21A TRANSMISSION MEASURING SET

(J94021A)

CONTENTS PAGE

1. GENERAL

1.01 This section describes the 21A (J94021A) transmission measuring set, its operation and use.

1.02 This issue corrects the figure giving the envelope curves for the frequency scale error, changes the performance checks, and makes other changes to bring the information up to date.

1.03 The circuit of the 21A transmission measuring set is given on SD-95115-01 (not attached). It is available in two forms. In the usual form it is an ac operated oscillator and detector. When the detector and meter are omitted it is an ac operated oscillator only. As an oscillator and detector it is primarily designed for making measurements of gains and losses on voice channel and program transmission circuits. The detector circuit includes a monitoring arrangement for listening for disturbing influences or signals on the circuit under test. For straightaway transmission measurements between two offices, the combined set will serve for either sending or receiving. Test power as transmitted by the oscillator and as received by the detector input are indicated in db with reference to 1 MW. Both circuits are 600 ohms impedance.

1.04 The set is portable, weighing about 37 pounds and is provided with a carrying handle and a removable cover. Without the cover, the set is about 17 inches long, 12 inches high, and 8 inches deep including the knobs and handle. A face view of the set is shown in Fig. 1.

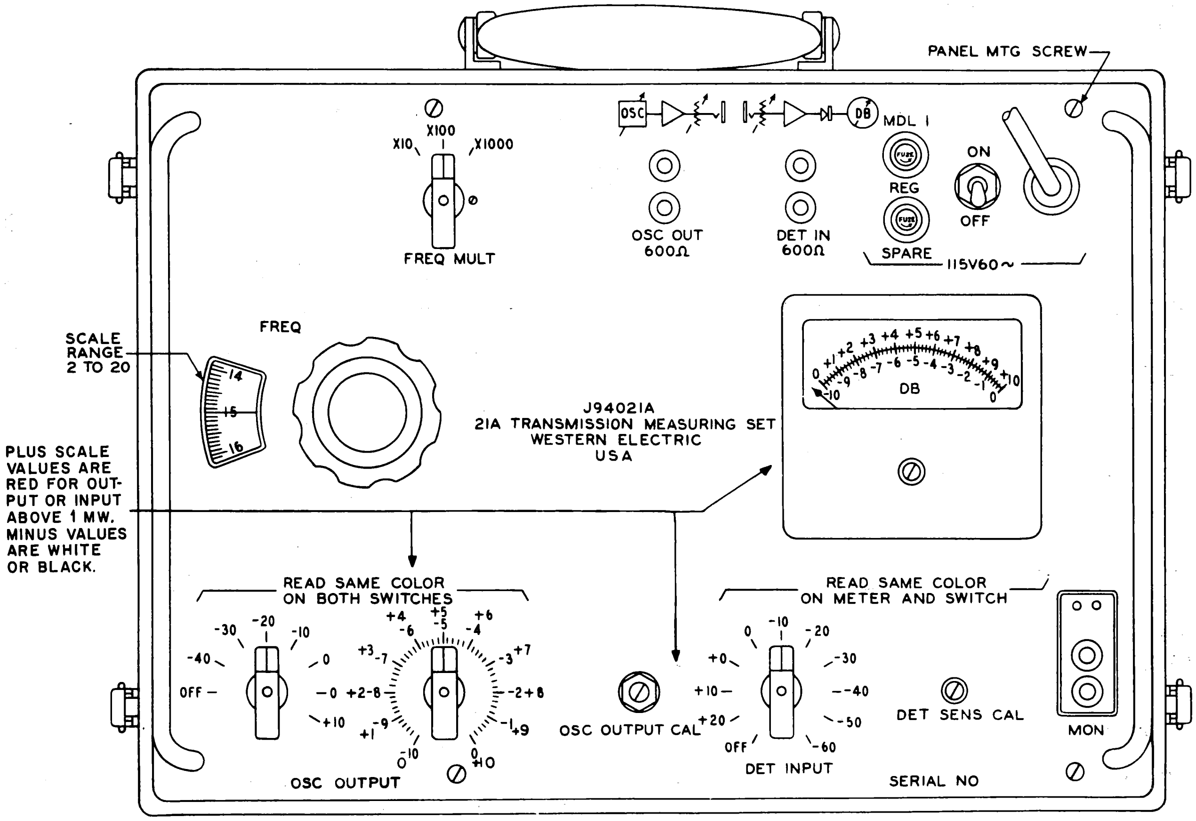

Fig. 1 — Top View, Cover Removed

1.05 The performance and operation of the set combine a high standard as to stability and accuracy with simple operating adjustments. The frequency responses are substantially the same for the full range of the set. No provision has been made for bridging measurements, or measurements of voltages in relation to the calibration of the set. The operating ranges are summarized in Table I.

TABLE I

	Oscillator	**Detector**
Impedance	600 ohms	600 ohms
→ Frequency Ranges	20 to 200 cycles 200 to 2000 cycles 2000 to 20,000 cycles continuously adjustable in each of three ranges.	20 to 20,000 cycles in a single wide band with substantially flat response.
Oscillator Output and Detector Sensitivity	+20 dbm max. output —50 dbm min. output Direct reading from two controls, one providing an independent continuously adjustable output over a 10 db range.	+30 dbm maximum —70 dbm minimum Direct reading from 10 db step control setting plus meter scale reading.

TABLE I (Cont'd)

	Oscillator	Detector
Power Supply Requirement	105 to 125 volts, 60 cycles, 60 watts	Same source, 15 watts additional.
Calibration Reference (recommended)	1000 cycles 1 MW: 7A transmission measuring set used with 2AA milliwatt reference set; otherwise, detector circuit of the 21A set, if provided.	1 MW, 1000-cycle source which has been properly calibrated. Only an occasional check is necessary.

1.06 A simplified block schematic of the set indicating the principal features is shown in Fig. 2. This is divided into three parts, the oscillator, the detector, and the power supply.

1.07 The oscillator supplies frequencies in three ranges from 20 to 200 cycles, 200 to 2000 cycles, and 2 to 20 kc, under control of a multiplier switch. Each frequency range is contin-

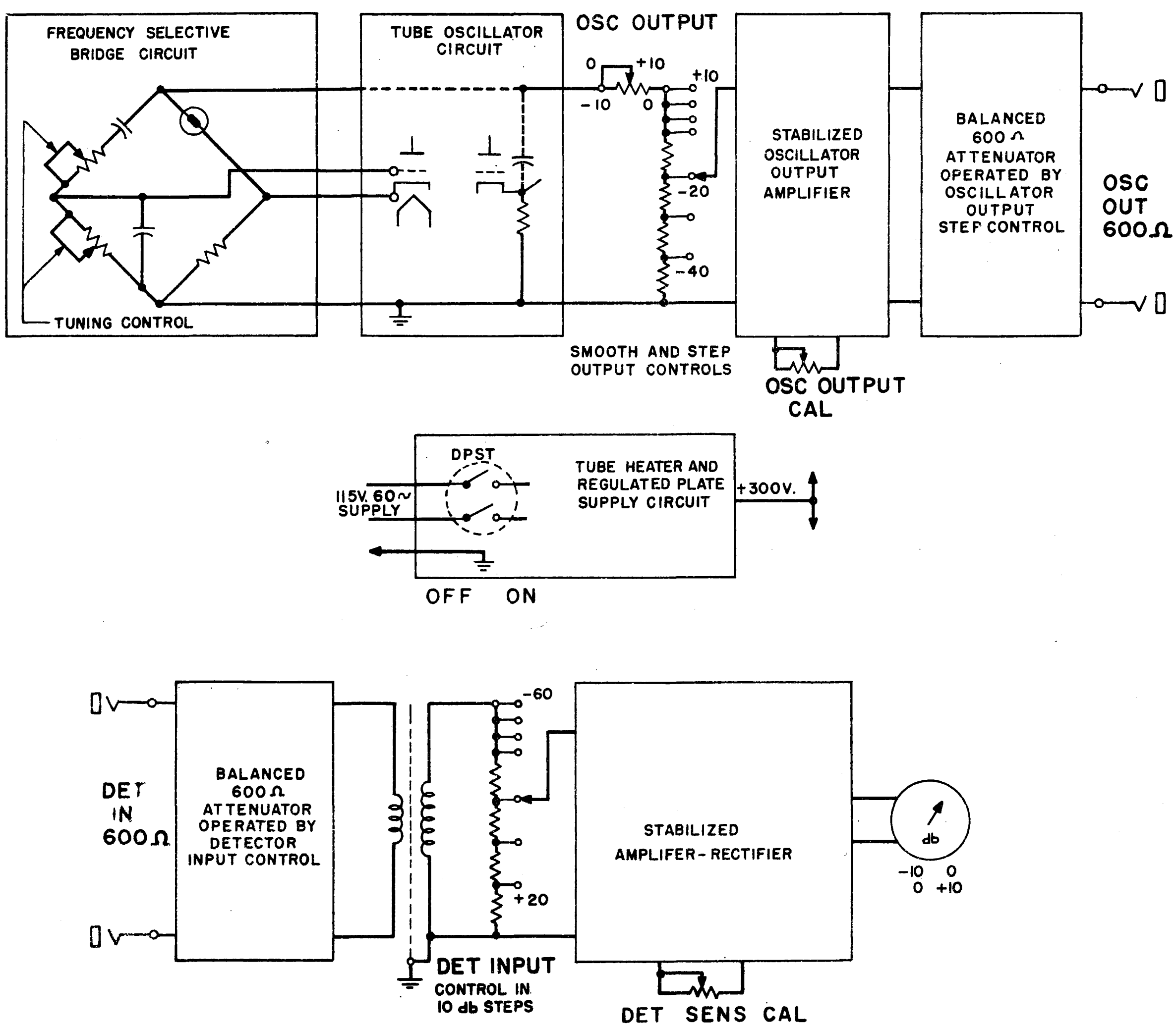

Fig. 2 — Block Diagram

uously adjustable by means of a single control with a calibrated scale range from 2 to 20. One output control is in 10 db steps and the other is an independent smooth control covering a 10 db range readable to the nearest 0.1 db.

1.08 The detector is a feed-back type amplifier-rectifier which supplies current to a dc meter calibrated in db. The sensitivity is adjustable in steps of 10 db each. The power supply is a conventional regulating tube arrangement to provide 300-volt dc plate and 6.3-volt (nonregulated) ac heater voltages, for the oscillator and the detector.

1.09 *It is necessary to keep dc out of the oscillator output and detector input circuits. The accuracy of set readings may be affected by the presence of dc in the circuit being measured, due to saturation effects in the output and input transformers. The input resistance network and coil are not designed to provide a holding bridge. When a dialed connection must be held to transfer to the transmission measuring set, supplementary arrangements are required.*

1.10 Section E40.206.1 (A702.614.1) contains procedures for a brief check of the calibration of the set. These checks should be made prior to the start of a test, or the first of any series of tests, which are made with the sets. These procedures are shown in Fig. 1 and are given also on a card attached to the section. The purpose of the card is so that it may be detached from the section, inserted in a transparent envelope, and attached to the handle of the 21A set. These procedures are not complete assurance that trouble is not present. More extensive calibration and maintenance procedures for trouble detection and clearance are given in Parts 4 and 6 of Section E40.206 (A702.614).

1.11 In some of the earlier sets the OSC OUTPUT smooth control turned so easily that it might be moved from a setting inadvertently. This condition is easily corrected locally by placing a felt washer between the knob and the panel.

2. TRANSMISSION PERFORMANCE

(A) General

2.01 The transmission performance of the 21A set is such that the direct indications may be used for most test applications without corrections. Calibration adjustments of the detector sensitivity and oscillator output are made to obtain a correct relation to 1 MW. Small deviations from true power at other magnitudes are normally to be expected due to meter scale and attenuator deviations, and to some extent, due to changes in room temperature and power supply voltage.

2.02 The performance data given in subsequent paragraphs are a partial explanation of the results to be expected on any set properly lined up and operated in accordance with normal procedures. It should be noted that optimum accuracy can not be assured during unfavorable conditions of operation. The following data are intended primarily as information and guidance in the determination of proper operation or possible existence of defective components during checking or maintenance tests.

2.03 The calibration adjustment of the oscillator output and of the detector input sensitivity should be made under conditions that are favorable, as explained in Part 4. Test power measurements at all other magnitudes in the range are dependent upon these settings.

2.04 In general the performance of the set is expected to be satisfactory for all transmission testing purposes normally encountered. Any difficulties in testing may be an indication of a defect that could be corrected by maintenance in accordance with subsequent parts of this section. Due to the high sensitivity of the detector circuit a small amount of crosstalk may be observed as a "beat" when either 60- or 120-cycle frequency is supplied by the oscillator circuit and at the same time is measured by the associated detector. The resultant error is negligible unless the "beat" exceeds 0.5 db.

(B) Oscillator

2.05 The performance of the oscillator has been stabilized for the normal range of test room conditions. Output power is somewhat sensitive to changing temperature so that a warm-up period of at least 10 minutes is always desirable. Errors in frequency due to scale calibration and lack of care in setting may be appreciable. Table II gives a summary of the performance of the oscillator.

TABLE II

Normal Oscillator Performance

Output Frequency	
Nominally within	± 0.5%
Drift (after 1 hour warmup)	Negligible
Scale calibration error	See Fig. 3
Output Power	
At maximum setting of smooth control and any step, 1000 ~	± 0.1 db
20 to 20,000 ~	± 0.2 db
Output control scale calibration error	± 0.1 db
Deviation due to temperature	See Fig. 4
Output Impedance	
At 1 MW output or less	600 ohms ± 1%
At maximum output	See Fig. 5

Harmonic Content Fundamental Output	*Freq.*	*Maximum Expected Output in db Below Fundamental Output* 2nd	3rd	All
At 1 MW or less	Any	41	34	32
At maximum +20 dbm	20 ~	40	32	30
	35 ~	45	36	33
	70 ~	45	39	36
	Above 100	46	42	39

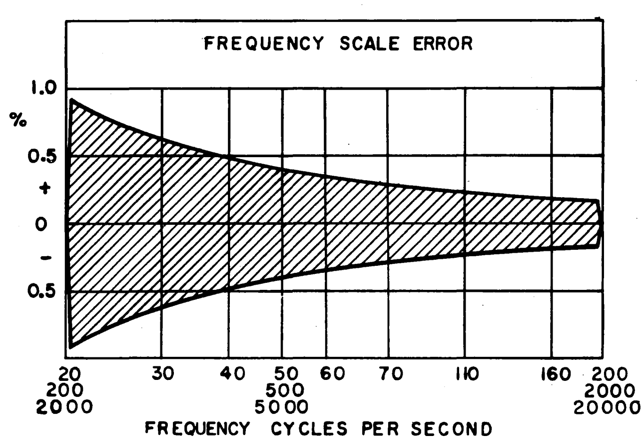

Fig. 3 — Frequency Scale Error

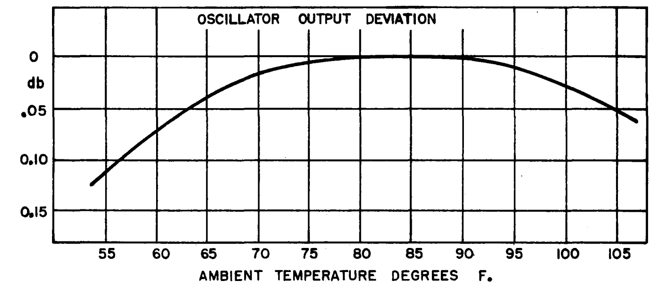

Fig. 4 — Output vs. Temperature

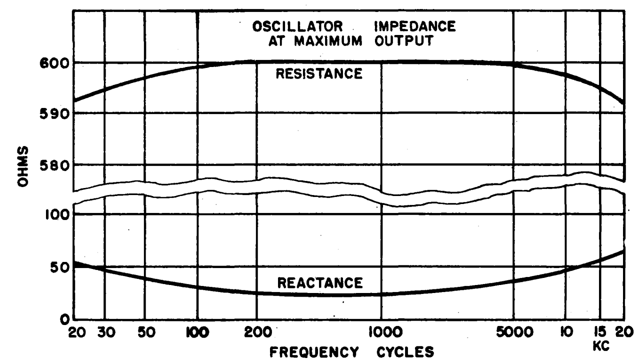

Fig. 5 — Oscillator Impedance

2.06 The use of series resistances, and also 10 or 20 db loss pads in the output circuit for the usual measurements, assures an oscillator-output impedance which is close to 600 ohms resistance. For magnitudes of output from 0 to + 20 dbm, the impedance variation with frequency may be somewhat greater as illustrated by Fig. 5.

2.07 The output wave form is substantially a pure sine wave. Any appreciable indication otherwise, such as by an oscilloscope, is normally a sign of trouble.

(C) Detector

2.08 The detector has a maximum sensitivity of — 70 dbm at minimum meter deflection. An input signal of any magnitude between — 70 and + 30 dbm at any frequency from below 20 cycles to above 20 kilocycles should result in a meter deflection, assuming proper setting of the DET INPUT switch. Deviations in sensitivity are small due to use of negative feedback and compensation adjustments for response made at the factory. Typical variation of sensitivity with frequency is shown in Fig. 6.

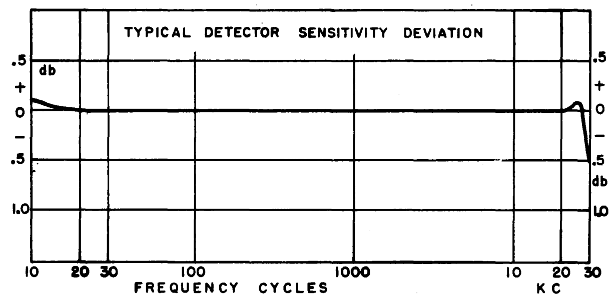

Fig. 6 — Detector Sensitivity

2.09 A single calibration adjustment for one milliwatt at 1000 cycles as covered by Part 4 CALIBRATION, when made under proper conditions is adequate for general use. The calibration of the meter scale is subject to deviations from true values by as much as 0.1 db, particularly at the lower scale values.

2.10 The variation of sensitivity with temperature after about a five-minute period of warmingup should be negligible. A possible cause of instability might be a defective varistor in the rectifier circuit. Assuming a correct calibration adjustment, the accuracy of a measurement made shortly after the set is turned on in an ambient temperature between 60° and 95° is less than 0.1 db from the true value for that input and frequency. The calibration setting of the DET SENS CAL control, unless manually disturbed, will assure accurate measurements for a long period of time. The detector may be used as reference for adjustment of the oscillator output (see Paragraph 4.03).

(D) Power Supply

2.11 A 250-watt electronically controlled line voltage regulator per KS-5650 is available for use where the commercial ac power has unsatisfactory voltage or frequency regulation. When this regulator is used, the sensitivity of the detector (and also the oscillator output) is substantially unaffected by line frequency or voltage variations. Without this regulator the 300-volt plate supply may show a slight deviation at the extreme values of line voltage.

3. DESCRIPTION OF EQUIPMENT AND CIRCUIT

(A) General

3.01 As shown in Fig. 1 the 21A transmission measuring set is portable, and includes an oscillator-attenuator section and, for the combined arrangement, an amplifier-rectifier-meter combination. The oscillator and the detector are operated from 105- to 125-volt 60-cycle supply. Both the output circuit of the oscillator and the input circuit of the detector are 600 ohms impedance. The sending and received testing powers of the set are indicated directly in db referred to 1 MW.

3.02 The power cord is connected internally at the set end. An ON-OFF switch is provided to disconnect the set from the ac supply. A fuse in the power input circuit serves to minimize possible damage in case of trouble within the set. The power cord includes a third conductor to connect building ground to the chassis of the set for protection purposes. If this terminates in a clip, the clip should be connected to a suitable ground point near the outlet. The oscillator output and detector input jacks at the top of the set provide means for test connections. Monitoring (MON) jacks are also provided so that observations can be made of detector input signals or background interferences. Either a test room headset or a monitoring receiver may be used with no effect on the measurement.

3.03 The multiplier switch indicates the 10, 100, or 1000 multiplier to be applied to the frequency control dial readings to obtain the output frequency in cycles per second. For example, a frequency of 1500 cycles is obtained using the X100 range and a scale reading of 15. On the 1000 multiplier setting, of course, the dial values are direct indications in kilocycles per second.

3.04 The two oscillator output control knobs are designated to indicate the test power in dbm at the OSC OUT 600 Ω jacks. Red is used on switch designations for values above 1 MW. White indicates values below 1 MW. It is necessary merely to add the switch designations using corresponding color markings, to obtain the dbm value. For example, the oscillator output to a 600-ohm circuit for the OSC OUTPUT settings shown by Fig. 1 (white on switch designations) would be — 25 dbm.

3.05 The detector circuit and meter scale are calibrated in db with ranges for loss and gain measurements. In all measurements the actual detector input power is designated by the sum of the DET INPUT switch setting and the meter scale indication of similar color. Red is used on switch designations and on the meter for values above 1 MW. White on switch designations and black meter readings indicate values below 1 MW. For example, the input to the detector which results in a midscale meter indication using the DET INPUT switch setting shown in Fig. 1 (white on switch designation, black on meter) would be —15 dbm.

3.06 When loop measurements are made, e.g., measurements of repeater gain, using both the oscillator and detector circuits of the 21A set, the measured result will be indicated as the algebraic difference between the detector input reading and the oscillator output. For example, assume the following settings apply for a 600-ohm amplifier:

OSC OUTPUT

Step control* at red +0
Smooth control* at red +9 } = + 9 dbm

DET INPUT

Step control† at red +10
Meter reading† at red + 2 } = +12 dbm

* Read on corresponding colors
† Read on corresponding colors

Subtract algebraically OSC OUTPUT from DET INPUT, i.e. +12 — (+9) = +3. This indicates, therefore, a gain of 3 db. By suitable manipulation of the controls, the gain can be measured for other specified inputs to or outputs from the amplifier.

3.07 It is usually recommended that voice repeaters be measured with the repeater output power between 0 and +10 dbm. This range of values corresponds to the red scale on the meter and is used when the red "0" detector input switch setting is used. Turning the smooth control OSC OUTPUT (right-hand) knob to maximum clockwise (white "0" position) and then adjusting the 10 db step knob to the white setting required for on-scale meter indication obtains the desired gain measurement. This method results in an input to the repeater under test, which is 1 MW or multiples of 10 db less than 1 MW. This number when subtracted algebraically from the meter indication, which is a red number between 0 and + 10, gives the desired numerical value of gain.

For example:

OSC OUTPUT

Step control* at white —10
Smooth control* at white 0 } = —10 dbm

DET INPUT

Step control† at red +0
Meter reading† at red +3.4 } = +3.4 dbm

* Read on corresponding colors
† Read on corresponding colors

Subtract algebraically OSC OUTPUT from DET INPUT, i.e. +3.4 —(—10) = +13.4. This indicates, therefore, a gain of 13.4 db.

3.08 The calibration adjustments are screwdriver operated from the front of the set. They provide means to make the oscillator output and the detector sensitivity switch indicate in db with reference to 1 MW. These adjustments should be changed only when reliable reference equipment is available. In particular, the DET SENS CAL should be changed only when a completely reliable standard of reference is available. The correct methods are described in Part 4 CALIBRATION.

3.09 The principal circuit features of the oscillator, the amplifier-rectifier, the attenuators, db meter and the power supply are shown in block diagram form in Fig. 2 and are described separately in Parts 3 (B), 3 (C), and 3 (D), respectively. Circuit drawing SD-95115-01 (not attached) gives additional information concerning the component parts.

(B) Oscillator

3.10 A schematic of the oscillator circuit is shown in Fig. 7. The oscillator is a Wien bridge type with which both the frequency and the output power can be accurately set by means of calibrated controls. Frequency control is obtained by setting a two-section potentiometer and a scale switch. These vary the resistance and capacitance respectively in two arms of the bridge. The setting of the three-step FREQ MULT switch determines the range covered, and the potentiometer, designated FREQ, varies the frequency smoothly over the range 20-200, 200-2000 or 2000-20,000 cycles.

3.11 The output power of the oscillator is controlled by a thermistor RT1 and made adjustable manually by means of two attenuators. The thermistor resistance changes with current and seeks to balance the bridge circuit and thus to provide a constant output from the oscillator.

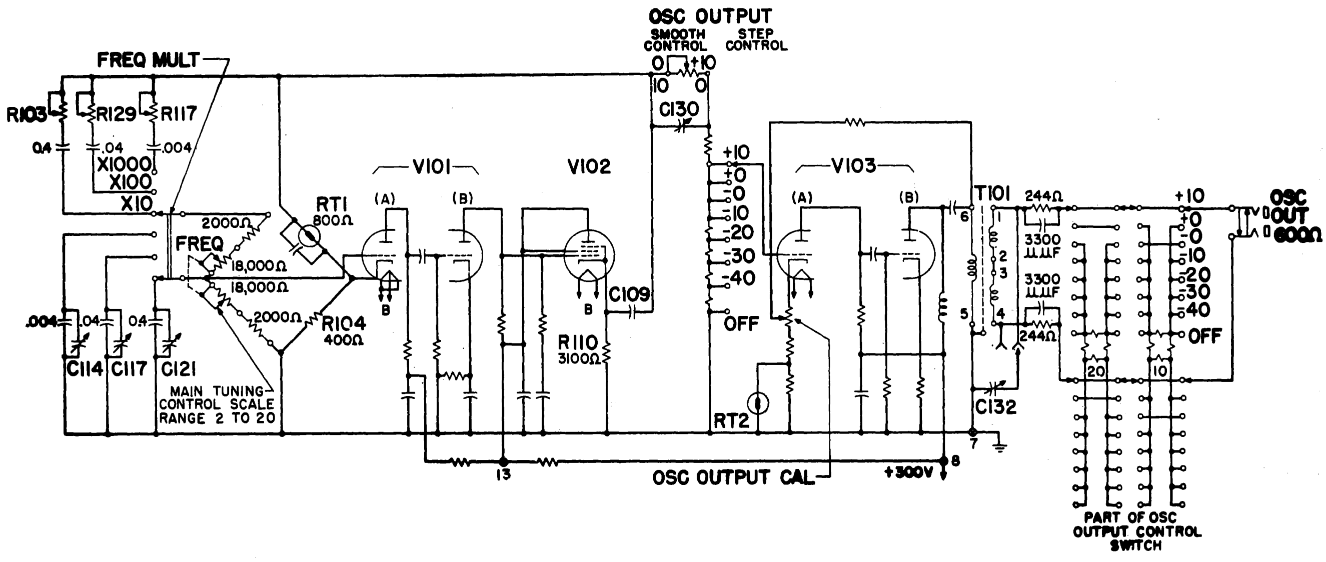

Fig. 7 — Oscillator

When a reference power at 1 MW in a 600-ohm resistance has been established by means of OSC OUTPUT CAL potentiometer the scale ranges of the two attenuators are brought into alignment to indicate the oscillator output directly in dbm. These attenuators are associated with an amplifier in order to isolate the bridge circuit and thus minimize the frequency errors.

3.12 The smooth control 10 db potentiometer acts as an adjustable resistance in series with the step control and includes a scale which has been graduated to show 0.2 db divisions for direct reading of output. The step control has 10 db steps with designations which can be associated with the smooth control scales to indicate the output in dbm. This step control operates seven 10 db steps, of which three use H-type pads in the output circuit. Four additional steps of attenuation are obtained by a potentiometer at the amplifier input circuit.

3.13 The amplifier section of the oscillator circuit is in two parts, one being interconnected with the bridge circuit and the other providing the means for high output and for controlling the output power. Oscillations are generated in the first section, consisting of tubes V101 and V102, by energy circulating through the amplifier to its output, through the bridge and back to the amplifier input. The frequency of the oscillations is determined by the two tunable arms of the bridge, and the oscillating power voltage is determined by the two arms employing the thermistor RT1 and resistance R104.

3.14 The first and second stages of the amplifier are formed by the two sections of the dual triode V101 which are interconnected by a conventional resistance-capacitance network. The third stage V102 is direct coupled to V101 (B) in order to simplify the problem of stabilizing the oscillator by eliminating the commonly used coupling capacitor and its inherent phase shift.

3.15 The output of the third stage V102 is connected as a cathode follower. The low output impedance of the cathode follower circuit minimizes the phase shift between the amplifier and the bridge. This is necessary so that the oscillator frequency will be determined only by the bridge arms and not by changes occurring within the amplifier.

3.16 The bridge network is formed by the frequency multiplier switch S101, capacitors, potentiometer R101, thermistor RT1 and resistors. The FREQ MULT switch S101 is a three-step scale switch and changes the frequency by connecting two groups of capacitors in or out of the bridge circuit for each step. This switch has two sections. One section controls the capacitance which is connected in series with part of potentiometer R101 and the other section controls an equal capacitance which is connected in parallel with the second part of potentiometer R101.

3.17 In operation, switch S101 functions in accordance with the following table.

Position of S101	*Frequency Range Cycles*	*Nominal Capacitance in Microfarads Connected into Series and Parallel Bridge Arms*	*Relative Capacitance Change*
X10	20-200	.4	1
X100	200-2000	.04	1/10
X1000	2000-20,000	.004	1/100

Other capacitors shown in the circuit drawing SD-95115-01 are for factory adjustment purposes and some may remain unconnected.

3.18 The main tuning control is a double potentiometer which varies the frequency by changing the resistance in two arms of the bridge. The two sections of this potentiometer are identical and are assembled on a common shaft. The resistance change in each section is tapered in such a way that the frequency of the oscillator varies linearly with angular rotation of the shaft. The purpose is to make the frequency scale markings relatively uniform so as to be easy to read and to set at desired values. To insure accuracy each potentiometer section is precision made, accurately adjusted and paired. The dual unit is then equipped with a dial and individually calibrated in accordance with actual performance.

3.19 The two arms of the bridge which determine the oscillator output do not appreciably affect frequency. Before applying power to the oscillator, the thermistor is at ambient temperature and has a high resistance; the bridge is unbalanced and the transmission loss through it is relatively small. After applying power, the amplifier gain is introduced and the oscillation starts. Energy from the amplifier output applied to the bridge heats the thermistor.

3.20 As the temperature of the thermistor increases, its resistance decreases tending to balance the bridge. When a bridge balance is approached a stable condition is reached, where the loss through the bridge equals the amplifier gain. Under this condition, the output voltage is stabilized and the thermistor reaches a value very close to twice the value of R104 or 804 ohms. The function of the capacitor across the thermistor arm of the bridge is to produce a small change in phase shift through the bridge to compensate for small phase shifts through the amplifier.

3.21 The second amplifier section consisting principally of the oscillator output controls, double triode sections A and B of the V103 tube, transformer T101, loss pads, condensers and resistors provides an adjustable gain to establish a definite magnitude of the oscillator output. At the input R111 is a continuously variable 10 db control, with a logarithmically shaped winding. This adjustment changes the amount of current in the step potentiometer S102 designated OSC OUTPUT.

3.22 As may be noted in Fig. 7 the voltage supplied to the tube grid circuit is the same for the first four potentiometer steps. The first 30 db of attenuation are inserted by connecting loss pads in the amplifier output. For the remaining three positions the step potentiometer operates in 10 db steps in the conventional manner with a final setting at zero input voltage at the amplifier.

3.23 The double triode sections A and B of the V103 tube, with the associated resistors and capacitors form a 2-stage negative feed-back amplifier. The negative feed-back path is from the plate (pin 6 of V103) through capacitance C131, the resistor R126 to potentiometer R118 in the cathode circuit of V103(A). This feed-back path is conventional except for RT2, a thermistor, which is included to compensate for a change in output of the oscillator due to temperature.

3.24 The amplifier output transformer T101 is coupled to the amplifier through retardation coil L101 and capacitor C131. This method of coupling prevents dc from flowing through the transformer and also to the feed-back network. The resistance-capacitance network in the line side of the transformer serves to stabilize the oscillator output impedance at substantially 600 ohms over the entire 20-20,000-cycle frequency range. Capacitor C132 also associated with transformer T101 is used to improve the capacitance balance of the output circuit. The loss pad resistors between the transformer and the output

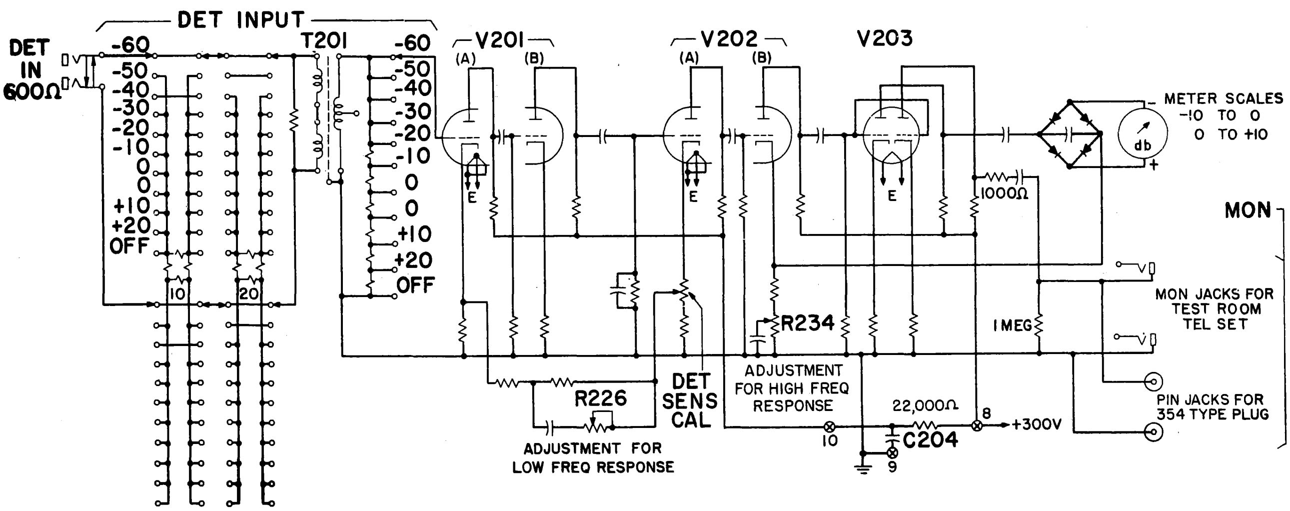

Fig. 8 — Detector

jacks are controlled by the OSC OUTPUT switch S102. One is a 10 db pad and the other is a 20 db pad. Switch S102 operates to connect the pads as shown schematically in Fig. 7.

(C) Detector

3.25 The measuring circuit or detector is formed by input jacks DET IN 600Ω, an attenuator and potentiometer arrangement controlled by the DET INPUT switch, transformer T201, a feed-back amplifier employing three double triodes, a varistor rectifier, a db meter and monitoring jacks. A schematic of this circuit is shown in Fig. 8. The sensitivity of the detector is controlled by DET INPUT switch with its associated loss pads and step potentiometer, in a manner which is similar to that of OSC OUTPUT (switch S102).

3.26 The input circuit consists of two loss pads on the 600-ohm side of the input transformer T201 and the step potentiometer circuit on the high side, (terminals 7-6-5). A shunting resistor is connected on the low side of this input transformer to improve the impedance characteristic of the detector input circuit. In this arrangement the impedance toward the transformer is essentially 600 ohms for the most frequently used ranges of the set. The transformer high side is terminated by six resistors in series, the sum of which is 25,000 ohms. The DET INPUT switch S201 operates to control the sensitivity in 10 db steps by means of loss pads and potentiometer steps as shown schematically in Fig. 8.

3.27 The first three stages of the amplifier section of the detector operate together as a negative feed-back amplifier. The feed-back path is from the DET SENS CAL potentiometer through an adjustable resistance-capacitance network to the cathode circuit of V201(A). The network is made adjustable for the purpose of correcting the frequency response of the detector amplifier at low frequencies.

3.28 The final two stages of the detector amplifier also operate together with resistors and capacitances to form a 2-stage negative feed-back amplifier. The feed-back path is from the plate, pin 4, of V203 through capacitor C208, varistor rectifiers, to an adjustable network in the cathode circuit of V202(B). This feedback serves effectively to make the source impedance for the rectifier a suitably high value and thereby to stabilize the operation of the rectifier by straightening its rectification characteristic. Capacitor C206 in parallel with potentiometer R234 serves to correct the response at high freqencies.

3.29 The dc output of the rectifier circuit is supplied to the db meter (M1), a dc meter with "shaped" pole pieces. The shaped pole pieces result in a meter db scale that is approximatelv linear.

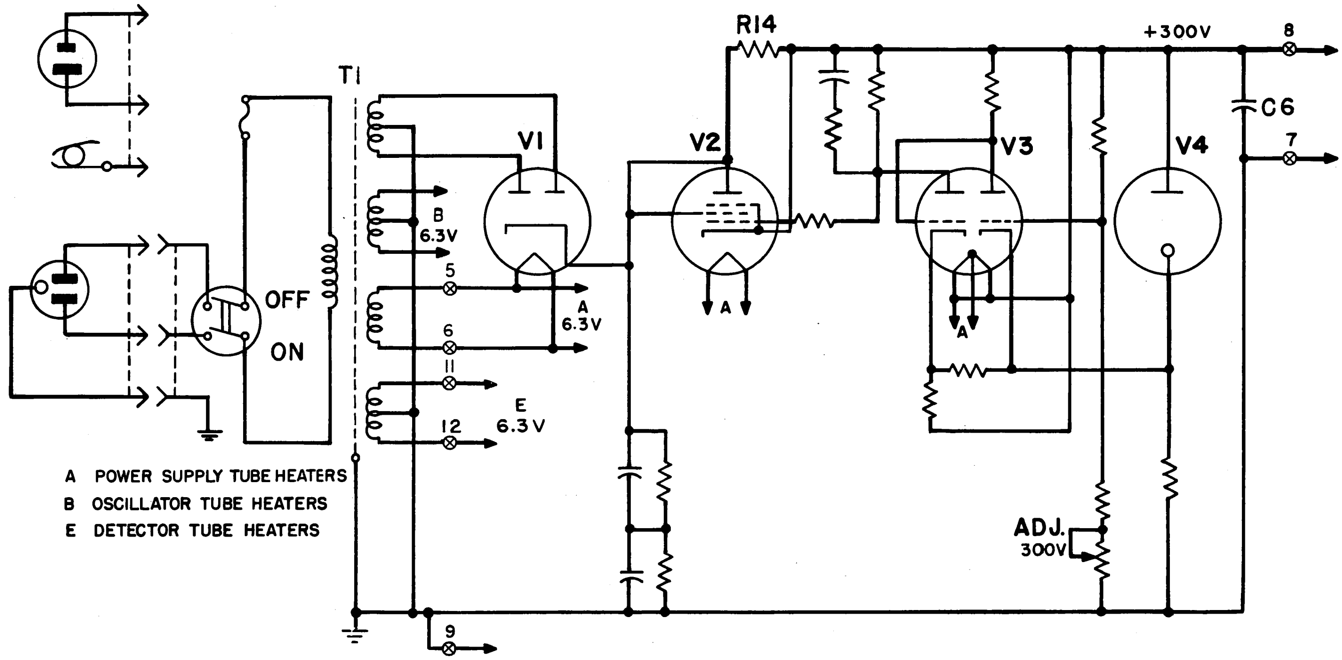

Fig. 9 — Power Supply

3.30 The second section, B, of the electron tube V203 with associated resistors and capacitors C209 provides a monitoring amplifier circuit. This separate amplifier is provided in order that even low impedance headphones may be inserted in either type of monitoring jacks MON without disturbing the measurement. The sensitivity of the monitoring circuit is adequate for monitoring or observing the received testing power and also most extraneous signals which would disturb a measurement.

(D) Power Supply

3.31 The principal components of the power supply are the power transformer T1, the rectifier V1, electron tubes V2, V3, and V4 and associated capacitors and resistors. A schematic of this circuit is shown in Fig. 9. The circuit operates from a 105- to 125-volt 60-cycle supply and provides unregulated 6.3 volts ac and regulated 300 volts dc for the oscillator and the detector circuits. Connections to the supply are made by means of a three-conductor cord; the third conductor being used to facilitate a ground connection between the chassis of the set and building ground. Overload protection is provided by a one-ampere slow-operating type fuse. The slow-operating feature reduces the danger of← burn-out on the starting transient. The ON-OFF switch is operated from the front of the set to control the power connection.

3.32 Power transformer T1 has five secondary windings. Winding 3-5 is an 850-volt winding with a center tap connected to the set ground. Three windings supply 6.3 volts for the tube heater circuits. Winding 6-7 (not shown in Fig. 9) is a 5-volt winding which is used to reduce the voltages in all secondary windings.

3.33 When the power source voltage is operating at 115 volts the output of V1 is in the order of 520 volts and 65 milliamperes dc of which about 12 milliamperes is supplied to the detector circuit. Electron tubes V2, V3, and V4 with associated capacitors and resistors reduce this voltage to a closely regulated 300-volt output. Capacitors C1 and C2 act as smoothing filter capacitors. Resistors R1 and R2 are for the purpose of equalizing the voltage between the two capacitors.

3.34 The operation of the voltage regulating circuit is conventional. Tube V4 is a voltage-regulator type tube which acts as a reference voltage. Changes in output voltages are applied at pin 3 of tube V3 and are amplified. They tend to restore the normal output voltage by changing the current flow through tube V2. This is a negative feedback action that maintains the output voltage constant at the value established by the setting of resistor R12. Resistor R14 serves as a partial bypass for tube V2 because of the relatively large dc current drain.

4. CALIBRATION

(A) General

4.01 Changes of the settings of the OSC OUTPUT CAL and the DET SENS CAL controls are seldom warranted. Both the oscillator and the detector circuits are stabilized to give good performance over long periods of time. The controls are provided for the purpose of making necessary and proper settings when conditions are favorable.

4.02 Of the two circuits the detector is expected to be the more reliable and therefore should normally be left undisturbed so that it may be used as a reference for the setting of the oscillator output. In order to assure the expected performance the detector circuit should be calibrated with reference to 1 MW with special care and only when a suitably accurate input is available. Due allowance should be made for known factors such as the loss of an impedance matching transformer when it is necessary to use one in the checking procedure.

(B) Oscillator Output

4.03 The oscillator output calibration consists primarily of an adjustment of the oscillator amplifier gain so that the 1000-cycle output is 1 MW in the reference circuit. This reference circuit normally is the detector circuit of the same set because of its inherent stability due to the feed-back arrangement. Because of its inherent stability the detector circuit may be used if some other more reliable source can not be made available. A thermocouple type power meter such as a 7A transmission measuring set used in conjunction with a 2AA milliwatt reference set provides the best Plant arrangement available. It should be used if practicable.

4.04 Apparatus:

2P14A or 3P14A Patching Cord, or equivalent

Screwdriver, 4″, AT6860N, or equivalent

7A Transmission Measuring Set which has been checked for its present accuracy with a 2AA Milliwatt Reference Set; or Detector Circuit of the 21A set

4.05 Procedure:

(1) Turn on the power switch of the 21A set. For best results, a warmingup period of at least one hour should elapse before changing the adjustment required in Item (7).

(2) Patch from OSC OUT 600Ω jacks of the set to the DET IN 600Ω jacks, or to the 7A transmission measuring set.

(3) Set the FREQ and FREQ MULT controls to supply 1000 cycles, unless another frequency setting is specified for this purpose.

(4) Set the OSC OUTPUT controls to supply 1 MW using the white scale designations 0. The smooth control should be at maximum clockwise setting.

(5) If the 7A set is used, make the check of the output power as covered in the section on the 7A set. If the 21A detector is used operate the DET INPUT switch to 0 in the white scale range.

(6) Note whether the meter pointer indicates approximately 0 db.

(7) It is not desirable to make readjustment in the calibration unless the 7A set and 2AA set are used to indicate the required amount. An exception would be to make an approximate correction for an appreciable error which, for practical reasons had to be based on the check with the set's own detector circuit. If an adjustment is necessary, adjust the OSC OUTPUT CAL control to obtain 0 db indication. Usually this adjustment should be made only after a warmingup period of one hour.

(8) As a check of the oscillator output vary the frequency to 20 cycles and to 20,000 cycles and note that the output is within ± 0.2 db of the calibrated output at 1000 cycles.

(C) Detector Sensitivity

4.06 The adjustment of the DET SENS CAL control should be changed only under favorable conditions, such as at an office where a source of 1 MW into 600 ohms of known precision is available. If not known, a 7A transmission measuring set in conjunction with a 2AA milliwatt reference set should be used, and the accuracy of the source should be determined. The resultant calibration of the detector sensitivity is not expected to change materially over long periods of time.

4.07 Apparatus:

2P14A or 3P14A Patching Cord, or equivalent

Screwdriver, 4″, AT6860N, or equivalent

Reference source of 1 MW 1000 cycles, 600 ohms

Note: The latter may be the oscillator section immediately after being calibrated accurately by the method of the preceding paragraphs.

4.08 Procedure:

(1) Patch from the reference 1 MW source to the DET IN 600Ω jacks of the set.

(2) Set the DET INPUT switch to 0 in the white scale range.

(3) Note whether the deflection of the meter pointer is approximately full scale. A large deviation may be an indication of trouble or an unauthorized adjustment of the control.

(4) Adjust, if necessary, the DET SENS CAL potentiometer to give a full scale indication of 0 db as closely as possible. The ambient temperature at the time of this adjustment should be between 60° and 95°, and the set should have been turned on for a warmingup period of at least one hour.

(5) When it is desired to check the frequency response of the detector input sensitivity repeat the above Items (1) through (4) using a measured source of 1 MW at other frequencies. If the deviations from the value at 1000 cycles exceed the expected values indicated in Part 2, the circuit should be investigated for trouble in accordance with Part 6, MAINTENANCE.

5. OPERATION

(A) Test Connections

5.01 The power cord of the 21A set is provided for connection to a 105- to 125-volt ac outlet. This cord includes a third lead for connection to building ground. The ground connection is necessary to obtain optimum performance of the set and must be connected to minimize the hazard which would result from an insulation failure in the cord or in the set.

5.02 The oscillator output and the detector input jacks are suitable for patching cords of the conventional twin plug type used at toll repeater positions, such as 2P14A or 3P14A. Equivalent cords are 2- or 3-conductor types equipped with 241-type plugs on both ends. Conversion cords of other make-up for connecting to other circuits to be tested will sometimes be necessary and should be provided locally as required.

5.03 The sleeves of the OSC OUT 600Ω and DET IN 600Ω jacks are connected to the chassis ground of the set. When it is desired to use the 21A set at a toll testboard or OGT position it will usually be necessary to provide a separate multiple jack circuit with suitable supervisory arrangements to avoid losing a dial connection during transfer to the measuring set.

(B) Oscillator for Sending

5.04 The operation of the 21A set for sending test power to a circuit under test, at any specified frequency and any output magnitude consists essentially of setting the controls and making a single patch connection. The available frequency range is from 20 cycles to 20 kilocycles per second. The output power range is from −50 dbm to +20 dbm. The following are typical procedures, using a 2P14A cord, or equivalent. As mentioned in Paragraph 2.05 a warm-up period of at least 10 minutes is desirable.

5.05 Procedure for sending 1 MW, 1000 cycles:

(1) Connect the power cord to the 115-volt ac power supply and if there is an associated test clip, connect it to building ground.

(2) Operate the 115V 60∼ switch to the ON position.

(3) Turn the FREQ MULT switch to X100 and the FREQ scale setting to 10.0 for 1000-cycle output.

(4) Adjust both OSC OUTPUT controls to 0 in the white or —dbm range.

(5) Patch from the OSC OUT 600Ω jacks to the trunk or circuit under test.

5.06 Procedure for sending —16 dbm, 3300 cycles:

(1) Connect the power cord to the 115-volt ac power supply and if there is an associated test clip, connect it to building ground.

(2) Operate the 115V or 60∼ switch to the ON position.

(3) Turn the FREQ MULT switch to X1000 and the scale setting to 3.3 for 3300-cycle output. (Fig. 10 shows the scale values available.)

(4) Adjust the 10 db step and the smooth OSC OUTPUT controls to the white or —dbm scale settings of —10 and —6, respectively.

(5) Patch from the OSC OUT 600Ω jacks to the trunk or the circuit under test.

(C) Measurements with Detector

5.07 Measurements of received test power can be made using the detector circuit with a range of sensitivity from —70 to +30 dbm and a frequency range which is flat between 20 cycles and 20 kilocycles. The result is indicated by the sum of a meter scale reading and a 10 db step switch designation. Scale values with red "+" are plus dbm for inputs above 1 MW. Values in the negative range designated "—" using the black scale of the db meter result when the input magnitude is below 1 MW.

5.08 When transmission gain or loss measurements are made the desired measured result depends on both the detector input reading and the magnitude of the test power at the sending end of the trunk circuit. When the latter value is known, the desired result is obtained by subtracting the sending power algebraically from the received power. If the sign of this difference is plus it represents gain, if it is minus it represents loss. The following table gives several typical examples:

	Send	*Rec.*	*Diff.*	*Loss or Gain in db*
(1)	+20	—57.0	—77.0	77.0 (loss)
(2)	0	—11.5	—11.5	11.5 (loss)
(3)	—20	— 5.5	+14.5	14.5 (gain)
(4)	—10	+ 4.5	+14.5	14.5 (gain)
(5)	—16	+ 7.2	+23.2	23.2 (gain)

5.09 The following are typical measuring procedures using the 21A set detector circuit.

5.10 Apparatus:

2P14A Cord or equivalent (see Paragraph 5.02).

5.11 Procedure for measuring received test power:

(1) Connect the power cord to the 115-volt ac power supply and if there is an associated test clip, connect it to building ground.

(2) Operate the power circuit ON switch.

(3) Turn the DET INPUT switch to maximum counterclockwise setting +20 or to the step nearest to the expected value if known.

(4) Patch from the DET IN 600Ω jacks to the trunk or circuit under test.

(5) Make the necessary arrangements for supplying testing power at the transmitting end of the trunk or circuit under test.

(6) Increase by a clockwise turn the DET INPUT step control until an on-scale meter deflection is obtained. Note the color and designation of the DET INPUT switch setting. Read the meter pointer deflection using the red scale if the control step designation is red, or the black scale if the control step designation is negative or white. Add the two values.

(7) The sum is the magnitude of the received test power in dbm. A red plus, "+", sign on control steps and meter scale indicates a power above 1 MW. A white minus, "—", control step designation sign with the black meter scale indicates a power below 1 MW.

(8) If it is desired to make a monitoring observation of the input to the detector, connect an attendant's telephone headset to the MON jacks. The impedance of the monitoring set does not affect the measurement. The sensitivity adjustment which is suitable for on-scale meter indication is normally adequate for monitoring.

5.12 Procedure for measuring noise, flat weighting:

(1) Connect the power cord to the 115-volt ac power supply and if there is an associated test clip, connect it to building ground.

(2) Connect an attendant's telephone headset to the MON jacks.

(3) Operate the power circuit ON switch.

(4) Turn the DET INPUT switch counterclockwise to the setting +20 or to the step nearest to the expected value if known.

(5) Patch from the DET IN 600Ω jacks to the trunk or circuit under test.

(6) Increase by a clockwise turn the DET INPUT control step by step until an on-scale meter deflection is obtained, and make monitoring observations of the nature or character of the input to the detector.

(7) Note the DET INPUT switch setting (usually white) and observe the meter pointer deflection on the corresponding color scale. When rapidly fluctuating readings are noticed it will be necessary to average the various pointer positions mentally for an approximate average indication, disregarding the occasional high spurts or surges.

(8) To the averaged reading add the step designation from the DET INPUT switch. This sum is the measured noise power flat weighting in dbm. To obtain the magnitude in a scale of db from reference noise the dbm magnitude should be subtracted from 90. For example, a measured noise of —68 dbm is equivalent to 22 db above reference noise at flat weighting.

(9) The monitoring observations usually will serve to identify the type of noise and in some cases aid in determining the source of excessive noise in the trunk or circuit under test.

(D) Repeater Gain Measurements

5.13 The measurement of repeater gain is normally a process of determining two values of test power in dbm and obtaining the difference. The following procedure covers such a measurement using the 21A set for determining both values.

5.14 Apparatus:

2—2P14A Cords or equivalent (see Paragraph 5.02)

5.15 Procedure:

(1) Connect the power cord to the 115-volt ac power supply and if there is an associated test clip, connect it to building ground.

(2) Operate the power circuit ON switch.

(3) Turn the DET INPUT switch to the red "0" (+ 0) setting. This is the proper sensitivity to result in an on-scale reading for a repeater output between 0 and + 10 dbm.

(4) Set the FREQ controls for the specified test frequency.

(5) Turn the OSC OUTPUT smooth control to maximum clockwise setting (0 white scale) and the 10 db step control to a low output or to a step approximately equal to or less than the repeater gain, if known.

(6) Patch from the OSC OUT 600Ω jack to the input of the repeater under test. Also patch from the output of the repeater to the DET IN 600Ω jacks.

(7) Increase the output of the oscillator if necessary to obtain an on-scale meter pointer deflection and note the step designation of the OSC OUTPUT control.

(8) The repeater gain is obtained by subtracting the oscillator output control setting algebraically from the red (plus) meter scale reading (the detector input control being on red 0).

5.16 Other settings of output and input may be used to meet special requirements. The following are some typical examples:

	Oscillator Output		*Detector Input*		
	Step (A)	*Smooth Control (B)*	*Step (red) (C)*	*Meter (red) (D)*	*(C)+(D)−(A)−(B)*
(1)	− 0	− 0	0	+ 3	+ 3 db (gain)
(2)	−10	− 0	0	+ 9	+19 db (gain)
(3)	+ 0	+10	0	+ 1	− 9 db (loss)
(4)	+ 0	+ 5	+10	+10	+15 db (gain)

5.17 In the case of measurement of E-type repeaters using the 2G repeater test set (J94002G) or the E repeater test set (J98612F) the normal procedure requires two measurements of loss, both of large magnitude, and the computation of the difference. Usually in both cases the maximum output of the oscillator is transmitted to the set and a low magnitude of test power is received by the detector input. In effect the desired result is numerically equal to the change in the value of detector input represented by the two readings.

(E) Miscellaneous Tests

5.18 This set together with hybrid coil arrangements is particularly suited for making return loss measurements. Important applications are office cabling balance tests at the major switching offices and also terminal balance tests on connections to toll connecting trunks. Its 70 db loss measuring sensitivity (at 0 dbm oscillator output) and direct reading features permit rapid measuring of return losses over a wide range of values. Experience indicates that these features with the ease of changing oscillator frequency settings result in considerable time saving compared with other measuring sets now available.

5.19 In certain cases the 21A set will be used for tests covered by specific procedures. For example, transmission loss measurements in exchange areas make use of auxiliary testing and switching equipment. If the part of the circuit being measured is not 600 ohms, impedance correcting transformers are necessary.

5.20 If the set is to be used on trunks which have dc present on them, it will be necessary to employ an isolating transformer to keep the dc out of the set. Otherwise the accuracy of the readings may be affected. This also means that external holding bridge arrangements must be made if it is necessary to hold a dial connection for the test. (See Paragraph 1.09.) These tests should conform to the following general method.

5.21 Procedure:

(1) Connect the power cord to the 115-volt ac power supply and if there is an associated test clip, connect it to building ground.

(2) Operate the power circuit ON switch.

(3) Turn the DET INPUT switch to the 0 step setting in the black scale range.

(4) Patch from the DET IN 600Ω jacks to the output of the trunk or circuit under test. When this circuit is not accessible by direct patch and the test procedure requires intermediate assistance by an operator or a testboard attendant, using test trunks, attenuator, impedance changing transformers, etc, it will be necessary to devise suitable arrangements locally.

(5) When sending power is supplied by the same 21A set, turn the FREQ control to the specified frequency setting and both of the

OSC OUTPUT controls to 0 with white scale designations for 1 MW (unless otherwise specified) and patch from the OSC OUT 600Ω jacks to the input of the trunk or circuit under test using auxiliary equipment such as holding bridging arrangements, impedance changing transformers, etc, as necessary.

(6) Measure the received test power by turning the DET INPUT switch clockwise to the step which results in an on-scale meter pointer deflection. Note the designation at the switch setting (white) and also note the meter pointer deflection (using the black scale). The sum of these two values is the received power in dbm.

(7) The transmission loss is numerically equal to the received power in dbm when 1 MW of test power is supplied at the transmitting terminal of the trunk or circuit under test. In the general case the transmission loss is a minus (—) quantity obtained by subtracting the sending power in dbm algebraically from the received power in dbm. (If the circuit being measured is found to be operating at a gain it may be necessary to change the oscillator output to a larger (more negative) value and to read the detector input control and meter scale with red (+) indications.) See Paragraph 5.15 for computation of the gain.)

(8) When part of the loss is in auxiliary circuits or equipment it will be necessary to make corrections or to increase the test power transmitted to compensate for a loss correction, when known.

(9) Examples of Computation, assuming no corrections.

	OSC Output	*Detector Input*	*Diff.*	*Net Loss*
(1)	−16	−39	−23	23 db
(2)	0	−12	−12	12 db
(3)	+20	−44	−64	64 db

6. MAINTENANCE

(A) General

6.01 The maintenance of the 21A set consists essentially of making occasional check tests to determine that the expected performance is obtained, of making required calibration adjustments, and of the replacement of defective components when necessary. Suggestions as to procedure are given in subsequent paragraphs but detailed methods will be governed by local circumstances. The check tests and calibration adjustments can be made without removing the chassis from the case. Tests of tube performance and search for trouble sources necessitate the removal of the chassis.

Caution: Since high voltages exist between certain apparatus terminals, the power supply cord plug should be removed from its receptacle before removal of the chassis of the set from the case. This is desirable even though the OFF-ON switch is operated to OFF. Use caution while testing the set in the exposed condition.

6.02 When the trouble conditions are too extensive or too difficult to handle locally the set should be returned to the factory for repairs and adjustments. Unsatisfactory performance will usually appear as either low or unstable output, an increase in harmonic content, a nontracking of the oscillator output controls with the detector input sensitivity control or the meter scale. An inoperative circuit resulting from a wiring trouble or defective switch contact may be cleared by an inspection and repair without great difficulty. The mechanical alignment of the index line for FREQ scale, and the pointer with the OSC OUTPUT control scale are important features in obtaining precise output frequency and power.

6.03 The alignment of the FREQ control R101 scale values 2.00 and 20.0 with the index line should correspond closely with maximum and minimum values of resistance, respectively. Assuming that it has been necessary to reassemble the control on the shaft, check the setting by measuring the two resistances in series using a Wheatstone bridge, between terminals 4 and 2 of the R101 control. Rotate the shaft so as to decrease the resistance gradually to its minimum value (approximately 4000 ohms). Turn the shaft back to the precise point where the bridge galvanometer indicates an increase in resistance. Reset the control on the shaft so that a 20.0 scale value is at the index line. This is an approximate setting. For the final setting turn the shaft in the opposite direction (through blank portion of the scale) till the resistance suddenly increases to the maximum value (approximately 40,000 ohms). Rebalance the bridge and continue to turn the shaft in the same direction to the precise point where the bridge galvanometer indicates a decrease in resistance from the maximum value. Note the alignment of the 2.00 scale value with the index line and carefully make the final setting of the control, if necessary, to obtain precise registration.

6.04 The alignment of the OSC OUTPUT control with the extreme values of resistance should be verified and adjusted when necessary by means of the friction-held lever underneath the panel. As the pointer is turned from +9 toward +10 the minimum value of resistance, 0, should be reached precisely as the pointer reaches +10, i.e., not at +9.9 or an equivalent amount beyond +10. A small amount of overtravel of the pointer for zero resistance is unimportant. The resistance can be measured with a bridge or the setting can be verified by a test and by observing the change of detector meter reading as the control setting is reduced from maximum. Turning the control with excessive pressure at either end position changes the setting of the friction-held lever and is the usual cause of a maladjustment. (See also Paragraph 1.11.)

(B) Check of Performance

6.05 In order to check the performance of the set completely it will be necessary to provide some auxiliary test equipment and make typical measurements. A complete 21A set is self-checking to a considerable degree except when either the detector, the oscillator or the power supply is inoperative. In such cases of trouble it will be necessary to start by verifying the power supply cord, the fuse, the various tubes and the dc voltages. If suspected of operating imperfectly make the following tests and clear the troubles when indicated by inoperative conditions or excessive deviations. The use of a vacuum tube voltmeter for some of the trouble investigations, with the detector unit unmounted, is covered in a subsequent paragraph.

(1) Patch from OSC OUT 600Ω to DET IN 600Ω or to a separate detector and measure the oscillator output at various control settings to determine whether any of the frequency or output ranges are inoperative or in trouble.

(2) Refer to Part 4 (B) Oscillator Output and (C) Detector Sensitivity for information concerning the calibration adjustments.

(3) The range and calibration of the 0 to +10 db output control can be checked approximately by comparing with the db meter scale, or more accurately when desired, using an external attenuator of known accuracy. This should be done in 1 db steps using a test frequency of 1000 cycles. The control should operate smoothly over the full range and the values should correspond to within ± 0.2 db. Repeat this test at 20 kc for the 1, 9 and 10 db points. If these values differ from the 1000-cycle values by more than 0.1 db it may be necessary to readjust C130. Refer to Part 6 (E) for this adjustment.

(4) Restore the oscillator controls to +20 dbm, and 1000 cycles and measure the output, using the detector circuit in order to verify the switch positions. See Table III for expected values. These checks can be made at any frequency in the range and the accuracy should be 0.2 db or better. Usually the tolerances should be very small at 1000 cycles.

TABLE III

OPERATION CHECK TESTS

Oscillator and Detector Control Settings for Meter Indications

Osc. Output		*Det. Input*	
Step	*Smooth*	*For Min. Meter Rdg.*	*For Max. Meter Rdg.*
+10 (Max.)	+10 (Max.)	+20	+10
+ 0 "	+10 "	+10	+ 0
− 0 "	− 0 "	+ 0	− 0
−10 "	− 0 "	− 0	−10
−20 "	− 0 "	−10	−20
−30 "	− 0 "	−20	−30
−40 "	− 0 "	−30	−40
−40 "	−10 (Min.)	−40	−50
Off "	−10 (Min.)	−60**	—

* ±0.2 db.

** No reading on meter.

(5) Check the accuracy of the oscillator output frequency using a 72A frequency meter, a frequency counter, or by comparing

with standard frequencies with the aid of an oscilloscope in the usual manner. Refer to Part 6 (C) Frequency Calibration.

(6) Check the detector meter scale deviations by making comparison tests using an oscillator output at 1000 cycles and an attenuator known to be accurate, which is adjustable in 1 db steps. With a full scale meter reading for an input of 1 MW, increase the attenuator loss in 1 db steps. The values should correspond to within 0.1 db.

(7) Check the detector sensitivity control steps by making comparison tests with an attenuator known to be accurate, using 1000 cycles from the oscillator, and noting the deviations at one point on the meter scale.

(C) Frequency Calibration

6.06 The output frequency of the 21A set oscillator may be checked for accuracy against other sources of frequency such as the 72A frequency meter, an approved frequency counter, or standard frequencies using an oscilloscope as a means of indication. It is recommended that changes of adjustment not be made unless local conditions are favorable and the reference frequencies are reliable. The set should be operating in an ambient temperature above 70° F and have a warmup of an hour. The ac line voltage should be approximately normal and substantially constant. If for any reason the FREQ dial has been loosened from its shaft, this should be reset in accordance with Part 6 (A) General. In those cases where no suitably accurate reference frequency is available it will be necessary to return the set to the Western Elecric Co. for recalibration.

6.07 Each of the three ranges of frequencies is calibrated with respect to two points on the FREQ control scale. These are substantially independent adjustments and it is possible that only one or two settings will need a change to obtain the desired precision. The low-frequency adjustments for each range are made by soldered strap connections. The end scale values 2 and 20 are the calibration points for each range and good frequency adjustments at these points should result in suitable correlation with frequency at all scale values. The setting of the FREQ dial to the index line is important. The

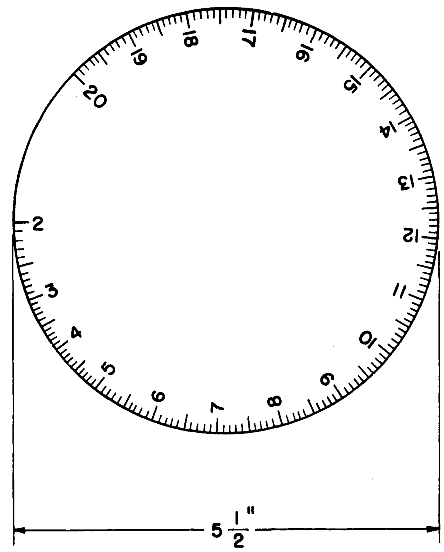

Fig. 10 — Oscillator Frequency Scale

adjustments of trimmer condensers and potentiometers using a screwdriver can be made to a close precision.

6.08 Procedure:

Caution: Dangerous voltages exist at certain apparatus terminals which are exposed when the set is removed from the case and operated for these tests. Power should be removed during strapping operations.

(1) Patch from the OSC OUT 600Ω jacks to the frequency meter, counter or oscilloscope circuit, whichever is to be used as reference.

(2) For 20 cycles set the frequency controls to X10 and a precise FREQ scale setting of 2.0. Note Fig. 10 for scale values.

(3) Set the OSC OUTPUT controls to supply an output of 1 MW, or as needed.

(4) If the 72A frequency meter is used, operate its controls to the proper settings for indicating a comparison with a frequency of 100 cycles. Verify the calibration of the 72A meter by operating the CAL switch, and

make readjustments if necessary. Measure the frequency of the 21A set oscillator.

(5) If adjustments are necessary, remove the set from the case and adjust the capacitance in the two arms of the bridge, as required, to obtain a stationary pattern to within 1 beat per 50 seconds. This is accomplished by adjusting C114, and C106, C107, and C108 so as to keep closely the same indicated capacitance in the total of C106, C107, and C108 as that of C114 when the final setting of frequency is obtained.

(6) After Item (5) is verified turn the FREQ control to a precise setting of 20.0 and measure this frequency. With the 72A meter at the same setting as before the 1:2 pattern should be made stationary to within 3 beats per minute by adjusting R103.

(7) Repeat Item (5) and readjust C114 if necessary.

(8) For 200 cycles set the frequency controls to X100 and a precise scale setting of 2.0, and the reference frequency to 1000 cycles for a 5:1 pattern, or, with the counter measure the frequency. Adjust capacitances C102, C103, C104, and also C116 and C117, as required, so as to keep closely the same indicated capacitance in the total of C102, C103, and C104 as that in the total of C116 and C117. For the final setting of frequency the pattern should be stationary to within 1 beat in 5 seconds.

(9) Turn the FREQ control to a precise scale reading of 20.0 and observe a 1:2 pattern against the same standard. This should be made stationary to within 2 beats per second by adjusting R129.

(10) Repeat Item (8) and readjust C117 if necessary.

(11) For 2000 cycles set the frequency controls to X100 and a precise scale setting of 2.0. In a similar manner for the 72A meter setting for 4000 cycles and a 2:1 pattern adjust capacitances C119, C120, and C121, and also C110, C111, and C112, as required, so as to keep closely the same indicated capacitance in the total of C119, C120, and C121 as that in the total of C110, C111 and C112. For the final setting the pattern should be stationary to within 2 beats per second.

(12) Turn the FREQ control to a precise scale reading of 20.0 and observe a pattern on the oscilloscope with a 4 kc reference frequency. In this case adjust R117 as necessary to obtain a stationary pattern to within 5 beats per second.

(13) Repeat Item (12) and readjust C121 if necessary.

6.09 Other output frequencies supplied by the oscillator can be measured in a similar manner to obtain a check of other points of the FREQ scale. The adjustments should be changed only in relation to the two selected points in each range. Other observations of frequency deviations can also be easily interpreted in relation to the scale readings by slowly adjusting the FREQ control to the point of true comparison with the reference frequency and noting the amount of deviation on the scale. The computed deviation should not exceed 1%.

(D) Trouble Investigations

6.10 When other operating difficulties are encountered it may be desired to check the circuit fully for defective components such as tubes, electrolytic capacitors, resistors, etc. The required tests to disclose these defects will be determined by local conditions and the available test equipment. Data are given in subsequent paragraphs to aid in these investigations.

Caution: Use an approved probe and due caution because of dangerous voltages on apparatus terminals.

6.11 The power supply circuit is normally operating properly when the gas tube V4 glows steadily. This indicates that the voltage is being regulated. Failure to glow or intermittent flashing of the gas tube is an indication of trouble. This may be due to the rectifier or the regulating tubes V1, V2, or V3, a burned out power circuit fuse or an unusually low power line voltage. Trouble elsewhere in the set causing excessive drain on the power supply will also reduce the 300-volt plate supply voltage and possibly burn out the power fuse.

6.12 The electron tubes used in the 21A set should meet the limits specified for a Hickok KS-15750 (or equivalent) tube tester.← A full set of tubes is supplied with the set and should be used in the sockets in accordance with designations of the circuit label and on the chassis. Additional electron tubes can be obtained in accordance with the following list.

Section of Circuit	*Tube Designation*	*Code*
Power	V1	6X4
"	V2	6AQ5
"	V3	12AX7
"	V4	5651
Oscillator	V101	12AX7
"	V102	6AQ5
"	V103	2C51/396A
Detector	V201	12AY7
"	V202	12AX7
"	V203	2C51/396A

6.13 Six electrolytic capacitors per KS-13686 each of 125 mf are provided in the power circuit unit of the set. They are designated and used as follows:

Designation	*Nominal dc voltage**
C1	530
C2	265
C6	300
C125	150
C126	265
C204	235

* Positive value at terminal 2 with respect to ground.

6.14 Deterioration of one or more of the electrolytic capacitors in the set will result in poor filtering of the dc voltage supplied to the electron tube plate circuits. This may be suspected if the oscillator output includes an excessive amount of 60 or 120 cycles, if the scale of the db meter is found to be inaccurate for small deflections of the meter, or if a low magnitude steady reading with no input is observed on the detector circuit meter. The electrolytic capacitor may be disconnected from the set and tested as described in Section A204.107 of the Bell System Practices. By substituting an equivalent capacitor for the one disconnected, the 21A set can be operated for the check measurement.

6.15 The voltages given in Table IV are nominal values to be expected when a 1000 ohms per volt dc voltmeter is used. The negative terminal of the dc voltmeter should be at ground for these check measurements. Deviations of 20% in the measured results at socket terminals are not necessarily an indication of trouble. This is due to the behavior of the particular tubes being used.

TABLE IV

Nominal DC Voltage Data

All values positive with respect to ground.

Terminal	*Volts*
TS8	300
TS10	235
TS13	265
TS14	150
TS6	300*

**Caution*: *This voltage is present at the 6.3-volt 60-cycle ac tube heater terminals on sockets for V1, V2, and V3 tubes.*

			Plate		*Cathode*	
Tube	*Section*	*Code*	*Term.*	*Volts*	*Term.*	*Volts*
V1	—	6X4	—	—	7	515
V2	—	6AQ5	5, 6	515	2	300
V3	A	12AX7	6	280	8	260
	B	12AX7	1, 7	260	3	215
V4	—	5651	1, 5	300	2, 4, 7	208
V101	A	12AX7	1	110	3	0.45
	B	12AX7	6	110	8	0.60
V102	—	6AQ5	5	260	2	115←
V103	A	396A	4	95	2	2.2←
	B	396A	6	240	8	4.0
V201	A	12AY7	1	120	3	1.9
	B	12AY7	6	120	8	1.9
V202	A	12AX7	6	160	8	1.4
	B	12AX7	1	200	3	1.5
V203	A	396A	6	220	8	4.8←
	B	396A	4	220	2	4.8←

TABLE IV (Cont'd)

Heater Circuits

	Term.	*Volts*
V1	3	300
V2	4	300
V3	9	300

6.16 When a vacuum tube voltmeter is available for trouble investigations, the data in Table V may be found helpful. The high values of voltage at 60 cycles in the power supply circuit are omitted.

Caution: Dangerous voltages appear on terminals which are accessible for test, particularly when the detector unit is unmounted from the panel and turned back.

TABLE V

Operating Voltages

RMS values using VTVM with one terminal to ground.

Oscillator

Output frequency at any setting.*
Output power at maximum except as indicated.

Test Point		*Volts*	
RT1	One term.	8-15	
RT1	Other term.	2.6-5	
T101	Term. 6	55	
"	6	17	With smooth control R11 at min. setting.
"	1	7	Connect grounded terminal of VTVM to terminal 2 of T101.
"	4	7	

* In general the frequency should be 200 cycles or less unless the VTVM is known to be suitable.

Detector

Oscillator output supplied to detector input and controls adjusted for full scale reading on meter.**

Test Point		*Volts*
MON	Jack Sleeve	20 or more
V201	Term. 2	.004

** The use of a monitoring set will be found useful for some trouble investigations.

(E) Adjustments for Frequency Response

6.17 The detector circuit includes two adjustable resistors which may be changed when necessary to compensate for deviations in the response between the middle and the extremes of the frequency range. The need for a readjustment normally is disclosed by the tests given in Part 6 (B). It is important that oscillator output deviations with frequency be negligible for the following tests. When the response at 20 cycles shows a deviation downward from the 200-cycle value by 0.2 db or more, change the setting of R226 counterclockwise by a slightly larger amount while observing the 200-cycle value and recheck both measurements.

6.18 After the deviation is eliminated it will be necessary to readjust the DET SENS CAL control. Similarly, when the response at 20 kc shows a deviation downward from the 2 kc value by 0.2 db or more, change the setting of R234 clockwise by a slightly less amount while observing the 20 kc value, and recheck both measurements. Again it will be necessary to readjust the DET SENS CAL control after the equalized setting is obtained. With the final settings the deviation in response at any frequency in the range should not exceed 0.1 db.

6.19 The oscillator output smooth control R111 has a slight frequency characteristic due to inductive reactance and has been compensated for by an adjustable capacitor C130. The correctness of this setting may be checked by measuring the output of the oscillator at the extreme settings in comparison with a 10 db step of the attenuator. Change the setting of C130 as necessary for optimum performance of R111. Care should be taken not to force the setting of the control and thereby change the alignment made in accordance with Paragraph 6.04. A direct comparison of the scale with the detector meter scale is not an equivalent test.

Oscillator Output

Freq.	*Step*	*Smooth*	*Detector Reading*
200	−20	0 (Max.)	A
200	−10	−10 (Min.)	A ±0.1 db
20,000	−20	0 (Max.)	B
20,000	−10	−10 (Min.)	B ± Same Diff.

"A" may differ from "B" by a small amount due to factors other than the potentiometer.

(F) Oscillator Output Balance Adjustment

6.20 The output circuit of the oscillator includes an adjustable capacitor, C132, for purposes of balancing the circuit at the output transformer T101, with respect to ground. This in some cases becomes relatively important in obtaining accurate measurements such as when a detector circuit is used which is not balanced to a high degree of precision. If it should become desirable or necessary to verify the setting of C132 and to make suitable readjustments, the following procedure may be found helpful particularly when the set includes a detector.

(1) Connect the two OSC OUT 600Ω jacks together (short circuit) and also to either of the two DET IN 600Ω jacks, with the other DET IN 600Ω jack connected to ground at the jack sleeve. ←

(2) Using an output frequency of 5 kc turn the oscillator output to maximum or +20 dbm. Also turn the DET INPUT switch clockwise toward maximum sensitivity, —60, or until a reading is observed on the meter.

(3) Adjust C132 associated with T101 as necessary to obtain minimum reading on the detector meter. If the settings of C132 indicate minimum capacitance it will be necessary to make the connection to the other terminal of T101 as shown in Fig. 7.

(4) The detector reading for the final setting should be —37 db or less. If a suitable VTVM is used in place of the detector it should be shunted by 600 ohms and a final reading of 10 millivolts or less should be obtained. The readings for other output settings may not be rigorously consistent due to the output attenuator and switch unbalances.

7. LIST OF DRAWINGS

7.01 Drawings (not attached) covering the circuit and equipment features of this set are as follows:

Title	*Drawing No.*
Schematic	SD-95115-01
Equipment Information	J94021A-( )