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A MODERN STANDARD-SIGNAL GENERATOR

● **SIGNAL GENERATORS** have reached a stage of maturity when new designs may be directed at requirements in details of operation and elimination of sources of error rather than improvement in the fundamental method.

In the new General Radio TYPE 605-A Standard-Signal Generator, the emphasis is on improved convenience and accuracy of operation. Perhaps no feature of earlier generators has been more annoying than the necessity for changing coils when operating over a wide frequency range, and this has been eliminated by the use of a range switch — and the frequency control dial is direct reading, doing away with calibration curves at the same time. Another long-desired feature — a-c operation — has been incorporated, but the generator may also be operated on batteries if desired. Electrically also, many annoyances of earlier instruments have been eliminated. Frequency modulation is negligible, as is reaction of the attenuator setting on carrier frequency. And no more will a blown thermocouple bring the day's work to a permanent end.

The instrument is the result of nearly two years' study of the problem of designing and manufacturing a signal generator which combines accuracy and general utility with a price that most radio receiver manufacturing laboratories, colleges, and engineers can afford to pay.

A wide frequency range is of primary importance in any general utility signal generator. The range of the TYPE 605-A Standard-Signal Generator extends from 9.5 to 30,000 kilocycles, covering carrier, supersonic and high audio frequencies as well as most of the radio-frequency spectrum.

The inductance and capacitance have been so proportioned that only two frequency scales are necessary on the dial of the tuning condenser. Seven coils are used in conjunction with a condenser having a 10 : 1 ratio of maximum to minimum capacitance. The

PLEASE NOTIFY US PROMPTLY WHEN YOU CHANGE YOUR ADDRESS

FIGURE 1. Panel view of the TYPE 605-A Standard-Signal Generator

ratio of maximum to minimum frequency for each coil is, therefore, the square root of 10, or 3.16, and the actual ranges in kilocycles are 9.5 to 30, 30 to 95, 95 to 300, and so on up to 30,000 kilocycles. Figure 2 shows the dial and scales in detail.

The main tuning condenser operated by this control has been designed to provide a logarithmic change in frequency with angular rotation. A given rotation will cause the same percentage change of frequency at any setting, and the percentage accuracy of reading is constant over the entire frequency range of the instrument.

The tuned circuit has been designed for a high degree of frequency stability. This is achieved by using a high value of circuit capacitance (1400 to 140 micromicrofarads) and by careful design of the inductors.

The three lowest-frequency coils for the range 9.5 to 300 kilocycles are wound on sectioned isolantite forms. The four higher-frequency coils are wound on treated low-loss linen-bakelite tubes. One of the isolantite coils is illustrated in Figure 3. This type of construction has reduced the frequency drift with time to less than 0.01% at any frequency after an initial warming-up period of 20 or 30 minutes.

Each coil has a magnetic-metal dust core which is adjusted to obtain correct inductance, and, once adjusted, the core is locked in place by two setscrews. Associated with each coil is a trimmer condenser. These features make it possible to adjust the oscillator coil to the correct inductance for its low-frequency point and to adjust the minimum capacity for the high-frequency end of scale. In this way the frequency scale is made direct-reading.

The coils are selected by the band-

FIGURE 2. The main frequency control dial

change switch controlled from the panel. On the dial, which is illustrated in Figure 4, each coil range is lettered and the actual range engraved on either the inner or outer circle of numbers. The inner and outer circle refer to the corresponding circle on the main frequency control so that there will be no confusion as to which scale to use for a given frequency band.

The band-change switch itself, which is shown in Figure 5, has been designed especially for this instrument. Both the movable and fixed contacts are of silver. A positive detent action is provided so that the correct centering of the switch at each stop is assured.

Frequency modulation and the reaction of the attenuator setting on carrier frequency have long been bothersome defects in commercial standard-signal generators. Both can be eliminated almost completely by the use of a master-oscillator power-amplifier circuit in which the modulation is introduced into the amplifier stage. The amplifier isolates the oscillator circuits from both the modulation and the output circuits, and this accomplishes the required result. These MOPA circuits are very easily achieved in single-frequency generators such as transmitters, but for a wide-frequency-range signal generator the problem is much more complicated. The conventional circuit involves the use of a complete duplicate set of radio-frequency tuning inductors, of which there are seven in the TYPE 605-A, and two ganged variable air condensers. The two tuned circuits must be accurately aligned for all frequencies. It also involves the push-pull output tube arrangement if high percentages of modulation are required.

The principal difficulty is that the duplicate tuned and push-pull circuits, with the attendant increase in calibration and adjustment costs, rules out the method for a moderately-priced instrument. An investigation of untuned radio-frequency amplifier circuits indicated that satisfactory results would be possible with aperiodic coupling, even over the extremely wide fre-

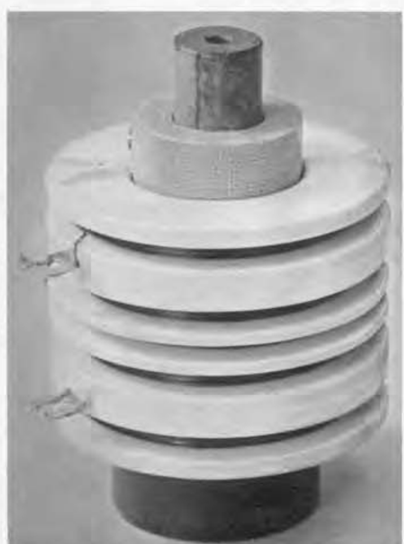

FIGURE 3. One of the low frequency coils showing construction

quency range required for a standard-signal generator.

The use of an untuned output circuit reduces the output power available but has the advantage of simplicity and also eliminates the probability of side-band clipping at high modulation frequencies. Even without a tuned output circuit quite high percentages of modulation can be achieved if two amplifier tubes are used in a push-pull circuit. These balanced circuits, however, also require a rather elaborate and expensive arrangement of additional equipment, especially when working into a grounded unbalanced attenuator system.

For these reasons, a single tube with an aperiodic output coupled directly into the attenuator has been used.

The maximum percentage of modulation depends entirely upon the amount of radio-frequency and audio-frequency distortion that can be tolerated. The latter distortion is rather more important. The r-m-s value of the audio-frequency harmonics in this instrument has been reduced to 3%* at 30% modulation; at 50% modulation the harmonics are somewhat less than 5%*. Therefore, 50% modulation was selected as the maximum.

FIGURE 4. The band-change dial

The TYPE 605-A Standard-Signal Generator is provided with a 400-cycle internal modulating oscillator. Its output is introduced into the grid circuit of the amplifier-modulator tube and is adjustable from zero amplitude to the maximum of 50% modulation. Its amplitude is read on the lower scale of the panel meter shown in Figure 6.

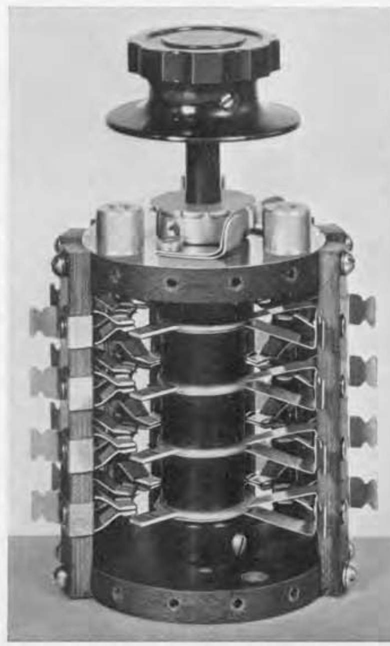

FIGURE 5. Construction of the band-change switch

Terminals are provided for external modulation, which is obtained from any external oscillator. The frequency range is from 30 to 15,000 cycles. Since the modulation is applied in a vacuum-tube grid circuit the power required is very low. Only five volts across 2500 ohms (10 milliwatts) are needed for

*These figures include the distortion in the audio-frequency oscillator itself.

FIGURE 6. Vacuum-tube voltmeter scales

30% modulation. In order to prevent effectively any radio-frequency leakage at the external-modulation terminals, two low-pass filters are provided. Below 300 kilocycles the maximum modulating frequency is limited to 1000 cycles. Above 300 kilocycles carrier frequency, the full external-modulation range of 30 to 15,000 cycles may be used.

For purposes of reliability and accuracy, vacuum-tube voltmeters are used to measure the amplitude of the carrier and the modulation voltage. Both voltmeters use the same microammeter, which can be switched from one circuit to the other as desired.

The audio-frequency modulating voltage is impressed on a TYPE 84 Rectifier Tube operating in a full-wave rectifier circuit. The current drain is so slight that the waveform is not affected by the rectifier across it.

The carrier-frequency vacuum-tube voltmeter is bridged across the carrier output of the radio-frequency amplifier at the beginning of the output attenuator system. It is essential that its input capacitance be low so that it will not bypass the higher radio frequencies. A TYPE 955 Tube has been selected as the most suitable. It is, in fact, the only readily-available commercial tube that will do the work successfully. The meter circuit may be adjusted to take care of slow drifts in the tube sensitivity due to reduced cathode emission over long periods of time.

The attenuator system has received particular attention. The amplifier tube works into an L-type attenuator having an impedance of 50 ohms. The circuit is shown in Figure 7. The shunt element, which is the most critical as to accuracy, is in appearance similar to the General Radio TYPE 301-A Potentiometer. The resistance wire is wound by the Ayrton-Perry method on a thin, narrow form. The magnetic field around this potentiometer is practically eliminated by an aluminum center which reduces the area enclosed by the movable switch blade. By proper proportioning of the various elements, almost all of the residual inductance is eliminated, making the potentiometer practically a pure resistance at all frequencies. The series rheostat is similar in construction. This L-network provides a continuous variation of the calibrated output voltage range over a

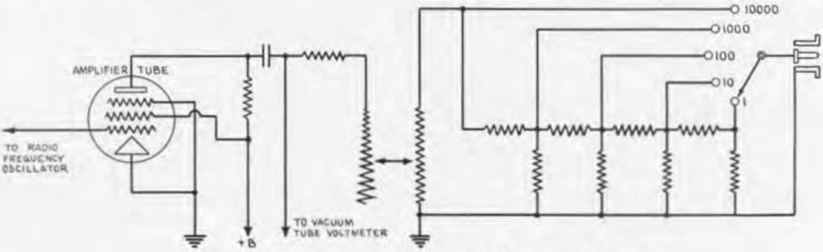

FIGURE 7. Schematic diagram of the output system

ratio of 1 to 20. Its control scale is calibrated from 0.5 to 10 in microvolts. The slide-wire assembly is followed by a five-step ladder network. Each step changes the output by a factor of 10, providing multiplying factors of 1, 10, 100, 1000, and 10,000. The resistor elements of the ladder are wound on very small mica cards in the conventional manner except that, by better proportioning of the dimensions, their frequency characteristics have been considerably improved. They are carefully shielded, and a concentric output plug is provided so that the shielding is maintained intact through to the end of the concentric shielded connector cable, also provided. The output microvoltage is continuously variable from 0.5 to 100,000 microvolts. The attenuator output impedance is constant at 10 ohms up to 10,000 microvolts and increases to 50 ohms for the range of 10,000 to 100,000 microvolts.

The instrument is designed for operation directly from the commercial alternating-current power mains. Since it is important that the output amplitude and frequency remain constant at all times, an automatic voltage-regulating transformer is used. It is possible to regulate the plate voltage by means of a gas-filled regulator tube or other means, but this does not eliminate the slow drifts due to changing cathode temperatures. The entire power input is, therefore, voltage regulated by means of a saturated-core-type regulating transformer. Care has been taken in its design to reduce external electromagnetic fields. Since a given design of this type of transformer is only suitable for a narrow range in the vicinity of one supply frequency, three models are available for use on 60-, 50-, or 42-cycle supply mains, which include most of the commercial frequencies used either in this country or abroad.

Battery operation is sometimes essential for mobile work. For this use, a battery power control panel may be ordered with the instrument instead of the alternating-current power unit. This control panel is equipped with a suitable meter for reading both *A* and *B* voltages, a filament, and a plate adjusting rheostat. The cathodes are operated at 6 volts (from an automobile storage battery for example), with total current requirements of 1.70 amperes. A single 200-volt battery capable of delivering 37 milliamperes continuously is required for the *B* supply. No other batteries are needed. The power input leads are filtered to prevent radio-frequency leakage.

The whole assembly is housed in a copper-shielded cabinet. The greatest care has been used to reduce radio-frequency leakage to a value so low that an unshielded receiver will not be affected by leakage even when working at the lowest microvolt levels.

— Arthur E. Thiessen

The Type 605-A Standard-Signal Generator was designed by Mr. E. Karplus in collaboration with Messrs. L. B. Arguimbau and A. G. Bousquet.

Type	*Power Supply*	*Code Word*	*Price*
605-A	60 cycles	ANNUL	$415.00
605-A	50 cycles	ANODE	415.00
605-A	42 cycles	ANVIL	415.00
605-A	Battery	APART	415.00

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