INSTRUCTION BOOK

for

MODEL LM-6

HETERODYNE RF METER

and

CRYSTAL CALIBRATOR EQUIPMENT

RANGE 195 to 20,000 KCS

Manufactured for

U. S. NAVY DEPARTMENT
BUREAU OF SHIPS
Contract NOs-72057
Dated 26 February 1940

By

BENDIX RADIO CORPORATION
BALTIMORE, MARYLAND

I.B. 279

Boatanchor On-Line Historical Radio Documentation Edition
Entered Into the Boatanchor Archives — 14 June, 1995
By Robert D. Keys/NA4G “Boatanchor Bob”

Dedication

This work is dedicated to.....

those students of life who strive to be

the very best

that their potential will allow.

(..... that includes all Boatanchorites!)

R.D.K.

WARNING

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OPERATING PERSONNEL MUST AT ALL TIMES OBSERVE ALL SAFETY REGULATIONS.

DO NOT CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE EQUIPMENT WITH HIGH VOLTAGE SUPPLY ON.

DO NOT DEPEND UPON DOOR SWITCHES OR INTERLOCKS FOR PROTECTION BUT ALWAYS SHUT DOWN MOTOR GENERATORS OR OTHER POWER EQUIPMENT.

UNDER CERTAIN CONDITIONS DANGEROUS POTENTIALS MAY EXIST IN CIRCUITS WITH POWER CONTROLS IN THE OFF POSITION DUE TO CHARGES RETAINED BY CAPACITORS, ETC.

TO AVOID CASUALTIES, ALWAYS DISCHARGE AND GROUND CIRCUITS PRIOR TO TOUCHING THEM.

THE ATTENTION OF OFFICERS AND OPERATING PERSONNEL IS DIRECTED TO BUREAU OF ENGINEERING CIRCULAR LETTER No. 5a, OF 3 OCTOBER 1934, OR TO ANY SUBSEQUENT REVISIONS THEREOF ON THE SUBJECT OF "RADIO-SAFETY PRECAUTIONS TO BE OBSERVED."

Preface

The Boatanchors On-Line Archives

Historical Radio Documentation

Project

The purpose of the project is to put on-line, electronically, historical radio documentation such as manuals, schematics, or other items of interest for anyone who desires to learn about "Boatanchor" style radios (i.e., those radios that "glow in the dark" or are powered by vacuum tube or earlier vintage technology, and usually weigh in with gusto on the scales).

Much of the documentation relating to boatanchors is fading into oblivion, and for whatever we can do to help conserve some of this material on-line, in the "computer" era, for general historical consumption, it will hopefully be beneficial to those who will follow after us in this fine and ancient art and craft of "boatanchoring" (learning about, operating, restoring, preserving old-time radio).

All documentation placed in the Boatanchors On-Line Archives Historical Radio Documentation Project archives is in the public domain. Its use is unrestricted. This normally limits such materials to government documents (for example surplus radio manuals and related information), works whose author has released them into the public domain or has expressly given permission for their use in the Boatanchor On-Line Archives Historical Radio Documentation Project archives, or works whose copyright has expired from the very early days of radio. Of particular interest are those works that may be from the spark radio era, or obscure bits of history, or personal observations, or how-to hints for radio servicing and preservation, or manuals for very commonly used equipments where the manuals have usually become lost in time. This work is an example of a government document manual for equipment very commonly found in surplus, but for which manuals are rather hard to find.

The general operational goals of this project are to key in into ascii format such documentation as may be desirable or of merit, and to provide a minimal standardized system of reproducing the manuals based upon the most simple style of document formatter. This basic simple formatter is patterned after the “runoff”, “roff”, “nroff”, “troff” style document formatters of the unix environment. It is geared to the general approach of KISS — Keep It Simple Stupid! This approach will hopefully allow NON-proprietary conservation formats to be used that are freely distributable to all for all operating systems from the earliest CP/M through DOS through Unix. In this way, the broadest possible audience can be served. Remember, “it is better to have the information keyed in, in a simple format, than to not have it keyed in at all”.

This project is a group effort. It is only as good as the group wants to make it. Hopefully, enough interested parties will take a few minutes over the course of a few days during the next year or two to key in a treasured manual or two, for the archives.

ALL files are 100% plain ascii at the lowest level for input and output, and the source code and documentation to the formatter is provided.

At a higher level, the typeset versions are available in the troff or the TeX/LaTeX style input files and the plain printable laserjet binary or PostScript format output files. The output files can be printed directly, and without any intermediate software, provided a proper laserjet or PostScript printer is available. This manual has been formatted in the simplest “roff” format.

The reasoning behind providing the simple lowest-level “roff” style formatter is to allow anyone who wishes to add documentation to the archives, in an easy manner, to be able to do so, and not have any end-user constraints in place. The lowest level printed output is always 100% ascii and will print on any printer. The second level is still ascii (PostScript) for printing of typeset output on any PostScript compatible printer. The highest level is machine specific for laserjet printers using the HP PCL Language binary printing, and will only handle typeset or plain ascii materials. But, it is a little more common than PostScript, at the present time (1995).

So, if you wish to contribute to the Boatanchor On-Line Archives Historical Radio Documentation Project archives, and have only a low-end computer and minimal printing capability, you can avail yourself of the lowest-level "roff" style document handling system. It will work very well at the lowest-level and it can be readily transformed at a later time into a higher-level typeset version.

If you wish to contribute at a higher level, please do so, but try to keep to the standard troff style or TeX/LaTeX style typesetters in universal use. If you are unable to use these systems, then at least type the material in, in 100% plain ascii text format, and allow another Boatanchorite to build it for you into a finished version for the archives. Alternatively, for whatever system you may have available for you to use, keep the output files printable to a laserjet or PostScript printer without the need for any further intermediary software for printing, and then make the input source material available in 100% ascii format (without ANY proprietary binary codes that are typical of ALL the usual forms of common "word processors"). If you do not understand whether or not your text input software will output a 100% ascii file, then consult with other Boatanchorites to work out the details. Also, as a general rule, make sure margins are less than 80 characters (usually 72 characters is a good right margin) and page lengths are a standard 66 lines (8-1/2 inch) which will at least allow printing of the ascii text on any printer.

The Boatanchors On-Line Archives Historical Radio Documentation Project is a community effort. Enjoy it as you may. Contribute to it as you may. Let us keep the spirit of "Boatanchoring" alive and worthy to be remembered by those who will follow after us. Remember, "we are but the temporary custodians and caretakers of the boatanchors we all enjoy". Keeping a goodly set of documentation appropriate for their preservation and available to all goes with the caretaking.

Thanks to all!

Happy Reading!

But Most of All — Happy Boatanchoring!

73 TU SU SK DE NA4G

"Boatanchor Bob"

This volume has been typeset using the LaTeX technical text processing typesetting system. This system was originated by Donald E. Knuth of Stanford University, Stanford, CA, who wrote the TeX typesetter and Leslie Lamport of Digital Research Corporation, Palo Alto, CA, who wrote the LaTeX macro package for TeX. This typesetter is commonly available at many on-line archives throughout the world, and runs well on Unix or DOS style computers. This document was typeset using the book style in 14 point type for quick and easy reading.

Robert D. Keys/NA4G
"Boatanchor Bob"
Raleigh, NC.

14 June, 1995.

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REPLACEMENT OF DEFECTIVE MATERIAL

The equipment, including all parts and spare parts, except vacuum tubes, is guaranteed for a service period of ONE YEAR with the understanding that, as a condition of this contract, all items found to be defective as to design, material, workmanship or manufacture will be replaced without delay and at no expense to the Government; provided that such guarantee and agreement will not obligate the contractor to make replacement of defective material unless the failure, exclusive of normal expected shelf life deterioration, occurs within a period or TWO YEARS from the date of delivery of the equipment to and acceptance by the Government, and provided further, that if any part or parts (except vacuum tubes) fail or are found defective to the extent of ten percent (10%) or more of the total number of similar units furnished under the contract (exclusive of spares), such part or parts, whether supplied in the equipment or as spares, will be conclusively presumed to be of defective design, and as a condition of contract subject to one hundred percent (100%) replacement by suitable redesigned units.

Failure due to poor workmanship while not necessarily indicating poor design, will be considered in the same category as failure due to poor design. Redesigned replacements which will assure proper operation of the equipment will be supplied promptly, transportation paid, to the Naval activity using such equipment, upon receipt of proper notice and without cost to the Government.

All such defective parts will be subject to ultimate return to the contractor. In view of the fact that normal activities of the Naval Service may result in the use of equipment in such remote portions of the world or under such conditions as to preclude the return of the defective item or unit prior to replacement without jeopardizing the integrity of Naval communications, the exigencies of the Service therefore may necessitate expedtious repair of such item in order to prevent extended interruption of communications. In such cases the return of a defective item or unit for examination by the contractor prior to replacement will not be required. The report of a responsible authority, including details of the conditions surrounding the failure will be acceptable for effective adjustment under the provisions of this contractual guarantee.

The above period of TWO YEARS and the service period of ONE YEAR will not include any portion of the time that the equipment fails to give satisfactory performance due to defective items and the necessity for replacement thereof. All replacement parts will be guaranteed to give ONE YEAR of satisfactory service.

Report of Failure of any part of this equipment, during its life, shall be made on Form N Aer. 4112 — "Report of Unsatisfactory or Defective Material," in accordance with the latest instructions issued by the Bureau of Aeronautics. Copies of this report shall be forwarded to the Bureau of Ships (3 copies), and to the Inspector of Naval Material (1 copy), Bendix Radio Corporation, 920 East Fort Avenue, Baltimore, Maryland. Copies required for other activities shall be forwarded in accordance with existing instructions. Such reports of failure shall include:

(a) Contract NOs 72057. Date of Contract 26 Feb, 1940

(b) Model Letter of Equipment _________ Navy Type ____________

(c) Serial Number of Equipment ______________________________

(d) Date of Acceptance by the Navy ___________________________

(e) Date Placed in service ___________________________________

(f) Part which failed ____

(g) Nature and cause of failure ______________________________

(h) Covered by contract guarantee ____________________________

(i) Replacement needed ______________________________________
(Yes or No)

(j) Remedy used or proposed ___________________________________

Contract NOs 72057. Date of Contract 26 Feb, 1940

Serial Number of Equipment ____________________________________

Date of Acceptance by the Navy ________________________________

Date of Delivery to Contract Destination _____________________

Date Placed in Service ____

Chapter 1

Introduction

1.1 Function

The Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment has been specially designed to provide a simple, accurate and reliable frequency indicating equipment of the crystal calibrated type for use in the Naval radio service. It is adaptable for adjusting adjacent radio transmitters and receivers to any desired frequency in the range from 195 to 20,000 Kcs. The equipment provides accuracies of 0.02 percent in the 195 to 2000 Kcs band, and 0.01 percent in the 2000 to 20,000 Kcs band, at any ambient temperature in the range from minus 32 to plus 65 degrees Centigrade.

1.2 Comparison With Model LM-2, LM-4 and LM-5 Equipments

The Type CRR-74023 RF Meter and Crystal Calibrator, a component of the Model LM-6 Equipment, is identical with the Model LM-5 Equipment; with the Model LM-4 Equipment (Increase); with the Model LM-4 Equipment, except for several minor improvements; and with the Model LM-2 Equipment, except for new symbol designations and several minor improvements. Corresponding parts are completely interchangeable.

1.3 Composition

Each Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment consists of the following component units:

Item	Qtty.	Description	Lbs.
A	1	Type CRR-74023 RF Meter and Crystal Calibrator, complete with one set of vacuum tubes (1 each of Navy types --- 76, 77, and 6A7). Dimensions 7-11/32" x 7-1/2" x 6-25/32".	12.0
B	1	Shockproof Mounting Base for the Meter Unit. Dimensions 8-3/16" x 8-9/16" x 1-21/32".	0.53
C	1	Type CRR-20104 Rectifier Power Unit, complete with one Navy Type 84 vacuum tube. Dimensions 8-3/16" x 8-5/8" x 8-3/16".	13.6
D	1	Shockproof Mounting Base for Rectifier Unit. Dimensions 7-7/8" x 8-7/16" x 11/16".	0.5
E	1	Shielded Power Cable, per Bendix Dwg. No. AL7124-2, 5-conductor, 6 feet long, 5-contact shielded plug at each end.	1.31
F	1	AC Input Cable, per Bendix Dwg. No. AL72091-1, 3-conductor, 96 inches long, shielded rubber covered, plug on rectifier end.	1.5

G	1	Calibration Book.	--
H	2	Instruction Book.	--
I	1	Waterproof Slip Cover, for Indicator Unit.	0.25
J	1	Set of Spare Parts.	--

1.4 Additional Equipment Required

The Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment is complete when the companion units Type CRR-74023, RF Meter and Crystal Calibrator, and Type CRR-20104 Rectifier Power Unit are connected together. For standard Naval installations the following items are necessary for operation in addition to those listed in Section 1.3.

Item	Description
a	Source of operating power, 100/130 VAC 50/60 cycles.
b	Telephone headset, low impedance (600 ohms).

1.5 Power Consumption

All power required for the operation of this equipment is drawn through two conductors of the shielded AC input cable. Typical current and voltage measurements are shown in the following table:

Input		Compensation			Output			
Volts	Watts	1	2	Volts	Rect. Fil. Volts	Meter Fil. Volts	Meter Plate Volts	Meter Plate Current
130	27.3	OFF	OFF	118	6.3	12.9	292	19.9
120	19.1	OFF	OFF	108	5.9	11.9	270	17.8
120	27.0	ON	OFF	118	6.3	12.9	292	19.9
110	22.6	ON	OFF	108	5.9	11.9	270	17.8
110	27.6	ON	ON	118	6.3	12.9	292	19.9
100	22.5	ON	ON	107	5.7	11.7	264	17.1

Normal voltage inputs are 105, 115, and 125 volts 60 cycle single phase AC. Compensation should be adjusted for a compensation voltage of between 110 and 120 volts. Thse values are typical for operation with the modulation switch turned to the on position, under which condition maximum plate current is drawn.

NOTE: The specified accuracies will be obtained, after correcting the heterodyne oscillator to calibration at the nearest crystal check point, at any input voltage between the above specified limits, provided: that neither voltage varies by more than plus or minus 10% during the period intervening between the correcting and measuring operations.

Chapter 2

Description of Units

2.1 Type CRR-74023 RF Meter and Crystal Calibrator

The Type CRR-74023 RF Meter and Crystal Calibrator contains a crystal controlled oscillator used as a reference standard; a heterodyne oscillator having two fundamental tuning ranges which, with their useful harmonics, provides continuous coverage from 195 to 20,000 Kcs; a 500-cycle modulator therefor; a high gain detector provided with independent means for coupling to each of three sources of excitation; an audio frequency amplifier; and a voltage regulator circuit which provides essentially constant plate voltage to the heterodyne oscillator for the plate supply between the limits of 260 and 475 volts. There are eight operating controls: a filament power switch S-102A, B, which breaks both the filament and plate supplies; a plate power switch S-103, for standby filament operation without plate load; a crystal oscillator switch S-104A, B; a two-position frequency band switch S-101A, B, for the heterodyne oscillator; a heterodyne oscillator worm and gear drive tuning control, together with its dial units and dial hundreds scales; a corrector control; an RF coupling control R-106; and a modulation on-off switch S-105A-D. All of these controls are mounted on the front panel together with an RF coupling terminal, a parallax adjusting screw for the dial hundreds index, a calibration card on which the settings for seven important frequencies may be logged, and an output phones jack J-101.

Two swinging cover plates near the corrector control allow access to the adjusting screws for the low and high band trimmer capacitors C-103 and C-104 respectively. A power input receptacle J-102 is located on the right hand side of the unit near the lower front corner. The voltage regulator cutout switch S-106 (marked 200-260, VOLTS, 260-475) should be set in the 260-475 position at the time of installation. As a safe-guard against subsequent inadvertent operation, it is mounted inside the cabinet to the rear of the power input receptacle. All parts are carried on an aluminum panel and chassis assembly and housed in an aluminum cabinet which is provided with a pocket at the bottom for stowing the calibration book. The external surfaces are finshed in a durable black wrinkle lacquer. Figures 1 to 8, inclusive, show the general construction and arrangement of parts.

The cathode, inner grid, and anode grid of the Navy Type CRC-6A7 vacuum tube V-102 (see Figures 19-A and 20) constitute the active elements of the crystal-controlled oscillator, which operates at the fixed frequency of 1000 Kcs when the crystal switch S-104A, B is on. The circuit is of a design which generates considerable harmonic energy in order that the crystal oscillator may be employed to calibrate the heterodyne oscillator at several points over its entire range. The necessary plate circuit impedance is built up across an untuned inductance L-103 which is housed in a bakelite case ruggedly constructed and thoroughly sealed against moisture. Likewise, the crystal Y-101 is supplied in a hermetically sealed and evacuated metal holder which provides permanent protection against humidity, corrosion, and dirt intrusion. One of the smaller type metal tube envelopes is employed in the construction of this holder; it plugs into a standard octal tube socket X-106 in mounting. The cut of the crystal and the internal consruction of the holder are such that, under any conditions of barometric pressure, humidity, voltage, vibration, shock or tilt, only the specified output frequency and the harmonics thereof are obtained. The crystal is ground for operation at a normal temperature of plus 10C. The temperature coefficient of the combined crystal, holder, and circuit, as expressed in percentage of the frequency, is less than 0.0001 percent per degree Centigrade as measured over an ambient range of 80C.

The Navy Type CRC-77 vacuum tube V-101 is used in an electron coupled circuit as a heterodyne oscillator (Figures 19 and 20). As previously stated, there are two continuously variable ranges which may be manually selected by the frequency band switch S-101A, B. In the low frequency position, a fundamental range of 195 to 400 Kcs is employed; which, by calibrating the first, second, fourth, and part of the fifth harmonics, gives continuous coverage throughout the range from 200 to 20,000 Kcs. The two inductors L-101 and L-102, in the tuned circuits, are wound on ceramic forms and thoroughly sealed against moisture. Tuning over both fundamental ranges is accomplished by the temperature compensated variable capacitor C-101, which is augmented by the variable corrector capacitor C-102 and the adjustable trimmer capacitors C-103 and C-104 which permit separate adjustments to the low and high bands to compensate for extreme conditions of humidity. C-101 is capable of continuous rotation in either direction without stops, and the dial assembly includes a 100/1 ratio worm gear drive mechanism so that 50 revolutions of the vernier dial are required for 180 degrees rotation of the main scale (on the capacitor shaft). The main, or dial hundreds, scale is engraved with 50 divisions over its useful 180 degree sector; and the vernier is marked with 100 dial units divisions over the entire 360 degrees. The arrangement thus provides 5000 effective readable divisions, of which the calibrated ranges occupy approximately the portion between 250 and 4745. Backlash in the gear mechanism has been reduced to less than three-tenths of one division on the vernier scale. A parallax adjusting screw is provided on the top left edge of the front panel, by means of which the dial hundreds index can be corrected to suit the angle of view peculiar to each installation (see Figure 7).

The calibration data for the heterodyne oscillator circuit are corrected to absolute frequency for a temperature range of plus 10C, and the dial settings of the successive harmonics (crystal check points) are noted along the calibration. The temperature coefficient of each range of the heterodyne oscillator, expressed in percentage of frequency, is less than 0.002 percent per degree Centigrade, as measured over a range of 97C. The corrector capacitor C-102, which is connected in parallel with C-101, makes it possible to reset the heterodyne oscillator to agreement with the crystal calibration at any harmonic for any ambient temperature between the limits of minus 32C and plus 65C. Thus, after the tube filaments have been lighted for at least ten minutes, and the heterodyne oscillator has been corrected to the nearest crystal check point, the heterodyne oscillator is capable of being reset to within 0.02% of the absolute for any frequency in the range of 195 to 20,000 Kcs, and to within 0.01% for any frequency between 2000 and 20,000 Kcs. These accuracies are obtainable under the most unfavorable combined influences due to 10% changes in filament and/or plate voltage, errors in calibration, changing tubes, crystal grinding errors, and variations of ambient temperature between minus 32C and plus 65C.

It was previously stated that the three inner elements of the Type CRC-6A7 tube V-102 are used in the crystal oscillator circuit. The remaining elements of this tube, comprising the control grid, screen grid, and plate, are used as a high gain screen grid detector; to which, by structure, the crystal oscillator is electronically coupled. The RF voltage developed across the load resistor R-104 in the plate output circuit of the electron coupled heterodyne oscillator is introduced into the control grid circuit of this detector through a small fixed capacitor C-105. The RF coupling terminal, mounted on the front panel, is also coupled to the control grid of the detector, through the RF coupling control potentiometer R-106, and the coupling capacitor C-106. This connection is made through S-104B of the crystal switch when it is in the off position only. As a result of these three coupling means, and dependent on the position of the crystal switch, the detector functions to mix the heterodyne oscillator output either with the fundamental and successive harmonics of the crystal oscillator, or with the transmitter frequency to be measured. When the crystal switch is thrown to the on position, section S-104B grounds the RF coupling terminal through R-106, and opens the circuit to the detector control grid through C-106, thereby preventing interference from external sources while correcting the heterodyne oscillator to the crystal calibrator.

The detector plate works into an audio choke L-104 and the beat frequency voltages built up across it are coupled through capacitor C-108 to the grid of the Navy Type CRC-76 vacuum tube V-103, provided the modulation switch S-105A-D is in the off position. The grid of V-103 returns to ground through grid leak rsistor R-112, the desired bias potential being obtained from the IR drop across the series cathode resistor R-111. The plate of V-103 returns to the positive plate supply through the primary of the output transformer T-101 and the filter resistor R-108, the latter being bypassed to the cathode through capacitor C-112. Cathode bypass to ground is provided through C-110A. The secondary of T-101 is completely insulated from the primary, so that no DC potentials are present in the output. This transformer and the audio choke L-104 are both completely enclosed in evacuated metal containers, insuring permanent protection against humidity. The secondary of T-101 is connected to the phones jack J-101 through sections S-105C-D of the modulation switch (off position), the winding ratio being designed to match the plate impedance to 600 ohm phones (see A and B, Figure 19).

The detector and audio amplifier combination is so designed that the output impressed across the phones is essentially a linear function of the input voltage for the output range of 0.06 to 50.0 milliwatts (beat frequency of 250 cycles). The audio system is peaked at 250 cycles. At frequencies of 100 cycles and 500 cycles the output is approximately 1.5 DB below the 205 cycle reference.

As previously stated, the heterodyne oscillator and the RF coupling terminal are coupled to the control grid of the detector through capacitors C-105 and C-106, respectively, when the crystal switch is in the off position. Therefore, under the same conditions, the heterodyne oscillator is coupled to the RF coupling terminal through C-105 and C-106 in series. Thus, the RF coupling terminal serves the dual purpose of detector input terminal for the measurement of frequencies of external origin, and a heterodyne oscillator output terminal for use in calibrating receivers. When the unit is employed for the latter purpose, 2500 microvolts or more of radio frequency energy will be available between the RF coupling terminal and ground at any frequency within the calibrated range. In the heterodyne oscillator fundamental ranges, where outputs of several thousands microvolts are available, the RF coupling potentiometer provides a means for attenuation to a minimum of approximately 100 microvolts.

MCW receivers may also be calibrated from this RF source, if the modulation switch S-105A-D is thrown to the on position. Under this condition, the grid of vacuum tube V-103 is disconnected from the audio coupling capacitor C-108 by switch section S-105A, and connected to the primary of T-101, through the modulator feedback capacitor C-114 (the primary of T-101 remains connected to the positive plate supply through the filter resistor R-108, this resistor being bypassed to the cathode through C-112). The plate of V-103 then returns to the positive plate supply through switch section S-105B, the secondary of T-101, and switch section S-105D. The plate is also connected through switch section S-105C to the capacitor C-113, which tunes the secondary of T-101 to approximately 500 cycles, and through the modulator coupling capacitor C-107 to the supressor grid of the heterodyne oscillator tube V-101. Thus, in the on position of the modulation switch, the output phones jack is rendered inoperative while the vacuum tube V-103 and its associated circuits function as an audio oscillator. This oscillator provides approximately 40% modulation of the RF output throughout the calibrated range (see C, Figure 19).

All power required for the operation of this unit is introduced through the power input receptacle J-102. The common filament and negative plate supply lead to vacuum tubes V-102 and V-103 connects to terminal 27 thereof, which is grounded to the chassis. Section S-102A of the filament power switch closes the 12.6 volt supply terminal (25) to the filament of vacuum tube V-101 (which is connected in series with the filament of V-102) and through dropping resistor R-113 to the filament of V-103. Section S-102B of this switch connects the positive high voltage input terminal (26) through the series plate power switch S-103 to the plate and screen circuits of vacuum tubes V-102 and V-103 and to the voltage regulator resistor R-103. Thus with the filament switch in the on position, and the plate switch turned off, the filaments of all tubes may be maintained at operating temperature without any drain from the high voltage supply.

It will be noted that the plate and screen power supply connections for the heterodyne oscillator tube V-101 are not mentioned in the previous paragraph. In order to maintain the calibration accuracy specified for the heterodyne oscillator, it is necessary that the plate and screen voltage supply to vacuum tube V-101 be held within certain limits. A special voltage regulator circuit and cutout switch has therefore been included to permit the use of the meter unit with a range of supply voltages (see Section 4.1 for operation of AC line voltge compensators). In the meter unit the voltage regulator circuit comprises the two neon glow tubes V-104 and V-105, the regulator output resistor R-116 shunted by the regulator cutout switch S-106, and the regulator limiting resistor R-103, all of which are connected in series across the power supply output terminals (when both power switches are turned on). The two neon tubes in series strike at about 210 volts and, because of their variable resistance characteristics, the arcing voltage thereafter remains fixed at approximately 130 volts. The V-101 plate and screen circuits are fed from the constant voltage drop across these tubes when the power supply input is between the limits of 260 and 475 volts, and the voltage switch S-106 is set to correspond (regular cutout resistor R-116 shortd out).

By reason of extreme refinements involving the type of design of the basic circuits, the relative arrangement of parts, character of intercircuit couplings, shielding, etc., the performance of this unit has been developed to a degree where no locking-in will occur between the heterodyne oscillator and either source of RF with which it may be coupled, at any difference or beat frequency down to 5 cycles per second. Although the phones become rapidly less efficient in audibly reproducing beat tones below 100 cycles per second, characteristic "rushes" coincident with the rise and fall of the beat frequency pulses are aurally recognizable well below the low frequency limit of audibility.

2.2 Type CRR-20104 Rectifier Power Unit

The Type CRR-20104 Rectifier Power Unit is a component part of the Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment. It supplies the indicator unit with the necessary filament and plate voltage. The rectifier power unit draws its primary source of power through the 3-conductor shielded AC input cable. Plug P-303 of this cable is inserted into

J-201 of the power unit. The black conductor connects to terminal 64 which goes to the common ground buss. With the DPDT power switch S-201A, S-201B in the on position voltage is applied, through fuses F-201, F-202, and through the compensation switches, to the primary of the power transformer T-201. The AC line is bypassed to ground through the primary bypass capacitors C-204A and C-204B. An AC voltmeter M-201 is permanently connected across taps 1 and 3 of the transformer primary. This is the normal voltage connection. When the line voltage is above the normal range of 110 to 120 volts, the AC input voltage is connected between terminals 1 and 4. When the AC input voltage is below the normal range the line is connected between terminals 1 and 2. Through the operation of the compensation switches 10 volts can be added or subtracted from the input line voltage (see Section 4.1). The secondary windings of the power transformer supply plate and filmament voltages to the full-wave rectifier V-201; 12.6 volts is also supplied for the heaters of the tubes in the indicator unit. This voltage is connected to terminals 25 and 27-36 in the power output receptacle J-202. Terminals 27-36 are connected together and make up the common ground buss. The rectifier tube V-201 delivers the high voltage DC to a pi-network filter which is composed of input capacitor C-201, series inductance L-201 and output capacitors C-202, C-203 in parallel. Across the output of the filter is a bleeder composed of R-201 and R-202 in series. This improves the regulation of the output and drains the charge off the filter condensers when the power unit is turned off. To protect the power transformer from overloads originating in the secondary circuit or in the indicator unit the negative return lead is fused by F-203. The high voltage DC positive lead is connected to terminal 26 on receptacle J-202 where it is picked up by the power supply to the meter unit cable. The schematic diagram of this unit may be observed by referring to Figure 22, while the power cable details may be observed in Figure 18.

2.3 Shockproof Mounting Bases

The structure of the meter unit shockproof mounting base may be seen in Figures 1 and 16. It consists of a rectangular aluminum frame member which is suitably drilled for rigid mounting and fitted with special Lord plate form rubber mountings at each of the four corners. Thse rubber mountings are provided with vertically projecting shouldered and grooved metal studs, to which the unit may be firmly secured by the operation of two snapslide tabs located at the bottom of the front panel

The details of the shockproof mounting base for the rectifier power unit are shown in Figures 1 and 17. The rectangular aluminum base plate is drilled with six No. 16 holes for rigid mounting. The top plate of this base assembly is permanently fastened to the rectifier power unit by rubber shock mounts in each corner. The two plates are securely fastened together by the operation of the two snapslide fasteners located on the front of the top base plate.

The size of the rubber mountings and the special manner in which they are assembled to the aluminum frame are such as to assure safe anchorage and adequate shockproofing of the unit in normal service. Flexible bonding connections are furnished between each of the mounting studs and the metal base, thus providing four direct ground paths of the meter or rectifier shielding. Snap studs are also provided at the four corners of the base for the meter unit to which the waterproof slip cover may be secured.

2.4 Shielded Power Cables

The cabling employed in the shielded power cable supplied with the equipment consists of five rubber covered stranded conductors. These conductors are enclosed in a rubber sheath covered with a braided tinned copper shield and a final outer covering of rubber. As shown in Figure 18, the cable is fitted with a Navy Type CLT-49067A straight shielded plug P-301 at the power supply end and a Navy Type CLT-49068A right angle plug P-302 for the input receptacle on the meter unit. The angle plug is so designed that the "L" may be oriented to lead away in any one of eight directions. As shown in Figure 20, only the plug contacts 25, 26, 27, and 37 are used in the operation of the equipment.

A three-conductor shielded cable is also supplied with the equipment. These stranded rubber covered conductors are enclosed in a rubber sheath covered with a braided tinned copper shield and a final outer covering of rubber. This cable is used as the AC input cable to the rectifier power unit. As shown in Figure 18, this cable is fitted with a Navy Type CLT-49071A straight shielded plug P-303 at the power supply end. At the other end the conductors are tinned and left open. These leads are to be connected to a plug or junction box depending upon the installation (see Section 4).

2.5 Calibration Book

The low frequency fundamental range of the heterodyne oscillator is calibrated at each one-tenth kilocycle between 195 and 400 Kcs, or a total of 2051 points. Likewise, the high frequency fundamental range is calibrated in increments of one kilocycle between 2000 and 4000 Kcs, or a total of 2001 points. These fundamental frequencies are legibly printed in columnar formation on the successive pages of the calibration book, together with associated columns listing the second, fourth, and portions of the fifth harmonics thereof. The dial settings, as determined by individual calibration, are then typed in opposite each such group. All figures representative of ordinary frequencies and their dial settings are both printed and typed in black, while those which refer to the crystal oscillator and its harmonics (crystal check points) are shown in red. The nearest crystal check points are also shown in red across the bottom of each page; and the first and last frequencies and dial settings tabulated thereon are indicated across the top. There are 42 inside pages, thumb tabbed as to page number. The calibration comprises pages 2 to 42 inclusive; Page 1 being an index to the dial settings. In addition, an index of frequencies in the high range is given on the rear cover. A brief summary of the essential steps in operating the equipment is given on the inside of the front cover. The calibration is printed on high quality white rag index paper which is both oil and waterproof, and the cover boards are specially selected for durability. A spiral spring type of binding is employed, so that the book lies flat when opened to any page.

Provision is made for stowing the calibration book in a metal pocket provided at the bottom of the meter unit cabinet. It is recommended that the unmounted copy be carefully preserved in a safe place, as the cost of duplication constitutes an appreciable percentage of the total cost of the equipment. As specified in the Contract, the dial settings are not typed into the spare copy, but an unmounted copy of the laboratory record is supplied therewith.

Chapter 3

Installation

As shipped from the factory, the Model LM-6 Heterodyne RF Meter and Crystal Calibration Equipments are attached to their shockproof mounting bases, and all vacuum tubes are inserted into their respective sockets and clamped. To remove the meter unit, draw the two plated snapslide tabs (located at the bottom of the panel) forward, and lift it from the mounting base. The ten nickel-plated screws located along the side and top edges of the panel and the three screws across the rear of the cabinet should then be removed, and the chassis should be drawn forward and removed from the cabinet for inspection for possible damages sustained during shipment. Prior to replacing, throw the voltage switch, located to the rear of the power input receptacle, to the 260-475 position. Also, test the vacuum tube grid clips for firm contact with their respective control grid terminals, and make sure that the crystal holder is pushed well into its socket.

This equipment should be installed in such a location that the shielded power cable will reach to the outlet, J-202, on the rectifier power unit and all panel controls will be readily accessible and clearly visible to the operator. If the mounting surface had not already been stenciled, the centers for the required mounting screw holes may be laid out from the data given in Figure 16, or they may be spotted directly from the shockproof mounting base. The base should then be secured to the supporting surface using four No. 10-32 RH machine screws, suitable washers, lock-washers, and nuts. Scrape the paint under the heads of the mounting screws so that the base will be well grounded if a metal mounting surface is used. Before replacing the meter, see that the snapslides are pulled all the way forward; then push the tabs all the way back after the unit has been carefully seated on each of the four mounting studs. Test each anchorage consecutively by pulling upward at the four bottom corners of the indicator unit.

The Type CRR-20104 Rectifier Power Unit should be removed from its base plate, the cover removed, and the unit inspected in the same manner as the meter unit. The shockproof mounting base should be secured to its supporting surface, using six No. 10-32 RH machine screws, suitable washers, lock-washers, and nuts. The location of the mounting holes can be determined from Figure 17 or spotted directly from the base plate.

The installation location need not be adjacent to the meter unit, but should be within reach of the AC power supply cable. It should also be installed close to a 100/130-volt AC source of primary power. The panel controls should be readily accessible and in clear view of the operator working with the meter unit. It should be mounted in a free space so it can vibrate to the limits of the shockproof mountings. Mounting in other than a horizontal position is not recommended. When replacing the rectifier power unit, make sure it is securely fastened by pushing the tabs all the way against the front mounting studs.

Set the power, crystal, and modulation switches to their off positions, and insert the angle plug P-202 in the power input receptacle J-102 located on the lower right hand side of the meter unit. As shipped from the factory, this plug is assembled so that the cable will lead away toward the rear. If this does not fit into the arrangement of the installation, remove the four screws which secure the plug cap, turn the shell to the most convenient of the eight possible angles, and replace the screws. Do not twist the shell more than 1/2 turn from its initial position in either direction; otherwise, the cable conductors may be strained or broken. Plug the other end of the shielded power cable into the J-202 receptacle on the rectifier power unit which supplies the necessary plate and filament voltages.

The AC input cable is inserted into the input receptacle J-201 by plug P-303. The other end of this cable has the three conductors brought out and tinned. The black lead is the ground conductor and should be connected to the cable shielding. If a ground terminal is available at the input, this lead should also be connected to it. It is recommended that this input end to the cable be fitted with a Navy Type D1 plug assembly No.9-5-4440-L-ALT.12 (Bendix Number A28365) if a removable connection is required. For a permanent installation the conductors may be wired into a convenient junction box.

A short antenna must now be provided for coupling to the receivers and transmitters which are to be adjusted. This should preferably be a fixed wire (not over 4 or 5 feet long overall); permanently mounted on stand-off insulators; provided it may be so installed that about two feet of its remote end will run parallel and close, to the transmitter and receiver antenna leads. Where these conditions cannot be realized, a flexible insulated pick-up wire may be employed. One end should be skinned and secured to the RF coupling terminal on the indicator unit. Then, if the remote end be fitted with a completely taped test clip (jaws dulled), it will be possible to secure the lead at various coupling points, as desired, without grounding or contacting thereto. Under no circumstances should the RF coupling terminal be conductively coupled to any part of the transmitter or receiver being measured.

Plug a pair of low impedance headphones (600 ohms at 1000 cycles) into the phone jack, then turn the filament switch to the on position (the rectifier power switch must also be turned on). Allow the vacuum tube filaments to warm for at least ten minutes, then the equipment will be ready for use.

Chapter 4

Operation

WARNING

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OPERATING PERSONNEL MUST AT ALL TIMES OBSERVE ALL SAFETY REGULATIONS. DO NOT CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE THE EQUIPMENT WITH THE HIGH VOLTAGE SUPPLY ON.

4.1 Power Supply Compensation

Before attempting to use the Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment the input AC voltage should be noted in the meter on the rectifier power unit. It should be made to read between the limits of 110 to 120 volts. When the line voltage is between these limits, or normal, compensation switch 1 is up and compensation switch 2 is down. If the AC line voltage drops, for example, to 100 volts, compensation switches 1 and 2 should be in the up position. This will raise the voltage to 110 volts. If the AC line voltage rises, to say 130 volts, switching number 1 down (position of number 2 makes no difference) will bring the applied voltage down to 120 volts as read on the meter. Therefore the maximum voltage that can be compensated for is 130 volts and the minimum is 100 volts to stay within the prescribed limits. These input voltage limits were set up to hold the voltages supplied the indicator unit to a tolerance that would allow maintenance of frequency stability and fixed calibration that might arise due to voltage variations.

4.2 Correcting to Calibration

When making any frequency adjustments, the heterodyne oscillator should always be corrected to agreement with the calibration through comparison with the crystal oscillator at the crystal check point nearest to the frequency desired. Comparison between the crystal and heterodyne oscillator may be made at many points over the calibrated range through the employment of the fundamental or harmonic frequencies of either or both oscillators (see Section 4.4). Comparison between the two oscillators is effected by rotating the heterodyne tuning control through a portion of the scale range corresponding to the crystal check point desired, and noting the beat tones as heard in a pair of 600 ohm headphones plugged into the PHONES jack (the MODULATION switch must be set to the OFF position).

To correct the heterodyne oscillator preparatory to setting on any desired frequency within the calibrated range, proceed as follows:

A. From the HIGH or LOW frequency indices on the front and rear covers of the calibration book, determine in which band the desired frequency is located, and set the FREQuency BAND switch to correspond.

B. Also, from the frequency indices, ascertain on which page the desired frequency is listed, and turn thereto. The crystal check point nearest the desired frequency together with the dial setting, therefor, will be found noted in red at the bottom of this page.

C. Set the heterodyne oscillator scales to agree with this crystal check point dial setting (CRYSTAL and both POWER switches ON; MODULATION switch OFF). A beat note will most probably be heard in the phones, as a complete absence of beat tone can result only from four possible conditions, to-wit: when the heterodyne oscillator is exactly on calibration, when it is so far off calibration that the beat frequency is above audibility, when the MODULATION switch is set to ON, and when the equipment is defective. However, should no beats be heard, which one of the first two of these conditions may obtain can be determined by rotating the CORRECTOR dial to where the beats become audible, and noting the direction of change. If the third or fourth condition be the cause, no beats should be heard at any point in the complete heterodyne oscillator range.

D. With the heterodyne oscillator dials on the desired crystal check point setting, the heterodyne oscillator frequency should be adjusted as close to the crystal oscillator frequency as possible, by rotation of the CORRECTOR dial only. Adjust the CORRECTOR to zero beat at the strongest beat point within its range. After the operator has become familiar with the equipment, it will be found that this adjustment can be precisely made to practically zero beat. This is possible because the design is such that all locking-in tendencies have been minimized, and the characteristic "rushes" due to the rise and fall of the beat frequency peaks are aurally recognizable well below the lower limit of audible tone.

NOTE: In making the first correction to calibration immediately after any installation or physical modification thereof, the DIAL HUNDREDS scale should be read from a position directly in line therewith. Following completion of the first operation (D), the parallax adjusting screw (see Figure 7) should then be reset to give the same DIAL HUNDREDS reading from the normal angle of view peculiar to the installation conditions involved. The parallax adjusting screw may thereafter be disregarded so long as no change is made in the normal operator's position relative to the location of the frequency indicator.

When so corrected, the heterodyne oscillator frequency will agree with the calibration (to within the reset accuracies previously quoted) throughout the range of frequencies included on all the pages to which this particular crystal check point applies, provided: that the ambient temperature remains constant, and the filament and/or plate supply voltages do not vary by more than 10% (see Section 4.3).

4.3 Readjustment of Trimmer Capacitors

It may be found that the heterodyne oscillator cannot be corrected to agree with the calibration as explained in Section 4.2, particularly if the frequency indicator is installed in a locality where either extreme condition of humitidy prevails. Under such conditions, and then only, it becomes necessary to reset the heterodyne trimmer capacitor C-103 and C-104. Access to the trimmer adjusting screws may be had through the holes in the upper right hand corner of the indicator panel after swinging aside the L and H cover plates. An ordinary screw driver will be required to make these adjustments, the necessary procedure being as follows:

A. Place the unit in operation, with the FREQuency BAND switch set to LOW and MODULATION switch at OFF. Allow the unit to warm up for a period of at least ten minutes before proceeding.

B. Set the DIAL UNITS and DIAL HUNDREDS scales to agree with the reading given for 400 Kcs on Page 22 of the calibration book. Set the CORRECTOR dial at midscale (4.5 divisions).

C. After determining that the dials are set correctly as in (B), insert the screw driver through the L hole in the panel and rotate the trimmer capacitor C-103 toward the right, while listening in the phones, until the heterodyne oscillator is set to zero beat with a strong beat of the crystal calibrator.

D. Check the ability of the CORRECTOR to reset to zero beat at all crystal check points listed on the back cover of the calibration book, proceeding as outlined in Section 4.2.

E. If the unit cannot be corrected at all crystal points in the low band with the trimmer adjustment that was made (or the CORRECTOR set at 4.5 for 400 Kcs), the processes outlined in (C) and (D) should be repeated, with the CORRECTOR set to 6 divisions for 400 Kcs.

F. By thus progressing, a setting of the L trimmer will be found where it will be possible with the CORRECTOR to reset the unit to zero beat at all crystal check point readings given for the LOW band in the calibration book.

G. Cover the L trimmer, and repeat the above described processes with the FREQuency BAND switch set to HIGH and the DIAL UNITS and DIAL HUNDREDS scales set to agree with the reading given for 4000 Kcs on Page 42 of the calibration book. Adjust the trimmer capacitor C-104 through the H hole to the position where it is possible with the CORRECTOR to reset to zero beat at all crystal check points listed for the HIGH band.

4.4 Beat Point Identification

It was stated in Section 4.2 that "comparison between the crystal and heterodyne oscillator may be made at many points over the calibrated range through the employment of the fundamental or harmonic frequency of either or both oscillators." When correcting the heterodyne oscillator to calibration, it will be found that there are numerous beat points at various harmonic combinations which are not listed as crystal check points in the calibration book. In most cases, the intensity of these unlisted beat points is relatively low. In order that there may be no confusion as to the actual crystal check points, however, the beat points encountered at the various lowest harmonic combinations of the two oscillators (and their relative outputs for a typical RF meter and crystal calibrator connected to its companion rectifier power unit) are given in the following tabulations (the calibrated crystal check points are marked with asterisks):

LOW BAND

Beat Point (Het. Fund. Freq.)	Lowest Het. Harm.	Lowest Crys. Harm.	Rel. Output, MW. (500 Cycle Beat)
195.12	41	8	9.25
195.65	46	9	0.19
200.00*	5	1	90.00
204.54	44	9	0.11
205.13	39	8	0.16
205.88	34	7	0.21
206.89	29	6	0.31
208.33	24	5	0.49
209.30	43	9	0.12
210.53	19	4	2.50
212.12	33	7	0.29
214.28	14	3	14.00
216.21	37	8	0.19
217.39	23	5	1.10
218.75	32	7	0.30
219.51	41	9	0.17
222.22*	9	2	24.00
225.00	40	9	0.17
225.81	31	7	0.40
227.27	22	5	1.20
228.57	35	8	0.29
230.76	13	3	8.50
233.33	30	7	0.41
235.29	17	4	4.00
236.84	38	9	0.20

LOW BAND (Cont.)			
Beat Point (Het. Fund. Freq.)	Lowest Het. Harm.	Lowest Crys. Harm.	Rel. Output, MW. (500 Cycle Beat)
238.09	21	5	1.55
240.00	25	6	0.92
242.42	33	8	0.38
243.24	37	9	0.28
250.00*	4	1	140.00
257.43	35	9	0.31
258.06	31	8	0.45
259.25	27	7	0.55
260.86	23	6	0.82
263.15	19	5	1.30
264.71	34	9	0.35
266.66	15	4	6.80
269.23	26	7	1.00
272.72	11	3	16.50
275.86	29	8	0.70
277.77	18	5	4.60
280.00	25	7	1.05
281.25	32	9	0.40
285.71*	7	2	55.00
290.32	31	9	0.45
291.66	24	7	1.40
294.11	17	5	5.00
296.29	27	8	0.85
300.00*	10	3	24.00
304.35	23	7	1.90

LOW BAND (Cont.)

Beat Point (Het. Fund. Freq.)	Lowest Het. Harm.	Lowest Crys. Harm.	Rel. Output, MW. (500 Cycle Beat)
307.69	13	4	15.20
310.34	29	9	0.80
312.50	16	5	7.40
315.79	19	6	3.90
318.18	22	7	2.10
320.00	25	8	1.30
321.43	28	9	0.95
333.33	3	1	190.00
346.15	26	9	1.20
347.82	23	8	1.85
350.00	25	8	1.30
352.94	17	6	5.00
357.14	14	5	11.00
360.00	25	9	1.25
363.63	11	4	29.00
368.42	19	7	3.80
375.00*	8	3	48.00
380.95	21	8	2.30
384.61	13	5	15.00
388.88	18	7	3.95
391.30	23	9	1.70
400.00*	5	2	140.00

HIGH BAND

Beat Point (Het. Fund. Freq.)	Lowest Het. Harm.	Lowest Crys. Harm.	Rel. Output, MW. (500 Cycle Beat)
2000*	1	2	310.00
2125	8	17	8.00
2143	7	15	14.50
2166	6	13	25.00
2200	5	11	50.00
2250*	4	9	80.30
2286	7	16	8.90
2333	3	7	193.00
2375	8	19	4.00
2400	5	12	32.50
2428	7	17	6.50
2500*	2	5	260.00
2571	7	18	5.80
2600	5	13	28.00
2625	8	21	2.10
2667	3	8	168.00
2714	7	19	3.70
2750*	4	11	54.00
2800	5	14	20.00
2833	6	17	6.80
2857	7	20	2.10
2875	8	23	0.80
3000*	1	3	275.00
3125	8	25	1.00
3143	7	22	2.40

HIGH BAND (Cont.)

Beat Point (Het. Fund. Freq.)	Lowest Het. Harm.	Lowest Crys. Harm.	Rel. Output, MW. (500 Cycle Beat)
3167	6	19	6.10
3200	5	16	13.90
3250*	4	13	37.50
3286	7	23	1.40
3333	3	10	90.00
3375	8	27	0.30
3400	5	17	9.80
3428	7	24	0.90
3500*	2	7	210.00
3571	7	25	0.70
3600	5	18	6.60
3625	8	29	0.20
3667	3	11	71.00
3714	7	26	0.50
3750*	4	15	17.20
3800	5	19	4.60
3833	6	23	1.80
3857	7	27	0.32
3875	8	31	0.15
4000*	1	4	280.00

NOTE: 0.1 milliwatt of the above listed outputs is electrical noise level. Under flight conditions, those beat points which are listed at levels of 5.0 milliwatts or less will probably not be heard.

4.5 Transmitter Adjustments

Briefly, the method of adjusting a transmitter to a desired frequency consists of zero beating the transmitter frequency with the proper heterodyne oscillator frequency, effecting the comparison by means of a pair of headphones plugged into the PHONES jack located on the front panel of the indicator unit. The CRYSTAL and MODULATION switches should be in the OFF position during the process.

Specifically, the procedure is as follows:

A. Correct the heterodyne oscillator to calibration at the crystal check point nearest to the desired frequency, as explained in Section 4-2.

B. Turn the CRYSTAL switch to OFF.

C. Turn the indicator tuning control to the dial setting of the desired frequency, as given in the calibration book. Do not disturb the CORRECTOR adjustment as made in (A) above.

D. With the indicator pick-up lead loosely coupled to the transmitter output, tune the transmitter to give an audible beat in the phones.

E. Adjust the R.F. COUPLING control to obtain a comfortable signal level in the headphones.

F. Tune the transmitter to zero beat with the indicator.

NOTE: Operations (B) to (F) should be accomplished in the shortest possible interval following operation (A), otherwise voltage and/or temperature changes may cause the frequency indicator to drift.

4.6 Receiver Adjustments

General

The method of adjusting a receiver to a desired frequency consists of tuning the receiver to the proper heterodyne oscillator output frequency, effecting the comparison by means of a pair of headphones connected to the receiver output circuit. The method varies with the character of signal reception involved.

CW Receiver Adjustments

To tune a CW receiver to a desired frequency, proceed as follows:

A. Correct the heterodyne oscillator to calibration at the crystal check point nearest the desired frequency, as explained in Section 4.2 (the MODULATION switch must be set to OFF).

B. Turn the CRYSTAL switch to OFF, and transfer the phones from the crystal frequency indicator to the receiver output jack.

C. Turn the indicator tuning control to the dial setting of the desired frequency as given in the calibration book. Do not disturb the CORRECTOR adjustment as made in (A) above.

D. With the indicator pick-up lead loosely coupled to the receiver antenna lead, tune the receiver to give an audible signal in the phones.

E. Adjust the R.F. COUPLING control to obtain a comfortable signal.

F. Adjust the receiver tuning to that side of zero beat which results in the best reception conditions for the particular operator concerned.

NOTE: The notation at the end of Section 4.5 applies to this and all other operations for which the Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment may be employed.

MCW Receiver Adjustments

To tune an MCW receiver to a desired frequency, the following procedure applies:

A. Correct the heterodyne oscillator to calibration at the crystal check point nearest to the desired frequency, as explained in Section 4.2 (the MODULATION switch must be set to OFF).

B. Turn the CRYSTAL switch to OFF, and transfer the phones from the crystal frequency indicator to the receiver output jack.

C. Turn the meter unit tuning control to the dial setting of the desired frequency, as given in the calibration book. Do not disturb the CORRECTOR adjustment as made in (A) above.

D. Turn the MODULATION switch to ON.

E. With the meter unit pick-up lead loosely coupled to the receiver antenna lead, tune the receiver to give an audible signal in the phones.

F. Adjust the R.F. COUPLING control to obtain a comfortable signal.

G. Adjust the receiver tuning for maximum response.

4.7 Frequency Measurements

The Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment may also be employed for accurately measuring a frequency emitted from an external source, whether it be of local or remote origin, provided that such frequency lies within the calibrated range.

If it is desired to measure the emitted frequency of an adjacent transmitter or oscillator accurately, the order of which is approximately known, the heterodyne oscillator is first corrected to the crystal check point nearest to the approximately known frequency with the MODULATION switch set to OFF, as explained in Section 4-2. The actual frequency is then determined, after loosely coupling the indicator pick-up wire to the source and turning the CRYSTAL switch to OFF, by turning the meter unit tuning control to the zero beat point found nearest the setting given for the approximate frequency and reading from the appropriate frequency column, opposite the resultant dial setting, in the calibration book.

If the order of the frequency to be measured is absolutely unknown, it may first be determined to an approximation most readily with the aid of an absorption type wavemeter, following which the actual frequency is determined as explained in the preceding paragraph.

When it is desired to measure accurately a frequency of remote origin, the signal is first tuned in on the radio receiver and the approximate frequency noted from the receiver calibration. The heterodyne oscillator is next corrected to calibration at the crystal check point nearest thereto. The CRYSTAL switch is then turned to OFF; the phones are transferred back to the receiver output jack; the meter unit pick-up wire is loosely coupled to the receiver antenna lead; and the meter unit tuning control is turned until its signal is heard in the phones. If the signal in question is CW in character, the receiver is tuned to zero beat therewith, and the meter is tuned to zero beat with the receiver. If the signal is modulated, both the receiver and indicator are adjusted for maximum response, and the MODULATION switch is turned to ON. In both cases, the frequency read from the appropriate column in the calibration book (for the resultant meter dial setting) is the frequency of the signal in question.

Chapter 5

Maintenance

5.1 General Routine

The Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment is ruggedly constructed to withstand the shocks and strains which may be normally sustained in service. Nevertheless, this equipment is extremely accurate and sensitive, and is, therefore, deserving of the careful handling normally accorded to instruments of precision.

All material used in the construction of this equipment is of the highest quality, and parts are rigidly inspected before and after assembly. In addition, all units such as resistors, capacitors, tubes, etc., which are subject to rapid deterioration through overloading, are operated at varying safety factors between the orders of from 3 to 10.

Normally, the only servicing required will be the occasional replacement of vacuum tubes. This should be done at regular intervals, dependent on the amount of usage to which the equipment is subjected. It is further recommended that a single drop of Pioneer Ball Bearing Oil for Aircraft Instruments No. 2 be placed on the gear teeth of the heterodyne oscillator capacitor driving mechanism occasionally. Do not lubricate any other part of the equipment.

5.2 Servicing Data

General

Any of the Navy Model OE Series of Radio Receiver Analyzing Equipments may be used for the location of electrical faults throughout the Model LM-6 Equipment.

Resistors and Capacitors

The cartridge resistors and small moulded capacitors supplied in this equipment are marked in accordance with the RMA Standard Color Code, as shown in the table on the following page.

In addition, all electrical parts are rubber stamped with symbol designations corresponding to those shown in the diagrams, and their nominal values can be determined by reference to Table II. Their actual values can readily be measured with the ohmmeter portion of the Selective Analyzer and the Capacity Meter units of the Model OE Equipment, respectively, by following the instructions furnished therewith.

RMA COLOR CODE FOR RESISTORS AND CAPACITORS

Color	1st Band Body 1st Dot	2nd Band End 2nd Dot	3rd Band Dot/Stripe 3rd Dot	4th Band* 4th Band* 4th Dot*	Res. (ohms) Res. (ohms) Cap. (mmf)
Black	.	0	.	.	
Brown	1	1	0	100**	
Red	2	2	00	200**	
Orange	3	3	000	300**	
Yellow	4	4	0000	400**	
Green	5	5	00000	500**	
Blue	6	6	000000		
Purple	7	7	0000000		
Grey	8	8	00000000		
White	9	9	000000000		
Red	.	.	.	+-2%*	
Gold	.	.	.	+-5%*	
Silver	.	.	.	+-10%*	
LEGEND	1st NUMERAL	2nd NUMERAL	CIPHERS TO FOLLOW	VOLTAGE* OR TOLERANCE**	

* Resistors, Tolerance (OLD STYLE MARKING)

```
               ----------------------------------
    ----------|            |XXXX|          |XXXX|----------
               ----------------------------------
               body     dot or stripe        end
```

```
** Micamold Capacitors (NEW STYLE MARKING)

                 --------------------------------
      ----------|  1  |  2  |  3  |  4  |       |----------
                 --------------------------------
                   1st   2nd   3rd   4th bands
```

Circuit Wiring

To facilitate tracing of circuits in the Model LM-6 Equipment, various color combinations are used in the insulating coverings of all inter-element wiring. It will be noted that this coding is arranged to permit the character of any circuit to be identified at a glance. Thus the following single colors are assigned to basic circuits:

Circuits	Color	Circuits	Color
Plates	Red	Filaments	Yellow
Screens	Blue	Ground	Black
Grids	Green	Negative ‘‘B’’	Slate
Suppressors	Orange	Audio Output	Brown
Cathodes	White		

Auxiliary circuits are then wired with mixtures of the above colors, to wit: red and blue for a circuit to a screen dropping resistor from the plate supply, blue from thence to the screen, and blue and black to the screen bypass to ground. These combinations, as employed in the wiring of the frequency indicator chassis, are shown by symbol letters throughout the wiring diagrams (Figures 22 and 23) and explained in the legend relating thereto. The color coding of the conductors in the power cables is shown in the full schematic diagrams, Figures 20 and 21. The ohmmeter portion of the Selective Analyzer and the test prods furnished with the Navy Model OE Equipment may be used in testing for continuity, grounds, etc., in all such circuits. All power supply circuits to the Model LM-6 Equipment should be opened while the ohmmeter is being used.

Voltage Analysis

In general, any abnormality in voltage or currents, as measured at the individual vacuum tube elements, will serve as a guide to the underlying causes of operational faults. The following tabulation, showing vacuum tube terminal voltages with respect to ground (chassis), is typical for a Model LM-6:

Socket Terminal	Voltage to Ground				
	V-101	V-102	V-103	V-104	V-105
Filament 1	13.3 AC	6.4 AC	6.8 AC	.	.
Filament 2	6.8 AC	0.0	0.0	.	.
Cathode	30.0	0.0	11.0	.	.
Inner Grid	.	-12.0	.	.	.
Anode Grid	.	166.0	.	.	.
Control Grid	-7.0	-1.0	0.0	.	.
Screen	136.0	65.0	.	.	.
Suppressor	8.0	.	.	.	.
Plate 1	129.0	175.0	213.0	136.0	.
Plate 2	.	.	.	.	0

The above values were obtained with a voltmeter having a resistance of 20,000 ohms per volt, and with the various switches on the Model LM-6 Equipment set to the following positions:

Switch	Position
FREQ. BAND	LOW
CRYSTAL	ON
MODULATION	OFF
VOLTS	260-475
POWER (FIL & PLATE)	ON

Similar measurements may be taken for comparison with these values, using the Selective Analyzer and Socket Selector units of the Navy Model OE Equipment. All such measurements should be made in accordance with the procedures outlined in the instructions furnished with the particular analzying equipment in use, and the values obtained, for a normal equipment, should agree with the above to within plus or minus 5%.

5.3 Inductor Data (Winding Information) Fig. 26

A. L-101; Low Frequency Coil Assembly

B. L-102; High Frequency Coil Assembly

C. L-103; RF Choke Coil

D. L-104; AF Choke Coil, part No. CRP-30380, Manufacturer No. 14, No Drawing

E. L-201; Inductive Reactor

F. T-201; Power Transformer

5.4 Crystal Specifications

The crystals for use in the Model LM-6 Equipment shall be ground so as to prevent the possiblilty of oscillation on any frequency other than the desired fundamental or harmonics of the fundamental, when operating at a temperature of 20 degrees Centigrade. The temperature coefficient is not to exceed 0.0001 percent (1 cycle) per degree Centigrade measured over a range of 44C. The crystals shall provide a high degree of oscillation activity and freedom from spurious frequencies when installed in random selected indicators of the same group at all temperatures in the range of minus 4C to plus 40C. The crystals shall be within 0.0001 percent (10 cycles) of the specified frequency when installed in random selected indicators of the same group.

The crystals shall be mounted in the holder so as not to vary more than 0.001 percent (10 cycles) for:

A. Prolonged vibration under simulated airplane conditions, i.e., vibration of 1/16 inch amplitude and with frequencies up to 3600 cycles per second.

B. After violent shaking by hand.

C. After turning equipment in any position, i.e., upside down or on side, etc.

The crystal shall be ground to a frequency of 1000 Kcs with dimensions of 17.85 mm x 14.72 mm x 1.69 mm.

Chapter 6

Vacuum Tube Data

The following tabulation shows the maximum operating characteristics for the tubes employed in the Model LM-6 Heterodyne RF Meter and Crystal Calibrator Equipment:

Symbol	V-101	V-102	V-103	V-104,V-105	V-201
Function	Het. Osc.	Crystal Osc/Det.	AF Amp. & Mod.	Voltage Regulators	Power Rect.
Name	Triple Grid Amp.	Pentagrid Converter	Amplifier Triode	Neon Glow	High Vac.
Navy Type No.	CRC-77	CRC-6A7	CRC-76	(none)	CRC-84
Com'l Equiv.	77	6A7	76	T-4-1/2	84/6Z4
Base	Small 6 pin	Small 7 pin	Small 5 pin	2 Contact bayonet	Small 5 pin

Heater V.	6.3V**	6.3V**	6.3V**	.	6.3V**
Control Grid V.	-3.0V	-3.0V	-13.5V	.	.
Screen V.	100.0V	100.0V	.	.	.
Plate V.	250.0V	250.0V	250.0V	90.0V	1000V*
Anode Grid V.	.	200.0V	.	.	.
Heat. Cur.	330MA	330MA	330MA	.	540MA
Scrn. Cur.	0.8MA	2.2MA	.	.	.
Plate Cur.	15.0MA	3.5MA	6.8MA	30.0MA	25.0MA
Anode Grid Cur.		4.0MA	.	.	.
Transcond.	1475	520	150 micromhos		

*Maximum Peak Inverse Anode Potential.

**Continuous operation above this specified value will result in rapid deterioration. In the interest of longer tube life, it is therefore recommended that filament voltage supplied from the Type CRR-20105 Rectifier Power Unit be held within — 10% of the required 12.6 volts. Operation within the proper limits may be insured by adjusting compensating switches so that the voltmeter reads between 110 and 120 volts.

NOTE: All tubes supplied with the equipment or as spares on the equipment contract, shall be used in the equipment prior to employment of tubes from general stock.

Chapter 7

Appendix

7.1 Table 1 — List of Major Units

LIST OF MAJOR UNITS MODEL LM-6 HETERODYNE RF METER AND CRYSTAL CALIBRATOR EQUIPMENT

Navy Type Number	Name	Qtty.	Mfr's Desig.	Wt. Lbs.
CRR-74023	RF Meter and Crystal Calibrator	1	.	12.53
CRR-20104	Rectifier Power Unit	1	.	14.10
.	Accessories	.	.	2.70

7.2 Table II — Parts List by Symbol Designations

PARTS LIST BY SYMBOL DESIGNATIONS FOR MODEL LM-6 HETERODYNE RF METER AND CRYSTAL CALIBRATOR EQUIPMENT

Symbol	Function	Description
	SECTION 1 (101-199) TYPE CRR-74923 RF METER AND CRYSTAL CALIBRATOR	
	CAPACITORS	
C-101	Heterodyne Tuning	20-170 Mmf, Var. air with 5 Mmf thermal compensator
C-102	Heterodyne Corrector	1.5-3 Mmf, Var. air
C-103	LF Het. Trimmer	3-10 Mmf, Adj. air
C-104	HF Het. Trimmer	Same as C-103
C-105	Heterodyne Coupling	10 Mmf +- 10%, 500VDCW, Mica
C-106	Antenna Coupling	25 Mmf +- 10%, 500VDCS, Mica
C-107	Modulator Coupling	0.04 Mfd +10% -3%, 200VDCW, Oil-paper
C-108	Audio Coupling	0.02 Mfd +- 10%, 600VDCW, Mica
C-109A	Het. RF Bypass	0.1/0.1/0.1 Mfd, 400VDCW,
B	Het. Plt/Scr. Bypass	Oil-paper
C	Het. Negative Bypass	
C-110A	Audio Cathode Bypass	0.1/0.1/0.1 Mfd, 400VDCW,
B	Plate Supply Bypass	Oil-paper
C	Negative HV Bypass	
C-111A	Det. Screen Bypass	Same as C-109
B	Crystal Anode Bypass	
C	Det. Screen Bypass	
C-112	Audio Plate Bypass	0.5 Mfd, 400VDCW, Oil-paper

C-113	Modulator Tuning	Same as C-107
C-114	Modulator Feedback	0.00025 Mfd +- 10%, 500VDCW, Mica
C-115	Audio Choke Bypass	0.001 Mfd +- 10%, 600VDCW, Mica

MISCELLANEOUS ELECTRICAL PARTS

E-101A	Push Post Assembly	Brass, Nickel-plated
B	Terminal Post Ins.	Ceramic, pair
E-102	Wire Clamp	Ceramic, pair
E-103	Wire Clamp	Same as E-102
E-104	Wire Clamp	Same as E-102
E-105	Wire Clamp	Same as E-102
E-106	Wire Clamp	Same as E-102
E-107	Wire Clamp	Same as E-102
E-108	Wire Clamp	Same as E-102
E-109	Feed Through Bushing	Ceramic, pair
E-110	Feed Through Bushing	Same as E-109
E-111	Feed Through Bushing	Same as E-109
E-112	Feed Through Bushing	Same as E-109
E-113	Grid Clip	Spring release type
E-114	Grid Clip	Same as E-113

JACKS AND RECEPTACLES

J-101	Telephone Jack	Open circuit, Short
J-102	Power Receptacle	5-cont., for 1-1/4" plug

INDUCTORS AND REACTORS

L-101	Het. LF Inductor	4.065 MH, 347 turns, 7x42 Litz, Ceramic form

L-102	Het. HF Inductor	42 Microhenry, 38-1/4 turns, No. 28 DSC, Ceramic form
L-103	Crystal RF Choke	1.7 MH, Universal winding, Sealed, 40 ohms DC
L-104	Audio Choke	600H at 1.0 MA DC, 6700 ohms DC, Evacuated

RESISTORS

R-101	Het. LF Cathode	10,000 ohms, +-10%, 1/2W, Comp., Pigtail
R-102	Het. HF Cathode	5,000 ohms, +-10%, 1/2W, Comp., Pigtail
R-103	Voltage Regulator	25,000 ohms, +-10%, 2.91W, WW, Lug Terminals
R-104	Heterodyne Plate	50,000 ohms, +-10%, 1/2W, Comp., Pigtail
R-105	Het. Negative HV	Same as R-102
R-106	RF Coupling Control	500 ohms Pot, 1W, Impregnated Strip
R-107	Detector Grid Leak	1,000,000 ohms, +-10%, 1/2W, Comp., Pigtail
R-108	Audio Plate	20,000 ohms, +-10%, 1/2W, Comp., Pigtail
R-109	Crystal Osc. Grid	Same as R-104
R-110	Detector Screen	Same as R-104
R-111	Audio Cathode	3,000 ohms, +-10%, 1/2W, Comp., Pigtail
R-112	Audio Grid	Same as R-107
R-113	Audio Filament	20 ohms, +-5%, 2.91W, WW, Lug Terminals
R-114	Heterodyne Suppressor	Same as R-102
R-115	V-102 Positive HV	15,000 ohms, +-5%, 2.91W, WW, Lug Terminals

R-116	Regulator Cutout	25,000 ohms, +-10%, 1/2W, Comp., Pigtail

SWITCHES

S-101A,B	Frequency Band	DPDT, Rotary
S-102A,B	Power On-Off	DPST, Toggle
S-103	Standby	SPST, Toggle
S-104A,B	Crystal On-Off	DPDT, Rotary
S-105A-D	Modulation On-Off	4PDT, Rotary
S-106	Regulator Cutout	Same as S-103

TRANSFORMER

T-101	Output and Modulator	20,000/600 ohms Imp. ratio; Pri: 1200 ohms, Sec: 60 ohms DC; Evacuated

VACUUM TUBES AND SOCKETS

V-101	Het. Oscillator	Triple Grid, Type 77
V-102	Crystal Osc. & Det.	Pentagrid Converter, Type 6A7
V-103	Audio Amp. & Mod.	Amplifier TRiode, Type 76
V-104	Voltage Regulator	2-Element, 1/4W, Neon, Bayonet base
V-105	Voltage Regulator	Same as V-104
X-101	V-101 Socket	6-contact, Ceramic
X-102	V-102 Socket	7-contact, Small, Ceramic
X-103	V-103 Socket	5-contact, Ceramic
X-104	V-104 Socket	2-contact, Bayonet type
X-105	V-105 Socket	Same as X-104
X-106	Crystal Recptacle	8-contact, Octal, Ceramic

CRYSTAL AND HOLDER

Y-101	Crystal Oscillator	1 Mc, A-cut, Evacuated holder, Octal tube base mounting

SECTION 2 (201 TO 299)
TYPE CRR-20104 RECTIFIER POWER SUPPLY

CAPACITORS

C-201	HV Filter	4.0 Mfd, +10% -3%, 600VDCW, Oil-paper.
C-202	HV Filter	Same as C-201
C-203	HV Filter	Same as C-201
C-204A	Primary Bypass	0.1 x 0.1 Mfd, +10% -3%, 400V
B	Primary Bypass	DCW, Oil-paper

FUSES

F-201	Primary Line	1.0 Amp. 250V, 3AG
F-202	Primary Line	Same as F-201
F-203	Secondary Ground	1/8 Amp. 500V, 3AG

RECEPTACLES

J-201	AC Input	3-contact, Shielded
J-202	Power Output	5-contact, Shielded

REACTOR

L-201	Filter Choke	30 H, 0.025 Amps, 870 ohms

METER

M-201	Compensator Volts Indicator	0-150 V, AC, Bakelite

RESISTORS

R-201	HV Bleeder	25,000 ohms, +-5%, Style C, 15W, WW
R-202	HV Bleeder	Same as R-201

SWITCHES

S-201A	Power On-Off	DPST, Toggle, Bakelite Case,
B	Power On-Off	3A-225
S-202	Compensation 1	SPDT, Toggle, Bakelite Case, 3A-125V
S-203	Compensation 2	Same as S-202

TRANSFORMER

T-101	Power Transformer	60 Cycles, AC; 510/255 volts, 0.025 Amp; 12.6V, 0.9 Amp; 6.3V, 0.5 Amp.

VACUUM TUBE

V-201	Full Wave Rectifier	Type 84
X-201	V-201 Socket	5-contact, Ceramic

PLUGS

P-301	Power Cable, Supply End	5-contact, 1-1/4" OD, Shielded, Straight
P-302	Power Cable, Indicator End	5-contact, 1-1/4" OD, Shielded, 90-degree, 8-position
P-303	AC Line Cable, Rectifier End	3-contact, Shielded

CABLING

W-301	Power Cable	5-cond; Shielded rubber covered; 0.495", 72" long
W-302	AC Line Cable	3-cond; Shielded rubber covered; 95" long

7.3 Table III — Parts List by Navy Type Numbers

PARTS LIST BY NAVY TYPE NUMBERS FOR MODEL LM-6 HETERODYNE RF METER AND CRYSTAL CALIBRATOR EQUIPMENT

(This table deleted from Boatanchor On-Line version.)

(This table contained Navy parts number listings which are not normally used since Boatanchorites rarely will use the Navy for spare parts in the course of restorations.)

7.4 Table IV — Spare Parts List by Navy Type Numbers

SPARE PARTS LIST BY NAVY TYPE DESIGNATIONS FOR MODEL LM-6 HETERODYNE RF METER AND CRYSTAL CALIBRATOR EQUIPMENT

(This table deleted from Boatanchor On-Line version.)

(This table contained Navy parts number listings which are not normally used since Boatanchorites rarely will use the Navy for spare parts in the course of restorations.)

7.5 Table V — List of Manufacturers

LIST OF MANUFACTURERS AND ASSOCIATED PREFIX SYMBOL DESIGNATIONS

Code No.	Mfr's. Prefix	Name and Address of Manufacturer
1	CRR	Bendix Radio Corporation, 920 E. Fort Avenue, Baltimore, Maryland
2	CRA	Carter Division, Utah Radio Products Co., 812 Orleans Street, Chicago, Illinois
3	CBN	Centralab, 900 East Keefe Avenue, Milwaukee, Wisconsin
4	CD	Cornell-Dubilier Elec. Corp., 1000 Hamilton Boulevard, South Plainfield, New Jersey
5	CG	General Electric Co., Bridgeport, Connecticut
6	CG	G. E. Vapor Lamp Co., Hoboken, New Jersey
7	CHC	Hammarlund Mfg. Co., 424 West 33rd Street, New York, N. Y.
8	CIR	International Resistance Company, 401 North Broad Street, Philadelphia, Penna.
9	CBU	Isolantite, Inc., 343 Courtland Street, Belleville, New Jersey
10	.	Frank W. Morse, 301 Congress Street, Boston, Massachusetts
11	CNA	National Company, Inc., Malden, Massachusetts
12	COC	Oak Manufacturing Co., 1260 Clybourn Avenue, Chicago, Illinois
13	COM	Ohmite Manufacturing Co., 4835 West Flourney Street, Chicago, Illinois
14	CRP	Raytheon Manufacturing Company, 190 Willow Street, Waltham, Massachusetts

15	CRC	RCA Radiotron Division, RCA Manufacturing Co., Inc., Harrison, New Jersey
16	.	Simplex Wire & Cable Co., 79 Sidney Street, Cambridge, Massachusetts
17	CLT or CUA	Mfd. by Lundquist Tool & Mfg. Co., for A. J. Ulmer, Sales Agent, 90 West Broadway, New York, N. Y.
18	.	Littlefuse, Inc., 4757 Ravenswood Ave., Chicago, Illinois
19	CV	Weston Electrical Inst. Company, 578 Frelinghuysen Avenue, Newark, New Jersey
20	.	American Radio Hardware Company, 576 Broadway, New York, N. Y.

7.6 Notes by NA4G

Power Connector Pinouts and Voltages

The Model LM Heterodyne RF Meter and Crystal Calibrator Equipment uses the following pinout on the 5-contact power connectors connecting the rectifier power supply unit to the indicator meter unit:

Contact Pin Number	Function
25	Filament voltage (12.6 volts DC)
26	Plate voltage (200-475 volts depending upon meter unit internal S-106 setting)
27	Ground
35	No connection, either unit
36	Heterodyne Oscillator regulated voltage (not required, taken from internal divider network of resistors)

The power connector pinout is as follows (as viewed from the external surface of the meter indicator unit or the rectifier power supply unit:

```
35   O             O   25


36   O             O   26

           O

           27
```

The Model LM Heterodyne RF Meter and Crystal Calibrator Equipment uses the following pinout on the 3-contact AC line power connector on the front of the rectifier power supply unit:

Contact Pin Number	Function
63	AC line input (110-120 volts AC)
64	Ground
65	AC line input (110-120 volts AC)

The AC line power connector pinout is as follows (as viewed from the external surface of the rectifier power supply unit:

```
65   O             O   63


           O

          64
```

Calibration Without the Calibration Book

My experiences indicate that if the calibration book is missing from the indicator unit, it is possible to do a very good calibration based upon harmonics at 100 Kcs intervals in the HF HIGH BAND range. Such 100 Kcs increments are not listed in the tables of crystal check points but can be readily ascertained if a modern digital receiver is used as a temporary calibration dial for obtaining the 100 Kcs crystal check points. Then very simple calculations can be made for the table of values at 1 Kcs increments in the fundamental HIGH BAND range (2000 to 4000 Kcs).

The FORTRAN LMCALIB.FOR program was written for this purpose, and should have been available where this manual was found, on-line.

It is also possible to calibrate the meter against a 100 kcs marker generator that has been set to zero beat against WWV.

Use of the LM as a VFO

The LM style frequency meter (or for that matter the BC-221 and the AN/URM-32, also) can be used as a very stable variable frequency oscillator (VFO) for controlling the frequency of a transmitter. The signal output of the meter is very low, and it needs to be amplified sufficiently to drive the transmitter input circuit (usually a crystal stage such as a 6AG7 or a 6CL6). This can be done very simply with two untuned amplifier stages running Class-A using tubes such as 6AC7's, followed by a tuned output driver tube such as a 6AG7 or 6L6. The basics of this are given in the 11th edition of the Editors and Engineers "Radio Handbook", 1947, pages 445-447 (the one 8-1/2 x 11 sized edition dating from just after WWII), and also in two articles appearing in QST of the same era (Conklin, E.H., Cmdr, Frequency meters as master oscillators, QST, August, 1946) (Johnson, H.W., The BC-221 frequency meter as a VFO, QST, March, 1947).

Properly done, this approach should allow one to drive any of the standard crystal controlled Boatanchor transmitters of the post-WWII era such as the DX series by Heath or similar designs in the pages of 73, CQ or

QST of the era. It also makes no significant modifications to the frequency meter, allowing the frequency meter to be used for other purposes when not used in the VFO mode.

In the original article, a T-21 (6L6) tube was used in the output stage with a pair of 6AC7 tubes as voltage amplifiers from the LM meter. In the second article, a 6AG7 was used for output after the 6AC7 tubes from a BC-221 meter. In the Radio Handbook version the output tube was a 6L6 with a pair of 6AG7 voltage amplifers from a BC-221 meter. The final tuned stages in each case were found to be very broadly tuned and not require further tuning for several watts output anywhere in the 80 meter band.

Notes about the Figures

Because of the disk space requirements for on-line storage of high-resolution scanned images of reference photographs (Figures 1 through 15) and drawings (Figures 16 through 26), only a limited but adequate subset of drawings (Figures 19, 20, 21, and 24) sufficient for the average service requirements of Boatanchorites are included with this Boatanchor On-Line Historical Radio Documentation Archives Project manual. A full set of high-resolution images may be available at a later date.

The following pages are reserved for the illustrations that accompanied the original manual. They should be in the same location where you found this manual.

A. Figures 1 through 15 are photographs of the equipment from various angles. You probably will not need these for general use and repair, unless a lot of repairs are required for your particular units. Figure 1 is a good general picture of the whole equipment, as issued.

B. Figures 16 and 17 are outline drawings of the meter and power supply. You probably will not need these for general use of the meter.

C. Figure 18 is the cabling drawing. It shows the details of the interconnecting cables. You probably will not need this, even if you have to make up your own cables, since the cable design is very simple.

D. Figure 19 is the fundamental theoretical circuits in the three different modes of operation. You probably will not need this unless major repairs are required or you desire a better working knowledge of the function of the circuits.

E. Figures 20 and 21 are the main schematic diagrams of the meter and rectifier power supply units. These you will need for any repair work.

F. Figures 22 and 23 are the practical wiring diagrams. You probably will not need these unless your units require major repair work.

G. Figure 24 is the cordage diagram. You might want this just to see what the basic units are when put together. If you don't know what the LM looks like, this will give you an idea as to what it looks like and how it is hooked up for use.

H. Figure 25 shows typical calibration curves. You probably will not need this since you already have the calibration book, or you are recalibrating the unit from scratch based upon the known calibration points or the 100 kcs calibration points against your digital receiver.

I. Figure 26 is the coil winding diagram. You probably will not need this since, if the coils are really messed up, you will not be able to find spares and will have to relegate the unit to parts or non-calibrated vfo use. It is possible to rewind the HF coil, without too much trouble, but the calibration would be significantly off without the original wax dips and the exact ceramic coil forms. The most probable course of action would be to draw parts from a spares chassis kept for the purpose.

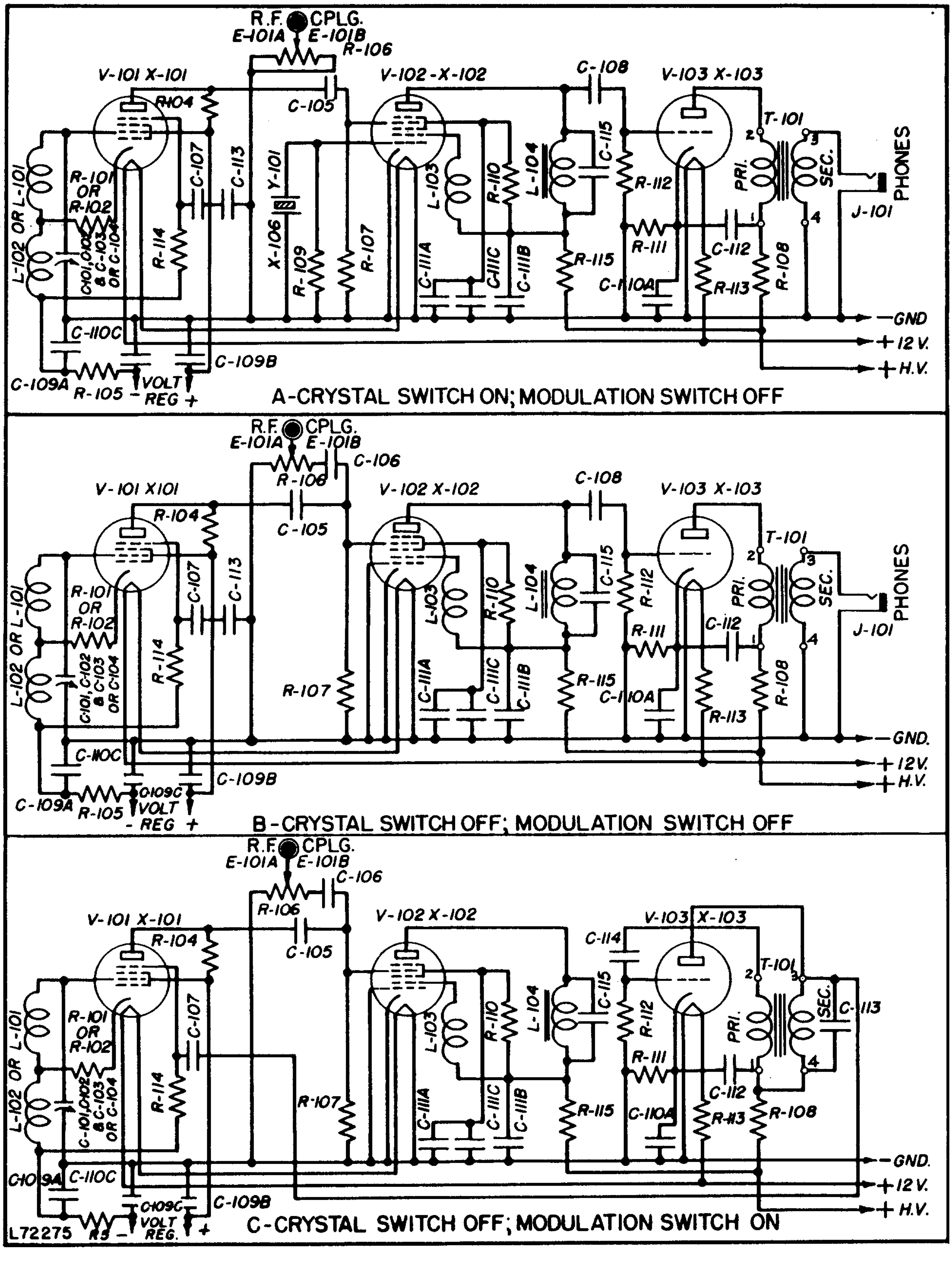

Figure 7.1. Fundamental Circuits.

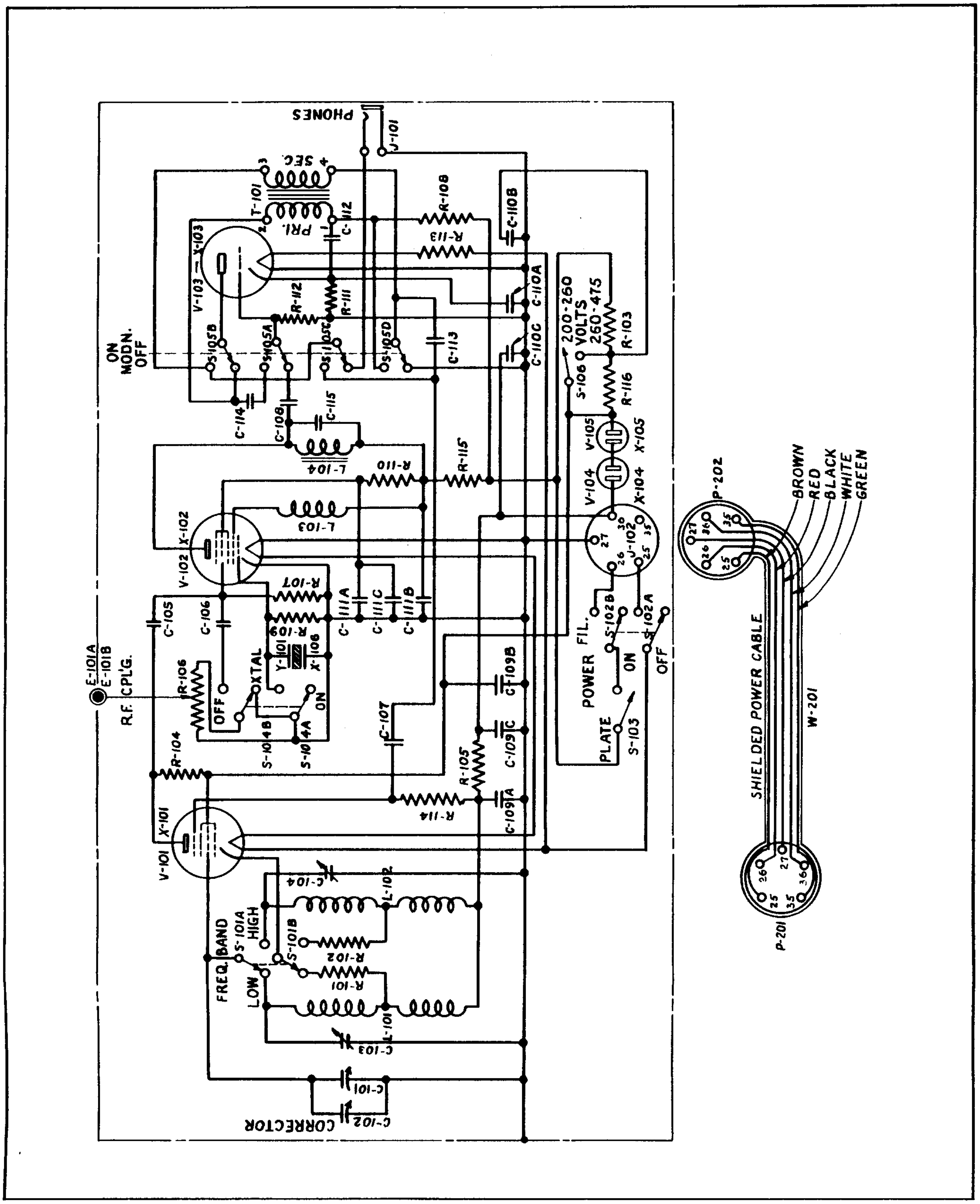

Figure 7.2. Schematic Diagram, Meter Unit.

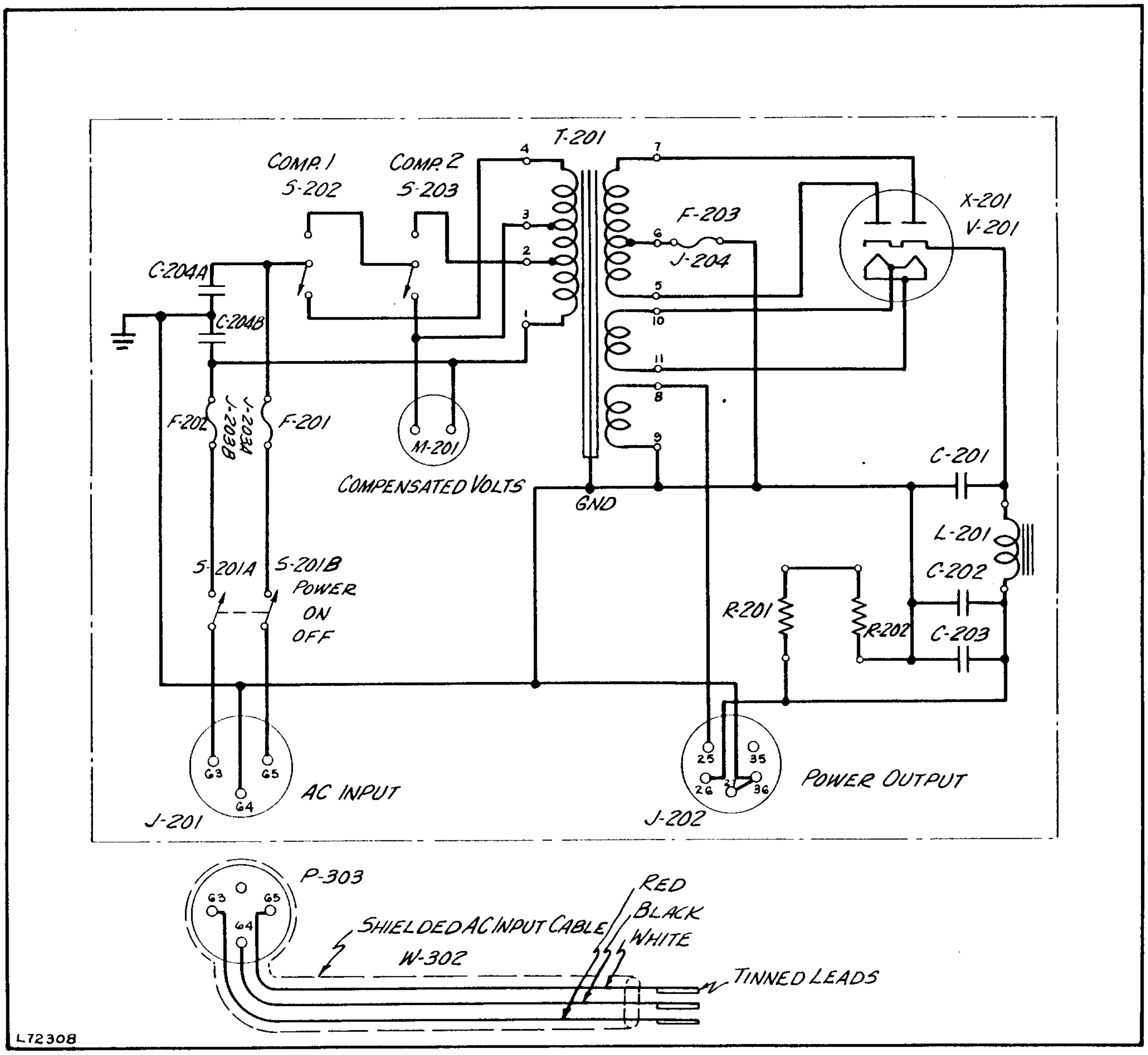

Figure 7.3. Schematic Diagram, Rectifier Unit.

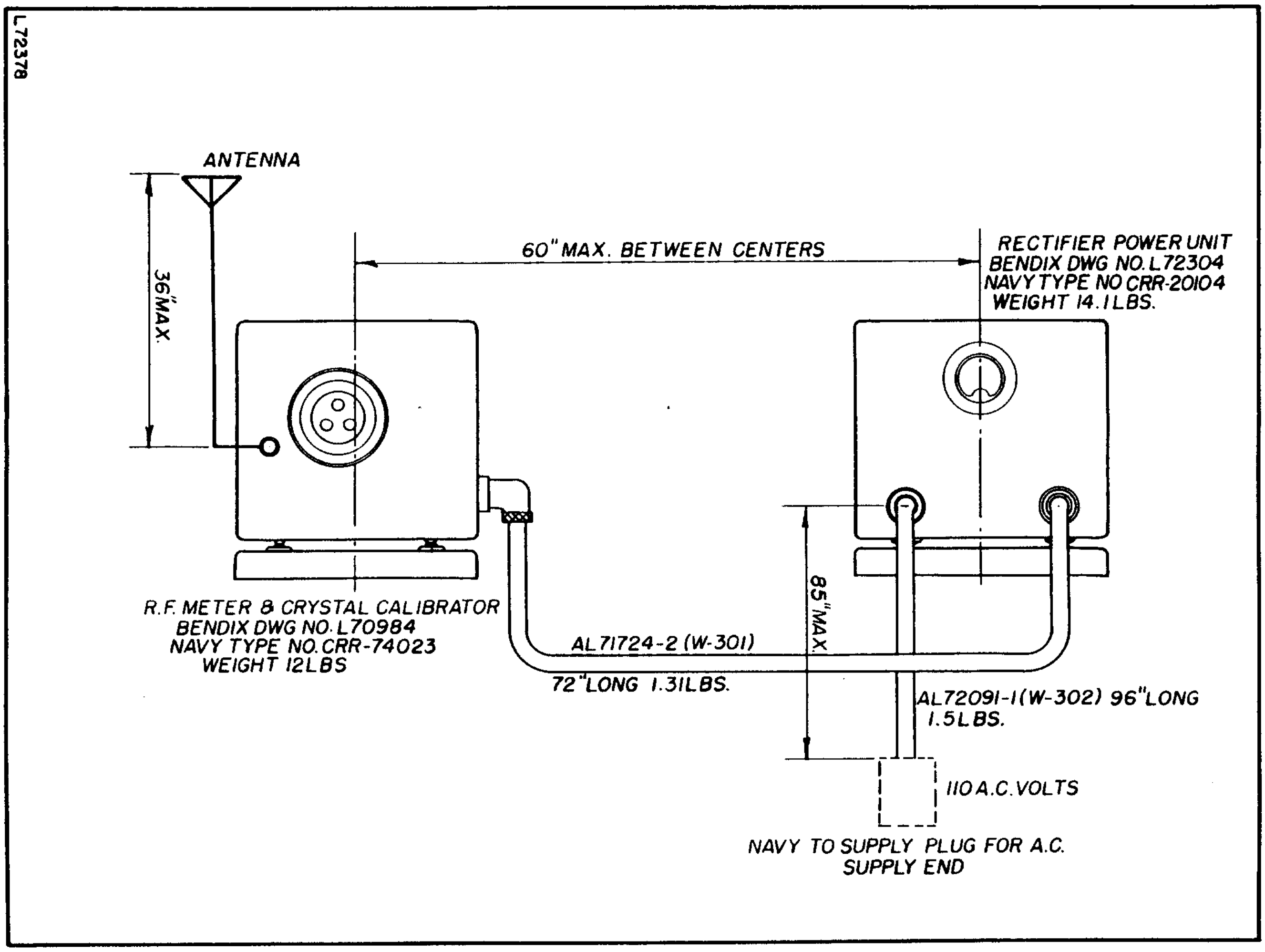

Figure 7.4. Cordage Diagram Model LM-6 Eqipment.