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NEW ATTENUATOR AND COMPARATOR

EXTEND FREQUENCY RANGE OF COMPARISON TECHNIQUE TO 1200 MC.

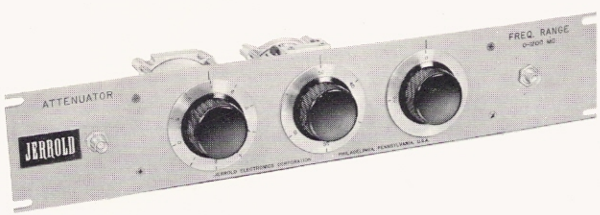


Fig. 2—Model ATV-109R Rack-Mounting Bank of Turret Attenuators

Fig. 1—Model TC-3 Coaxial Comparator

SUMMARY: A new drum attenuator and a transistorized three-way coaxial comparator are described, which allow accurate sweep-frequency measurements of transmission loss, gain, and reflection coefficient in 50-ohm coaxial systems from DC to 1200 MC.

INTRODUCTION

For the past six years, Jerrold has been offering as accessories to the 900-A and 900-B Sweep-Frequency Generators a comparator (high speed coaxial switch Model FD-30) and variable attenuators (Model AV-50). When used with a wide-band sweep-frequency generator these allow quite accurate measurements of transmission gain and loss[1], and when used with a suitable bridge, measurement of reflection coefficient (return loss)[2] to a limit of accuracy determined by the characteristics of these accessories. The FD-30 Comparator and the AV-50 Attenuator were originally designed for use in the frequency-range up to 250 MC, where they had excellent characteristics, with reasonably good performance up to 500 MC. Since the Model 900 Sweep Generators provide coverage up to 1200 MC there has been a need for improved accessories, making the comparison technique available up to the limit of the sweep capability.

The new Model TC-3 Transistorized Comparator and the Model ATV Turret Attenuators have been developed to meet this need. They provide measurement accuracy up to 1200 MC, somewhat better than that obtained with the older equipment up to 250 MC, and in addition feature several marked improvements in operating convenience over the older equipment.

1. Jerrold Technical Newsletter Volume 2, Number 1—March 1964. COMPARISON TECHNIQUE IMPROVES SWEEP FREQUENCY MEASUREMENTS. Ken Simons, Jerrold Electronics Corporation.

2. Jerrold Technical Newsletter Volume 1, Number 4—August 1960. A BRIDGE METHOD OF SWEEP FREQUENCY IMPEDANCE MEASUREMENT. (Same author.)

Figure 1 shows the Model TC-3 Coaxial Comparator. It consists of two basic housings arranged so that they can be mounted one on top of the other to form a convenient package for bench-mounting, or mounted side-by-side to form a 3½″ high panel in a standard 19″ rack. One of the units houses the transistor driver and the controls; the other houses the two coaxial switch assemblies. Each switch assembly consists of three reed relays mounted to form a single-pole triple-throw coaxial switch.

At frequencies in the gigacycle region, jumper cables present a major limitation on the accuracy of measurements. Therefore, accuracy is greatly improved if jumper lengths are kept to an absolute minimum. For this reason each assembly switch has been designed so that it can be removed from the housing and extended on a long cable so that it can be placed immediately adjacent to the units being tested. The reed relays operate equally well in any position; thus the switching heads can be positioned to suit the physical position of the units under test.

The operation of the new comparator can best be explained by comparing it with the FD-30. Figure 3a illustrates application of the FD-30 to the measurement and display of the frequency response of a resonant network. The sequence of operations when the unit is used with a 60-cycle supply is illustrated in Figure 3b and the resulting scope trace is shown in Figure 3c. Note that the complete cycle occurs in one-thirtieth of a second, and that the zero line is traced out twice in each cycle.

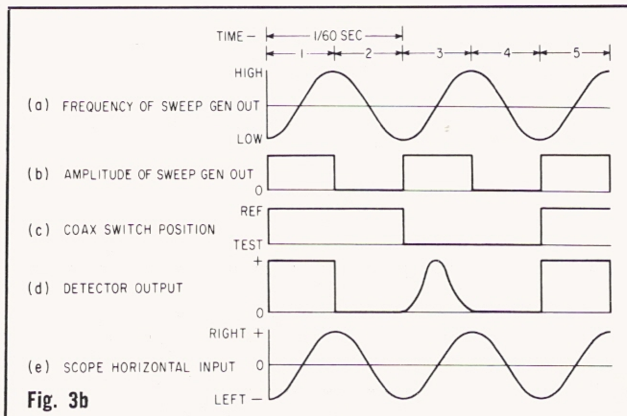


Fig. 3b

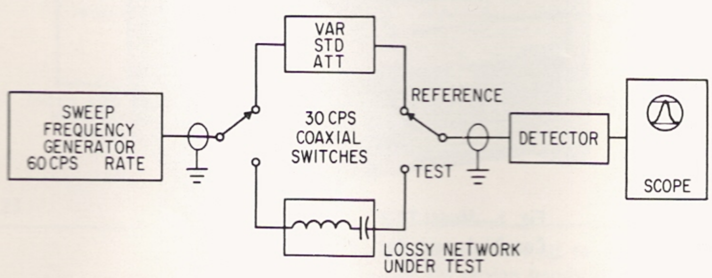


Fig. 3a—Operation of 2-Way Comparator Model FD-30

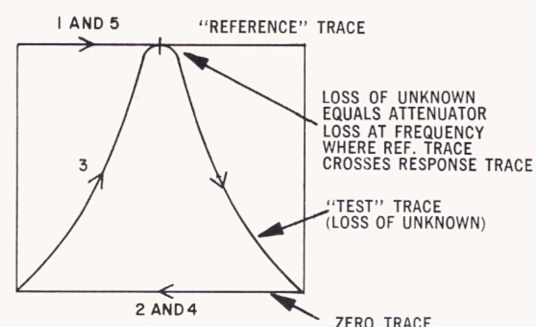
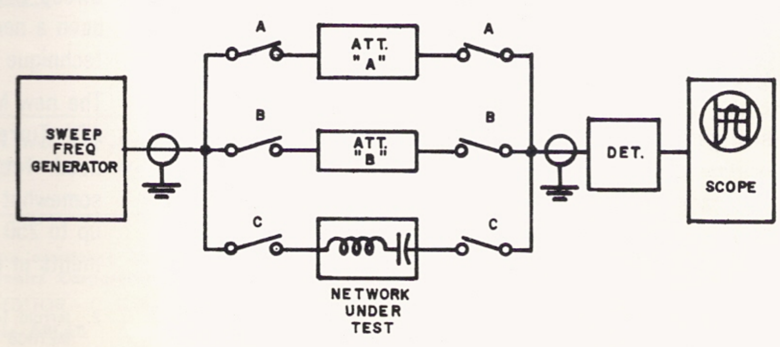


Fig. 3c

Figure 4a illustrates the application of the three-way comparator using two attenuators to show simultaneously the maximum response and the 3 db down point of a resonant circuit on an oscilloscope. Figure 4b diagrams the sequence of operations. Note that the switches "A" close during the first quarter cycle, connecting attenuator "A" into the circuit; switches "B" close during the next quarter cycle connecting attenuator "B" into the circuit; during the third quarter cycle, switches "C" close, connecting the unknown; and all switches are open during the fourth quarter cycle, producing the zero base line. The resulting scope trace is shown in Figure 4e. The response curve is displayed with a zero base line and two reference lines. The position of the reference lines on the trace corresponds to the attenuation of two separate attenuators.

Fig. 4a
Operation of
3-Way Comparator
Model TC-3



This three-way display allows, for example, setting up a production test position with high and low limits of gain, loss, or impedance, keyed into the scope so that all calibrations are independent of generator output or scope drift.

Figure 5 shows a block diagram of the transistor driver employed to obtain this operation. With the input switch in INT position, the synchronizing input is obtained from a 60-cycle AC connection to the power supply through a 360° phase shifter. With the switch on EXT, an external synchronizing input may be used at any frequency between zero and several hundred cycles. A source capable of supplying six volts peak-to-peak into 20,000 ohms is required. Regardless of the input wave form, the switches will operate about one millisecond after each zero volt cross-over.

The internal or external synchronizing signal is shaped by a Schmitt trigger and clipper and the resulting square wave, which has the same frequency as the synchronizing source, is applied to a two-to-one counter generating a square wave at ½ that frequency. Both square wave voltages are applied to a diode AND gate, which controls the input to three driver transistors so that these are keyed in the sequence required to drive the relay coils. A function switch selects one of three switching mode connections to the driver transistors so that relay switching can be performed either: manually, or by three-way automatic switching, or by two-way automatic switching giving operation similar to the FD-30.

Three reed relays are used in each of two heads, mounted coaxially to obtain the best possible impedance match up to 1200 MC. The impedance match, when the switch is terminated in a precise 50 ohms, is held to a close tolerance as shown by the characteristic in Figure 6. The relay units were selected to give an unusually high degree of isolation when open, and low insertion loss when closed. The insertion loss, when the switch is closed, is less than 0.1 db from DC to 1200 MC. When open, the capacity is less than 0.085 pf giving an insertion loss which decreases with frequency, as shown in Figure 7.

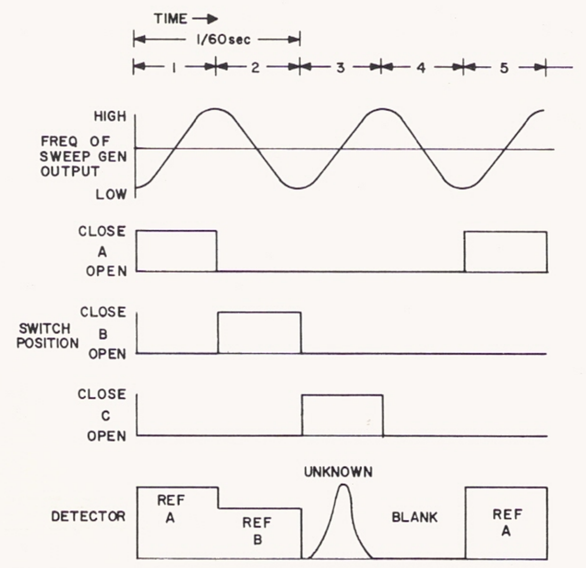


Fig. 4b

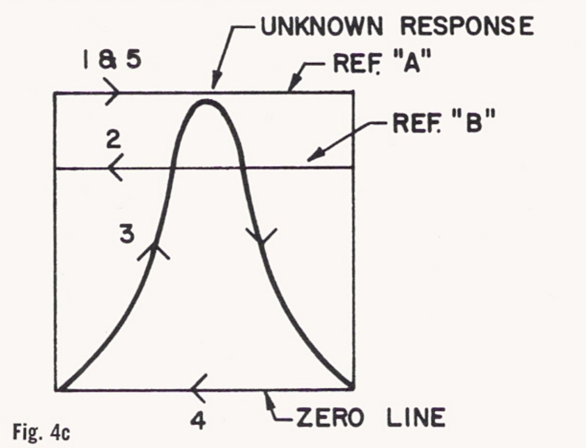


Fig. 4c

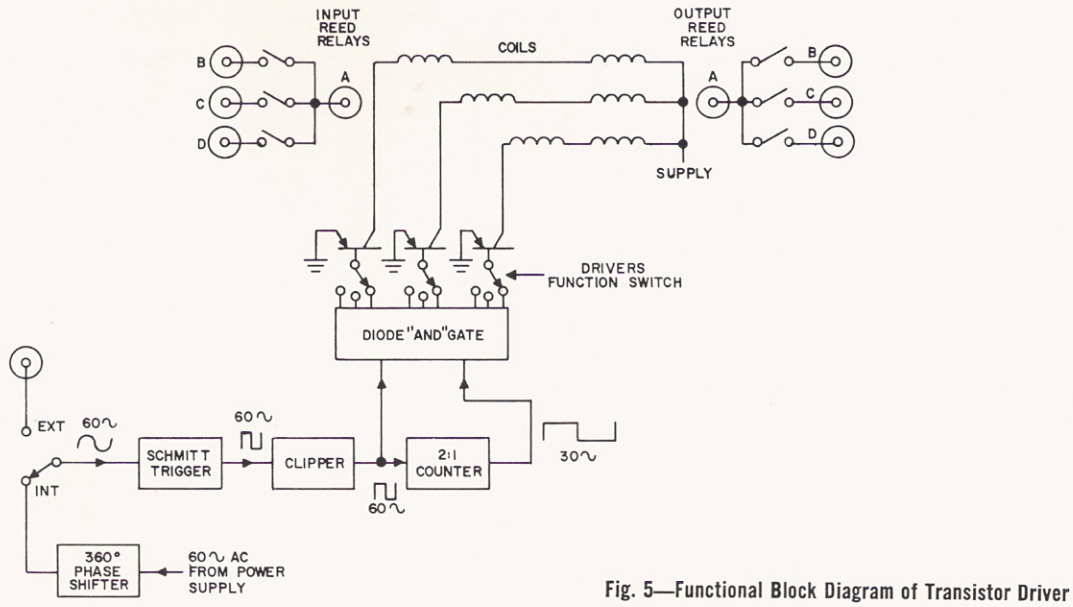


Fig. 5—Functional Block Diagram of Transistor Driver

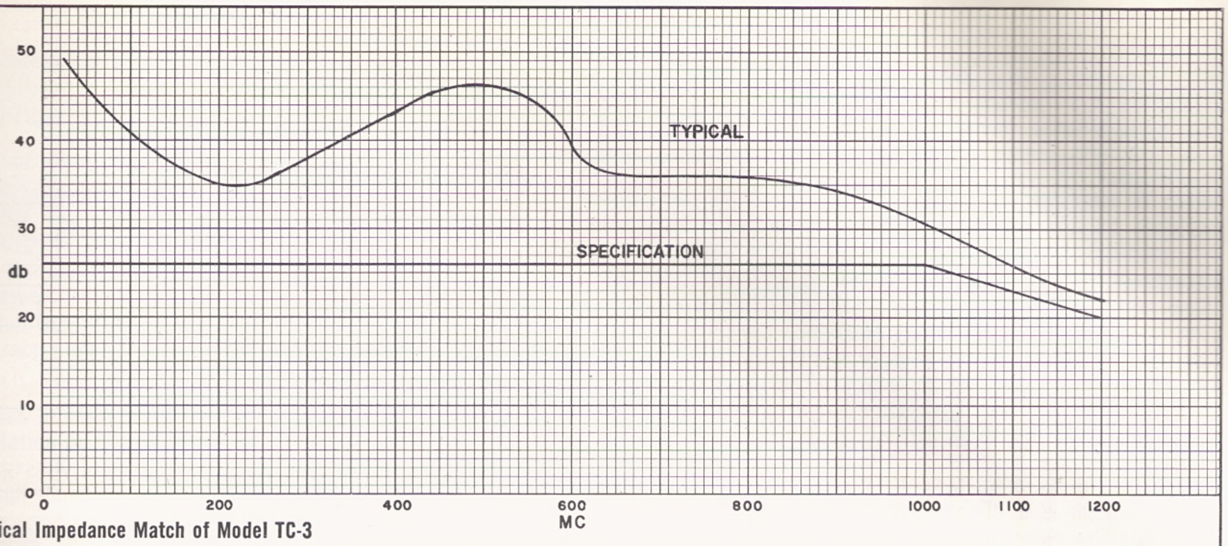


Fig. 6—Typical Impedance Match of Model TC-3

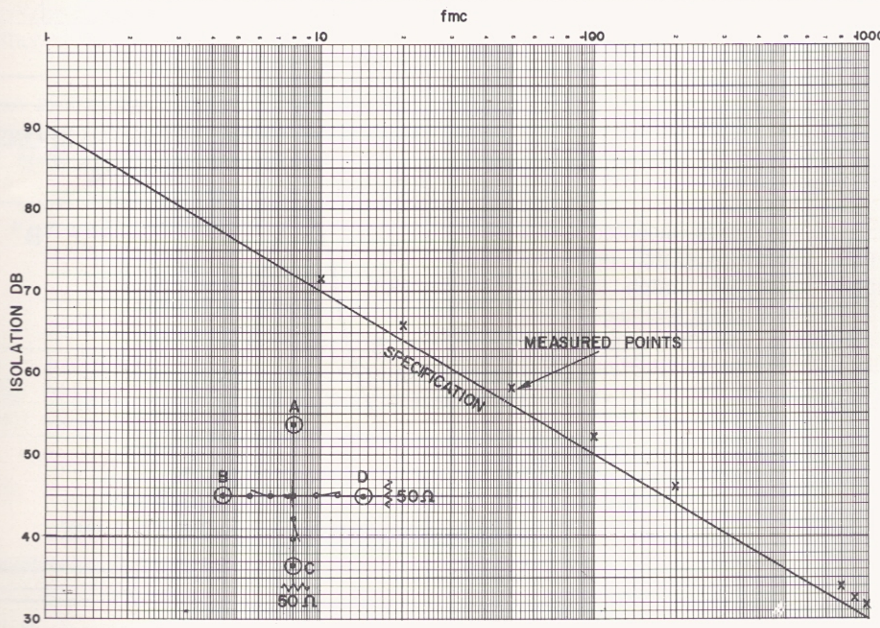


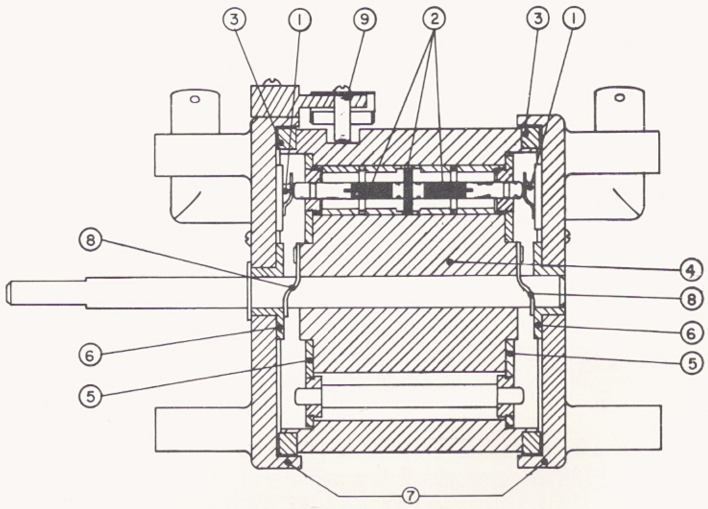
Fig. 7
Isolation in Model TC-3, Shown for Transmission from A to B.

MODEL ATV ATTENUATORS

The design selected for the new attenuators strikes a happy compromise between two extremes. Variable attenuators available today fall into two general categories. The best commercially available units are drum attenuators with an upper frequency limit of 2 to 4 GC. Several of the available types are pull-and-turn mechanisms which have optimum electrical performance at the expense of mechanical convenience. Prices are in the vicinity of $750 to $800 for a 10-position drum. All of the best units use disc and rod assemblies with either deposited carbon or film resistors.

At the other extreme there are many types of less expensive attenuators which cost less than $200. These generally use deposited or molded carbon resistors and various switching arrangements, either the progressively additive type (like our AV-50) or rotary switches. While these are excellent for low frequency applications and have good mechanical convenience, it is very difficult to maintain acceptable performance up to 1 GC with any arrangement where resistive elements are connected into the attenuator with wire leads.

Fig. 2 illustrates a rack-mounting bank of attenuators (Model ATV-109). A cross-section view of a turret is given in Figure 8. The highest quality deposited carbon rod and disc assemblies are used, mounted coaxially to take full advantage of their excellent match and attenuation capabilities. Spring contacts are employed between the attenuator element and the input and output connectors. While this construction does not provide as good a coaxial connection as might be obtained with a pull-and-turn arrangement, with careful design it has been made to give excellent performance to our top frequency objective of 1200 MC. The carefully-machined castings and well-designed detent ensure accurate and trouble-free operation. Complete RF shielding is assured by the use of RF gasketing material. The impedance match characteristics and attenuation accuracy of a typical 0-50 db drum are illustrated in Figures 9 and 10.



1. Coin silver contacts.
2. Disc and rod pad resistors for accuracy and long time-stability. Low VSWR assured with machined compensating sleeves.
3. Resilient rf gasketing for good ground contact and shielding.
4. Solid aluminum rotor, precision machined for accuracy and stability.
5. Important rf grounds carried by silver plated brass rings.
6. Brass bearing inserts for minimum wear.
7. Machined aluminum end castings to maintain alignment.
8. Coin silver inner contact grounding spring (necessary on some models only).
9. Positive spring-loaded ball bearing detent mechanism with faultless resolution.

Fig. 8—Cross-Section of Turret Attenuator

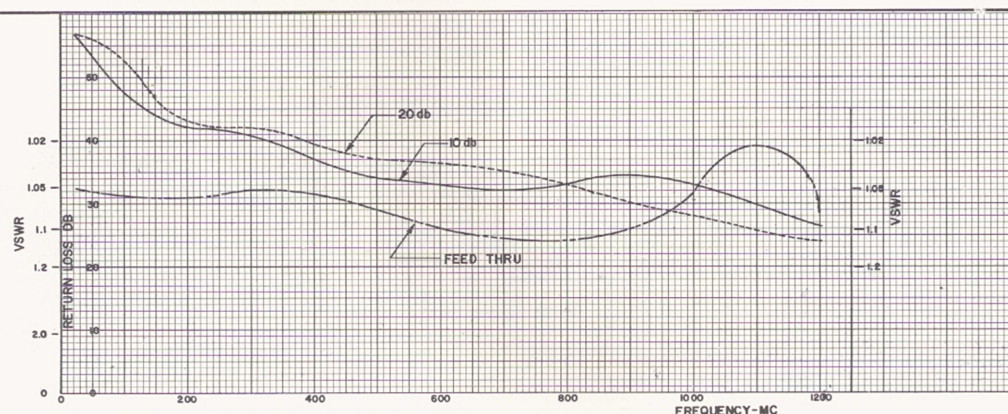


Fig. 9—Typical Impedance Match of Model ATV-50 at Various Settings

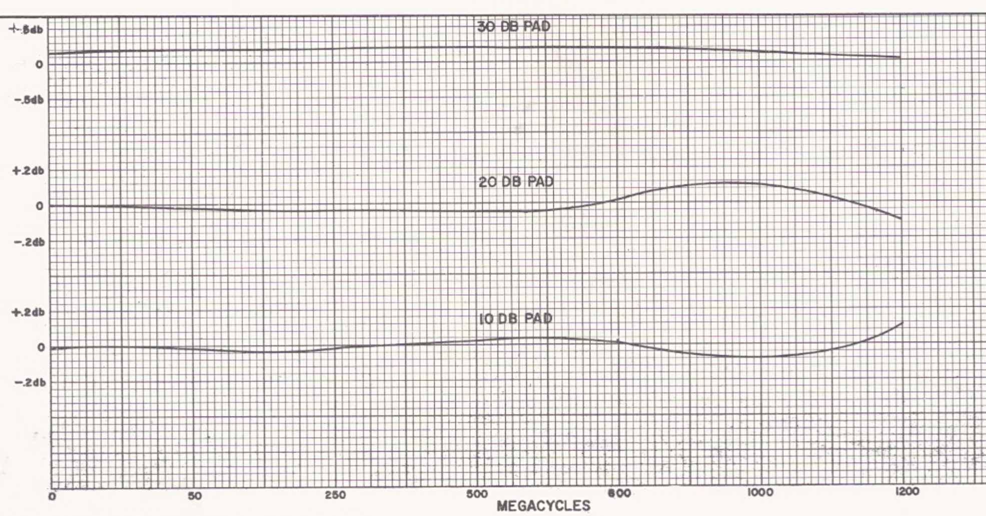


Fig. 10—Typical Attenuation Tolerance of Model ATV-50

Design of the attenuators and comparators was carried out under the direction of Henry Arbeiter. He also is responsible for electrical design of the attenuator, working with Eric Winston on mechanical design. John Austin designed the reed-relay heads on the TC-3, Frank Egenstafer is responsible for the transistor driver, and Earl Nickerson for the styling.

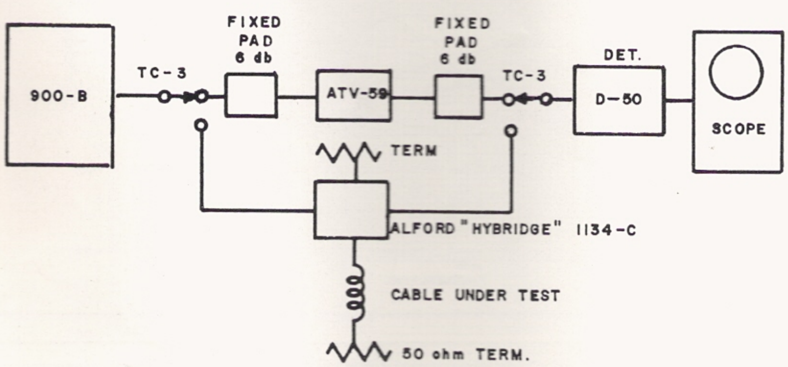
MODEL 890 WIDE-BAND SWEEPER

Model 890

Latest in Jerrold's proven group of sweep frequency generators is the new, moderately priced Model 890. This sweeper, although somewhat less sophisticated in its design than the Model 900-A, nevertheless incorporates all of that instrument's basic circuitry necessary to permit a highly economical production line test set-up.

Together with the new comparator and attenuators, the 890 will afford fast, repetitive measurements for simultaneous low and high limit comparison. Tests can be made up into the UHF range of 1100 MC, at a top center frequency setting of 1000 MC with a sweep width variable from 100 KC min. to ± 10% of center frequency.

TYPICAL APPLICATIONS IN MEASUREMENTS BY COMPARISON



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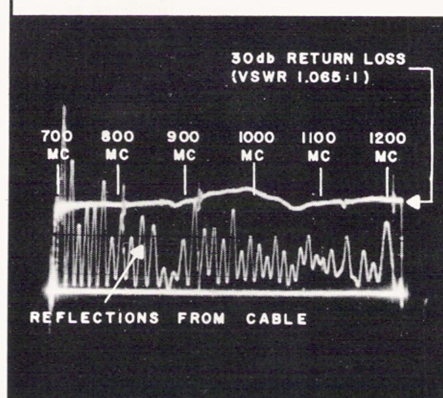
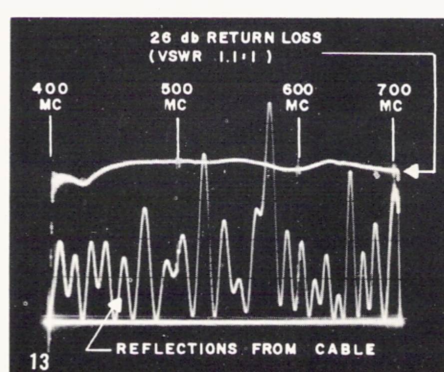


12

Application of Models TC-3 and ATV-50 in testing the impedance characteristics of coaxial cables. The test involved approximately 50 ft. of type RG-8A/U flexible coaxial cable, carefully terminated at the other end. Photo 12 illustrates the trace for measurement between 700 and 1200 MC; photo 13 illustrates the trace for measurement between 400 and 700 MC. The impedance variations on each trace are due to mechanical irregularities in the tested cable.

Note that there are decidedly less irregularities in photo 12, where the cable would meet a specification of 30 db (better than most cables).



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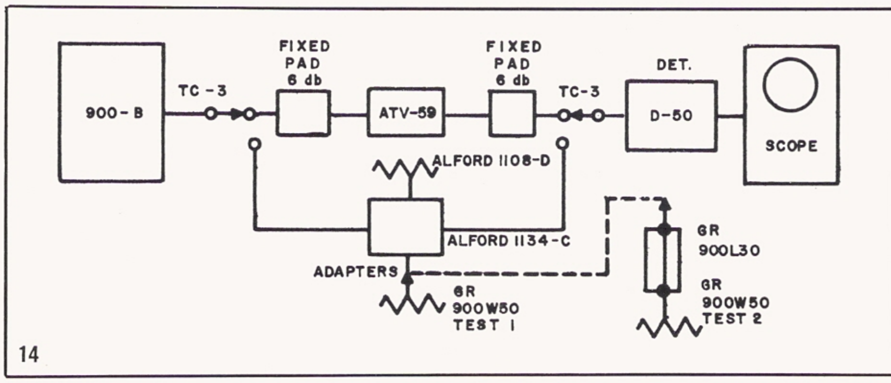

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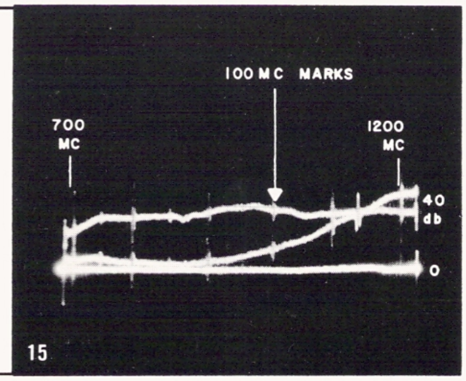

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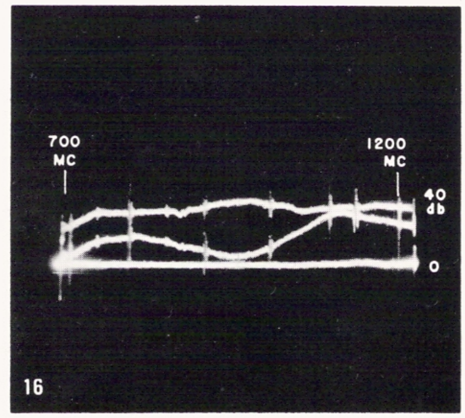
Application of Models TC-3 and ATV-50 in testing the sensitivity of Model 900-B and for checking the accuracy of the bridge test set-up.
Two tests were made:

1. connecting a General Radio type 900W50 precision 50-ohm termination through two adapters, first a General Radio type 900Q874, followed by a General Radio type 874QNP, to the bridge.

   Photo 15 shows that the bridge measured somewhat better than 40 db match (VSWR 1.02:1) up to 1100 MC.

2. connecting a 30 cm length of precise 50-ohm air dielectric line, General Radio type 900L30, between the termination and the 900Q874 adapter.

   If the characteristic impedance of the air line were exactly equal to that of the termination, the impedance would be unchanged in the second test. As seen in photo 16, there was a slight change, but the resulting impedance was still seen by the bridge as better than a 40 db match.



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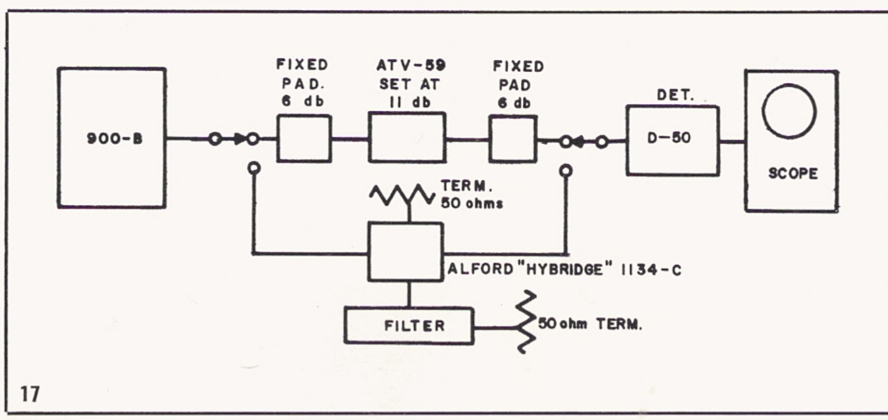

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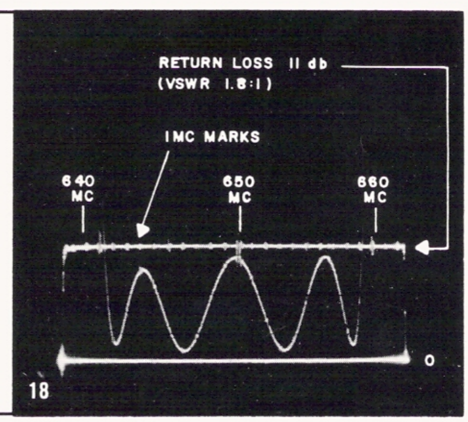

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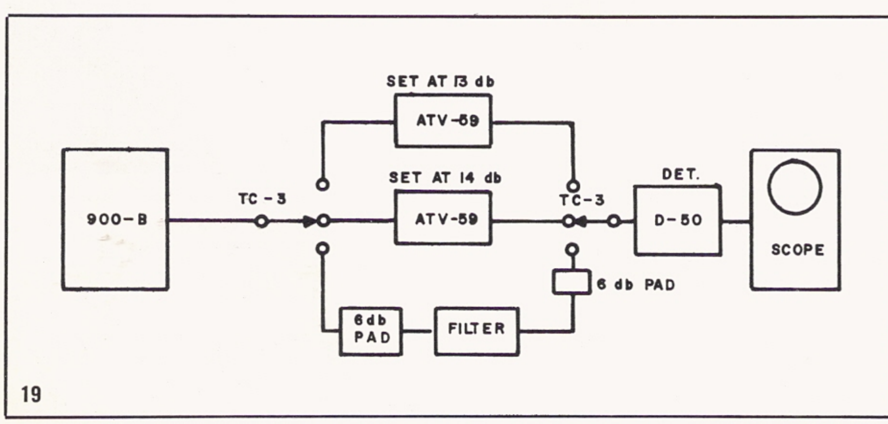
Application of Models TC-3 and ATV-50 to impedance match measurement on a four-pole band-pass filter.



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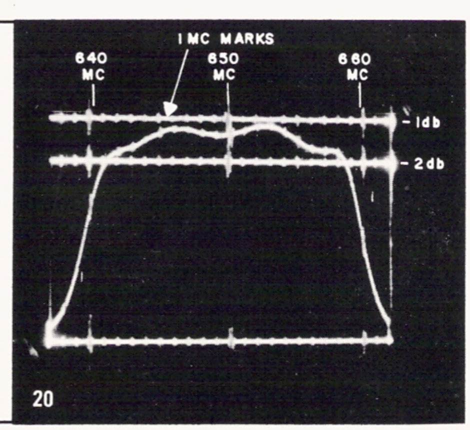

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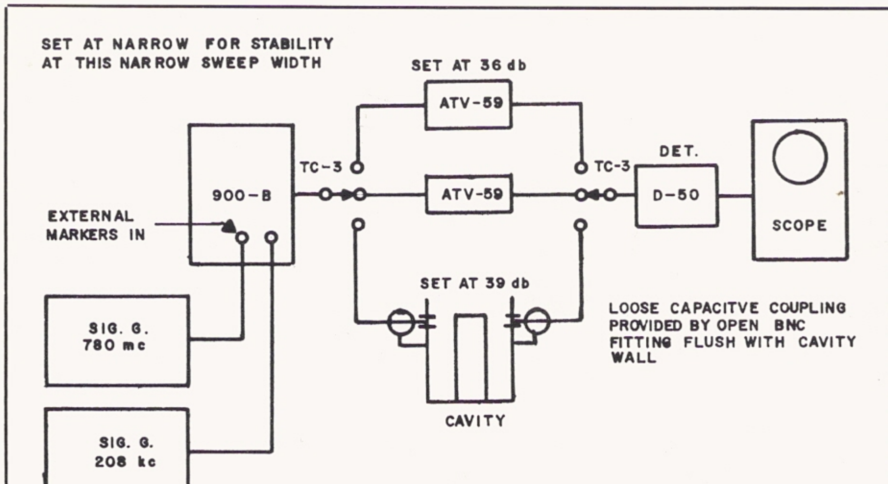
Application of Models TC-3 and ATV-50 to measurement of insertion loss of filter the match of which was shown in photo 18.



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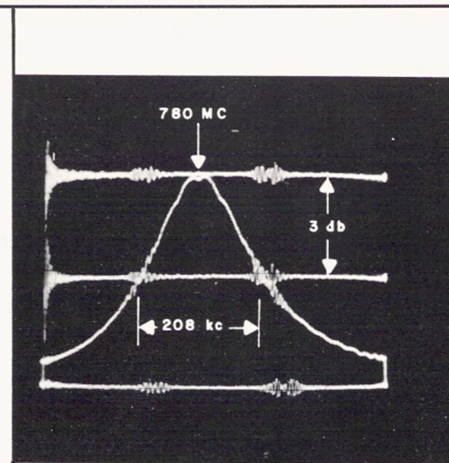

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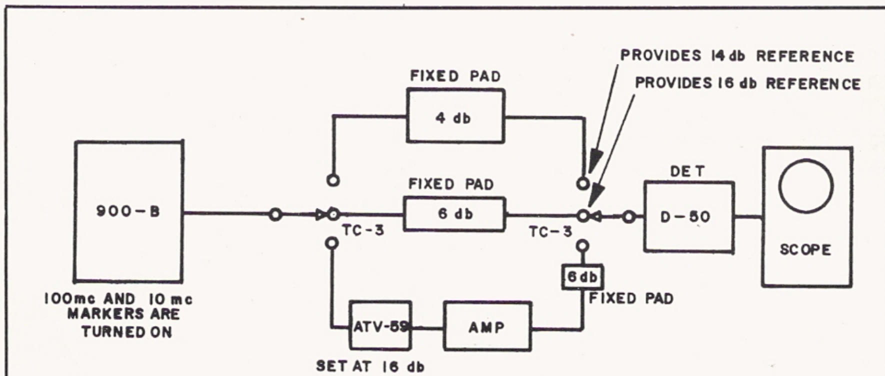
Application of Models TC-3 and ATV-50 to measurement of unloaded bandwidth and thus Q of 780 mc resonant cavity. Resulting $Q = \frac{f_o}{\Delta f} = \frac{780}{0.208} = 3750$



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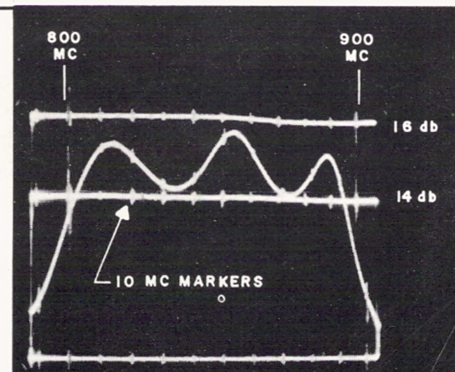

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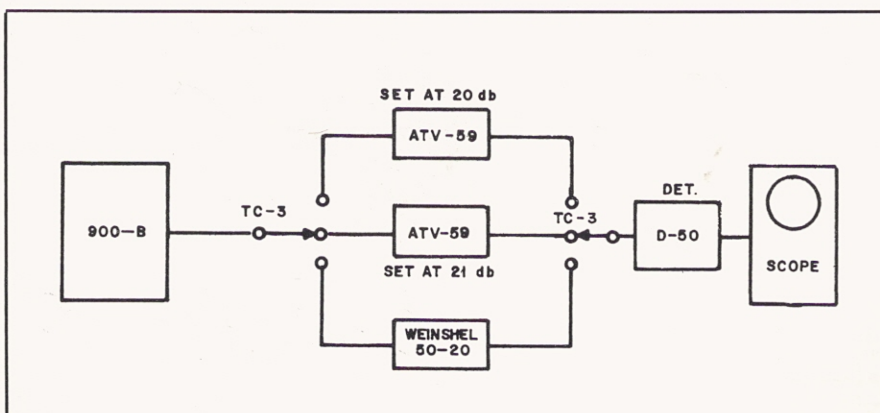
Application of Models TC-3 and ATV-50 to measurement of gain of a transistorized UHF amplifier. Gain limits are 16 and 14 db; design bandwidth was 806 to 890 MC.



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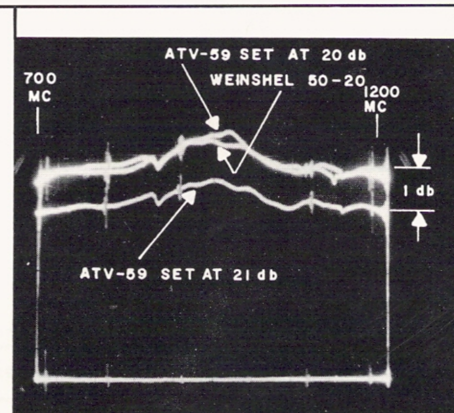

26

Comparison of Model ATV-50 with a Weinshel attenuator pad which had been calibrated at 20.0 db at 1000 MC. Differences between the two curves are about 0.1 db maximum, some of which is due to short cable jumpers.

NOTE — Additional copies of this paper and engineering assistance on the application of Measurements By Comparison may be obtained by contacting the Industrial Products Division, Jerrold Electronics Corporation, 15th & Lehigh, Phila., Pa. 19132. Phone: BAldwin 6-3456 — Ext. 215.

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