

Its most striking feature is that it violates the fundamental concept of the unit line by incorporating its own power supply. This was justified as an economy because an iron-coil inductor is used as the tuning inductance of a Hartley circuit, and an output coupling coil, wound on the same core, can be used to isolate the output terminals from any direct connection to the oscillator. A Type 117N7-GT Diode-Pentode tube, used as a voltage-doubler, can then be worked directly off the line without danger of cross-up of grounds on load and a-c line.

A small thyrite piece is used from grid to ground to limit the oscillator amplitude. The third-harmonic limiting resulting from the symmetrical current-voltage characteristic contributes substantially to the low distortion of the oscillator and helps to maintain stability of output as the line voltage is varied.

Figure 5. Panel view of the Type 1214-A Unit Oscillator.

SPECIFICATIONS

Frequency: 400 and 1000 cycles, accurate to ±2%.

Output: The maximum output power is over 200 milliwatts; the output impedance is about 8000 ohms with the (10 kΩ) output control at maximum. Open-circuit voltage about 80 volts.

Distortion: Less than 3% into matching load.

Output Circuit: The output can be isolated from ground for using the oscillator as a modulator in the plate circuit of a high-frequency oscillator, such as the TYPE 1208-A or the TYPE 1209-A. The output control is adequate for external d-c currents as great as 36 ma in the output circuit.

Controls: A toggle switch to select frequency, an output control, and a power switch.

Terminals: Jack-top binding posts with standard ¾-inch spacing; a ground terminal is provided.

Power Supply: 115 volts, 40-60 cycles, 16 watts.

Accessories Supplied: Spare fuses.

Tube: One 117N7-GT supplied.

Mounting: Black-crackle-finish panel and sides. Aluminum cover finished in clear lacquer.

Dimensions: (Height) 5¾ x (width) 5 x (depth) 6¼ inches, overall, not including power cord.

Net Weight: 4½ pounds.

Type		*Cord Word*	*Price*
1214-A	**Unit Oscillator** (including power supply)	ALLAY	**$60.00**

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General Radio Unit Instruments are inexpensive high-quality instruments for use in laboratories operating on limited budgets. The instruments described here, in conjunction with the previously described U-H-F and V-H-F Unit Oscillators[2] and the appropriate TYPE 874 Coaxial Elements, make it possible to assemble many specialized setups by the building-block method. Thus, signal generators, test oscillators, heterodyne-detection systems, voltage calibrators, etc., can be made available by simply plugging together elements already available in the laboratory.

[2]See Footnote 1.

HARMONIC GENERATION IN THE U-H-F REGION BY MEANS OF GERMANIUM CRYSTAL DIODES

In the course of the development of u-h-f monitoring equipment, it has been necessary to provide frequency multipliers to generate selected harmonics of the reference crystal oscillator. For frequencies below 300 Mc, conventional miniature receiving-type vacuum tubes work well as amplifiers or harmonic generators, and there is little temptation to explore unconventional methods of frequency multiplication. At frequencies above 300 Mc, however, difficulties arise and become increasingly important as the frequency is raised. For monitoring applications, output powers of the order of 10 to 20 milliwatts are satisfactory for use in mixer stages to convert the u-h-f signal to the desired intermediate frequency. It is somewhat surprising to find that powers far exceeding this level can be obtained from germanium crystal diodes operated as harmonic generators, as much as 60 milliwatts being available from a doubler stage at 500 Mc.

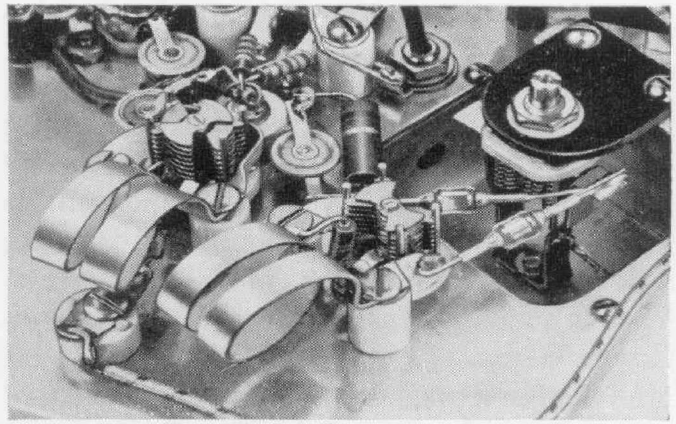
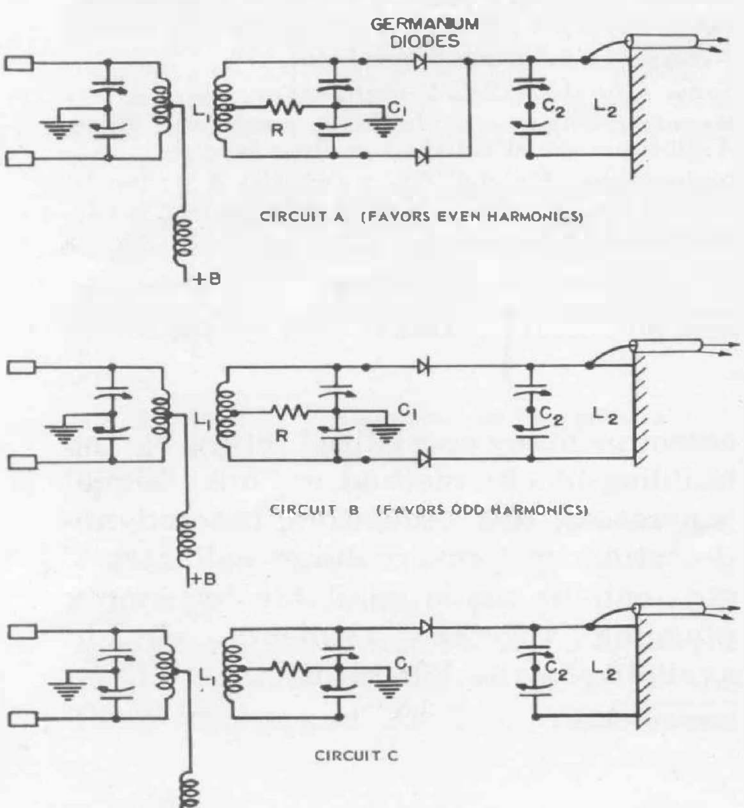


Figure 2. View of the harmonic generator incorporating the circuits of Figure 1.

The general considerations in the use of diodes as harmonic generators are similar for all frequencies. Power is fed in at the fundamental frequency and taken out at the desired harmonic. When germanium crystals are used, it has been found essential that a d-c bias be selected to produce the greatest output at the desired harmonic. The circuits should provide the proper impedances at the input and output frequencies and a means for providing bias. Either fixed d-c bias or self-bias can be used.

Figure 1. Circuits used for harmonic generation with germanium diodes.



A form of this harmonic generating circuit is shown in the circuit diagram of Figure 1 and the photograph of Figure 2. Small butterfly-type condensers* are used, tuning a lumped-inductance circuit for the input and a capacitance-tuned parallel-wire line for the output circuit. The circuit shown covers 200-270 Mc at the input and 460-790 Mc at the output. It is connected as a push-

*Made by E. F. Johnson Co., Waseca, Minn.

push doubler for 460-540 Mc and as a push-pull tripler for 600-790 Mc.

The self-biasing arrangement used is shown in the photograph, the d-c resistance load being a compromise between the values which give the most output in the doubler and tripler connections. This value of bias resistor is also high enough to give some protection from burning out due to overheating caused by too high current. The available input voltage is not sufficient to cause crystal burnout from voltage alone, partly as a result of the dissipation in the crystal diodes which cuts down on circuit Q.

Various kinds of germanium crystal diodes were tried in order to select crystals that would be most effective for this type of application. The best crystals found were the 1N34A and 1N34, these types producing at least 20% more r-f power output than the other types tried. Crystals produced by different manufacturers show appreciable differences in power output. Types 1N21 and 1N21B silicon crystals were tried, but the maximum power output available from these is only approximately 30% of that produced by the germanium diodes in the 400-1000 Mc range.

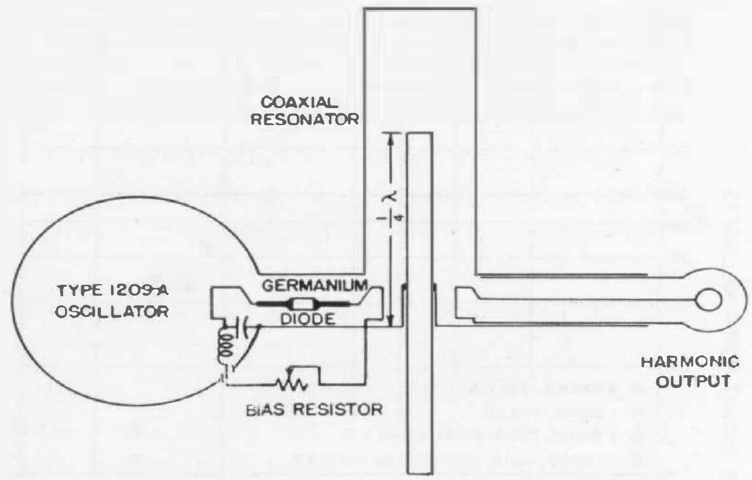


Figure 3. Circuit used in obtaining the data for Table II.

In Table I, below, is shown the maximum output power measured from various circuit arrangements with an input power of approximately 500 mw.

TABLE I

Circuit	*Input Frequency (Mc)*	*Output (Mc)*	*Output Power (mw)*
Figure A	267	534	63.0
Figure B	259	777	28.5
Figure C	259	518	50.5
Figure C	259	777	31.0

TABLE II

Single 1N34A Frequency Multiplier Driven from 1209-A Oscillator

Input Freq. (Mc)	*Harmonic*	*Output Freq. (Mc)*	*Output Power (Milliwatts)*	*Crystal Current (Ma)*	*D-C Load Resistance*
400	2nd	800	37	0.75	25 kilohms
400	3rd	1200	16.5	0.3	100 kilohms
400	4th	1600	5.5	0.3	100 kilohms
400	5th	2000	2.2	0.5	40 kilohms
500	2nd	1000	33	0.7	20 kilohms
500	3rd	1500	10.4	0.2	100 kilohms
500	4th	2000	2.2	0.3	100 kilohms
600	2nd	1200	22	0.45	20 kilohms
600	3rd	1800	4.4	0.3	40 kilohms
700	2nd	1400	17.6	0.4	20 kilohms
700	3rd	2100	2.2	0.15	100 kilohms
800	2nd	1600	6.6	0.5	12 kilohms
900	2nd	1800	2.4	0.3	12 kilohms

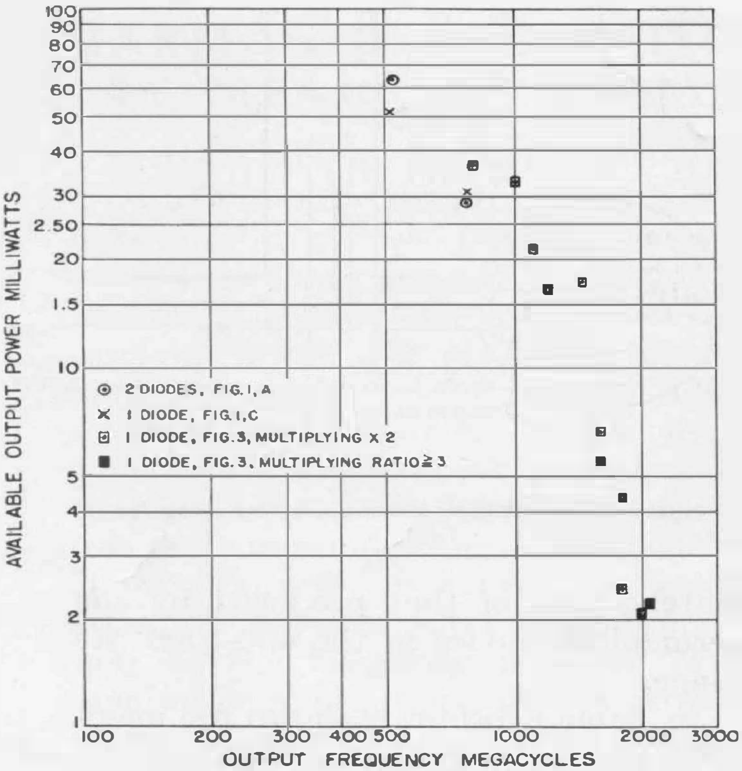


Figure 4. Maximum harmonic power output available from 1N34-A germanium diodes at various frequencies.

Further investigation of the power output capabilities of one type of germanium crystal as a function of frequency produced the data given in Table II. Input power was obtained from a General Radio TYPE 1209-A Unit Oscillator. The circuit, shown in Figure 3, used a coaxial-line resonator to select the output signal frequency, and the d-c load resistance was adjusted for maximum r-f output power. The maximum output power available at various output frequencies from 1N34A germanium diodes is summarized on the graph of Figure 4. The available input power was not accurately measured, but was probably a maximum of 500 mw at 400 to 500 Mc, falling off to near 100 mw at 900 Mc. Since germanium crystals are not very efficient rectifiers at frequencies above 100 Mc, the d-c crystal current is not an accurate indication of the input power.

The generally desirable features of the germanium-diode harmonic-generator circuit include (1) such items as lack of any tendency to oscillate, (2) small capacitances and inductances contributing less loading to the necessary tuned circuits, and (3) a power-handling capacity of the proper magnitude to take care of the local-oscillator signal level for a large variety of applications.

— FRANK D. LEWIS

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GENERAL RADIO COMPANY
275 MASSACHUSETTS AVENUE
CAMBRIDGE 39 MASSACHUSETTS
TELEPHONE: TRowbridge 6-4400

BRANCH ENGINEERING OFFICES

NEW YORK 6, NEW YORK
90 WEST STREET
TEL.—WOrth 2-5837

LOS ANGELES 38, CALIFORNIA
1000 NORTH SEWARD STREET
TEL.—HOllywood 9-6201

CHICAGO 5, ILLINOIS
920 SOUTH MICHIGAN AVENUE
TEL.—WAbash 2-3820

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