ADDENDUM TO

INSTRUCTION BOOK FOR

CRYSTAL CALIBRATED WAVEMETER

TYPE TE-149

In all wavemeters with Serial Numbers above 99 the variable ceramic type trimmer capacitor C14 shown in the photographs in this book and described in the parts lists has been replaced by a variable air trimmer capacitor identical to that used as the Crystal Trimmer. This air trimmer capacitor has been mounted on the chassis between the rotating coil L2 and the oscillator plate feed choke L1. Also, the Calibrated Oscillator Tank Capacitor C2 has been made 0.0009 mfd. instead of 0.00095 mfd. One replacement for this capacitor has been added to both the Primary and Secondary spare parts.

In the List of Electrical Components, Section 8-1, and the List of Secondary (Major) Spare Parts, Section 8-3 read for part C14:-
Condenser, variable, air, trimmer, 0.000003 to 0.000025 mfd.

In all Parts Lists, Sections 8-1, 802, and 8-3 read for part C2:
Condenser, 0.0009 mfd. ± 2% 500 V., D.C.

In addition to the batteries listed on page 12 as suitable for use in the wavemeter an Eveready X478 may be used as the AB unit.

INSTRUCTION BOOK

for

CRYSTAL CALIBRATED WAVEMETER

Type TE-149

RCA VICTOR COMPANY LIMITED

Montreal, Canada.

IB.149

December 1941.

III INSTALLATION

3-1 ASSEMBLY

The Type TE-149 Crystal Calibrated Wavemeter is ordinarily shipped with all valves and batteries in place so that the equipment is ready to operate as soon as received. However, in special cases, when specified by the customer, the equipment is shipped less valves and/or batteries. In this case the following procedure is necessary:

(a) Remove the eight screws from the lip of the front panel and slide chassis out of box.

(b) Insert one IN5GT, one 1A7GT and 1G5GT valve in their respective sockets.

(c) Place cap connectors on IN5GT and 1A7GT valves.

(d) Connect one General H3BF C Battery to the wires coming off the side of the power cable. The green wire connects to the negative (-) terminal while the black wire connects to the positive (+) terminal.

(e) Plug in power plug into socket on General 60A2L A & B Battery making sure OFF-ON switch is turned to OFF.

(f) Place the C battery in the small clip in the upper left side of case so that the terminals project out. Make certain that the lugs on the wires do not touch the bracket or sides of box.

(g) Slide A & B battery into position with power plug directly below C battery.

(h) Carefully slide chassis into case allowing cable to fold into the space provided. Do not permit it to fold sideways between chassis and A & B battery.

(i) When chassis is all the way home replace the eight retaining screws. This operation is most readily performed while the equipment is sitting on its back.

(j) Plug in phones, turn OFF-ON switch to ON, CALibrate-OPERate switch to CALibrate and check for operation. Turn OFF when check is completed.

Osc. Freq.	Osc. Har.	Xtal. Har.	Beat Freq.	
3250	4	13	13000	23.5
3333.3	3	10	10000	30
3400	5	17	17000	17.7
3500	2	7	7000	43
3600	5	18	18000	16.6
3666.7	3	11	11000	27
3750	4	15	15000	20
4000	1	4	4000	75
4250	4	17	17000	17.7
4333.3	3	13	13000	23.5
4500	2	9	9000	33.3
4666.7	3	14	14000	21.4
5000	1	5	5000	60

Now if the calibrated oscillator dial is set on one of these check points and the frequency of the calibrated oscillator varied, by means of the TRIMMER capacitor, to zero beat the calibration of the wavemeter is correct at that point. The accuracy of the calibration at this point is now the same as the accuracy of the crystal calibrator frequency which is very high. If the TRIMMER is not disturbed the frequency of the calibrated oscillator may now be varied and the measurements taken. For the highest accuracy always use the crystal check point nearest to the dial setting at which the measurement will be made. For less accurate work it is only necessary to calibrate at the even 500 kc/s. points on the dial, which are marked in red.

25 - 5000 Kcs

IV OPERATION

4-1 GENERAL

4-1-1 GENERAL THEORY

Before attempting to operate this instrument be sure to study the Detailed Description, Section II, so as to become familiar with the general theory of operation.

4-2 FREQUENCY RANGE AND USES

4-2-1 Although the Type TE-149 Crystal Calibrated Wavemeter may be used for a number of different purposes, its use will generally fall in one of the following classifications:

(a) The determination of the frequency of a transmitter or oscillator which is operating on an unknown frequency.

(b) The adjustment of the frequency of a transmitter or oscillator to a desired frequency.

(c) The determination of the frequency to which a receiver is tuned or to measure the frequency of a received signal.

(d) The setting of a receiver on a desired frequency.

4-2-2 The fundamental frequency range of the calibrated oscillator is 2,500 to 5,000 kc/s. By utilizing the harmonics present in their output, transmitter frequencies as low as 200 kc/s. may be measured. Similarly by utilizing the harmonics of the calibrated oscillator, the frequencies of transmitters as high as 20,000 kc/s. may be determined.

4-2-3 By using the fundamental and harmonics of the calibrated oscillator, receiver frequencies between 2,500 and 20,000 kc/s. may be measured. Since good present day receivers do not radiate it is generally necessary to have a modulated test oscillator if receiver frequencies below 2,500 kc/s. are to be determined.

4-3 CONNECTIONS TO CHECK TRANSMITTER FREQUENCY

To make measurements of transmitter frequencies, sufficient input voltage may usually be obtained by connecting a small antenna, consisting of several feet of insulated wire, to the R.F. terminal on the front panel of the wavemeter. Never connect the wavemeter directly to the transmitter. For low-power transmitters or oscillators it may be necessary to place the pickup wire close to the antenna lead.

Always use the minimum coupling that will produce a satisfactory signal in the headphones since excessive input voltage may cause the calibrated oscillator to lock with the transmitter and reduce the accuracy of measurement.

3-2 MOUNTING

When the Type TE-149 Crystal Calibrated Wavemeter is installed in aircraft trucks, boats or mobile craft always use a Type TE-149 Shockproof Mounting Base.

The mounting dimensions of the shockproof base are given in Figure 7.

Use sixteen 6/32 machine screws or suitable woodscrews to fasten down shockmounts. Leave sufficient clearance around case so that it may vibrate freely without interference, ½" on all sides being sufficient.

When the equipment is mounted in aircraft fasten a piece of flexible braid to the bottom end of the stud coming out the centre of one of the shockmounts and ground to the mounting shelf.

Always leave sufficient space in front of the instrument to remove unit from its shockmounting.

3-3 CONNECTIONS

For fixed installations connect a short length of insulated wire of approximately #16 gauge to the HF terminal and place in the vicinity of the receiver antenna lead. A direct connection should not be necessary in the majority of cases. The lead may usually be left in this same position when checking the transmitter. Never connect this lead directly to the transmitter since this might damage the Wavemeter. X

Leave sufficient slack in the r-f lead so that the movement of the instrument on its shockmounting is not constrained.

Do not connect a tuned circuit between the R.F. terminal and ground. A high impedance circuit so connected may cause the mixer to oscillate and produce spurious beats.

4-4 CONNECTIONS TO CHECK RECEIVER FREQUENCY

For a sensitive receiver connect a length of insulated wire to the R.F. terminal and lay the other end near the receiver antenna lead.

If the receiver has a low gain it may be necessary to wrap the insulated wire directly around the antenna lead. A direct connection should only be necessary when frequencies above 10,000 kc/s. are being determined.

4-5 DETERMINING TRANSMITTER FREQUENCY

4-5-1 The operating frequency of a transmitter is determined as follows:

(a) Make connections to R.F. terminal as explained in Section 4-3, plug in headphones and turn OFF-ON switch to ON.

(b) Determine the approximate frequency of the transmitter. This may usually be done by referring to the transmitter dial or calibration. Sometimes it is convenient to use an absorption type wavemeter if the approximate frequency cannot be determined from the transmitter calibration.

(c) Place CALibrate-OPERate switch on OPERate. Slowly rotate dial across tuning range and note points where strong beats are obtained.

(d) Accurately determine the frequency of each beat by setting the CALibrate-OPERate switch on CALibrate, rotate the dial to the nearest crystal check point and reduce the audible beat to zero by rotating the TRIMMER control. Now, without disturbing the TRIMMER, set the CALibrate-OPERate switch on OPERate and turn the main dial back to the beat. When the beat is exactly zero-beat its exact frequency may be read directly from the dial.

(e) The transmitter frequency is an integral multiple or integral fraction of these beats and can be determined by finding the lowest common multiple for frequency above the fundamental range of the wavemeter or the highest common factor for frequencies below the fundamental range of the wavemeter. This relationship holds true if the strong beats only are used. These strong beats occur between the fundamental of the transmitter and harmonics of the wavemeter for frequencies above the fundamental range, and between harmonics of the transmitter and the fundamental of the wavemeter for frequencies below the fundamental range.

(e) Continued
Weak beats due to harmonics of the transmitter beating with harmonics of the wavemeter will not be integral multiples or fractions of the transmitter frequency. For example, if the transmitter is operating in the range of 2,500 to 5,000 kc/s. its frequency may be read directly on the dial of the wavemeter. When the transmitter is operating below 2,500 kc/s. the dial reading must be divided by the correct harmonic ratio. If the frequency is below 1666 kc/s. the correct frequency may be determined by the largest common factor between adjacent beats. When the transmitter is operating above 5,000 kc/s. the dial reading must be multiplied by the correct harmonic ratio to give the transmitter frequency.

(f) Turn the main power switch OFF after completing measurements.

4-5-2 Although it is unlikely, there are certain cases where the approximate frequency of a transmitter may be entirely unknown. The general method of determining such an unknown frequency is given below. However, before such measurements are attempted it is essential that the basic theory of heterodyne measurements is thoroughly understood.

(a) Make connections to R.F. terminal, plug in headphones and turn instrument on.

(b) Determine the frequency of all strong beats between 2,500 kc/s. and 5,000 kc/s.

(c) Find the largest common factor or smallest common multiple of these beats. For example, suppose that a number of strong beats are obtained across the dial at 2653, 3102, 3411 and 3790 kc/s., etc. The largest common factor of these frequencies (the difference between them) is 379 kc/s. which is the transmitter frequency.

As a second example, take the case where strong beats are obtained at 3144 and 4176 kc/s. The largest common factor of these frequencies is 1572 which is the transmitter frequency.

Should only one strong beat be obtained, say at 3472 kc/s., we know that the transmitter frequency must be 1736, 3472, 7944 or 10416 kc/s., etc. If the transmitter frequency is 1736 kc/s., weak beats will be noted at 2604 and 4340 kc/s. The 2604 kc/s. beat is the third harmonic of the transmitter beating against the second harmonic of the frequency meter while the 4340 kc/s. beat is the fifth harmonic of the transmitter beating with the second of the frequency meter. If a weak beat is heard at 4596 kc/s. in addition to the one strong beat at 3472, it indicates that the two fundamental frequencies are beating and that the transmitter frequency must be 3472 kc/s. The 4596 beat is the fourth harmonic of the transmitter beating with the third harmonic of the wavemeter.

(c) Continued
Now take the case where strong beats are obtained at 2714.3, 3166.7, 3800 and 4750 kc/s. The lowest common multiple of these frequencies is 19,000 kc/s. since 4x4750 = 5x3800 = 6x3166.7 = 7x2714.3 = 19,000 kc/s.

Suppose strong beats were obtained at 2500 and 3750 only, here the lowest common multiple is 7500 kc/s.

A little experience is essential when frequencies of a completely unknown value are being measured. However, as shown above, an unknown frequency can be identified by finding either the lowest common multiple or the highest common factor of the beats obtained across the dial provided these beats are between harmonics of the wavemeter and the fundamental of the transmitter for frequencies above 5000 kc/s. or between harmonics of the transmitter and the fundamental of the wavemeter for frequencies below 2500 kc/s. For frequencies between 1666 kc/s. and 5000 kc/s. only one strong beat will be obtained.

In all cases it is advisable to use the minimum input to the wavemeter that will give audible beats. This minimizes the possibility of higher order harmonics causing confusion.

(d) Turn the main power switch OFF after completing measurements.

4-6 SETTING A TRANSMITTER ON FREQUENCY

4-6-1 To adjust a transmitter or an oscillator to a desired frequency, the following procedure is used:

(a) Make connections to R.F. terminal as explained in Section 4-3, plug in headphones and turn OFF-ON switch to ON.

(b) When the desired frequency is between 2,500 kc/s. and 5000 kc/s., select the crystal check point nearest the required frequency. The recommended crystal check points are tabulated on the front panel. If the desired frequency lies outside of the 2,500 kc/s. to 5,000 kc/s. range, multiply or divide it by the smallest whole number that will bring it within the calibrated range of the wavemeter dial. Select the crystal check point nearest to the required frequency and set the main FREQUENCY dial on this point.

(c) Turn the CALibrate OPERate switch to CALibrate and adjust the TRIMMER for zero beat on the headphones.

(d) Turn the CALibrate-OPERate switch to OPERate.

(e) Set the main FREQUENCY dial on the desired frequency (or proper harmonic or subharmonic of it).

(f) Adjust the transmitter's oscillator to zero beat with the wavemeter.

(g) Turn the OFF-ON switch to OFF after completing measurements.

4-6-2 If an approximate calibration of the transmitter is not available and there is any doubt as to which harmonic is heard in the wavemeter, check the frequency as outlined in Section 4-5.

4-6-3 Use the minimum coupling that will produce a satisfactory signal in the wavemeter. Always make certain that the frequency measured is the output frequency and not some lower frequency drive stage or oscillator. After the transmitter has been completely tuned up check the operating frequency to make certain that subsequent tuning operations have not affected the oscillator frequency.

4-7 DETERMINING RECEIVER FREQUENCY

4-7-1 To determine the frequency of a received signal the following procedure should be followed.

(a) Make connections to the R.F. terminal, as explained in Section 4-4, plug in the headphones and turn OFF-ON switch ON.

(b) Tune the receiver so that the incoming signal is at zero beat on the receiver. Turn off the receiver beat oscillator if a CW signal is being received.

(c) Note the approximate frequency of the receiver dial setting and select the crystal check point nearest this frequency. If the receiver frequency is above the 2,500 kc/s. to 5,000 kc/s. range, divide the receiver dial reading by the smallest whole number that will bring it within the 2,500 kc/s. to 5,000 kc/s. range.

(d) Turn the CALibrate-OPERate switch to CALibrate.

(e) Set the main FREQUENCY dial of the wavemeter to the nearest crystal check point.

(f) Adjust the TRIMMER capacitor so that the check point is brought to zero beat in the headphones.

(g) Turn CALibrate-OPERate switch to OPERate and tune wavemeter slowly across the approximate frequency (or multiple thereof) of the receiver until a beat is heard in the receiver. Adjust the wavemeter dial until this beat is zero.

(h) Multiply or divide reading of FREQUENCY dial on wavemeter by appropriate harmonic to give frequency of received signal.

(i) Turn OFF-ON switch OFF after completing measurements.

V MAINTENANCE

5-1 GENERAL

If reliable and uninterrupted service is to be obtained with this equipment a regular inspection schedule must be set up and followed. Servicing personnel must be thoroughly familiar with the apparatus if intelligent maintenance is to be expected.

5-2 TOOLS

No tools other than those usually required for radio service are required to service the equipment.

5-3 LUBRICANTS

When a lubricant is required at a point that carries current such as switch contacts, coil bearings, etc., a mixture of 10% by volume Mark C.P. Lanolin (hydrous) dissolved in clean carbon tetrachloride is used. When not in use the mixture must be kept tightly sealed, otherwise the carbon tetrachloride will evaporate and the mixture will become sticky and unusable. Lanolin, in common with vaseline, has the property of reducing contact resistance as well as lubricating the contacts themselves. It is used in preference to vaseline, since it is cleaner and does not hold dirt and dust as readily. It is best applied with a camel hair brush and should be used sparingly. One application to a surface is sufficient and more only tends to make that surface sticky without doing any further good. In an emergency a small amount of vaseline may be used if the lanolin is not available.

For the front panel bearing a small quantity of vaseline is recommended in preference to lanolin.

Never lubricate the contact wheel, contact wheel or wire on the rotating coil with any lubricant whatsoever.

5-4 MAINTENANCE SCHEDULE

Since this is a calibrated precision instrument the less the amount of unnecessary servicing the better it will perform. The only items that should require attention are the batteries and rotating coil.

5-4-2 Every six months check the condition of the batteries. Replace the AB unit if the A voltage is less than 1.15 volts or the B voltage is less than 75 volts while the equipment is operating. If necessary, the battery may be left in until the A voltage is 1.1 volts or the B voltage is 67½ volts, but this is not recommended unless a replacement is not available.

4-7-2 If the receiver has a tuning meter, it may be used to indicate zero beat in lieu of using the audio beat. Zero beat is identified by a slow swinging motion of the meter pointer, or a slow opening and closing of the "magic-eye" tube image.

4-7-3 If the receiver frequency is below 2,500 kc/s., zero beat a test oscillator with the received signal and then determine the frequency of the test oscillator as explained in Section 4-5. This will give the frequency of the received frequency.

4-8 SETTING A RECEIVER ON FREQUENCY

4-8-1 To calibrate or set a receiver on a desired frequency, the following procedure should be employed in cases when the receiver is equipped with a beat oscillator:

(a) Make connection to the R.F. terminal as outlined in Section 4-4, plug in the headphones and turn the OFF-ON switch to ON.

(b) Select the crystal check point that is closest to the desired frequency or multiple thereof.

(c) Set main FREQUENCY dial on the crystal check point.

(d) Turn the CALibrate-OPERate switch to CALibrate and adjust TRIMMER capacitor to zero beat.

(e) Turn CALibrate-OPERate switch to OPERate.

(f) Turn main FREQUENCY dial to exact frequency required or mutiple thereof. Do not disturb TRIMMER capacitor.

(g) Turn on receiver beat oscillator and set at zero.

(h) Tune receiver to the point where the signal from the wavemeter is at zero beat in the receiver output. The receiver will now be on the desired frequency.

(i) Turn the OFF-ON switch OFF after completing measurements.

4-8-2 If the frequency of the receiver is outside of the 2,500 to 5,000 kc. range, always make sure that the proper harmonic of the wavemeter is being used. The approximate calibration of the receiver should make this easy to determine.

4-8-3 If the receiver is not equipped with a beat oscillator, zero beat with the wavemeter may be determined by the tuning meter, receiver blocking or a sudden decrease in background noise. However, the best method to use in this case is to resonate a modulated test oscillator with the wavemeter and then resonate the receiver to the modulated oscillator with due regard to any harmonics being employed.

VI LOCATION AND REMEDY OF FAULTS

6-1 GENERAL

The TE-149 Crystal Calibrated Wavemeter is a comparatively simple piece of equipment with few component parts, therefore, faults are unlikely to occur. Before assuming that the instrument is at fault when it fails to operate or operates improperly, first check the position of the controls and make sure that the transmitter being checked is actually delivering a signal. A good check is to operate the equipment as when calibrating. If the beats are strong the wavemeter is probably operating satisfactorily and the fault lies elsewhere.

6-2 FAULTS

6-2-1 Beats are weak on both OPERate and CALibrate.

Location:

(a) Check battery voltages with equipment operating. Replace if A voltage is below 1.15 or B voltage below 75.

(b) Substitute new valves one at a time commencing with V3 (1Q5GT).

6-2-2 Beats are weak on OPERate and strong on CALibrate.

Location:

(a) Make certain that sufficient signal voltage is applied to the RF terminal.

(b) Check continuity of switch S1 in the OPERate position.

(c) Check condition of C6, C7, and R2.

6-2-3 No beats are heard on CALibrate.

Location:

(a) Check batteries.

(b) Check continuity of S1 in the CALibrate position.

(c) See that no foreign matter is lodged between the plates of trimmer capacitor C8 short-circuiting it.

Once a year replace all batteries. This includes the C battery.

Never leave discharged batteries in the instrument since they may expand and make removal difficult.

6-4-3 Once a year carefully clean the contact wheel, contact wheel rod, and rotating coil wire with a piece of soft clean cloth dampened with carbon-tetrachloride. Test all tubes.

If noisy operation should develop when the tuning dial is slowly rotated it may be necessary to clean these parts more frequently as required to ensure quiet operation.

5-5 WARNING

Never tamper with the crystal frequency trimmer C8 or oscillator tank trimmer C14 unless facilities are available for resetting the frequency. These should require no attention in the field unless the equipment has been damaged.

VII VOLTAGE DATA

The information listed below is for the convenience of service personnel only. It should be realized the voltages obtainable depend upon the condition of the batteries. Therefore, the following values are indicative only when fresh batteries are in use:

Filament Voltage	1.5	Volts
High Voltage Supply	90	"
Mixer Plate	90	"
Mixer Screen	43	"
C Bias for 1Q5GT	4.5	"
Audio Amplifier Plate	90	"
Audio Amplifier Screen	90	"

6-2-4 Noise is heard in headphones when dial is rotated

Location:

With a clean soft cloth dampened with carbon tetrachloride carefully clean the contact wheel on the rotating coil L2 and the surface of the wire. Also clean the shaft on which the contact wheel rotates.

6-2-5 Noise is heard in headphones when dial is stationary.

Location:

Change the C battery E1.

NOMENCLATURE	SYMBOL	FUNCTION
Inductances:-		
Fixed:-		
0.25 millihenry	L3	Crystal Oscillator Tank
0.4 millihenry	L1	Calibrated Oscillator Plate Feed
Variable:-		
8 microhenry	L2	Calibrated Oscillator Tank
Jacks, single circuit	J1	Audio Output
Plugs, battery, 4-point	P2	A & B Battery Connection
Resistors, No. 3-A, ½-watt:-		
22,000 ohms	R1	Calibrated Oscillator Grid
33,000 ohms	R2	High Pass Input Filter
33,000 ohms	R5	Mixer Screen Voltage Dropping
150,000 ohms	R4	Mixer Signal Grid
330,000 ohms	R3	Crystal Oscillator Grid
560,000 ohms	R6	Amplifier Grid
Switches, rotary, 2-pole, 2-way	S1	Calibrate - Operate
Switches, rotary, 2-pole, 2-way	S2	OFF - ON
Terminals, instrument, Eby	P1	R.F. Input
Transformers, A.F. 25,000 to 150/600 ohms	T1	Output
Valves, W.T., type:-		
1A7GT	V2	Crystal Oscillator and Mixer
1N5GT	V1	Calibrated Oscillator
1Q5GT	V3	Audio Amplifier

VIII PARTS LIST

8-1 LIST OF ELECTRICAL COMPONENTS FOR EACH WAVEMETER

NOMENCLATURE	SYMBOL	FUNCTION
Batteries, dry, wavemeter, crystal, calibrated:-		
AB	E2	Filament and Plate
C	E1	Amplifier Grid Bias
Chokes, A.F., 130 H. at 0.003 amp., D.C.	L4	Mixer Output Filter & Coupling
Condensers:-		
0.000005 mfd., ± 10% 500 V., D.C.	C9	Calibrated Oscillator Coupling
0.0000185 mfd., ± 5% 500 V., D.C.	C1	Temperature Compensator
0.000025 mfd., ± 20% 500 V., D.C.	C15	Crystal Oscillator Feedback
0.00005 mfd., ± 10% 500 V., D.C.	C6	R.F. Input Blocking
0.00005 mfd., ± 10% 500 V., D.C.	C7	High Pass Input Filter
0.0005 mfd., ± 10% 500 V., D.C.	C4	Calibrated Oscillator Grid
0.00095 mfd., ± 2% 500 V., D.C.	C2	Calibrated Oscillator Tank
0.00095 mfd., ± 2% 500 V., D.C.	C3	Calibrated Oscillator Tank
0.01 mfd., ± 20% 300 V., D.C.	C10	B Battery Bypass
0.01 mfd., ± 20% 300 V., D.C.	C12	Mixer Output Filter
0.01 mfd., ± 20% 300 V., D.C.	C13	Amplifier Grid Coupling
0.5 mfd., ± 10% 200 V., D.C.	C11	Mixer Screen Bypass
Variable:-		
Air, trimmer:-		
0.000003 to 0.0000175 mfd.	C5	Calibrated Oscillator Trimmer
0.000003 to 0.000025 mfd.	C8	Crystal Frequency Trimmer
Ceramic, trimmer:-		
0.000003 to 0.000012 mfd.	C14	Oscillator Tank Trimmer
Crystals, in holder, 1000.00 kc/s., ± 0.005% (V-cut low temperature co-efficient)	Y1	Calibrator
Holders, valve, octal, 8-pin:-		
Bakelite	X3	Amplifier Valve Holder
Steatite	X1	Calibrated Oscillator Valve Holder
Steatite	X2	Mixer Valve Holder

NOMENCLATURE	QTY	REPLACEMENT FOR
Studs, brass, 6/32 x 1-1/4 in.	1	P1 stud
Switches, rotary, 2-pole, 2-way	1	S1, S2
Terminals, instruments, Eby	1	P1

N O T E

(a) Replacement for X3 is normally Holders, valve, octal, 8 pin, bakelite

(b) Boxes for spare valves are included in this box of minor spare parts; however, valves, if included, are to be accounted for seperately and are not to be considered as components of the sets of minor spare parts. Similarly, if valves are supplied in the Wavemeter, crystal calibrated, they are to be accounted for separately.

8-2 RECOMMENDED PRIMARY (MINOR) SPARE PARTS FOR EACH WAVEMETER

NOMENCLATURE	QTY	REPLACEMENT FOR
Bushes:-		
Female:-		
Isolantite, No. 923	1	Oscillator choke bush
No. 925	1	Input terminal bush
Male:-		
Isolantite, No. 903	1	Oscillator choke bush
No. 905	1	Input terminal bush
Condensers:-		
0.000085 mfd., ± 10% 500 V., D.C.	1	C9
0.0000185 mfd., ± 5% 500 V., D.C.	1	C1
0.000025 mfd., ± 20% 500 V., D.C.	1	C15
0.00005 mfd., ± 10% 500 V., D.C.	1	C6, C7
0.0005 mfd., ± 10% 500 V., D.C.	1	C4
0.00095 mfd., ± 2% 500 V., D.C.	1	C2, C3
0.01 mfd., ± 20% 300 V., D.C.	1	C10, C12, C13
0.5 mfd., ± 10% 200 V., D.C.	1	C11
Handles, bakelite, bar	1	Panel bar handle
Holders, valve, octal, 8-pin, Steatite	1	X1, X2, X3 (a)
Inductances, fixed, 0.4 m H	1	L1
Plugs, battery, 4-point	1	P2
Resistors, No. 3A, 1/2 watt:-		
22,000 ohms	1	R1
33,000 ohms	1	R2, R5
150,000 ohms	1	R4
330,000 ohms	1	R3
560,000 ohms	1	R6
Screws, machine, brass, binding head:-		
6/32 x 1/4 in.	4	Panel retaining screw

NOMENCLATURE	QTY	REPLACEMENT FOR	PACKED IN BOX NO.
Handles, bakelite:-			
Bar	3	Panel bar handles	6
Round	1	Main tuning handle	6
Inductances:-			
Fixed:-			
0.25 m H	1	L3	2
0.4	1	L1	2
Variable:-			
8 u H	1	L2	2
Jacks, single circuit	1	J1	1
Plugs, battery, 4-point	1	P2	4
Resistors, No. 3A, 1/2 watt:-			
22,000 ohms	1	R1	4
33,000 ohms	2	R2, R5	4
150,000 ohms	1	R4	4
330,000 ohms	1	R3	4
560,000 ohms	1	R6	4
Screws, machine, brass, binding head:-			
6/32 x 1/4 in.	8	Panel retaining screws	6
Studs, brass, 6/32 x 1-1/4 in.	1	P1 stud	6
Switches, rotary, 2 pole, 2 way	2	S1, S2	4
Terminals, instrument, Eby	1	P1	4
Transformers, A.F., 25,000 to 150/600 ohms	1	T1	3

8-3 RECOMMENDED SECONDARY (MAJOR) SPARE PARTS FOR EVERY 10 WAVEMETERS

NOMENCLATURE	QTY	REPLACEMENT FOR	PACKED IN BOX NO.
Bushes:-			
Female:-			
Isolantite, No. 923	1	Osc. choke bush	6
No. 925	1	Input terminal bush	6
Male:-			
Isolantite, No. 903	1	Osc. choke bush	6
No. 905	1	Input terminal bush	6
Chokes, A.F., 130 H. at 0.003 amp., D.C.	1	L4	3
Clips, grid, valve	2	Grid clip on V1, V2	4
Condensers:-			
0.000005 mfd., ± 10% 500 V., D.C.	1	C9	1
0.0000185 mfd., ± 5% 500 V., D.C.	1	C1	1
0.000025 mfd., ± 20% 500 V., D.C.	1	C15	1
0.00005 mfd., ± 10% 500 V., D.C.	2	C6, C7	1
0.0005 mfd., ± 10% 500 V., D.C.	1	C4	1
0.00095 mfd., ± 2% 500 V., D.C.	2	C2, C3	1
0.01 mfd., ± 20% 300 V., D.C.	2	C10, C12, C13	1
0.5 mfd., ± 10% 200 V., D.C.	1	C11	1
Variable:-			
Air, trimmer:-			
0.000003 to 0.0000175 mfd.	1	C5	1
0.000003 to 0.000025 mfd.	1	C8	1
Ceramic, trimmer:-			
0.000003 to 0.000012 mfd.	1	C14	1
Crystals, in holder, 1000.00 kc/s., ± 0.005% (V-cut low temperature co-efficient)	1	Y1	5
Holders, valve, octal, 8-pin:-			
Bakelite	1	X3	6
Steatite	1	X1, X2	5

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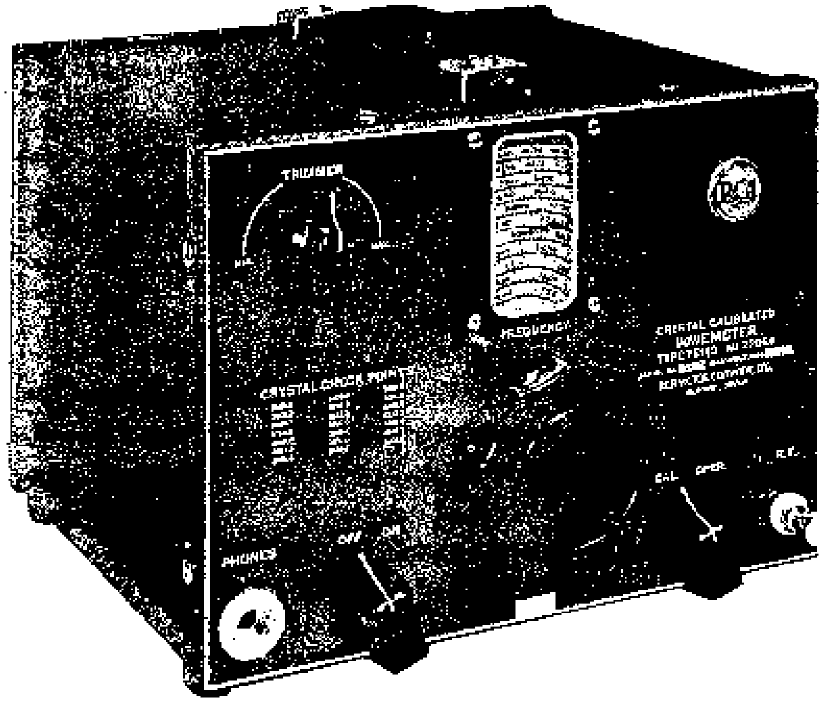
TEXT



Frontpiece—Photograph 149-1
Type TE-149 Crystal Calibrated Wavemeter.

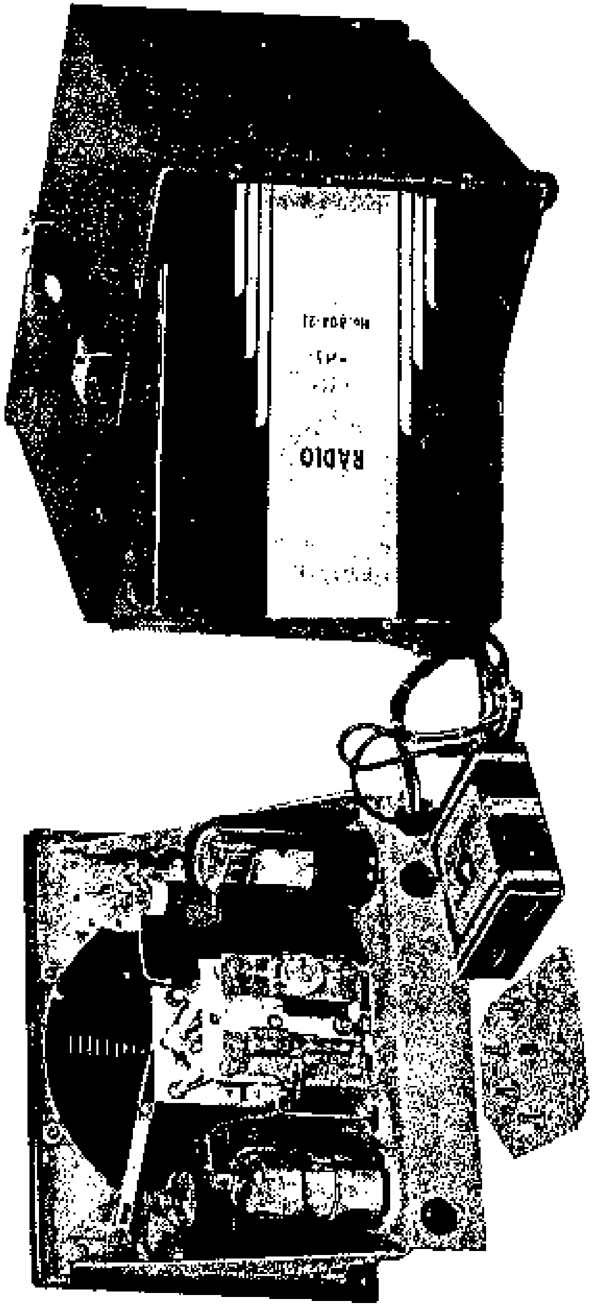


Figure 1—Photo 149-2
Wavemeter, Removed From Case.

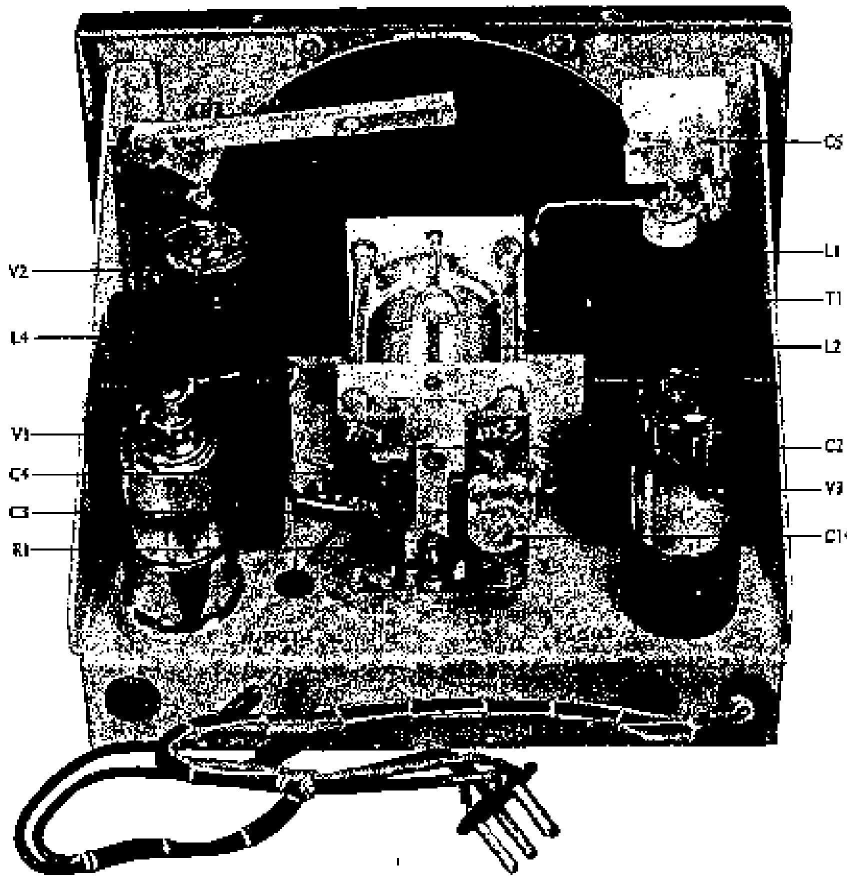


Figure 2—Photo 149-3
Rear View of Wavemeter Chassis.

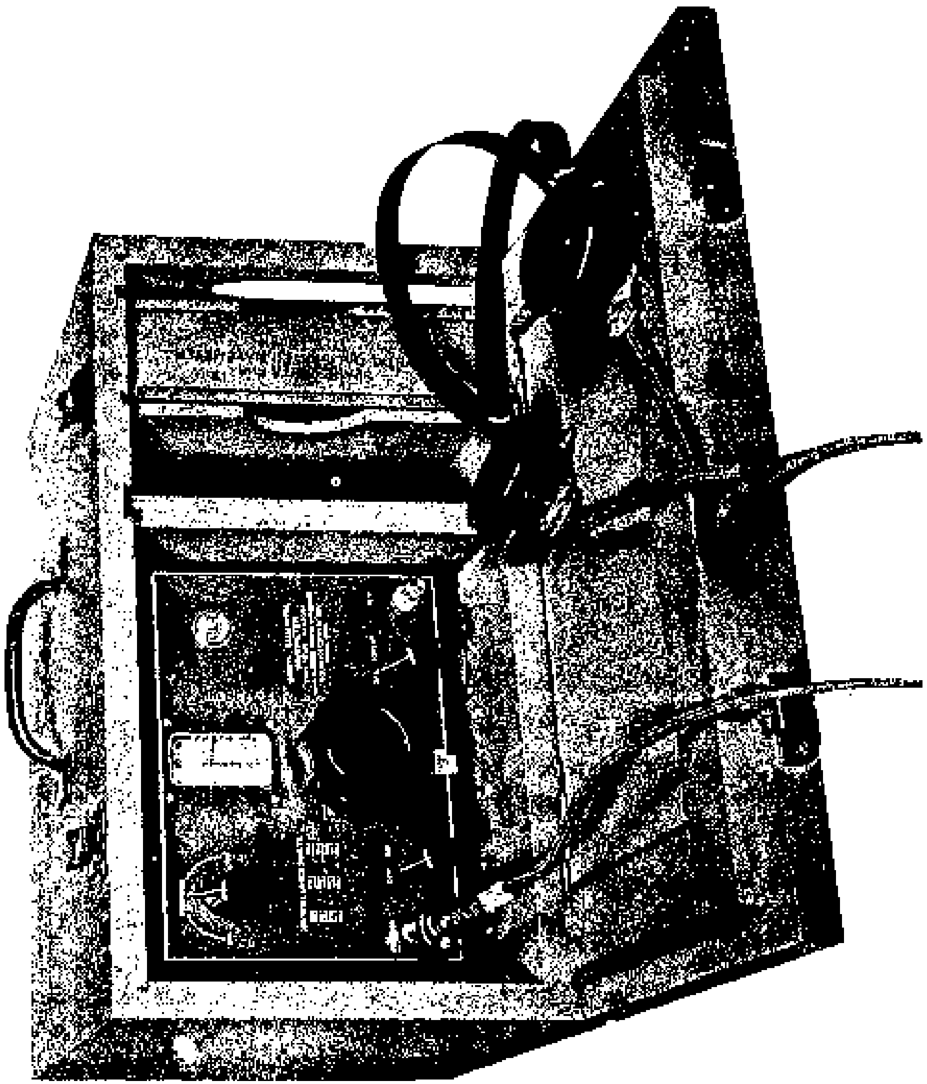


Figure 4—Photo 149-5
Wavemeter in Field Carrying Case.

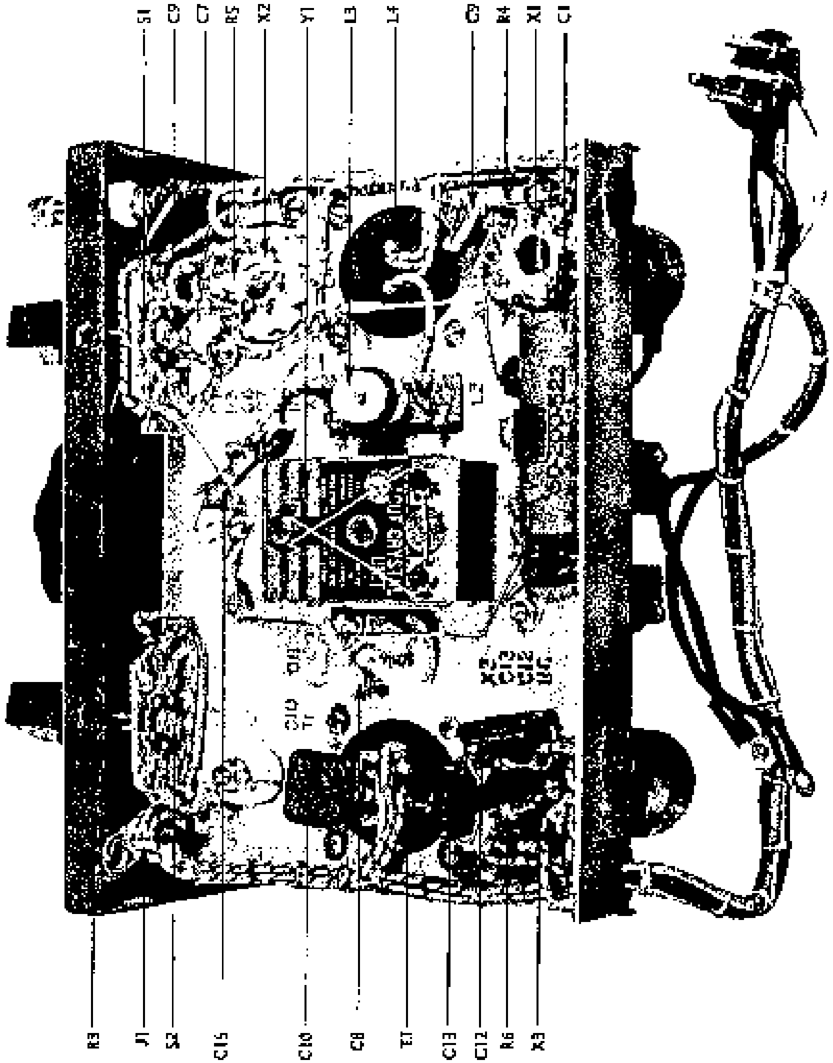


Figure 3—Photo 149-4
Bottom View of Wavemeter Chassis

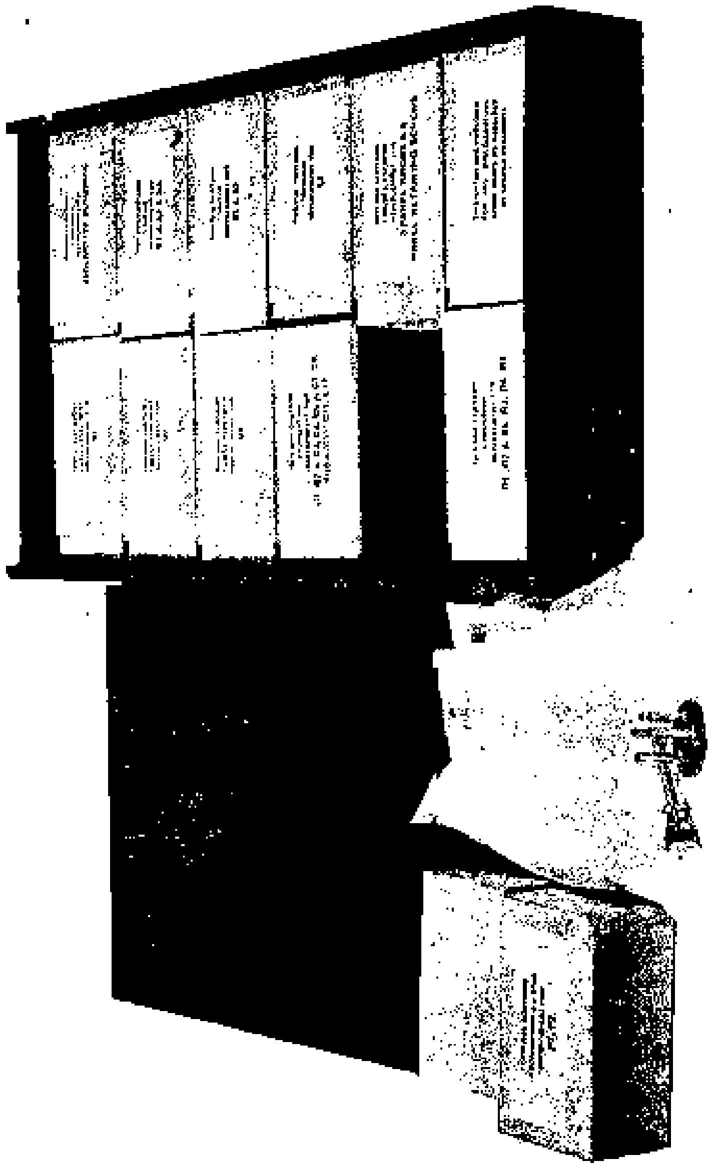


Figure 5—Photo 149-6
Primary (Minor) Spare Parts.

OPERATING PERSONNEL PLEASE NOTE

ALWAYS RETURN MAIN POWER SWITCH TO OFF AFTER USING EQUIPMENT. TO LEAVE IT ON FOR EXTENDED PERIODS WILL DISCHARGE BATTERY.

DESPITE ITS SIMPLICITY THIS IS A PRECISION INSTRUMENT. TREAT IT ACCORDINGLY.

DO NOT DISTURB TRIMMER CAPACITORS C8 AND C14.

DRAWINGS

DIAGRAMS

Description	Reference
Type AVA-35 Headphones, low impedance complete with headband, cord and plug.	MI-5803-3
Type TE-149 detachable Shockproof Mounting Base for aircraft and mobile installations.	MI-22066
Type TE-149 Primary (Minor) Spare Parts suitably packed in a light wooden box. These spare parts are recommended for each equipment when used for field service.	MI-22098
Type TE-149 Secondary (Major) Spare Parts suitably packed in rugged wooden box. One set of these spare parts is recommended for every ten equipments when used for field service.	MI-22095
Type TE-149 Wooden Carrying Case for military field use. Space is provided for the Type TE-149 Crystal Calibrated Wavemeter on a shockproof mounting, phones, primary spare parts, instruction book and other small items. The Type TE-149 Shockproof Mounting Base is included as a part of this case.	MI-22099

1-4 ELECTRICAL CHARACTERISTICS

1-4-1 OVERALL ACCURACY

Any frequency within the range of the equipment may be determined with an error not exceeding + 0.02% when used under average operating conditions and as directed in Operation, Section IV.

1-4-2 FREQUENCY RANGE

This equipment has been designed primarily to provide an accurate determination of frequency of transmitters and receivers over the frequency range of 2.5 to 20 megacycles. The fundamental frequency range covered by the calibrated oscillator is 2.5 to 5.0 megacycles. For frequencies from 5 to 10 and from 10 to 20 megacycles the second and fourth harmonic respectively are used. In addition, by utilizing the harmonics in the output, the frequency of transmitters operating between 250 kc/s. and 2.5 megacycles may be readily determined.

1-4-3 AUDIO OUTPUT

Since practically all frequency measurements are made at or near "zero beat" the design is such that the higher audio frequencies are sharply attenuated while excellent response is obtained at the lower frequencies. This minimizes extraneous noise and increases useability since

I INTRODUCTION

1-1 FUNCTION

This Crystal Calibrated Wavemeter is intended for portable,mobile and aircraft services for accurately calibrating or determining the frequency adjustments of transmitters and receivers. This equipment is designed and constructed to perform satisfactorily under the extreme conditions encountered in such services. It is a precision instrument designed for rapid and efficient use in the hands of regular service personnel.

1-2 COMPONENT PARTS

Each frequency measuring equipment consists of the following major components:

Quantity	Description	Reference
1	Type TE-149 Crystal Calibrated Wavemeter complete with crystal, but less valves and batteries. Olive drab finish. Special phone jack for Royal Canadian Corps of Signals.	MI-22064
1	Type TE-149-B Crystal Calibrated Wavemeter complete with crystal, but less valves and batteries. Air Force blue finish. Standard phone jack with provision for additional special output connections.	MI-22100
1	Set of valves consisting of: 1 - 1A7GT 1 - 1N5GT 1 - 1Q5GT	
1	Set of batteries comprising: 1 - General 60A2L A & B Battery 1 - General E3BF C Battery	

1-3 ACCESSORIES

To complete an installation one set of low impedance (150 to 600 ohm) headphones are necessary. The additional accessories listed below are available for specialized services:

special hookup wire, suitable impregnation of inductances and ceramic insulation provide stable operation for long periods in atmospheres of high relative humidity. An increase in relative humidity from 25 to 90 ± 5% at a constant temperature of 50 ± 3°C. causes a shift in frequency of less than 0.005%.

(e) Utmost care has been exercised to provide a simple and rugged circuit. This results in a frequency shift of less than 0.001% when the equipment is vibrated four hours at a frequency of 60 c.p.s. with an amplitude of 5 G.

(f) The shift in frequency caused by lowering the surrounding pressure at constant temperature, from normal to that existing at 25,000 feet of altitude is less than 0.0025%. No parts are used that will fail at this reduced pressure.

(g) When the crystal oscillator valve is replaced by valves of similar type and manufacture which are within the manufacturers' maximum-minimum limits, the frequency shift is less than 0.001%. It should be pointed out that the average shift will be approximately 0.0005%.

(h) High quality parts and simple circuits are used throughout so that with normal aging of components the frequency should shift less than 0.0005% under identical conditions of measurement.

(i) When set at the factory the absolute frequency of the quartz crystal will be within 0.005% of 1,000 kc/s. Under normal operating conditions experience has shown that the frequency deviation is less than 0.01% for any algebraic summation of the frequency deviations as listed in paragraphs (b) to (h) inclusive. Should the equipment be accidentally damaged so that the crystal calibrator circuit is affected the calibrator may be quickly set back on frequency in the field by checking against any standard source of 1,000 kc. (or harmonic multiples thereof) such as another frequency meter or standard frequency transmissions if such are available. This adjustment is made by means of a small trimmer condenser (C8) across the crystal which is permanently locked after adjustment.

(j) The design of this equipment is such that the application of 1 volt of r-f voltage to the input terminal will not cause blocking or appreciable interlocking of the circuits.

"zero beat" may be more easily determined permitting precise determination of a frequency. All audio output measurements are made at the audio frequency of maximum output which is approximately 100 cycles.

An r-f voltage of 0.5 volts applied to the input terminal will produce a minimum of 100 mw. audio output into the proper load impedance over the frequency range of 2.5 to 5 mc/s. Between 5 and 20 mc/s. the output decreases, but is sufficient to permit satisfactory use.

The maximum audio output obtainable is approximately 200 mw.

1-4-4 R.F. OUTPUT

Approximately 10 millivolts is available on the "R.F." terminal for checking receivers. The r-f output is unmodulated.

1-4-5 CRYSTAL CALIBRATOR PERFORMANCE

The rugged simplicity of the calibrator circuit insures a maximum of precision during the entire life of the equipment. The electrical design is such that changes in the circuit components due to temperature, humidity, vibration and aging have a minimum affect on the crystal frequency. The circuit components themselves are of the best and most suitable materials now available. Ceramic insulation has been liberally used. A standard low drift V-cut crystal in a hermetically sealed ceramic crystal holder permanently installed as an integral part of the equipment provides stable and trouble-free operation. The individual sources of deviation may be tabulated as follows:

(a) The total warm-up drift from a cold start is less than 0.001% and after the first 30 seconds is less than 0.0001%. This fine performance means that no long waits for warming up are necessary. The equipment can be turned on and used immediately.

(b) A decrease of battery voltages from 90 to 67½ volts on the plates and from 1.5 to 1.1 volts on the filaments causes the frequency to shift less than 0.0005%. Therefore, aging batteries will have no appreciable affect on the accuracy of the equipment. However, in actual service the batteries should never be allowed to reach this extremely low voltage if reliable and satisfactory service is to be expected.

(c) The overall frequency drift with changing ambient temperature is less than 2 cycles/mc/°C. over the temperature range of -30°C. to +55°C. Thus for any 30°C. the drift is less than 0.006%. This is the largest and most important source of crystal frequency variation and every effort is made to minimize this factor.

the precise determination of zero beat. External circuits tied to the input cause inappreciable reaction with the frequency calibration, being less than 0.0005%.

(j) Under identical conditions of measurement the error caused by resetability is less than 0.005%. The dial is driven through a positive friction drive that results in a smooth tuning operation. The tuning knob is of adequate size to comfortably grasp, turns smoothly and easily which is conducive to a maximum of mental ease when operating the unit. The dial is calibrated every kilocycle from 2.5 to 5 mc/s.

1-4-7 POWER REQUIREMENTS

The filament drain is approximately 200 ma. at 1.5 volts, while the plate and screen circuits require approximately 12.5 ma. at 90 volts. No current is drawn from the C battery.

1-4-8 POWER SUPPLY

The power supply consists of a combination AB battery and one C battery. Either a General 60A2L and H3BF or a Burgess 5DA60 and 5360 may be used. These batteries are included inside the case to provide a completely self-contained piece of equipment and will provide approximately 120 hours of service when used a maximum of 4 hours a day. The A battery is heavy enough so that should it be inadvertently left on for longer periods the battery life will not be materially shortened. The 120 hours of battery service is based on an end point of 67½ volts for the B battery and 1.1 volts for the A battery.

In general, dry batteries freeze at approximately -24°C. This equipment may be used at lower temperatures if the batteries are not allowed to remain in this colder ambient long enough to freeze.

1-5 GENERAL DESCRIPTION

1-5-1 GENERAL

The Type TE-149 Crystal Calibrated Wavemeter is completely self-contained in a metal case and is provided with a rugged carrying handle. All controls are located on the front panel.

The design of this equipment is such that even though various factors may influence the frequency calibration of the variable oscillator, it can always be brought back on frequency by means of a small tuning condenser used in conjunction with the crystal calibrator. This permits a simple design which results in a material saving manufacturing cost which in turn reduces the selling price. However, the oscillator is ruggedly built of the finest and most suitable materials available to ensure reliable and trouble-free operation. Isolantite insulation is employed in the main tuning coil and valve socket. The performances listed below are only an indication of the performance of the oscillator and should not be confused with the overall accuracy of the frequency meter. Any improvement made in the performance as listed below would be entirely unwarranted since the additional expense and complication would yield no increased overall accuracy.

(a) From a cold start the total warmup drift is less 0.01% and after the first 30 seconds is less than 0.0025%. This means that no long warming up periods are necessary.

(b) The total uncorrected shift in frequency caused by the battery voltages dropping from 90 to 67½ volts and 1.5 to 1.1 volts is less than 0.01%.

(c) Variations in ambient temperature of 30°C. within the range of -30°C. to +55°C. will cause an uncorrected frequency shift of less than 0.05%.

(d) Varying the relative humidity from 25% to 90 ±5% at constant temperature causes an uncorrected shift in frequency of less than 0.05%.

(e) Four hours of continuous vibration at 60 c.p.s. with an amplitude of 5 G. will cause the frequency calibration to shift less than 0.01%. No operational failures will result from this vibration.

(f) The frequency will not shift by more than 0.01% between sea level and 25,000 feet altitude, other conditions remaining the same.

(g) When the master oscillator valve is replaced by valve of similar type and manufacture within the manufacturers' maximum-minimum limits, the uncorrected frequency shift is less than 0.05%.

(h) Normal aging is impossible to measure and is of no real significance since any variations are always corrected when the variable oscillator is calibrated against the standard frequency of the crystal. The trimmer capacitor used in the calibrated oscillator is of adequate size to take care of any and all of the individual variations as listed in paragraph (b) to (g) inclusive.

To facilitate servicing, all wiring is color coded. The color code used is as follows:

Black - Ground and negative filament

Brown - Positive filament

Green - Grid and bias circuits

Red - Positive high voltage

Blue - Plate circuits

Orange - Screen circuits

Special low loss insulation is used on all insulated wiring where practical to minimize losses.

1-5-6 EXTERNAL CONNECTIONS

For general use in the field the only external connection necessary is a light wire connected to the RF terminal on the front panel.

This wire need not connect to the transmitter or receiver being checked but is used solely as an antenna.

When installed in aircraft and trucks it is recommended that the shockproof base be grounded by a short length of flexible braid or wire.

1-5-7 CONTROLS

All controls are grouped on the front panel and are at ground potential. These are:

OFF-ON switch

CALibrate-OPERate switch

TRIMMER capacitor

TUNING control

1-5-8 IDENTIFICATION OF COMPONENTS

Each electrical component of the equipment is identified by a letter and a number. The letter indicates the type of part while the numbers differentiate between similar parts. In this equipment the following code has been used:

C - Capacitors

E - Batteries

J - Jacks

L - Inductors

The Type TE-149 Crystal Calibrated Wavemeter is approximately 6-25/32 inches high, 8-3/16 inches wide and 9-3/8 inches deep. These are overall dimensions and include all projections.

Outline Drawing Figure 6 shows the principle dimensions. When used with the shockproof mounting base the height is increased to 7-9/32 inches and the depth to 9-7/16 inches.

Mounting dimensions for the shockproof mounting base are given on shockproof Mounting Dimensions Drawing Figure 7.

The wooden carrying case for field use is approximately 10-15/16 inches high, 16-3/16 inches wide and 12 inches deep when closed. These dimensions include all projections. The outline and principle dimensions are given in Carrying Case Outline Drawing Figure 8.

1-5-3 WEIGHTS

TE-149 Crystal Calibrated Wavemeter complete with valves, crystal and batteries	13 pounds
TE-149 Shockproof Mounting Base	3/4 pound
TE-149 Primary Spare Parts	2½ pounds
TE-149 Wooden Carrying Case (including Type TE-149 Shockproof Mounting Base)	17 "
AYA-35 Headphones	3/4 pound

1-5-4 CONSTRUCTION

The case and chassis of the Crystal Calibrated Wavemeter are ruggedly constructed of aluminum. Rivetting is extensively employed to prevent the possibility of parts becoming loose in the field. However, the design is such that all parts are readily accessible and any part that might possibly require replacement may be quickly and easily removed.

This equipment is constructed of the best materials suitable for each specific application. Non-inflammable material has been used whenever practicable.

All metal parts are suitably protected whenever possible from the effects of saltwater corrosion. The exterior is finished with a durable wrinkle, while the interior is protected by clear lacquering. Nickel silver and nickled brass parts are extensively employed. No ferrous materials are used except in magnetic circuit cores which are suitably protected.

The primary spare parts box, secondary spare parts box and carrying case for field use are constructed of wood suitably protected by a weather resistant paint.

II DETAILED DESCRIPTION

2-1 GENERAL

The TE-149 Crystal Calibrated Wavemeter consists basically of a calibrated variable frequency oscillator, a crystal controlled oscillator, a mixer or detector in which the output of the calibrated oscillator may be compared with either an externally introduced signal or the output of the crystal oscillator, and an audio amplifier feeding a pair of headphones by means of which an audible beat between the two signals entering the detector may be heard and zero beat determined.

Self-contained batteries supply both filament and plate voltages.

The design and functions of the various circuits will now be covered in detail.

2-2 ELECTRICAL CIRCUITS

Valve V1 (a triode-connected pentode type 1N5GT) is the calibrated oscillator. It is connected in a Colpitts circuit with capacitors C2 and C3 dividing the tank voltage between the plate and grid circuits. The frequency is varied by means of the variable inductor L2. Capacitor C1 has a negative temperature coefficient and compensates for the positive temperature coefficient of the inductor L2, thus keeping the calibration of the oscillator more nearly constant with changing ambient temperature. Capacitor C14 is a ceramic type trimmer which is adjusted and sealed at the factory to compensate for variations in stray circuit capacity between individual wavemeters. It should never be disturbed. Variable capacitor C6 is controlled by the knob marked TRIMMER on the front panel and is used to set the calibrated oscillator exactly to zero-beat with the crystal oscillator at one of the check points on the dial. Capacitor C4 blocks the plate voltage from the grid of the tube and in combination with R_1 supplies grid-leak bias. Plate voltage is fed through radio-frequency choke L1 since both sides of the tank circuit are above ground. Capacitor C10 by-passes the plate supply to ground for r-f.

The output of the calibrated oscillator is coupled very loosely by means of capacitor C9 which is only 5 micromicrofarads and resistor R4 to the first grid of valve V2. Valve V2 is a pentagrid converter, type 1A7GT, and functions both as a calibrating crystal oscillator and mixer.

When the CALibrate-OPERate switch S1 is in the CALibrate position, the 1,000 kc/s. crystal Y1 is connected to the fourth grid of V2 and the input circuit is grounded. Under these conditions the crystal will oscillate since inductor L3 in the plate circuit is adjusted to provide the proper impedance and feedback to the grid occurs through capacitor

P - Connectors and Terminals

R - Resistors

S - Switches

T - Transformers

V - Valves

X - Sockets

Y - Crystals

The identifying symbol of each part is stencilled adjacent to it in the equipment.

The description and characteristics of each part are listed in the Parts Lists, Section VIII, where all parts are indexed according to symbols, being arranged alphabetically and numerically.

The Schematic Diagram of the Crystal Calibrated Wavemeter is given in Figure 9.

1-6-9 VALVE COMPLEMENT

The valves used for the different services in the TE-149 Crystal Calibrated Wavemeter are:-

Service	Quantity	Type
Calibrated Oscillator	1	1N5GT
Crystal Oscillator and Mixer	1	1A7GT
Audio Amplifier	1	1Q5GT

Theoretically a beat will occur whenever

$$Af_o = Bf_x$$

where

A = any whole number

B = any whole number

f_c = Frequency of calibrated oscillator (2,500 to 5,000 kc/s.)

f_x = The second or unknown frequency

Transposing: $f_c = \frac{B}{A} f_x$

The significance of this relation lies in the fact that whenever the quantity $\frac{B}{A} f_x$ is between 2,500 and 5,000 kc/s. a beat should be heard on the wavemeter dial at that point. However, in actual practice the beats become so weak as to be inaudible if A exceeds 6 or 7 and B exceeds 15 to 20 depending upon the magnitude of the input voltage. Stated in another manner it may be said that in general up to the 6th or 7th harmonic of the calibrated oscillator may be used and up to the 15th or 20th harmonic of the external signal may be used.

2-3-2 The wavemeter contains an oscillator calibrated from 2,500 to 5,000 kc/s. and a 1,000 kc/s. crystal oscillator for checking the calibration of this oscillator. Since factors such as temperature, humidity, vibration, changing voltages, etc. will slightly affect the calibration of the oscillator some means must be used to correct these variations so that the calibration is always within the accuracy required. This is accomplished by comparing the harmonics of the 1,000 kc/s. crystal oscillator with the fundamental or harmonics of the calibrated oscillator. These check points are obtained at the following frequencies and are a result of the various harmonics listed beating together:

Osc. Freq.	Osc. Har.	Xtal. Har.	Beat Freq.
2500	2	5	5000
2571.4	7	18	18000
2600	5	13	13000
2666.7	3	8	8000
2750	4	11	11000
2800	5	14	14000
2833.3	6	17	17000
3000	1	3	3000
3200	5	16	16000

C15. Resistor R3 is the crystal oscillator grid leak. Variable capacitor C8 is used to set the crystal oscillator frequency to within .005 percent of 1000 kc/s. It is adjusted and locked at the factory and should not be disturbed unless it is necessary to change crystals in the field.

With switch S1 in the OPERate position the crystal is disconnected and grounded and the input terminal is connected to the fourth grid via a high-pass filter network consisting of capacitors C6 and C7 and resistor R2. The purpose of the high-pass filter is to prevent voltages induced in a lead connected to the input terminal by low-frequency a-c fields (from a power transformer for example) from being impressed on the grid of the mixer valve and causing hum.

When the fundamental or harmonic of the calibrated oscillator frequency is near that of the signal or a harmonic of the signal impressed on the fourth grid (either from an external source or from the crystal) the plate current of the mixer valve will fluctuate at an audible rate and a voltage will be set up across reactor L4 and transferred via coupling capacitor C13 and grid resistor R6 to the grid of the audio amplifier tube V3. Since only the low audio frequencies are of value in determining when the two radio frequencies applied to the mixer tube are identical (zero-beat) the high audio frequencies are attenuated by means of capacitor C12. This helps to cut down extraneous noise and prevent "blasting". C12 also by-passes radio-frequencies to ground from the bottom of L3.

Resistor R5 drops the battery voltage to approximately 45 volts for the screen grids of V2. Capacitor C11 is the screen by-pass capacitor.

The audio amplifier valve V3 is a type 1Q5GT beam power amplifier. Battery E1 supplies 4.5 volts of grid bias for this valve. Transformer T1 couples the audio output to the headphone via jack J1. It is designed to work into low-impedance headphones (nominally 125 or 600 ohms, depending on how it's output windings are connected).

2-3 THEORY OF OPERATION

2-3-1 The general theory of operation of the wavemeter depends upon the fact that when two radio-frequency signals are impressed on a non-linear circuit element (such as a detector or mixer) other frequencies are produced. These other frequencies consist of the harmonics of the fundamental frequencies, the sum and difference of the fundamentals and the sums and differences of all the various harmonics. In the operation of the wavemeter we are interested only in the difference between the fundamentals or harmonics since when the difference is small the beat frequency is audible. This audible beat is heard in the headphones and when it is reduced to zero the fundamental frequency or some two harmonics of the frequencies impressed upon the detector are equal.

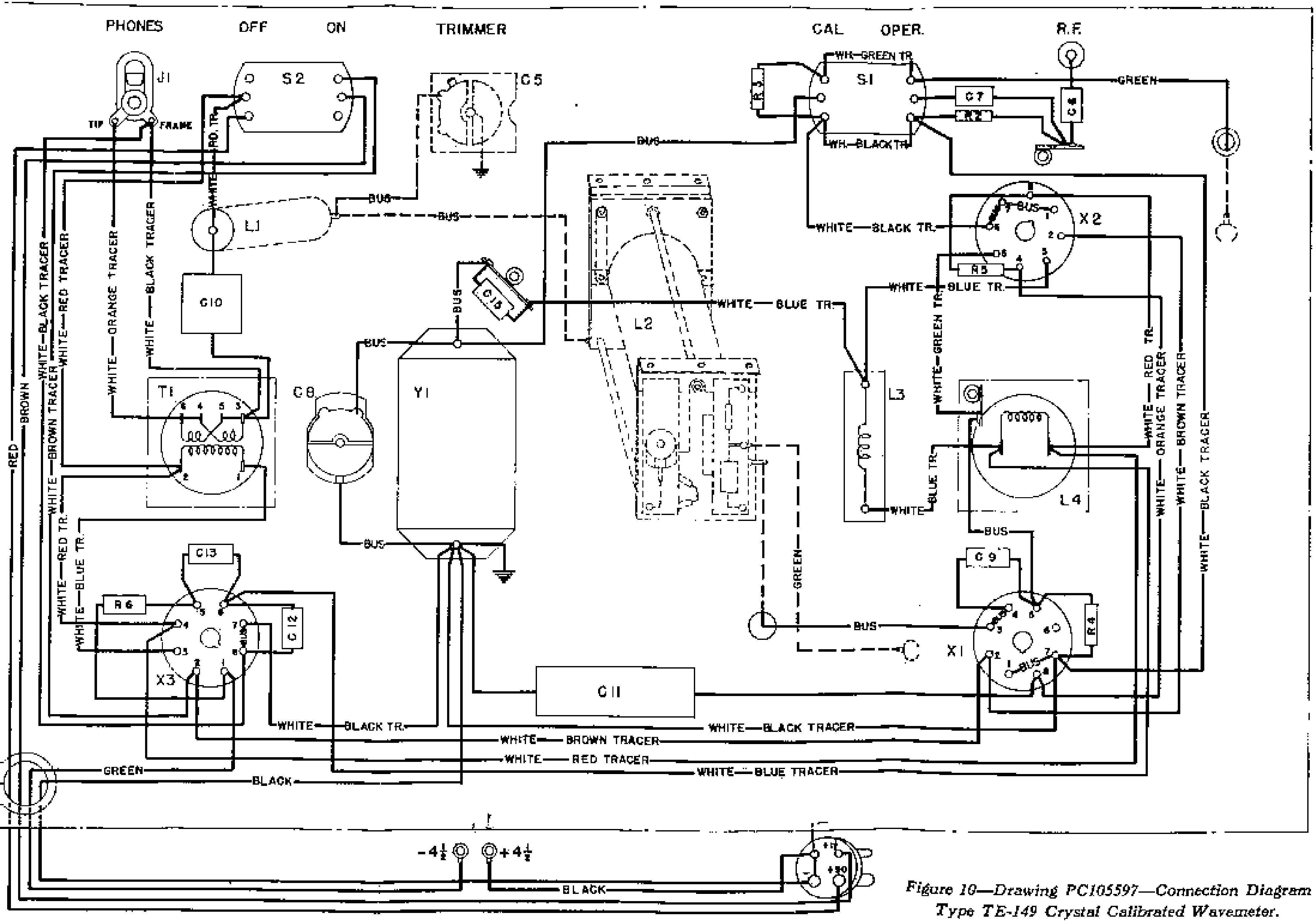


Figure 10—Drawing PC105597—Connection Diagram Type TE-149 Crystal Calibrated Wavemeter.