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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

A VERSATILE POWER AMPLIFIER

Also

IN THIS ISSUE

● **AN APERIODIC POWER AMPLIFIER** of wide frequency range and substantial output finds many applications in the laboratory and in general testing. Such amplifiers, when needed, can be built up in the laboratory, but the development work necessary to get adequate performance usually proves to be excessively expensive, and considerable time is consumed that could be more profitably used for other and more important projects.

To make this type of amplifier generally available, the General Radio Company has designed the Type 1233-A Power Amplifier.

Three output combinations are provided:

(1) 20 cycles to 20 kilocycles, into 150 or 600 ohms balanced or grounded. On this range, an output of 15 watts is available between 50 and 15,000 cycles.

(2) 20 kilocycles to 1.5 megacycles into 50 ohms, balanced or grounded. Maximum output is 15 watts from 20 kilocycles to 0.5 megacycle; 8 watts at 1.5 megacycles.

(3) 20 cycles to 3 megacycles. Output is 150 volts peak-to-peak, for a

Figure 1. Panel view of the Type 1233-A Power Amplifier.

high impedance load with a gain of 60 db. With grounded output, voltage is limited to 50 volts, peak-to-peak, with a gain of 54 db. Rise time is approximately 0.1 microsecond, with negligible overshoot.

Maximum output is obtained in all cases with an input of 0.2 volt. Distortion is below 3% at maximum output over most of the frequency range, and noise is between 60 and 70 db below 15 watts.

A diode voltmeter, with full-scale ranges of 150, 50, and 15 volts, indicates the magnitude of the output voltage.

APPLICATIONS

The Type 1233-A Power Amplifier is useful in the testing and development of audio-frequency equipment, and in driving supersonic generators. At standard broadcast frequencies, it can be used to excite antennas for measurements with deflection-type instruments. When used with an antenna and tuned input, it can drive a Type 1931-A Modulation Monitor to monitor remote transmitters. On the 20 c-to-3 Mc range, the amplifier has sufficient output for use as an oscilloscope deflection amplifier.

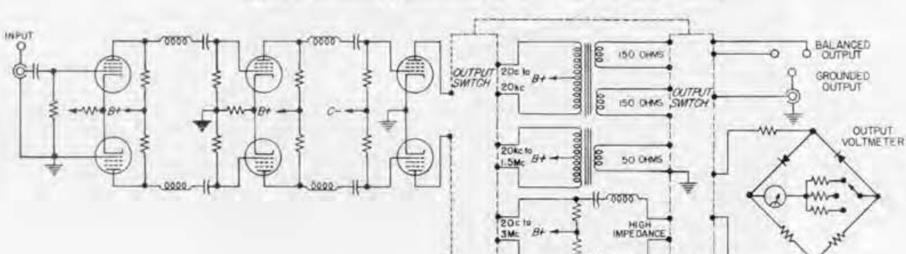
CIRCUIT

Basically, the amplifier consists of three push-pull broad-band stages and three possible output circuits, selectable by a range switch. Figure 2 is a simplified schematic. The interstage couplings are of the series-peaked type, designed for constant gain up to 5 megacycles. The input stage functions as a phase inverter by virtue of a high common cathode resistor.

OUTPUT SYSTEM

Separate output transformers are used for the 20 c-to-20 kc and the 20 kc-to-1.5 Mc ranges. Both transformers are of toroidal construction. The low frequency transformer is arranged with two secondaries so that a parallel or series connection can be selected by the output switch to provide for 150 or 600 ohm loads. The output switch also selects a grounded or ungrounded output by connecting the secondaries of this transformer to the grounded or balanced output terminals. The high frequency transformer is arranged with one secondary for 50-ohm grounded loads. This transformer is wound on a small high-permeability strip-wound toroidal core. Special care in the design and the construction of this transformer were necessary to achieve satisfactory performance at the relatively high frequency at which it operates. Both the leakage reactance between the primary and secondary windings and the distributed capacitance of the primary are limiting factors in determining the high-frequency performance. These conflicting factors in the transformer design require a compromise spacing between the grounded secondary and the primary to achieve maximum performance. Polystyrene cups are used as the interwinding insulation

Figure 2. Elementary schematic circuit diagram of the amplifier.



to keep the capacitance due to dielectric constant of the insulation to a minimum. Single-layer spaced windings are used for both the primary and secondary, and reversed windings are used on the two halves of the toroid circumference to minimize the distributed capacitance.

For the 20 c-to-3 Mc range, push-pull output is supplied through a series-peaked video network.

Type 874 Coaxial Connectors are provided at the input and output. Grounded binding posts spaced ¾-inch from the center conductor of these connectors permit connection to be made also by means of Type 274-MB Double Plugs if desired. Two insulated binding posts are provided at the output which are used when balanced output is selected.

TUNED OUTPUT

The available power output drops rapidly above 1.5 megacycles on the 20 kc-to-1.5 Mc range. However, if desired, full output can be obtained, up to 5 megacycles, by disconnecting existing leads and connecting a suitable external tuned circuit from plate cap to plate cap on the output tubes and connecting the center tap of this circuit to the high voltage plate supply.

VOLTMETER

An output voltmeter is provided which indicates the output terminal voltage on the 20 to 20,000-cycle range and the 20 kc-to-1.5 Mc range. On the 20 c-to-3 Mc range, the output voltmeter is connected to the grounded output terminals, which are not used for this range, making the voltmeter available for external use or permitting an external jumper to be used to connect it to either of the balanced output terminals. The voltmeter is provided with full-scale ranges of 150, 50, and 15 volts, and has an impedance of approximately 15,000 ohms. The voltmeter is compensated to 5 megacycles and functions as a full-wave-average type. The meter can also be switched to indicate the plate current of the output amplifier tubes.

The voltmeter uses crystal diode rectifiers in a bridge circuit.

POWER SUPPLY

The high voltage power supply uses selenium rectifiers in a full-wave voltage-doubling circuit and a two-section LC filter. A bias supply also using selenium rectifiers provides fixed bias for the output stage.

— W. F. Byers

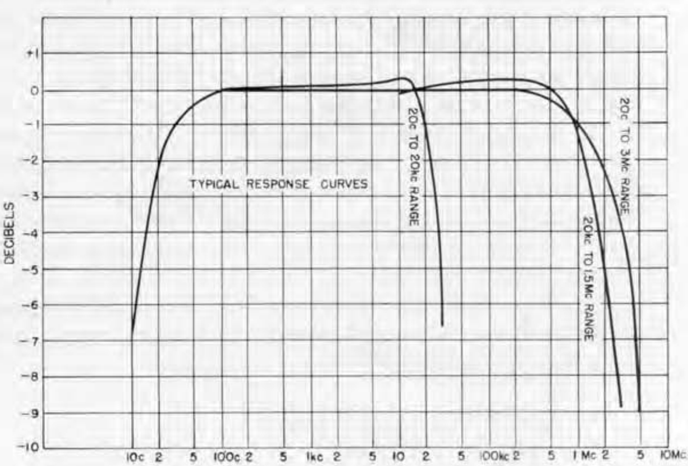


Figure 3. Typical response curves for the three amplifier ranges. The 20 c-to-3 Mc range is given a smooth roll-off at the high end to assure good transient response.

SPECIFICATIONS

Frequency Range: Three ranges are provided:
20 cycles to 20 kilocycles
20 kilocycles to 1.5 Mc
20 cycles to 3 Mc

Power Output:
20 c-to-20 kc range — 15 watts from 50 c to 15 kc; 8 watts at 20 c and 20 kc.
20 kc-to-1.5 Mc range — 15 watts from 20 kc to 0.5 Mc; 8 watts at 1.5 Mc.
Maximum available power output at low distortion depends upon power-line voltage. Rated output is obtainable at 105 line volts. At higher line voltages, output is greater.

Voltage Output: 20 c-to-3 Mc range — 150 volts, peak-to-peak.

Load Impedance:
20 c-to-20 kc range — 600 or 150 ohms, balanced or grounded.
20 kc-to-1.5 Mc range — 50 ohms, grounded.
20 c-to-3 Mc range — deflection-plate terminals of cathode-ray oscilloscope, connected with 36-inch leads and with an effective input resistance of at least one megohm.

Transient Response: 20 c-to-3 Mc range — approximately 0.1 microsecond rise time, with negligible overshoot.

Input Voltage: Less than 0.2 volt for full output.

Input Impedance: 100,000 ohms in parallel with 37 $\mu\mu$f (grounded).

Distortion: Less than 3% at rated output on all ranges.

Noise Output:
20 c-to-20 kc range, 60 db below 15 watts output.
20 kc-to-1.5 Mc range, 70 db below 15 watts output.
20 c-to-3 Mc range, less than 0.3 volt peak-to-peak balanced.

Frequency Response: See typical curves.

Power Supply: 105 to 125 (or 210 to 250) volts, 40 to 60 cycles a-c.

Power Consumption: Approximately 140 watts at 15 watts output; approximately 120 watts at zero output.

Voltmeter:
Ranges, 150, 50, and 15 volts full scale.
Accuracy, ±5% of full scale.

Mounting: The panel is designed for mounting in a 19-inch relay rack, but removable end frames are supplied so that it may be used equally well on a table.

Tubes: 2 — 6AC7, 2 — 6AG7, 2 — 807, 1 — 6J6

Terminals: Type 874 Coaxial Terminals at input and output. Adjacent ground posts for connecting by Type 274-MB Plugs are provided.
Two insulated binding posts for balanced output.

Accessories Supplied: Seven-foot power cord; two Type 274-MB Double Plugs; two spare line fuses; two Type 874-C Cable Connectors.

Accessories Available: Type 874-R10 Patch Cords; Type 874 Connectors and Adaptors.

Dimensions: 19⅜ x 14¼ x 7½ inches, overall.

Net Weight: 45 pounds.

Type		*Code Word*	*Price*
1233-A	Power Amplifier	ANGER	$525.00

U. S. Patent 2,125,816, also Patent Applied For.

MECHANICAL DESIGN

"The term 'mechanical design' creates different pictures in individual minds. To some people it means styling or dressing up a product, while to others it conjures up a mechanized nightmare of shafts, gears, cams, and pulleys.

"In my mind really good design has no room for either of these extremes. Streamlining equipment which does not swim or fly, or adding chromium strips to an already complete structure, are not productive contributions. There is no fundamental difference between such attempts at decoration and a border of pink roses around an instrument panel; it is only a matter of degree. There is inherent beauty, however, in a smooth functional shape with an honest seam or bump here and there. Look at a woman! Would she be improved with a torpedo-shaped body and white side walls?

"Likewise the design which just grew along the path of least resistance contains very little creative head work. It is no accomplishment to add a feature to a machine by adding a mess of single-purpose parts. It is real accomplishment to gain the feature by designing the original parts to serve the extra purpose.

"A good design is one which combines the requisite features into the simplest possible whole with each part easy to make and each part performing as many functions as possible. This automatically results in fewer parts, clean-cut shape, and low cost, which I consider synonymous with good performance, good appearance, and good salability.

"This kind of design solution is seldom the obvious one and requires more effort than an elaborate answer. The only approach to it is to apply concentrated thought from the broadest possible viewpoint, and the only useful working tools are knowledge of materials and methods plus common sense. The results are proportional to the effort expended as in any other job and cannot be attained quickly by divine inspiration or by a shot in the arm.

"Another popular idea with which I am at odds is that a modern design must use mysterious new manufacturing processes and supernatural new materials. When one reads about these things they are intriguing, but there are generally years of pioneering between their discovery and their practical commercial application. The most economic designs use down-to-earth, proven fabrication techniques which fit available equipment and know-how and materials which can be shipped from local warehouses."

— *Excerpt from a talk by* Harold M. Wilson, *of the General Radio Mechanical Design Group, outlining the functions of the group to General Radio foremen at their monthly meeting.*

VARIAC® PHASE-SHIFT CIRCUITS

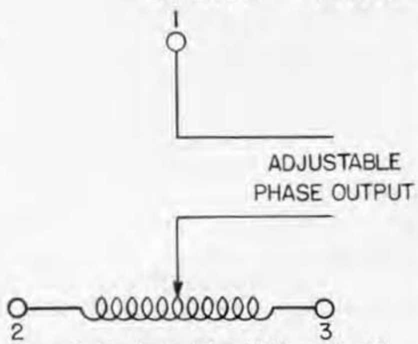


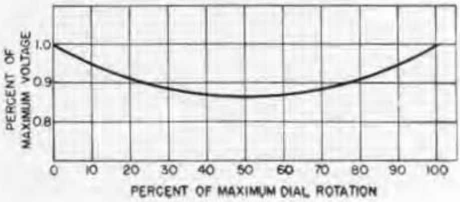
Figure 1. Simple circuit for obtaining adjustable-phase output from a 3-phase system.

In response to our recent article[1] on phase-shift circuits, we have received two letters suggesting the simpler circuit shown in Figure 1. The total phase shift obtainable is 120° and the accompanying voltage variation is small, as shown in Figure 2.

This circuit was first called to our attention by Mr. Reginald H. Rennis of the Boston Edison Company, who has been using the circuit for some years. Mr. Gordon Thompson, Chief Engineer of the Electrical Testing Laboratories, states that this circuit has been in use at E.T.L. for many years, and that tapped autotransformers were used before the introduction of the Variac. He has also used a second Variac, cam-operated from the shaft of the first, to maintain the voltage constant to 1% while phase angle is varied.

We are grateful to Mr. Rennis and Mr. Thompson for calling this circuit to our attention, and we are glad to recommend it to our readers.

Figure 2. Voltage variation as a function of dial rotation.



[1] Gilbert Smiley. "A Variac Phase-Shift Circuit," *General Radio Experimenter*, October, 1950.

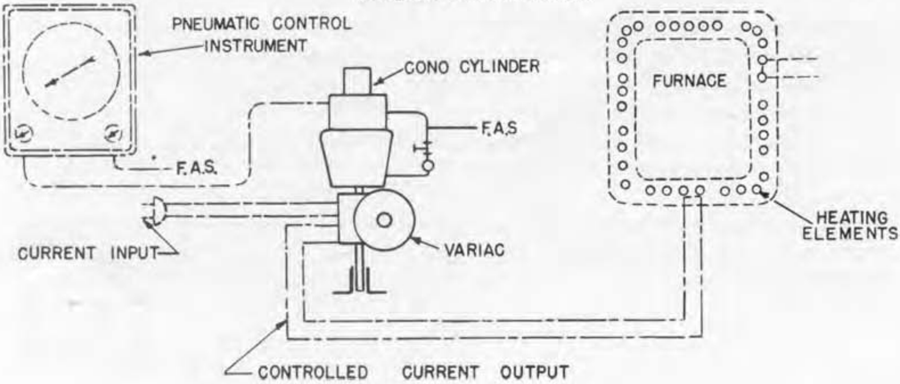
THROTTLING CONTROL USES PNEUMATICALLY OPERATED VARIAC

Figure 1. View of the Pneumatic Current Controller showing rack and pinion drive. Inset shows front view.

Among the modern devices for industrial control applications are the *Cono* Pneumatic Current Controllers for throttling control service, manufactured by the Conoflow Corporation, Philadelphia. Operating from the output pressure of a conventional industrial pneumatic controller, the *Cono* Model EB, shown in the photographs, Figure 1, combines the features of a *Cono* Pneumatic Cylinder and a Variac® autotransformer to provide the precise control of current input that is required in many industrial operations and processes. A typical application of such a controller is shown in Figure 3.

The *Cono* Pneumatic Cylinder permits positioning by pneumatic means to one part in 500. The unit consists of a pneumatic cylinder with a constant loading pressure on one side of the piston and the output air pressure of a built-in positioner on the other side of the piston. The positioner unit is built in to the upper end of the cylinder and the piston stem is extended through the bottom of the cylinder. The piston stem has a rack cut in it which engages a pinion gear on the extended shaft of the Variac unit. Opposite the pinion gear on the other side of the stem, there is a roller bearing to provide perfect alignment and engagement. This method of arrangement provides ample travel and power, with sensitivity and accuracy of positioning for conventional industrial control service.

Figure 2. Diagram showing the Current Controller, operating through a standard pneumatic control instrument, to regulate an electric furnace.



I.R.E. MEMBERSHIP DRIVE

The current membership drive of the Institute of Radio Engineers has as its objective the strengthening of the society in representing the interests of engineers working in the electronic and nucleonic fields.

The newly formed Professional Groups, organized to bring together specialists in various phases of these broad fields, are expanding rapidly. If your work or interest in electronic or nucleonic engineering is either general or specialized, you will find it worth while to be a member of the I.R.E.

Members receive every month a copy of the PROCEEDINGS OF THE I.R.E, the magazine which is recognized as one of the most important contributions to the engineering progress of radio. From time to time Institute Standards covering various aspects of radio engineering are published in the PROCEEDINGS. The Yearbook, containing information on over 22,000 members, is also sent to all members.

The benefits of I.R.E. membership include participation in technical meetings of the local Section and Professional Groups as well as the Regional and National Conventions. Technical Committee activities in setting standards and Professional Group activities in procuring papers and arranging meetings offer stimulating contacts with other engineers and further opportunities for direct contributions to the progress of the industry.

If you are not a member, now is the time to join. Membership grades are Student Associate, Member, and Senior Member and you are eligible for one of them. Application blanks and information on requirements can be obtained from your local Section officers or directly from the Institute of Radio Engineers, Inc., at 1 East 79th Street, New York 21, New York. The grade of Fellow cannot be applied for as it is conferred by action of the Board of Directors in recognition of distinguished achievement.

MISCELLANY

We are indebted to Professor H. E. Ellithorn of the Department of Electrical Engineering, Notre Dame University, for the accompanying photographs showing how TYPE 874 Coaxial Elements can be packed for convenient storage and transportation.

The box is the storage case supplied with the TYPE 874-LB Slotted Line. Mounting facilities for air lines and for the vertical shaft of the TYPE 874-Z Stand have been added to the cover, while receptacles for the smaller parts, ells, tees, and terminations, have been built into the box itself. Patch cords are stored loosely in the remaining space.

Figure 1. View of the storage box, showing the various coaxial elements that are accommodated.

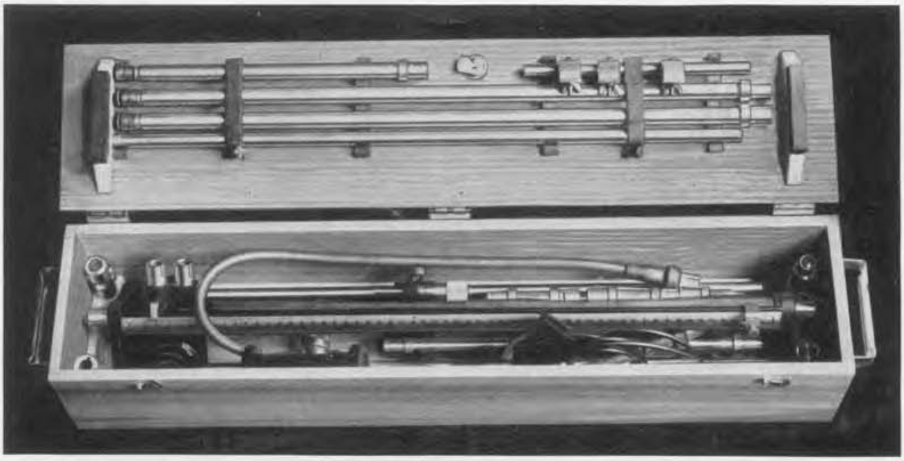


Figure 2. View of the box with elements packed in place.

The addition of handles at the ends makes the converted box a convenient, easily transported case, requiring a minimum of storage space.

RECENT VISITORS to our plant and laboratories — Dr. H. Moss, Chief Engineer, Electronic Tubes, Ltd., High Wycombe, Bucks, England; Mr. P. E. N. Towle, Mullard Electronics Products, Ltd., London, England; Mr. R. C. Auriema, of Ad. Auriema, New York, export representative for General Radio products in Latin America; and Mr. Leopoldo Brandt, of Mauricio Brandt S.R.L., Buenos Aires, Argentina, who handles General Radio products in the Argentine.

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