DATA SYSTEMS - COMMON CIRCUITS, EQUIPMENT AND PROCEDURES

TESTING OF PAIRS FOR DATA CIRCUITS

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1. GENERAL

1.01 This section describes the preliminary testing necessary on local and toll voice frequency facilities to be used for data transmission circuits. This preliminary testing should be done as soon as possible after facilities are allocated so that any irregularities may be found and remedial measures applied before circuit line-up procedure is started.

1.02 The majority of facility sections used for data circuits require equalization for envelope delay distortion. The required equalization to be specified for a particular circuit is computed for the facility and length involved under the assumption of a smoothly loaded and terminated line with no appreciable impedance irregularities. Any irregularities on a particular pair may affect the delay distortion and hence circuit performance. Since it is generally not feasible to make delay distortion measurements and provide delay equalization for irregular conditions, it is necessary to determine in advance if such irregularities do exist and eliminate them whenever possible.

1.03 Typical irregularities which may be encountered that will effect envelope delay conditions include:

(a) Missing loading coils.

(b) One or more coils of different inductance.

(c) Long or short loading end sections.

(d) Long or short intermediate or looping sections.

(e) Missing subscriber loop loading.

(f) Bridged taps on subscriber cables.

(g) Cables of different capacitance per mile.

(h) Incorrect or missing terminations.

The existence of any of these faults to a degree that will effect the envelope delay and circuit performance can be detected by impedance-frequency measurements on the proposed pairs as described below.

2. TESTING PROCEDURE

2.01 All pairs involved should first be tested for opens, shorts, crosses and grounds before impedance measurements are made. Measurements of dc resistance should be made on all facilities to determine any possible error in assignment records and any high resistance splices or other conductor fault. When measuring on nonsoldered facilities special attention should be given to any varying resistance conditions indicative of splice faults. In making these resistance measurements, a low battery voltage should be used in order to avoid clearing or breaking down high resistance joints. Detailed instructions for these Wheatstone bridge measurements are given in the E41 and G72 series of these practices.

2.02 The above measurements should be checked against the layout information to determine any possible error in the records of the assigned facilities.

2.03 Impedance-frequency measurements should be made on the terminal exchange facilities and on sections of toll voice-frequency facilities. On the exchange facilities, pairs should be connected through from the toll testboard to the subscribers' premises and, for testing purposes, terminated in a 600-ohm impedance using inequality ratio repeating coils if required. Impedance-frequency measurements on voice-frequency toll facilities should be made in both directions between testboards with the pair terminated smoothly at the far end in an impedance matching that of the line facility.

2.04 Measurements should be made with the impedance bridge section of the new E-type repeater test set or equivalent impedance bridge suitable for measurement in the 200- to 3000-cycle range. An oscillator similar to the Hewlett-Packard type 200C or 200CD or the 19C will be required and a detector such as the 2B noise measuring set, Hewlett-Packard type 400C vacuum tube voltmeter or similar voltmeter to operate with the impedance bridge. Test cords will be required to connect the oscillator and detector to the impedance bridge and from the impedance bridge to the line terminals.

2.05 In making the impedance-frequency measurements for this purpose, it will be sufficient in most cases to determine only the impedance magnitude. The angle of the impedance and its sign is generally not required to determine the smoothness of the circuit to the degree necessary nor to locate any irregularities that may be present. This limitation to magnitude measurements only will simplify the operation of the test set and require considerably less testing time per circuit.

2.06 Measurements should be made in such a way as to record the absolute maximum and minimum peaks of impedance magnitude rather than values at discrete frequencies. These peaks can be detected most readily by swinging the oscillator frequency control through a peak and watching the detector needle for maximum and minimum indications, changing scales on the detector or the oscillator output when necessary.

2.07 Test arrangements for impedance measurements with the E-repeater test set are outlined below and shown on Fig. 1.

(a) Connect the output of the 19C or HP200 oscillator to the OSC jack of the test set with a W3AL test cord.

(b) Connect the HP400C vacuum tube voltmeter to the DET jack of the test set with a W3AL test cord. A 600-ohm resistor and 0.01 mf capacitor should be connected to a General Radio Co. 274MB plug and patched into the input of the HP400C voltmeter.

(c) If the 2B noise measuring set is used as a detector, connect the input of the set to the DET jack of the repeater test set with the W3AL cord. Patch the 2B set patching cord into the LINE jacks. Calibrate the 2B set according to standard procedures using FLAT weighting and dummy plugs in the SOUND jacks. Rotate DB dial to maximum counter-clockwise position.

(d) Connect the line to be measured to the repeater test set IMP I jack by suitable test cords, disconnecting any terminal or office equipment from the cable pair terminals.

2.08 Detailed operation of the E-repeater test set is covered in Section E40.658. Part 4 and Part 6 covering impedance measurements and Figs. 9 and 10 showing test equipment connections. However, where only the impedance magnitude of line facilities is required the following simplified procedure will be found adequate.

(a) Connect and terminate circuit and test equipment as in Paragraph 2.03 and Paragraph 2.07.

(b) Turn the selector switch S1 of the test set to the REF 1 position under IMPEDANCE.

(c) Set the oscillator at a desired frequency and adjust the oscillator output control and the sensitivity of the detector to obtain a convenient meter reading. Note this reading.

(d) Rotate the selector switch S1 to position MAG and adjust the four dials of the resistance standard on the front of the test set to obtain the same db reading of the detector as noted in Paragraph 2.08 (c). The reading of the resistance standard is the magnitude of the line impedance in ohms. Check the accuracy of the adjustment by switching back and forth between the REF 1 and MAG positions of selector switch S1.

(e) Repeat the above procedure while slowly sweeping the oscillator frequency over the desired band and recording the impedance magnitude at all indicated maximum and minimum peaks of impedance. (Minimum voltage peaks on the voltmeter will indicate maximum impedance points and maximum voltage will give the minimum impedance points.)

2.09 The value of all peaks of impedance magnitude should be measured from 200 cycles to cutoff including values at sufficient discrete values of frequency where no discernible peaks occur to be able to plot the characteristic over the entire voice-frequency band. Although only the band from 1000 to 2500 cycles is of interest for envelope delay characteristic, the entire band will be useful in the identification and location of any irregularities that exist.

3. RESULTS

3.01 The impedance values obtained should be plotted on cross-section paper with a vertical scale such as to definitely show the maximum and minimum peaks and the recorded points connected with straight lines. (Form E-138-A or Form 1015 "Impedance Measurement Curve Sheets" will be found convenient for this purpose.)

3.02 Draw vertical lines at 1000 and 2500 cycles and determine the maximum and minimum impedance values between these limits. The per cent impedance irregularity should be computed as a departure from the average of these two values. For example in Fig. 7:

Maximum Impedance = 1880 ohms (2500 cycles)
Minimum Impedance = 930 ohms (2000 cycles)
Average = 1405 ohms
Max. Departure from Avg. = 475 ohms
Per Cent Irregularity = 33.8%

Note: This circuit with the bridged tap removed is shown in Fig. 5 having an impedance irregularity computed as above of 15.8%.

3.03 For terminating sections of the circuit (from the test point to the customer's termination), the impedance irregularity, as computed above should not exceed 20 per cent. For line sections between testboards with the far end smoothly terminated the irregularity should also be no greater than 20 per cent.

3.04 In those cases where impedance irregularities greater than those indicated in Paragraph 3.03 exist the impedance-frequency characteristic for the complete band from 200 cycles to cutoff should be plotted and the irregularity located in accordance with standard locating practices (Section E31.130). In long sections with intermediate offices, it may be desirable to repeat these measurements at local testboards within the section and closer to the irregularity. Remedial measures may then usually be applied to meet the above limits between 1000 and 2500 cycles.

3.05 Figs. 2 to 7 illustrate the type of impedance measurements to be expected on typical combinations of loop and trunk facilities. The magnitude of the deviations encountered from such items as long sections, bridged taps, and missing loading coils will, of course, depend not only on the magnitude of the fault but its distance from the measuring end.

Attached
Figures 1 thru 7 inclusive

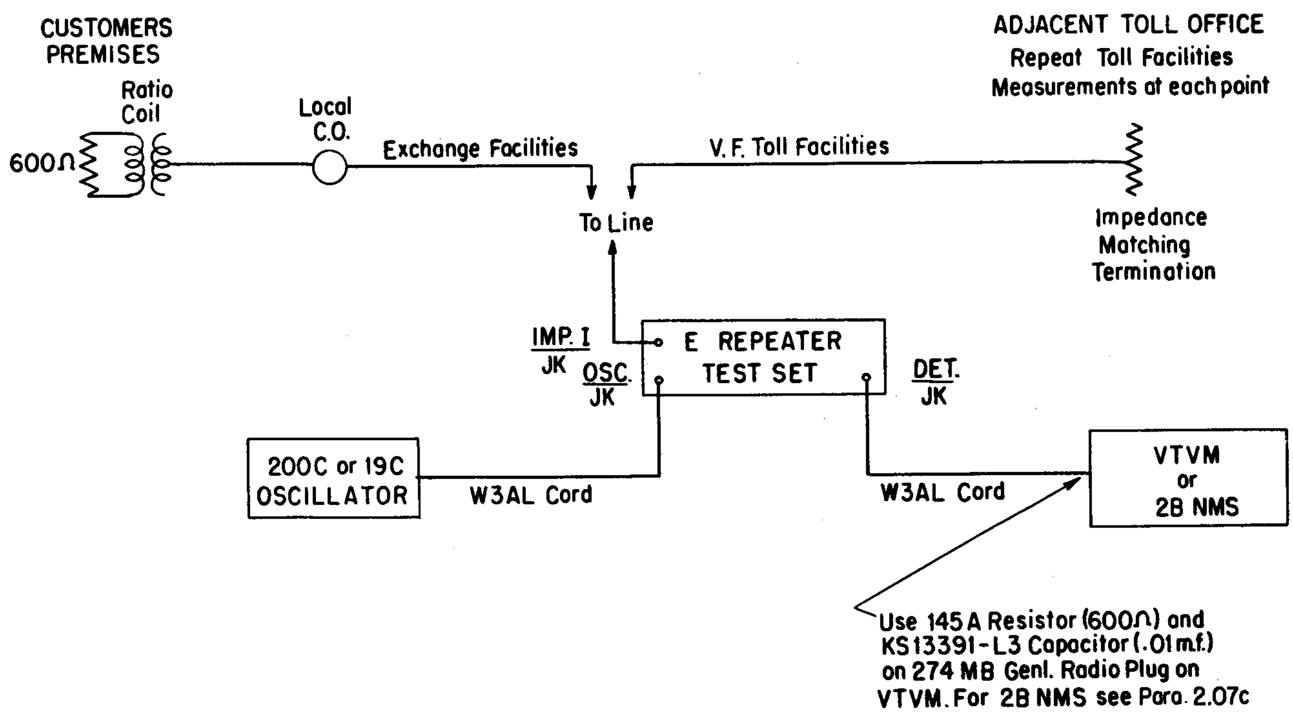

Fig. 1 ARRANGEMENT OF TEST EQUIPMENT FOR IMPEDANCE MEASUREMENTS

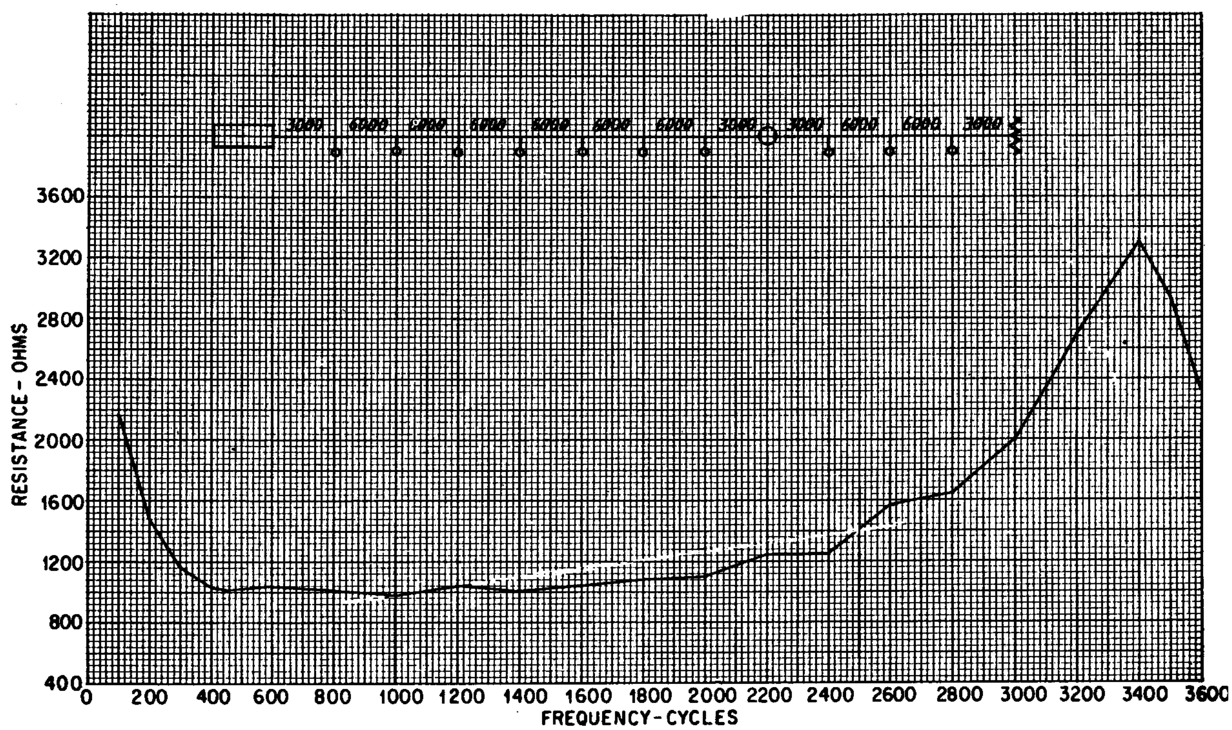

Fig. 2 - Smooth Line
60,000 ft. - 22H88 - 3000 ft. end sections
Impedance Irregularity = 17.5%

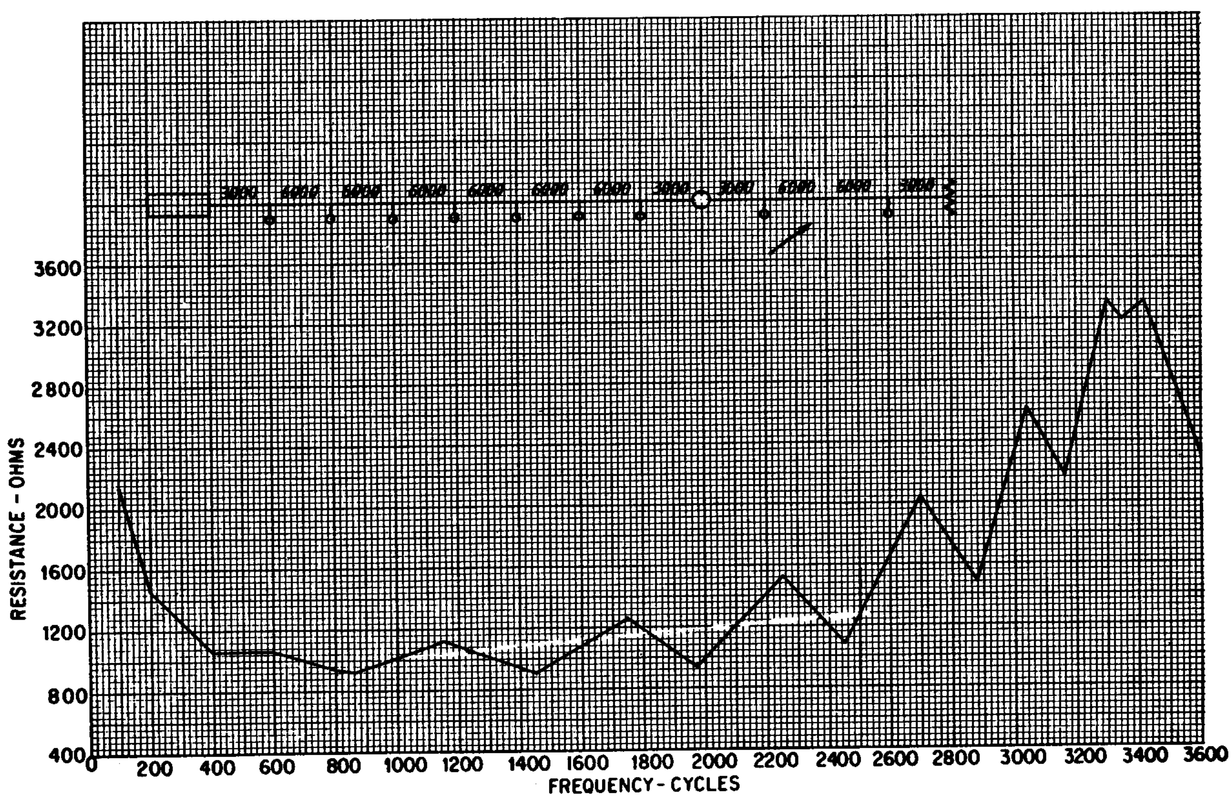

Fig. 3 - Effect of Missing Loading Coil
60,000 ft. - 22H88 - 3000 ft. end sections - 9th coil missing
Impedance Irregularity = 24.9%

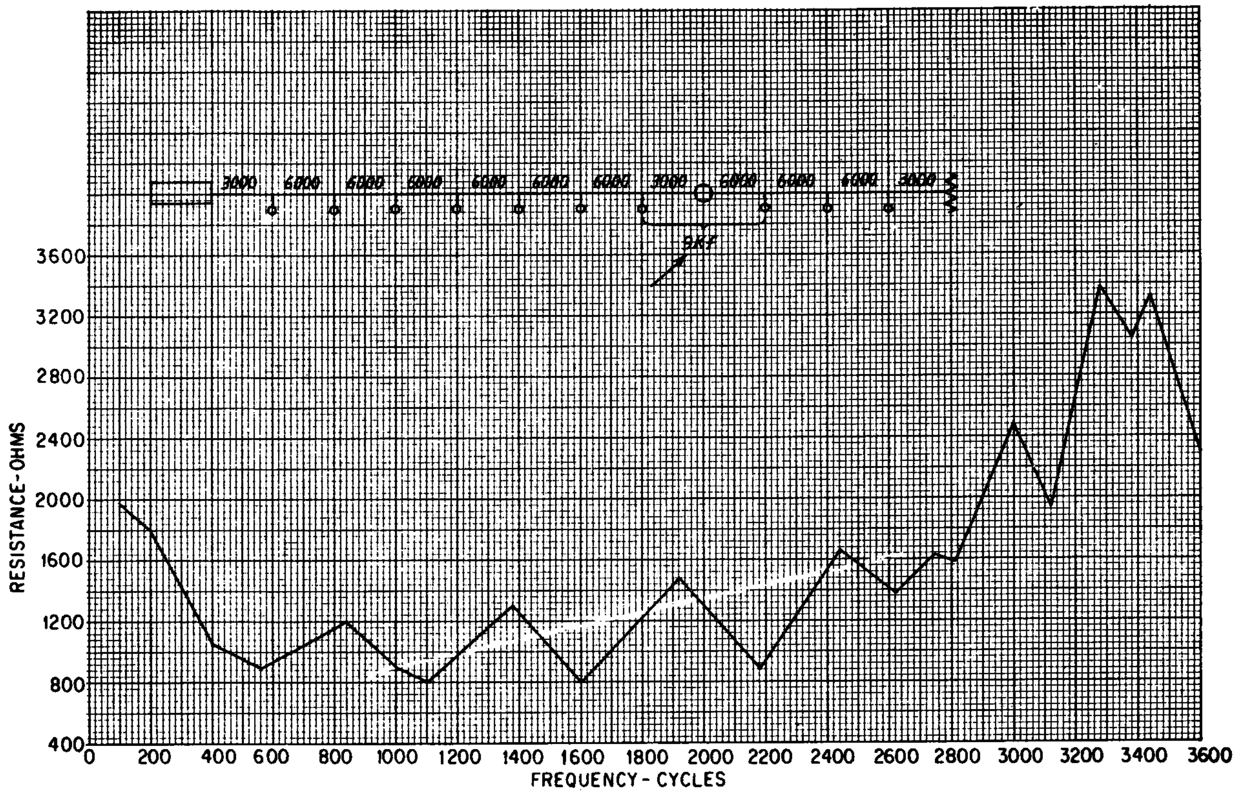

Fig. 4 - Effect of Long Looping Section
63,000 ft. - 22H88, 3000 ft. end sections
3000 ft. excess at looping point
Impedance Irregularity = 35%

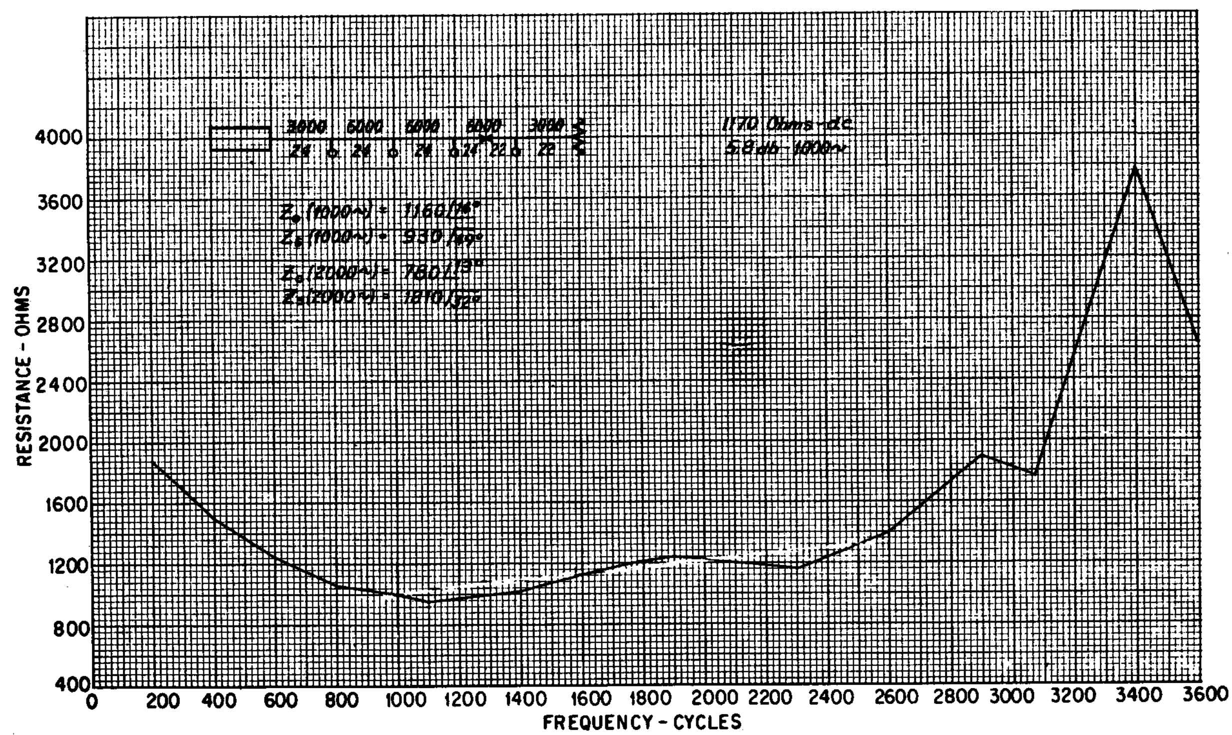

Fig. 5 - Smooth Combination Gauge Loop
24,000 ft. - 22/24H88 - 3000 ft. end sections
Impedance Irregularity - 15.8%

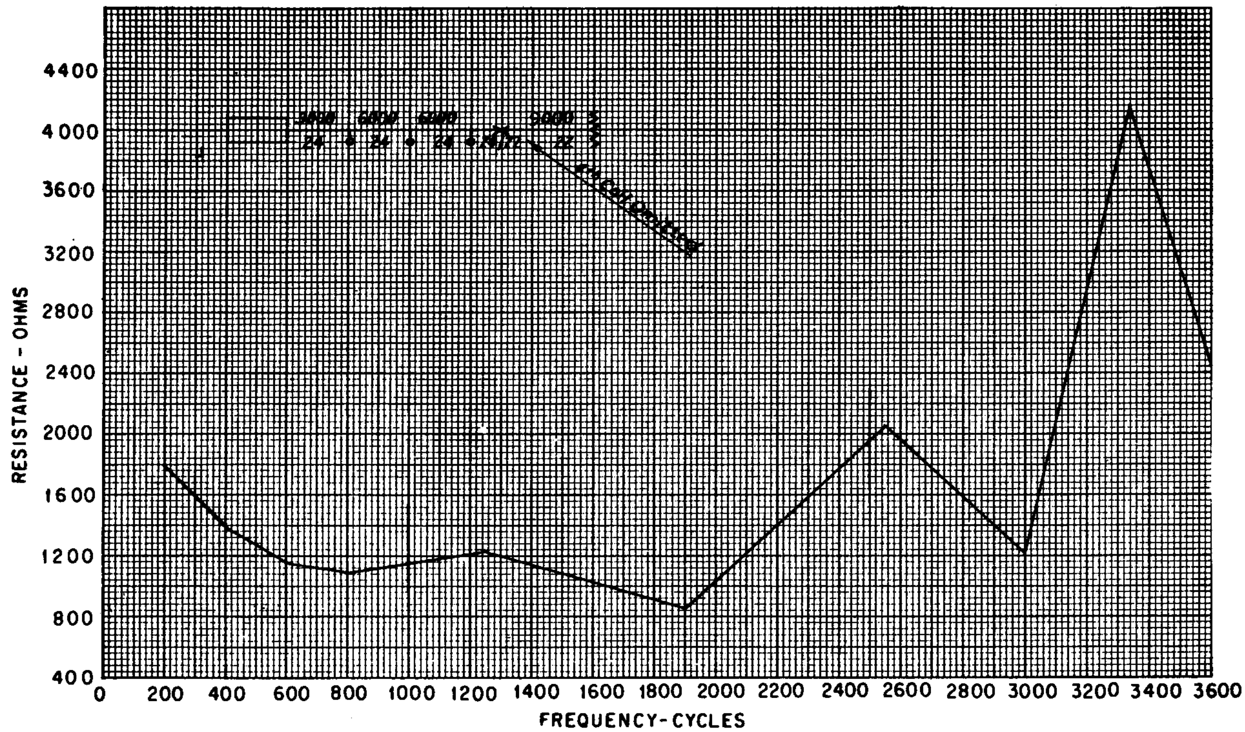

Fig. 6 - Combination Ga. Loop - Terminal Coil Omitted
24,000 ft. - 22/24H88 - 3000/9000 ft. end sections
Impedance Irregularity = 38%

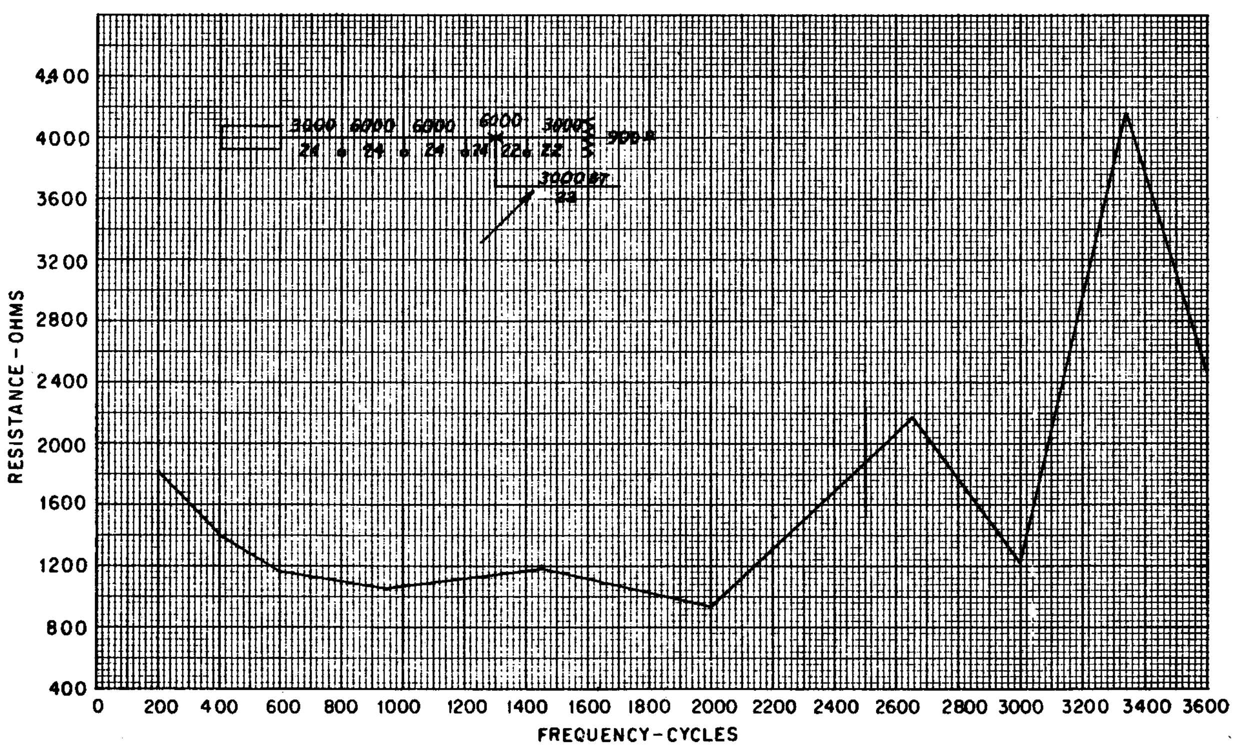

Fig. 7 - Combination Ga. Loop with Bridged Tap
24,000 ft. - 22/24H88 - 3000 ft. end sections
3000 ft. B.T. between third and fourth coil
Impedance Irregularity = 33%