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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS®

A THREE-QUARTER HORSEPOWER VARIAC® MOTOR SPEED CONTROL

Also

IN THIS ISSUE

● **THE VARIAC SPEED CONTROL** provides adjustable-speed operation of d-c motors from a-c power lines. This control uses no electronic tubes, so is capable of instant starting, without warm-up. Its basic simplicity makes possible a compact, single-unit construction with the ruggedness and reliability needed in industrial applications.

Since the Variac Speed Control was first introduced, there has been a persistent demand for a unit large enough to handle light production machine work. The one-third horsepower rating of the Type 1700-B Variac Speed Control is insufficient for this duty, although it has proved ample for many special applications such as toroidal winding machines, resistance-card-winding machines, and for lathes used in finishing small parts. It has been apparent that a unit of about three-quarter horsepower rating

Figure 1. Panel view of the Type 1702-A ¾-hp Variac Speed Control.

would greatly extend the field of application of controls of this type. The TYPE 1702 Variac Speed Control shown in Figure 1 is now offered to meet this need.

Characteristics

The circuitry, construction, and performance of the new three-quarter horsepower control are all practically identical with those of the one-third horsepower TYPE 1700-B Variac Speed Control recently announced.[1]

Figure 3 is a schematic circuit diagram. An adjustable armature voltage is supplied by a bridge-connected selenium rectifier fed by a Variac® autotransformer. A fixed shunt-field voltage is supplied by a separate transformer and rectifier system. The base speed of the motor can be increased if desired by about 15 per cent by shifting the output lead of the field-supply transformer to the low-voltage tap provided.

Some of the important features of this control are:

(1) The use of selenium rectifiers eliminates tube replacement and the warm-up time delay when the unit is first turned on. The rectifiers adopted for these controls are of a type having long life even when operating in high ambient temperatures.

(2) The control is simple and rugged and is easy to install and maintain. A compact, single-unit construction is employed, including dynamic braking and a manually operated starting and reversing switch. The size of the three-quarter horsepower control is not proportionately larger than that of the one-third horsepower unit and is still small enough, 15 x 13 x 5³⁄₁₆ inches, so that it can be mounted beside a machine within convenient reach of the operator.

(3) An isolated field supply permits the use of compound-wound motors with their greatly improved starting characteristics. Since the control has very large short-period overload capacity, this means that heavy loads can be started or reversed quickly and often, without damage to the control system.

(4) The choke (L_1 in Figure 2) reduces the a-c ripple in the armature circuit, thus lowering motor losses and eliminating torque pulsation at the ripple fre-

[1]W. N. Tuttle, "An Improved Variac Speed Control," *General Radio Experimenter*, Vol. 25, May, 1951, pp. 1-5.

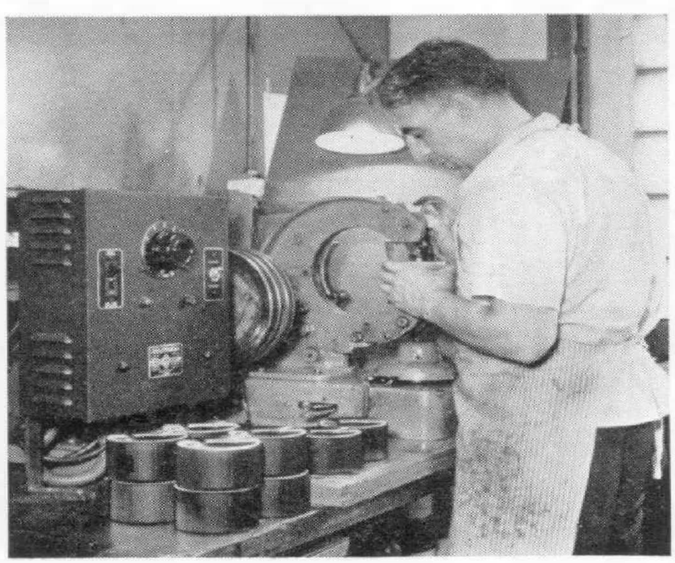


Figure 2. Typical installations of the ¾-hp Variac Speed Control, *(left)* on a lathe, and *(right)* on a toroidal winder.

quency. This feature is particularly important in precision grinding operations where other types of controls are unsatisfactory.

(5) The armature voltage source has a low internal impedance so that the inherently good regulation characteristics of shunt or compound-wound motors are largely preserved. The regulation with a standard compound-wound motor is about 24 per cent at base speed. Speed-torque curves are given in Figure 4.

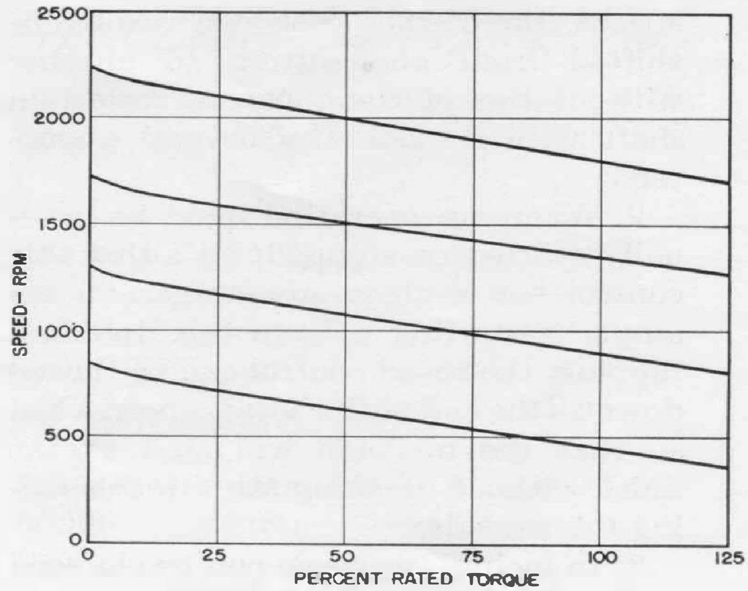


Figure 4. Typical speed-torque curves for the Type 1702-A Variac Speed Control operating a ¾-hp compound motor.

Motors

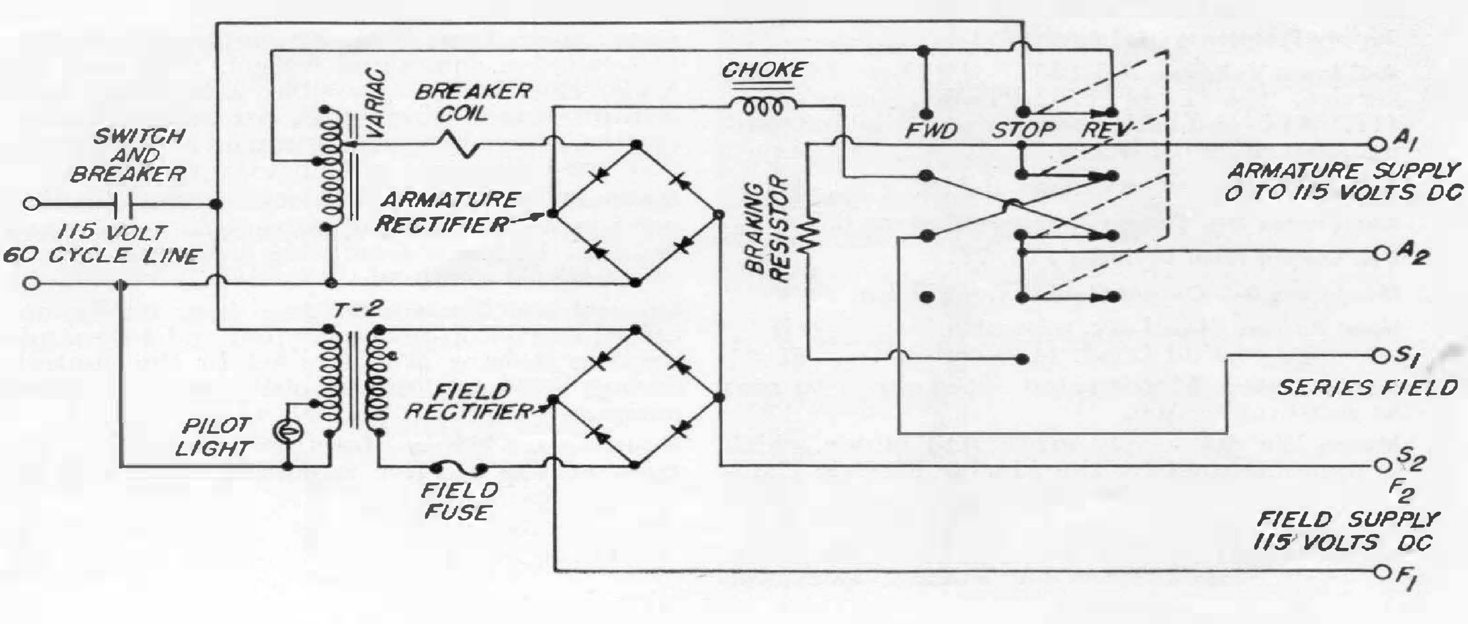
Motors can be purchased directly from the motor manufacturer or from the General Radio Company. In the selection of motors, armature currents should be checked to determine that full-load ratings conform to the output rating of the Variac Speed Control as listed in the specifications, page 4.

Applications

Experience with the three-quarter horsepower controls in our own production work has shown that their characteristics are excellent for a wide range of applications. These include not only a large proportion of the cases where some sort of continuously adjustable speed control is obviously required, but also many applications where conventional step-pulley drives were formerly employed and where increased production efficiency has been found to result from substitution of the Variac Speed Controls. The reaction of the operators has been that this drive is the best that they have ever used. A few situations in which the new controls have saved production time are the following:

1. Where several lathe operations are done on the same piece at different

Figure 3. Schematic circuit diagram of the Type 1702-A Variac Speed Control.



speeds, the Variac knob can readily be shifted from one setting to another without loss of time. An example is a shaft with shoulders of several diameters.

2. Where an operation must be gradually started or stopped, an adjustable control has a great advantage. An example is starting a large tap. In blind tapping, the speed control can be turned down as the end of the hole is approached so that the machine will stall at the finish without breaking the tap or spoiling the threads.

3. In facing, the speed can be changed as the diameter of the cut changes.

4. Since speed can be changed quickly and easily, certain operations such as withdrawing a tap are naturally speeded up to the limit, with appreciable saving in production time.

5. Some operations require rapidly repeated starts, stops, and reversals. Since an induction motor starts very inefficiently, such service may cause overheating and short motor life in conventional drives. A compound-wound motor, as used with the Variac Speed Controls, has much better starting characteristics, so starts faster and heats up less.

6. Since the optimum speed for a given operation can be quickly determined with an adjustable control, faster production is frequently obtained than with conventional drives which provide only three or four fixed speeds.

In many of the lathe installations made in our shops, the three-speed step-pulley drive of the original equipment has been retained, only the motor and control being changed. In these cases, it has been observed that the operator usually shifts the belt only when increased torque is required at low speeds. An installation has recently been made with the motor belted directly to a back-geared lathe at a fixed speed ratio. This has proved entirely satisfactory, there being plenty of overlap between the minimum useful speed with direct drive and the maximum speed using the back gears. This is a particularly simple and satisfactory installation.

This new three-quarter horsepower unit extends the application of the Variac Speed Control to light production operations, where its many advantages are even more evident than in the specialized jobs for which the lower-power models are suited.

— W. N. Tuttle

SPECIFICATIONS

Supply Frequency: 60 cycles.

A-C Input Voltage: 105-125. For 210- to 250-volt service, the Type 1702-P1 Autotransformer (1KVA) is available to step down the line voltage. See price list below.

D-C Output Armature Voltage: 0-115.

Continuous D-C Output Armature Current: 6.5 a.

D-C Output Field Voltage: 115, 75.

Maximum D-C Output Field Current: 0.4 a.

Input Power: Stand-By, 65 watts.
Full Load, 1150 watts.

Speed Range: Motor rated speed down to zero at constant torque.

Motor: We can supply our MOD-6 motor, which is manufactured by the Master Electric Company: their Type DM, Frame No. 66, ¾ hp, 115-volt d-c, compound wound, 1725 rpm, six leads, electrically reversible, interpoles, open drip-proof mounting, 40°C. rise continuous operation, sleeve bearings, arranged for horizontal floor mounting. See price list on page 5.

Overload Protection: Magnetic circuit breaker permits heavy starting current but will open between 7.25 and 9 amperes armature current on sustained overload.

Reversal and Dynamic Braking: A manually operated start-stop-reverse switch and a dynamic braking resistor are included in the control. Strong braking action is obtained in the stop position.

Mounting and Wiring: Holes are provided in the back of the box for mounting on a wall or bracket. Mounting must be vertical and must permit free access of air through the bottom of the cabinet. Two holes for BX or conduit wiring are located in the center of the bottom of the box.

Dimensions: Box, 13 x 15 x $5\frac{3}{16}$ inches; overall, including knobs, $13\frac{9}{16}$ x 15 x $6\frac{5}{8}$ inches. TYPE 1702-P1 Autotransformer, $3\frac{1}{2}$ x $4\frac{1}{4}$ x $5\frac{9}{16}$ inches.

Net Weight: TYPE 1702-A Variac Speed Control, 41 pounds; TYPE 1702-P1 Autotransformer, $20\frac{1}{4}$ pounds.

Type		*Code Word*	*Price*
1702-A	Variac® Speed Control* — ¾ hp	AMAZE	$230.00
1702-P1	Autotransformer, 230 to 115 volts	WOVEN	27.50
MOD-6	¾ hp Motor	MOTOR†	80.90

*U. S. Patent No. 2,009,013.
†To order speed control with motor, use compound code word AMAZEMOTOR.

PRICE REDUCTION ON MOD-4 MOTOR

The price of the TYPE MOD-4 universal motor, $\frac{1}{15}$ hp, for use with the TYPE 1701-AU Variac® Speed Control** is reduced from $29.85 to $17.50. This new price is effective on all orders now on hand, as well as those received in the future.

**W. N. Tuttle, "A Smaller Variac Speed Control," *General Radio Experimenter*, XXIV, 5, October, 1949.

USES OF VARIACS IN ELECTRICAL ENGINEERING POWER LABORATORIES

by Abraham Abramowitz††

Variac® autotransformers have been widely used in communication and electronics laboratories. Because of their relatively late arrival on the equipment scene, particularly in the larger sizes, they are less commonly found in the power laboratory. For many purposes, they can take the place of large, costly, adjustable-voltage sources. In addition, they offer the advantages of simple installation and complete portability.

For example, transformers are always tested by means of standard no-load tests, namely the open- and short-circuit tests. For these tests 220- to 110-volt transformers of 1- to 5-kva capacity are commonly used. A 115-volt Variac in conjunction with a step-down autotransformer is ideal for this test. Fortunately, the Variac required can be considerably smaller than the transformer rating.

Let us take, for an illustration, a 220- to 110-volt, 3-kva transformer. Reference to tables of representative losses in transformers such as "Electrical Engineering Laboratory Experiments," fourth edition, by C. W. Ricker and Carlton E. Tucker, yields the following data: Exciting current, 4.5 per cent of load current; impedance voltage, 3.4 per cent. At rated low-voltage input, the no-load current will be $\frac{3,000}{110} \times 0.045 = 1.23$ amperes. For test purposes, it is desirable to overvoltage the transformer say 10 per cent. If this is done, the transformer becomes saturated, and the no-load current will rise approximately 2.5 times. Thus a 5-ampere (V-5) Variac will more than suffice. For the short-circuit test (input on the high side), the voltage will be $0.034 \times 220 = 7.48$ volts at $\frac{3,000}{220} =$ 13.65 amperes. In order to overload the

††Professor of Electrical Engineering, College of the City of New York.

transformer, about 15 volts should be provided. This can be done by using a 110-volt to 20-volt step-down transformer of 500 volt-ampere capacity. The Variac will be called upon at maximum to furnish $\frac{500}{110} = 4.54$ amperes. Thus, a 5-ampere Variac will be more than ample. The step-down transformer does more than cut the required Variac capacity, since it permits much better control than an appropriate large Variac.

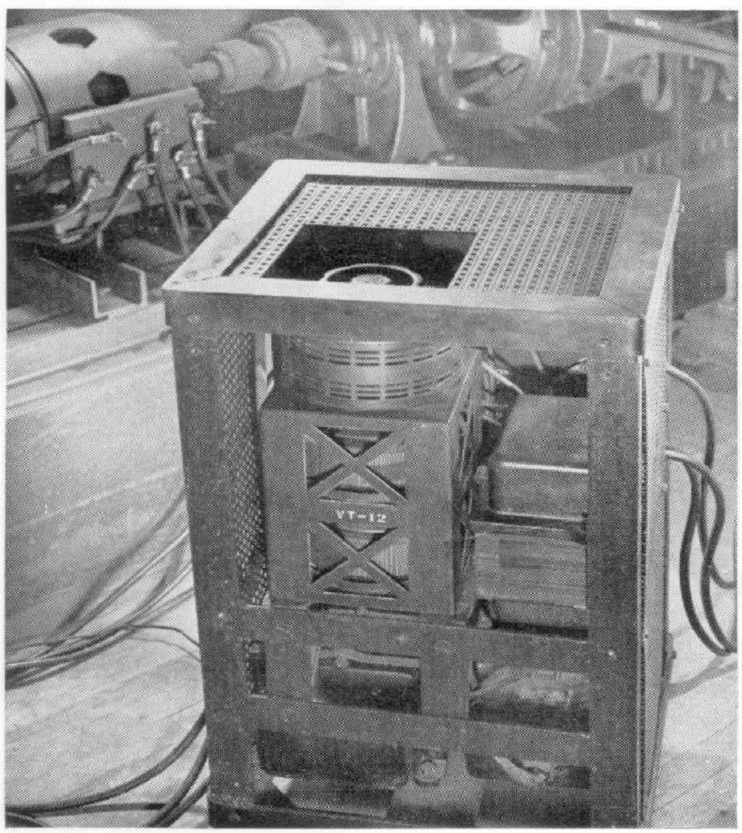
We see that a 5-ampere Variac is sufficient for testing a 3-kva transformer. For use in the power laboratory, the Variacs should be ordered for the largest unit to be tested, if the test transformers can be used to change the voltage available from the Variac.

Three-phase ganged Variacs also have a place in the power laboratory. Three-phase variable voltage is commonly used for running-light and blocked-rotor testing of induction motors and for the slip test on salient-pole alternators. Here, too, the Variacs can have smaller capacity than the machines to be tested.

In the electrical engineering laboratories of the College of the City of New York, two three-gang 20-ampere Variacs have been employed for several years for testing a 15-horsepower, 220-volt, 39-ampere, wound-rotor induction motor and for performing the slip test on a 15-kva, 39-ampere, 220-volt, salient-pole alternator. The results have been extremely satisfactory. The unit has become so popular that an auxiliary variable-voltage a-c motor-generator is rarely used.

View of the three-gang Variac assembly used in the electrical engineering laboratories of the College of the City of New York.

(Photo by McManus Studios)



The Variac is supported on an angle-iron frame mounted on casters to insure portability. Two-to-one step-down autotransformers are mounted integrally with the Variac. A three-pole double-throw switch permits the selection of either 0-220 volt or 0-110 volt output (actually due to the voltage available in the laboratory, 0-208 volts and 0-104 volts are obtained). The Variac and autotransformers are both "wye" connected. A 40-ampere unit has been built with delta-connected autotransformers. The Variac is not connected for output voltages higher than the input, although this can be done if desired. The unit is protected against overload by a Heineman magnetic breaker with a type-2 delay curve.

The 0-220 volt position is used for the induction motor running-light test and the lower voltage position for the blocked-rotor test. For the blocked-rotor test about 50 volts is required, and a four-to-one step-down transformer could be used. However, the 0-110 volt position makes the unit more versatile for all-around use. There is ample control for the low voltage. The low-voltage position is also used to apply less than 80 volts to an unexcited salient-pole alternator running near synchronous speed. As the poles line up and fall out of phase with the resulting rotating field of the stator, the input line current fluctuates. This permits the direct and quadrature axis reactances to be measured. Incidentally, when alternators are used for this purpose, the input voltage fluctuates due to poor alternator regulation. This effect is so small with Variacs that students often think something is wrong with the test.

Ganged Variacs can also be used to build adjustable reactors and capacitors by connecting suitable single-phase units in delta across the Variac output.

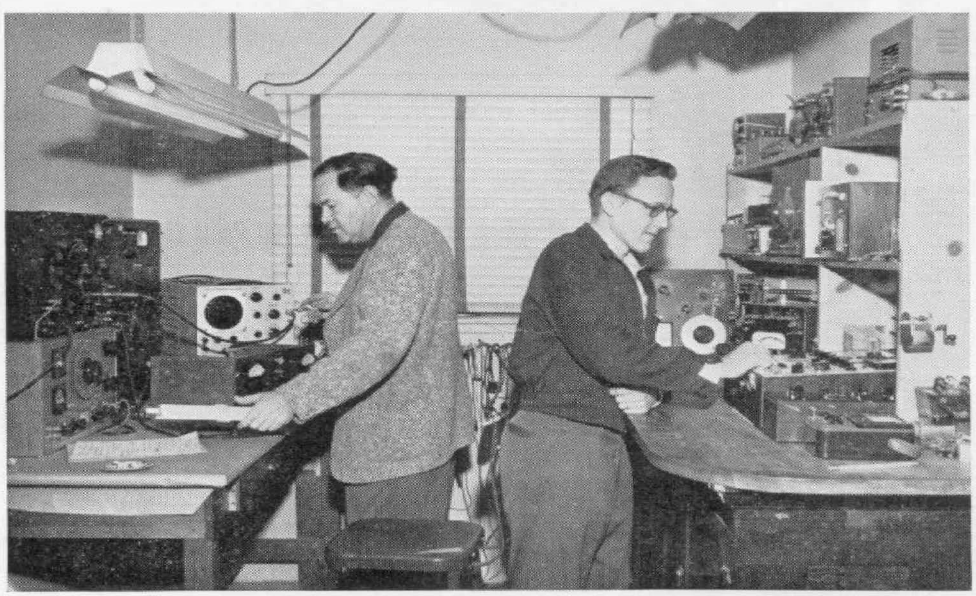
I wish to acknowledge the encouragement given me by Professor Harold Wolf, Chairman of the Electrical Engineering Department, and to Mr. Otto Sauer, who actually constructed the units.

WESTERN INSTRUMENT COMPANY OFFERS REPAIR SERVICE TO WEST COAST CUSTOMERS

West Coast users of General Radio instruments can now have their equipment repaired and recalibrated in California, thus avoiding the expense and delay that now occur when material is returned to our factory.

Western Instrument Company, 826 North Victory Boulevard, Burbank, California, has been appointed West Coast service agency for General Radio products. This firm has a well-equipped laboratory and machine shop to give prompt and competent repair service on all General Radio instruments. Their repairs and calibrations are made to the same specifications and standards as used at our factory, and we are glad to recommend their service to our friends in the West Coast states and adjacent areas.

Western Instrument Company is owned and operated by Albert K. Edgerton, who was graduated from Pomona College with the degree of A.B. in Physics in 1934. For the next three years he was employed in electronics in the Los Angeles area, and in 1936 he established the Western Instrument Company.



View of the modern, well-equipped laboratory at Western Instrument Company.

From the first, this company has been concerned with consulting and measurement services in electrical and related fields. Development and design facilities for industrial and laboratory controls, as well as measuring equipment, have been a corollary activity. Mr. Edgerton has been engaged in small-quantity production lots of special electrical and measuring equipment. During World War II he was a staff member of the Radiation Laboratory at M.I.T. in Cambridge, Massachusetts, for eighteen months, later becoming Chief Test Engineer for the Research Construction Company, an engineering and production organization affiliated with the Radiation Laboratory. Since 1946 he has devoted his full time to the operation of the Western Instrument Company, which continued during the war as an electrical measurements laboratory facility for Southern California industry.

Mr. Edgerton has found an increasing interest in the need for maintenance and calibration facilities for electrical and electronic laboratory equipment on the West Coast, and in early 1951 he became affiliated with the General Radio Company to handle their service and repairs in the area.

Engineering and commercial matters are still to be referred to our Los Angeles Office at 1000 North Seward Street, staffed by Mr. Frederick Ireland and Mr. James G. Hussey, but problems concerning the repair and recalibration of General Radio equipment can be taken up directly with Mr. A. K. Edgerton at the Western Instrument Company, 826 North Victory Boulevard, Burbank, California.

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