John Showalter

INSTRUCTION MANUAL

FOR

TUNED BRIDGE BALUN

MODEL TB-LF (50-150) 600/50-20

50-150 KHz (20 KW)

FOR

U. S. NAVAL RADIO STATION (T)

LUALUALEI, HAWAII

CONTRACT NO. NBy-70650

MULTRONICS, INC.

John Howatt

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I. INTRODUCTION:

A. General:

This Instruction Manual covers the installation, adjustment, operation and maintenance of Model TB-LF (50-150) 600/50-20 Tuned Bridge Balun furnished under Contract NBy-70650 for installation at the U.S. Naval Radio Station (T) Lualualei, Hawaii.

The balun is designed to operate with an AN/FRT-19 or similar transmitter having a power output not exceeding 20 KW average.

It provides a means of matching the transmitter 600 ohm balanced output to a 50 ohm unbalanced coaxial transmission line (3" heliax #H78-50A).

B. Technical Specifications - Tuned Bridge Balun - Model TB-LF (50-150) 600/50-20:

Frequency Range	50 to 150 KHz
Power Rating	20 KW average
Input	600 ohms (balanced) (AN/FRT-19 Transmitter)
Output	50 ohms (unbalanced) Coaxial Transmission Line 3" Heliax #H78-50A
Enclosures	(2) Cabinets #MI-27626-B 84" high x 34" wide x 32 1/2" deep
Physical Input	Bowl B1 on roof of Cabinet #1 and Bowl B3 on roof of Cabinet #2
Physical Output	On floor at left rear corner of Cabinet #2

II. INSTALLATION:

A. Initial Inspection:

The TB-LF (50-150) 600/50-20 Tuned Bridge Balun has been given a thorough mechanical checkout by the manufacturer previous to shipment. Upon arrival at the operating site, inspect the packing cases and their contents immediately for any possible equipment damage. Inspect the packing cases to determine that you have received all items on the Components List (A0212) (See Appendix). Although the carrier is liable for any damage to the equipment caused during shipment, Multronics, Inc. will assist in describing and providing for repair or replacement of damaged items.

B. Connections:

The mechanical and electrical connections required for the Balun are to be made after the two cabinets have been located (front view; cabinet #1 to the left of Cabinet #2) at their operating position. The connections (internal and exterior) should be made in accordance with the instructions that follow in the sections on mechanical and electrical installation.

C. Mechanical and Electrical Installation:

(1) Cabinet Installation:

Position the cabinets, as already described, in such a manner that the transmission line can be easily routed to the termination point in Cabinet #2 where the line will be attached to the #2062 EIA End Terminal (and pressurized) in accordance with the directions of the transmission line manufacturer.

(2) Components Installation:

Install the Balun components in accordance with Layout drawings C0204 (1 and 2). (See Appendix.)

CAUTION: IT SHOULD BE NOTED THAT THE VARIABLE VACUUM CAPACITORS, C2 AND C5, REQUIRE SPECIAL ATTENTION BECAUSE ROUGH HANDLING CAN CREATE INTERNAL SHORTS DUE TO PLATE MISALIGNMENT CAUSED BY JARRING.

Previous to shipment these components have been tested against the peak voltage breakdown rating of the units (7.5 KV) with a Jennings JHP-70 Hipot Tester. If a Jennings JHP-70 (no other tester) is available on site, the capacitors should once again be tested. These capacitors are to be mounted by means of the FM4 flanges, C0069-3 brackets and 4" x 1" steatite insulators that have been furnished.

To install the variable capacitors you should:

(a) Install the veeder counter assembly and its black plastic front panel disk on the operating panel.

(b) Attach the insulated flexible coupling to the shaft of the veeder counter assembly.

(c) Turn the shaft of the variable capacitor to its full counter-clockwise travel position (it will now be loose). Next, turn clockwise until the first sign of tightening. Stop, the capacitor now has its plates fully meshed; it is set at minimum reactance (maximum capacity).

(d) Set the veeder counter assembly to "zero".

(e) Pre-check for alignment of capacitor shaft with insulated coupling on counter shaft (use shims on insulators, where required).

(f) Carefully insert the variable shaft of the capacitor into the insulated coupling. Secure the insulators to the shelf.

(g) Secure the capacitor shaft to the coupling with the cotter pin that is provided.

(h) The counter should still read "zero"; and the control handle should now be turned clockwise to its full travel which should be approximately 63 turns.

<u>CAUTION</u>: NEVER FORCE THE CAPACITOR SHAFT AND NEVER GO IN THE COUNTERCLOCKWISE DIRECTION BEYOND THE "ZERO" READING.

(i) Inductors L1 and L7 are to be mounted by means of the 5" x 1" steatite insulators that are furnished. To install the variable inductors you should:

(aa) Follow steps (a) and (b) of the preceding capacitor instructions.

(bb) While facing the "strap" end of the variable inductor, turn the shaft to its full counterclockwise travel position. The inductor is now set at minimum reactance (minimum inductance; all turns "shorted").

(cc) Follow steps (d), (e), (f), and (g) of the preceding capacitor instructions.

(dd) The counter should still read "zero".

Three RF ammeters are used in the balun (M1 through M3). Previous to installation the meters should be given a basic continuity check; and if possible an RF current check against the transmitter's RF output meter. The meter manufacturer specifies these meters are calibrated for non-magnetic panel mounting; consequently an insulated mounting plate is provided for placement between the metal mounting panel and the case of the meter. For shipment a shunt strap is connected across the terminal of the meter (this should now be removed). Next, install the meters and make connections to their terminals with the flexible straps that are furnished.

For M3 (which is an external thermocouple type instrument) a set of calibrated leads (enclosed in a braid shield) is furnished in addition to two .01FMD (size CM30) by-pass capacitors. Connect one capacitor from the (+) terminal to the third terminal of the meter and the other from the (-) terminal to the third terminal. Connect the leads between the meter and thermocouple and then connect the shield to the center terminal of the thermocouple and the third terminal of the meter. (Never connect the shield to ground.)

J-Plug Assemblies after installing the female portion of the J-Plug (using the base plate for those that attach to the interior work panels of the cabinet) the male handle should be inserted. Drawing D0102A (See Appendix) lists those handles or J-Plugs which will need to be removed (to open the circuit) for tune up on specific frequencies.

(3) Cabinet Connections:

(a) Connect Bowl Insulators B2 and B4 with the silver plated copper tubing length provided for that purpose.

(b) Connect the transmission line to the EIA End Terminal which has been secured in Cabinet #2 position.

(c) Make all connections between components in the cabinets per the "tagged" instructions on the individual tubing lengths that have been provided. Check your finalized circuitry against schematic D0102.

(d) Connect the AN/FRT-19 Transmitter Outputs to bowl insulators B1 and B3 with lengths of copper tubing.

(4) Interlock Connections:

Each cabinet has interlock switches (for both upper and lower, rear doors) connected to terminal boards to which you must connect the leads of your transmitter interlock circuitry.

III. THEORY:

A. Introduction:

The principle of the tuned bridge balun is simple and straightforward.

The following theoretical discussion assumes that the reader has basic radio theory.

B. Basic Theory:

(1) General:

The word balun means balanced to unbalanced. Therefore the purpose of a balun is to match a balance generator to an unbalanced load. Conversely by reciprocity, it can match an unbalanced generator to an unbalanced load. In our case we will be matching a balanced 600 ohm generator (transmitter) to an unbalanced 50 ohm load (coaxial line to antenna).

There are two types of baluns, tuned and broadband (untuned). Our balun is a tuned type.

The following is a simplified diagram of our tuned balun.

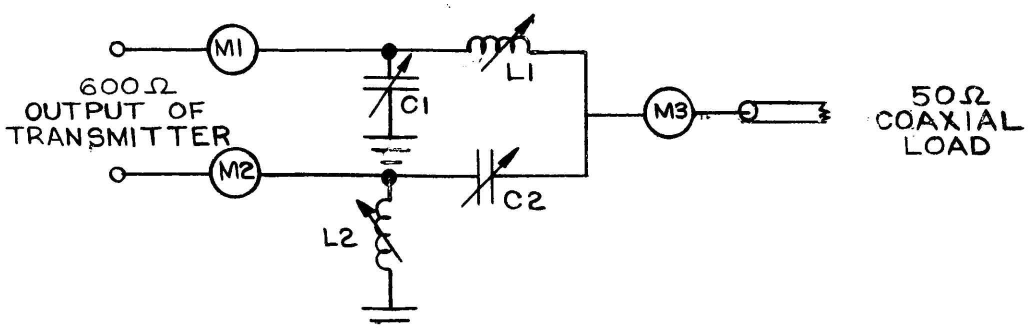


FIGURE 1

M1 and M2 refer to the transmitter output line meters, while M3 represents the combined output or line current to the antenna.

Network C1, L1 and L2, C2 represent two networks similar to L's. Each of these networks are adjusted to the same value of reactance; consequently the upper network (C1, L1) creates a 90^{o} lagging phase shift, whereas the lower netwoek (L2, C2) produces a 90^{o} leading phase shift, thus we can redraw Figure 1 as follows:

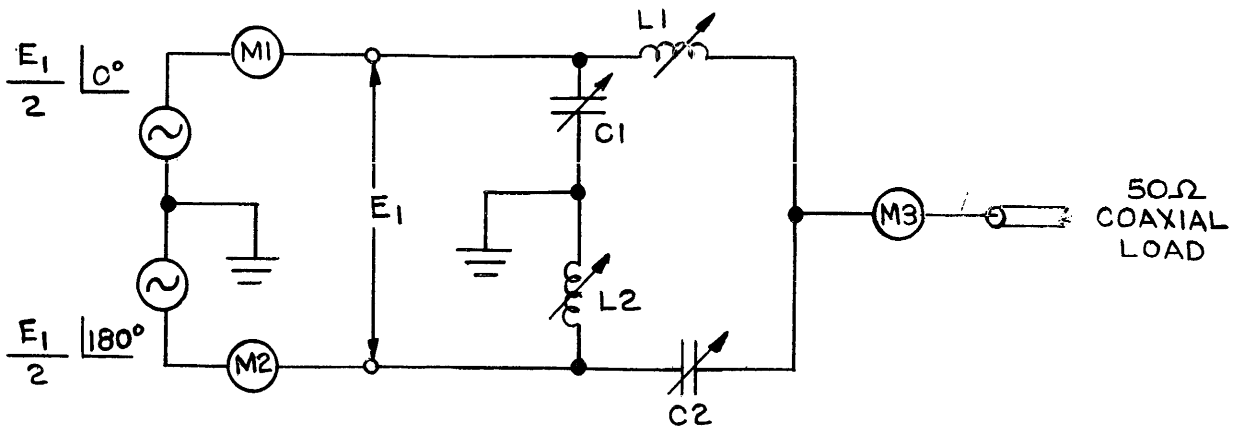


FIGURE 2

Referring to Figure 2, the transmitter or balanced generator has been replaced by two generators, each having a magnitude equal to one-half the total voltage across the line and their phase difference being 180^{o}.

NOTE: This can be proved by noting that:

$$E_1 = \frac{E_1}{2}\angle 0^\circ - \frac{E_1}{2}\angle 180^\circ,$$ but $$\frac{E_1}{2}\angle 180^\circ = \frac{-E_1}{2}\angle 0^\circ;$$ therefore

$$E_1 = \frac{E_1}{2}\angle 0^\circ - \left[\frac{-E_1}{2}\angle 0^\circ\right]^2 = E_1\angle 0^\circ$$

It should be evident from Figure 2 that in order to function properly the balun must combine the outputs of the two generators in the 50 ohm load.

In order to do this, two things must be accomplished, first the phase difference between the two generators must be reduced to zero. This is effected by introducing a -90° phase shift into the upper generator path (C1, L1), and a $+90^{\circ}$ phase shift in the lower generator path (L2, C2).

Second, we have to match the 600 ohm transmitter or generator impedance to the 50 ohm (load). Inasmuch as Figure 2 shows two generators for the transmitter, we can assign one-half of the 600 ohms or 300 ohms for each generator. Since our ultimate goal is to tie the outputs of these two generators in parallel and obtain a 50 ohm output impedance, we must convert the 300 ohm impedance of each generator to a 100 ohm value, and when these are tied together in parallel a 50 ohm output impedance will result.

The following equation is used to determine the magnitude of the reactance for each component of our tuned balun.

$$X_1 = \pm j \left[\frac{R_1}{2} \; (2R_2) \right]^{\frac{1}{2}} \qquad (1)$$

It can be reduced to:

$$X_1 = \pm \; (R_1 R_2)^{\frac{1}{2}} \qquad (2)$$

Where:

X_1 = value of reactance in ohms

R_1 = value of transmitter resistance in ohms

R_2 = value of load or transmission line resistance in ohms

Inasmuch as we are using a 600 ohm transmitter output and a 50 ohm load or transmission line, we can substitute these values in equation (2) and obtain $\pm j173$ ohms.

Figure 1 can now be redrawn as:

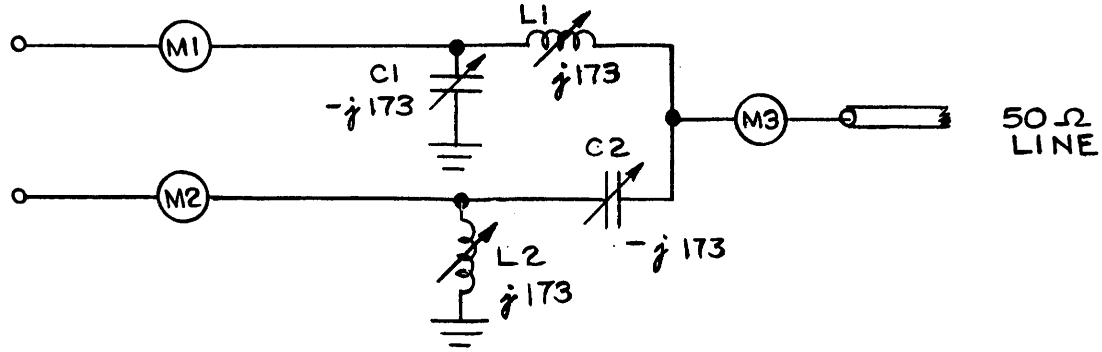


FIGURE 3

(2) Our Case:

Drawing D0102 illustrates our tuned balun. It is the same as Figures 1 and 3 except that additional components are provided to allow continuous tuning between 50-150 KHz.

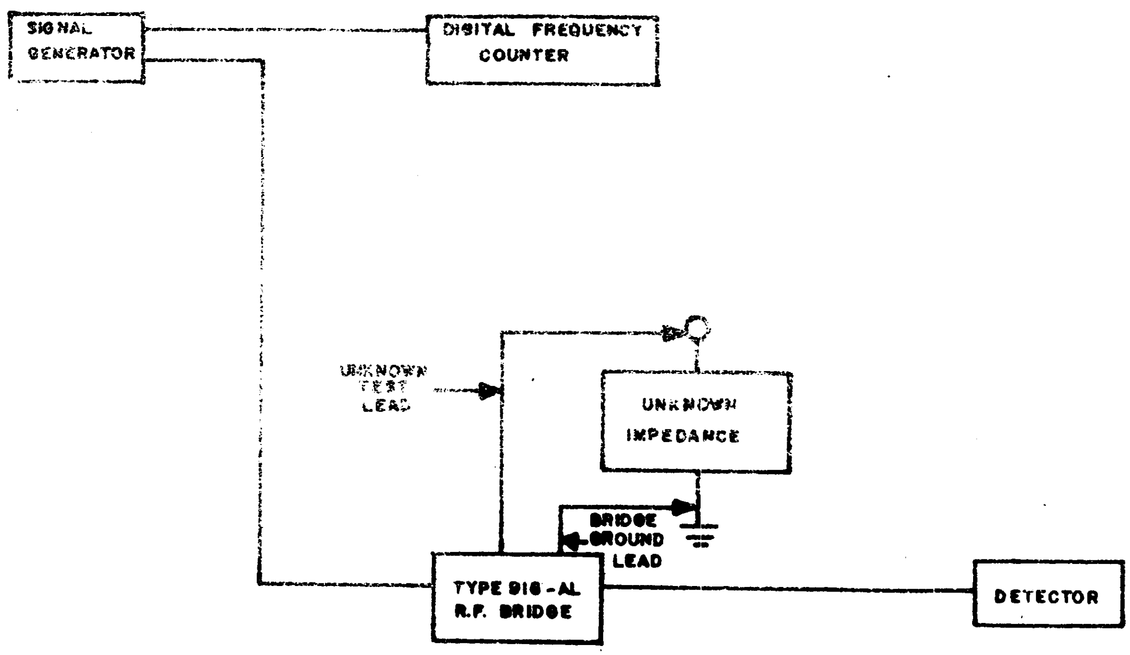
The "J-Plugs" make it possible to parallel or series different components, or completely lift them from the circuit for tuning purposes.

(3) Design Data:

Equation (2) was used to determine X_1, or the reactance value for each leg of the balun. It has already been shown that X_1 in our case should always be $\pm j173$.

In practice it is not always possible to obtain such a value with one component; therefore it becomes necessary to series and/or parallel a group of components to get $\pm j173$ at any frequency between 50-150 KHz.

Drawing D0102A gives design data information. It shows the number of capacitors and inductors required for each frequency, position of J-Plugs, actual reactances, and the expected ammeter readings for a 15 KW transmitter output power. (AN/FRT-19 should be operated at 15 KW average output power.)



BLOCK DIAGRAM OF IMPEDANCE MEASURING EQUIPMENT

MULTRONICS, INC.

FIGURE 4

The value for the inductive reactance was determined by:

$$X_1 = 2\pi fL \qquad (3)$$

Where:

X_1 = inductive reactance in ohms

$2\pi = 6.28$

f = frequency in cycles/second

L = inductance in henries

and the value for the capacitive reactance was determined by:

$$X_1 = \frac{-159.2}{fc} \qquad (4)$$

Where:

f = frequency in KHz

c = capacity in microfarads

The current for the transmitter output line meters (M1, M2) was determined by:

$$I = \sqrt{\tfrac{1}{2}P_T / \tfrac{1}{2}R_1} \qquad (5)$$

Where:

I = line current in amperes for M1 and M2

P_T = total transmitter output in ohms

R_1 = transmitter output resistance in ohms

and the current for the line meter was determined by:

$$I = \sqrt{P_T / R_2} \qquad (6)$$

Where:

I = line current in amperes for M3

P_T = total transmitter output in watts

R_2 = load or coaxial line output resistance in ohms

IV. ADJUSTMENT AND OPERATION:

A. General:

Initial adjustment of the tuned balun should be made using RF bridging equipment. Thereafter once pre-sets have been established, a small change in frequency can be accomplished by setting up to the nearest frequency for which pre-sets are available and at reduced power, carefully tuning each leg of the balun until equal currents are obtained on M1 and M2. The power can then be raised to the desired level by monitoring M1 through M3.

B. Equipment Required For Adjustment:

The following equipment should be used for setting up the tuned balun.

(1) General Radio Type 916-AL RF Bridge.

(2) Detector such as the AN/FRT-21 Low Frequency communication receiver Field Intensity Meter, or equivalent.

(3) AN/URM-25D RF Signal Generator or equivalent.

(4) Digital Frequency Counter.

(5) Assorted Patch Cables and Connectors for the above items.

C. Use of The General Radio Type 916-AL RF Bridge:

(1) General:

Though there are several methods of measuring antenna or network impedances, the use of a General Radio Type 916-AL RF Bridge is recommended because they are usually available at all communication stations.

The description and use of this instrument is covered in the General Radio Company's instruction book, but a condensed version is presented here in specific regard to adjusting the Multronics Model TB-LF (50-150) 600/50-20 Tuned Bridge Balun.

Figure 4 illustrates a block diagram set up for impedance measurements.

In setting up the equipment at the balun, operating personnel should be sure that the proper bridge input transformer is in use, in accordance with the instruction book. Next, ground the bridge to the pig-tail ground strap (which runs throughout the cabinet) at a point nearest to the component to be measured, and connect all patch cables as shown in Figure 4.

Do not use multiple grounds on the measuring equipment because it can cause erroneous readings. Grounding leads should be flat braided shielding material. A good source of this is the outer sheath from a piece of RG-8/U or RG-11/U cable. Remove a length of this shielding, flatten it, and attach clips to each end. DO NOT USE MULTIMETER TEST LEAD OR SIMILAR WIRE FOR BRIDGE TEST LEADS OR GROUNDING BECAUSE IMPAIRED ACCURACY WILL RESULT.

(2) Bridging Procedure:

As a safety rule, only after the measuring equipment is grounded via the bridge's ground lead should the AC line plugs for the test equipment be inserted and the power be turned on. After a five minute warmup, set the signal generator to the desired frequency by use of the frequency counter. Keep the generator frequency within 20 cycles of the operating frequency.

Do not use the audio modulation of the signal generator. The receiver BFO should be used to produce an audible beat output in the head-phones. Tune in the signal in the receiver with a moderate RF level setting. Adjust receiver front end tuning and sensitivity until the signal is properly tuned in the receiver passband with maximum receiver selectivity. Adjust the

BFO as required to produce a desirable beat note in the headphones.

On the Type 916-AL RF Bridge, the unknown resistance and reactance are read directly on the resistance and reactance dials. A ΔX dial is included as a simple vernier on the main reactance dial. With the unknown test clip lead shorted to ground, the RESISTANCE dial is set to zero, and the REACTANCE dial is set to zero when the unknown impedance is expected to be inductive. The LC switch is set in the L position. Next, the initial balance dials must be adjusted for a sharp or deep null. The receiver RF gain should be advanced as the null is approached. At final null, the RF gain may be advanced all the way up to verify the null. It is often advisable to use the receiver S-meter as a visual null indicator concurrently with the audible signal in the headphones, as the S-meter will read small changes in signal level which may not be apparent to the ear, during the early portion of the balancing process. The initial balance dials must be adjusted carefully to obtain a complete null. <u>They should then be locked in position and not touched again during subsequent measurements</u>.

The RESISTANCE dial will now read the resistance directly when the clip lead is connected to the unknown. The REACTANCE dial reading must, however, be corrected for the frequency in use to obtain the true reactance of the unknown. Simply divide the dial reading by f/100, where f is the frequency of measurement. For example, if measurements are being made at 50 KHz, divide the REACTANCE dial reading by 0.5. In taking a final balance on an unknown reactance, the reactance dial reading will move up-scale if the unknown reactance is inductive.

If it is expected to be capacitive, the initial short circuit balance must be taken with the reactance dial set at a value which will exceed the estimated value of the unknowns. The RESISTANCE dial will move up-scale as usual, but the REACTANCE dial will move down-scale in the direction of its zero point on the dial. The final REACTANCE dial reading is the difference between its initial balance and final balance readings. As a rule, inductive impedances will move the REACTANCE dial up-scale and capacitive impedance will move down-scale. In the latter case one must, of course, note and remember the initial balance reading of the REACTANCE dial. The LC switch on the bridge panel is somewhat misnamed. Either L or C may be measured anywhere along the scale of the REACTANCE dial. The LC switch is actually nothing but a scale range switch and should be used as follows. Always try to initially balance the bridge first with the LC switch in the L position. There may be cases when a capacitive unknown is being measured where the desired starting point on the REACTANCE dial must be set too high up the scale to achieve initial balance. If no initial balance can be obtained with the switch in the L position, under those conditions, the switch should then be shifted to the C position.

(3) Setting the Balun With the Bridge:

Refer to Drawing D0102.

Then:

(a) Set up bridging equipment to rear of balun cabinet number one.

(b) Adjust oscillator frequency to 50 KHz, and balance bridge in L position at j200.

During all of the following measurements you will be measuring REACTANCE only. Your RESISTANCE dial should read zero or a very small resistance less than an ohm. The resistance would be a function of the Q of the components. (Q = X/R). Any resistance readings over 1Ω means you have a poor or loose connection.

(c) Remove all J-Plugs (J1 through J19) in both cabinets.

(d) Plug in J2, J3 and J4.

(e) Clip the General Radio Bridge test lead on the output side of J1 (side closest to Meter M1). (Note: Your bridge will now become unbalanced and the audio beat note will be very loud; back receiver gain down to keep from overloading front end.)

(f) Now adjust bridge reactance dial to j113. (This is equivalent to -j87 which is same as -j173.(-87/0.5 = -173) Your bridge will still be unbalanced.

(g) Next have an assistant go around to front of cabinet number one and adjust Power #1 (C2) veeder counter until you obtain a good null or balance while bridge is set to j113.

(h) Log the veeder counter setting on Drawing D0102B, the calibration chart. You now have first leg of bridge setting for 50 KHz.

(i) Our next step is to set the inductive leg of the balun in cabinet number one. Now open up or take out J2.

(j) Next plug in J5, J7B, and J8A.

(k) Put a ground lead from input end J9 (output of L3) to ground.

(l) Leaving your bridge test lead still at output of J1, set your bridge reactance dial (initial balance should still be at j200) to j287. (This is equivalent to j173 at 50 KHz.)

(m) Next have an assistant adjust "Output #1" veeder counter control (L1) to where a good null or balance is obtained on the bridge. You now have inductive leg of balun properly set for 50 KHz.

(n) Now before moving to cabinet number two, restore J plugs, J1 and J2. Also remove ground from J9 and insert J9.

The following J plugs should be inserted in cabinet number one (J1, J2, J3, J4, J5, J7B, J8A and J9.) (See Drawing D0102A.)

(o) Now go to rear of cabinet number two where we will go through the same procedure we have just finished for cabinet number one.

(p) Put bridge lead on output of J10. Then insert J plugs, J11, J13B, J14A, J15, and J16.

(q) Now set bridge reactance scale to j287 (assumes initial balance at j200) and have assistant adjust "Power #2" veeder counter control until you obtain a good null or balance on bridge. You now have inductive leg set to j173 at 50 KHz.

(r) Remove J16, and J18. Also place ground lead on input of J19.

(s) Adjust bridge reactance dial to -j113, and have assistant adjust "Output #2" veeder counter control to obtain good null or balance on bridge. You now have capacitive leg adjusted to -j173 at 50 KHz.

(t) Now disconnect bridge. Then insert following J plugs in cabinet number two, J10, J11, J13B, J14A, J15, J16, J18, and J19. Close rear doors on both cabinets.

The balun is now ready for power at 50 KHz.

(4) Other Frequency Settings:

Drawing D0102B gives the settings for the contract frequencies. If it is desired to set the balun at other frequencies:

(a) Refer to Drawing D0102A for nearest frequency and insert proper J plugs.

(b) Use same bridge technique as already described and set each leg to $\pm j173$ at operating frequency.

(c) Log new veeder counter settings for future reference.

(5) How to Determine and Measure Transmission Line Impedance:

It is assumed that the transmission line impedance is 50j0. In practice it is not unusual for so-called 50 ohm transmission line to vary somewhat; hence, if there is any question that the line is not 50 ohms, the following procedure can be used for measuring its impedance.

(a) Set up bridging gear at input of transmission line.

(b) Follow same procedure for use of bridge already discussed.

(c) Have J plug at input to line termination (at antenna) opened so transmission line output is floating.

(d) Next clip bridge test lead on center conductor of transmission line (at transmitter building). Make sure everything is disconnected from line except bridge.

(e) Read value of resistance and reactance. Correct value of reactance by dividing bridge reading by operating frequency in megahertz. You now have determined the Z_{oc} (open circuit impedance) of the transmission line. (Note: the value of resistance will be zero or very close to zero. Reactance can measure over 50.)

(f) Now have assistant place short circuit across output end of transmission line, (use very short lead), and remeasure the input end.

(g) You now have Z_{oc} and Z_{sc} (open and short circuit impedance of transmission line). Don't forget to remove short when through measuring.

Using the above parameters, determine the line impedance from:

$$Z_o = \sqrt{Z_{oc} \cdot Z_{sc}} \qquad (7)$$

Where:

Z_o = transmission line impedance in ohms

Z_{oc} = open circuit impedance of line ohms

Z_{sc} = short circuit impedance of line ohms

As an example, assume that you determine the following values for the open and short circuited impedance:

Z_{oc} = 0j22.7

Z_{sc} = 0-j107

Substituting in equation (7) we have:

$$\sqrt{22.7 \times 107} = 49.5 \text{ ohms} \qquad (8)$$

(6) <u>Application of Power</u>:

(a) Set balun to desired frequency from pre-set Drawing D0102B.

(b) Then patch balun into dummy load.

(c) Bring transmitter power up to normal output. Shut down.

(d) Then patch balun to antenna transmission line; and bring transmitter power up to normal output. You are now ready for operation.

(7) Extended Range of Balun:

Although the contract calls for a 50-150 KHz tuned bridge balun, it should be noted that the Multronics Model TB-LF (50-150) 600/50-20 can be tuned from 50 to 300 KHz with an input power of 20 KW and provide a match between a 600 ohm balanced transmitter output to an 50 ohm load or transmission line. The same bridge procedures for determining settings between 50-150 KHz can be used for frequencies between 150-300 KHz.

V. PREVENTATIVE MAINTENANCE:

In General the Model TB-LF (50-150) 600/50-20 Tuned Bridge Balun requires very little maintenance.

Preventative maintenance within the balun will be confined primarily to keeping the enclosures and the components clean and free from dirt. The vacuum capacitors, coils, and all insulators should be wiped free of dirt with a soft cloth. Connections should be checked for normal tightness. J-plug contacts should be kept clean and free from dirt.

From time to time it may be found desirable to place a small amount of lubricant on the veeder root counters and the door interlocks. A good silicon libricant is recommended.

Before performing any preventative maintenance operations within the balun, shut the transmitter down and use a clip lead or other ground connection between the output end of J19 and ground. It is always preferable to patch the balun to dummy load before proceeding with preventative maintenance in which case a ground is not required on J19.

VI. TROUBLE SHOOTING:

A. General:

Convenience of layout and lack of complexity in the balun makes it relatively easy to trouble shoot in the event of a failure, if a few basic procedures are followed.

Observe all high voltage precautions while trouble shooting the balun, especially guarding against shock from inducted RF voltages.

B. Outages:

When an outage occurs in the transmitting system, the following procedure is recommended for tracing the difficulty:

(1) Go to the patch panel and switch the transmitter output into the dummy load. Now raise the transmitter power to full carrier and observe any difficulties. If the transmitter operates normally, the trouble is at the antenna (could be coax, but such conditions are quite rare).

(2) Use antenna instruction book to determine best trouble shooting procedures.

(3) If the transmitter will not work through the balun into the dummy load, your trouble is either in the transmitter or balun.

(4) If based on your past experience the transmitter does not appear to be at fault:

(a) Leave balun on dummy load.

(b) Remove back doors on both cabinets, and disable interlock switches, by pulling straight out to disable position.

(c) Observe the components while an assistant gradually brings up the power at the transmitter (be careful to observe all safety precautions as high voltages exist in these units). If corona is observed, note the source and have the transmitter shut down, then examine all components, connecting straps, hardware, and insulators in the area for burrs, plating blisters, or chipped insulation. Also listen for arcing or flashover.

(d) If no visible troubles are evident, shut transmitter down.

(e) Remember if evidence of arcing is not observed, it is possible that one of the vacuum capacitors in the balun is shorted or arcing under power. The great majority of so-called "shorts" in vacuum capacitors are due to fatigue in the plate supporting structure, causing the plates of the capacitors to move closer together. Since this ordinarily shows up under power, it is unlikely that an ohmmeter check of the capacitors in the system will show any defects. Hence each capacitor should be checked with a Jennings Hi-Pot checker. (A Jennings Hi-Pot should be used for these tests as others may yield erroneous indications on the Jennings vacuum capacitors.) If one or more capacitors are defective, replace them with spares. Each spare capacitor should be removed from its packing case and subjected to a Hi-Pot test to see whether it meets ratings. Defective capacitors will generally be found to arc over at voltages less than half the rated voltage.

(f) If the procedures above do not localize the trouble, check meters M1 through M3 for continuity. If one or more meters are defective, replace; otherwise set up bridging equipment at rear of cabinets and check each leg of balun as already described in paragraph IV C (3) of this manual.

C. Special Problems:

If unusual or persistent problems are experienced with the balun, contact:

Director of Engineering
Multronics, Inc.
5712 Frederick Avenue
Rockville, Maryland 20852

See Appendix for our Guarantee.

A P P E N D I X

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MULTRONICS, INC.

DRAWING LIST
TUNED BRIDGE BALUN
MODEL TB-LF (50-150) 600/50-20
50-150 KHz (20 KW)

MULTRONICS DRAWING NO.	SHEET	DESCRIPTION
D0102	1 of 1	R.F. Network Schematic
D0102A	1 of 1	Design Tabulations
D0102B	1 of 1	Calibration Tabulations
C0204	1 of 2	Layout: Cabinet #1
C0204	2 of 2	Layout: Cabinet #2
A0212	1 of 1	Components List

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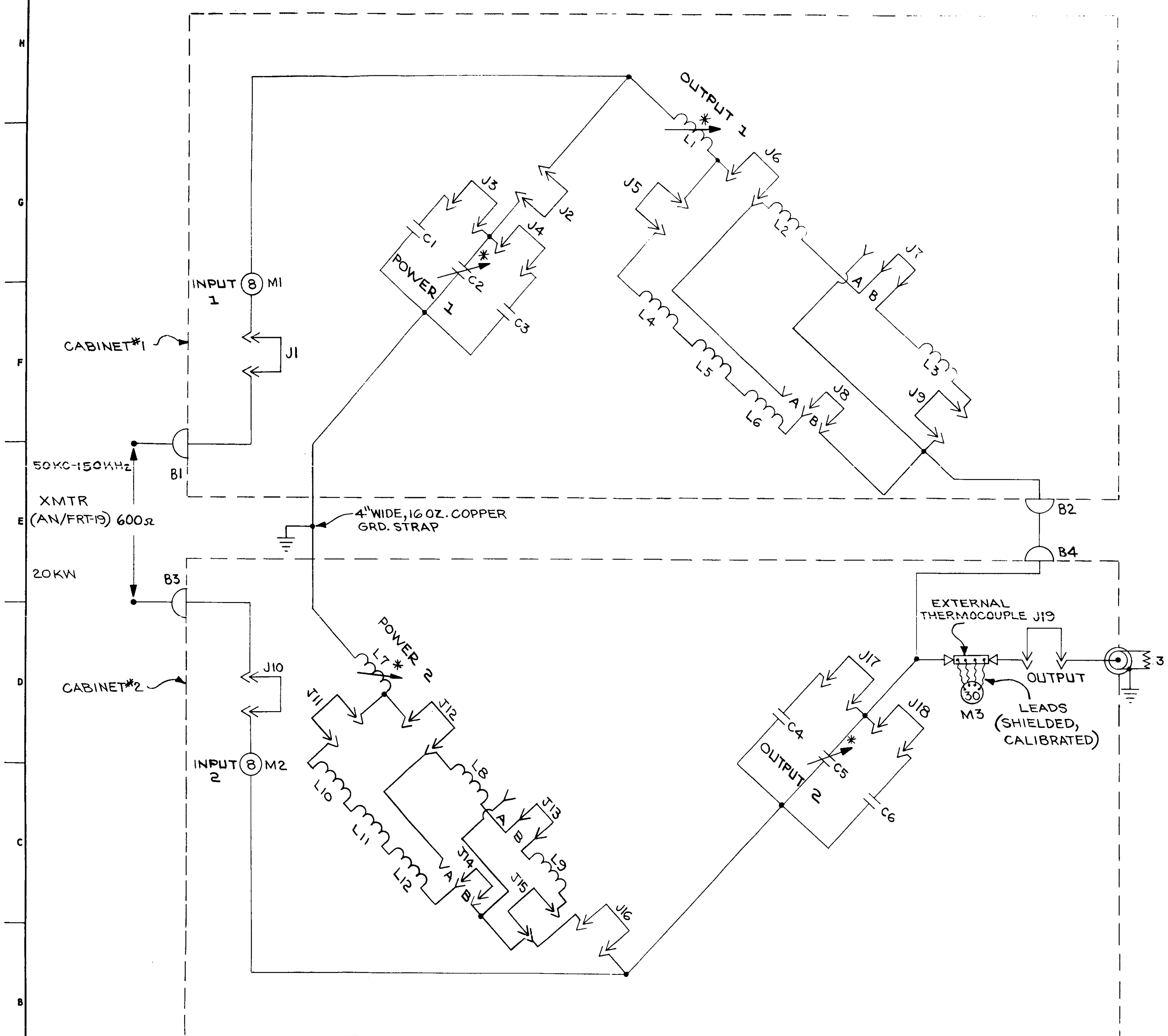
ZONE	SYM.	DESCRIPTION	DATE	APPROVAL
-	A	KC DESIGNATION CHANGED TO KHz 5 PLACES	11-7-66	[illegible]



NOTES:

1. MULTRONICS , TUNED BRIDGE BALUN 50KHz-150KHz (20KW) #TB-LF (50/150) 600/50-20
2. MATCHING 600Ω BALANCED XMTR OUTPUT (AN/FRT-19) TO A 50Ω UNBALANCED COAXIAL TRANSMISSION LINE (3" HELIAX # HJ8-50A)
3. * INDICATES FRONT PANEL CONTROLLED (VEEDER COUNTER) VARIABLE COMPONENT
4. CABINETRY : (2) 84" HIGH X 34" WIDE X 32 1/2" DEEP (MI-27626-B)
5. DESIGN: MULTRONICS, INC. 5712 FREDERICK AVE. ROCKVILLE, MD.

CONTRACT NO. NBY 70650
MULTRONICS JOB NO. 128-28
SITE LOCATION NAVAL RADIO STATION (T) LUALUALEI, HAWAII

REQD.	PART NO.	ITEM	DESCRIPTION	MATL. OR MFR	MATL. SPEC. OR CAT. NO	CKT. SYM.	UNIT WT.	ZONE

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DEC. FRACT. ANG. RMS. FIN.
MATERIAL:
FINISH:
USED ON | NEXT ASSY.

	SIGNATURE	DATE
DR	KAD	7/2/65
CHK.	H. H. M.	
ENGR.	George B. Howard	7/2/65
PROJ. APPD.		

TUNED BRIDGE BALUN
MODEL TB-LF(50-150)600/50-20
R.F. NETWORK SCHEMATIC
50KHz-150KHz (20KW)

MULTRONICS, INC.

SCALE:

D0102 REV. A

SHEET 1 OF 1

APACITORS REQ INDICATES IN USE					INDUCTANCE REQUIRED		INDUCTANCE REQUIRED	
					L1 THRU L6	L1	L7 THRU L12	L7
C2	C3	C4	C5	C6	Uh / +jXL	Uh / +jXL	Uh / +jXL	Uh / +jXL
X	X	X	X	X	550 / +j173	71 / +j22.3	550 / +j173	71 / +j22.3
X	X	X	X	X	458 / +j173	86 / +j32.4	458 / +j173	86 / +j32.4
X	X		X	X	417 / +j173	45 / +j18.7	417 / +j173	45 / +j18.7
X	X		X	X	393 / +j173	21 / +j9.25	393 / +j173	21 / +j9.25
X	X		X	X	344 / +j173	51 / +j25.6	344 / +j173	51 / +j25.6
X	X		X	X	306 / +j173	13 / +j7.35	306 / +j173	13 / +j7.35
X		X	X		276 / +j173	90 / +j56.5	276 / +j173	90 / +j56.5
X		X	X		250 / +j173	64 / +j44.2	250 / +j173	64 / +j44.2
X		X	X		230 / +j173	44 / +j33.2	230 / +j173	44 / +j33.2
X		X	X		212 / +j173	26 / +j21.2	212 / +j173	26 / +j21.2
X		X	X		196 / +j173	10 / +j8.8	196 / +j173	10 / +j8.8
X		X	X		184 / +j173	105 / +j99	184 / +j173	105 / +j99

INDUCTORS REQUIRED X INDICATES IN USE												R.F. AMMETER SETTINGS (AMPS)		
L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	M1	M2	M3
X	X	X	X	X	X	X	X	X	X	X	X	5.00	5.00	17.4
X	X		X	X	X	X	X		X	X	X	↑	↑	↑
X	X		X	X	X	X	X		X	X	X			
X	X		X	X	X	X	X		X	X	X			
X			X	X	X	X			X	X	X			
X			X	X	X	X			X	X	X			
X	X	X				X	X	X						
X	X	X				X	X	X						
X	X	X				X	X	X						
X	X	X				X	X	X						
X	X	X				X	X	X						
X	X					X	X					↓	↓	↓

TABULATION OF J-PLUG ASSEMBLIES X INDICATES: PLUG INSERTED																						
J1	J2	J3	J4	J5	J6	J7A	J7B	J8A	J8B	J9	J10	J11	J12	J13A	J13B	J14A	J14B	J15	J16	J17	J18	J19
X	X	X	X	X			X	X		X	X	X			X	X		X	X	X	X	X
X	X	X	X	X			X	X		X	X	X			X	X		X	X	X	X	X
X	X		X	X				X			X	X		X		X			X		X	X
X	X		X	X				X			X	X		X		X			X		X	X
X	X		X	X					X		X	X					X		X		X	X
X	X		X	X					X		X	X					X		X		X	X
X	X	X	X		X		X			X	X		X		X				X	X		X
X	X	X			X		X			X	X		X		X			X	X	X		X
X	X	X			X		X			X	X		X		X			X	X	X		X
X	X	X			X		X			X	X		X		X			X	X	X		X
X	X	X			X		X			X	X		X		X			X	X	X		X
X	X	X			X	X					X		X	X					X	X		X

DESIGN TABULATIONS TUNED BRIDGE BALUN TB-LF (50-150) 600/50-20

D0102A

MULTRONICS, INC.

FREQ. KHz	CAPACITANCE REQUIRED C1 C2,C3 MFD	C1 C2,C3 −jXc	C2 MFD	C2 −jXc	CAPACITANCE REQUIRED (MFD) C4,C5 C6 MFD	C4,C5 C6 −jXc	C5 MFD	C5 −jXc
50	.018350	−j173	.004550	−j 700	.018350	−j173	.004550	−j 700
60	.015300	−j173	.001500	−j 1765	.015300	−j173	.001500	−j1765
66	.013900	−j 173	.004800	−j 506	.013900	−j 173	.004800	−j506
70	.013100	−j173	.004000	−j 566	.013100	−j173	.004000	−j 566
80	.011150	−j173	.002050	−j 969	.011150	−j 173	.002050	−j 969
90	.010200	−j173	.001100	−j 1605	.010200	−j 173	.001100	−j 1605
100	.009200	−j173	.004500	−j 352	.009200	−j 173	.004500	−j 352
110	.08350	−j 173	.003650	−j 395	.08350	−j173	.003650	−j395
120	.007555	−j 173	.002855	−j 465	.007555	−j 173	.002855	−j 465
130	.07060	−j 173	.002360	−j518	.07060	−j 173	.002360	−j 518
140	.006550	−j 173	.001850	−j 613	.006550	−j 173	.001850	−j 613
150	.006130	−j173	.001430	−j 740	.006130	−j173	.001430	−j 740

FREQ. KHz	CAPACITORS REQ X INDICATES IN USE C1	C2	C3	C4	C5	C6
50	X	X	X	X	X	X
60	X	X	X	X	X	X
66		X	X		X	X
70		X	X		X	X
80		X	X		X	X
90		X	X		X	X
100	X	X		X	X	
110	X	X		X	X	
120	X	X		X	X	
130	X	X		X	X	
140	X	X		X	X	
150	X	X		X	X	

FREQ. KHz	INDUCTANCE REQUIRED L1 THRU [illegible] Uh	L1 THRU [illegible] +jXL	L1 Uh	L1 +jXL	INDUCTANCE REQUIRED L7 THRU L12 Uh	L7 THRU L12 +jXL	L7 Uh	L7 +jXL
50	550	+j 173	71	+j 22.3	550	+j 173	71	+j 22.3
60	458	+j 173	86	+j 32.4	458	+j173	86	+j 32.4
66	417	+j 173	45	+j18.7	417	+j 173	45	+j 18.7
70	393	+j 173	21	+j 9.25	393	+j 173	21	+j9.25
80	344	+j 173	51	+j25.6	344	+j 173	51	+j25.6
90	306	+j 173	13	+j7.35	306	+j 173	13	+j7.35
100	276	+j 173	90	+j56.5	276	+j 173	90	+j56.5
110	250	+j 173	64	+j44.2	250	+j173	64	+j 44.2
120	230	+j173	44	+j 33.2	230	+j 173	44	+j 33.2
130	212	+j 173	26	+j21.2	212	+j173	26	+j 21.2
140	196	+j 173	10	+j 8.8	196	+j 173	10	+j 8.8
150	184	+j 173	105	+j 99	184	+j173	105	+j 99

FREQ. KHz	INDUCTORS REQUIRED X INDICATES IN USE L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	R.F. AM… SETT… (AM… M1	M…
50	X	X	X	X	X	X	X	X	X	X	X	X	5.00	5.…
60	X	X		X	X	X	X	X		X	X	X	↑	
66	X	X		X	X	X	X	X		X	X	X		
70	X	X		X	X	X	X	X		X	X	X		
80	X			X	X	X	X			X	X	X		
90	X			X	X	X	X			X	X	X		
100	X	X	X				X	X	X					
110	X	X	X				X	X	X					
120	X	X	X				X	X	X					
130	X	X	X				X	X	X					
140	X	X	X				X	X	X					
150	X	X					X	X					↓	↓

DESIGN TABULATIONS TUNED BRIDGE BALUN TB-LF (50-150) 600…

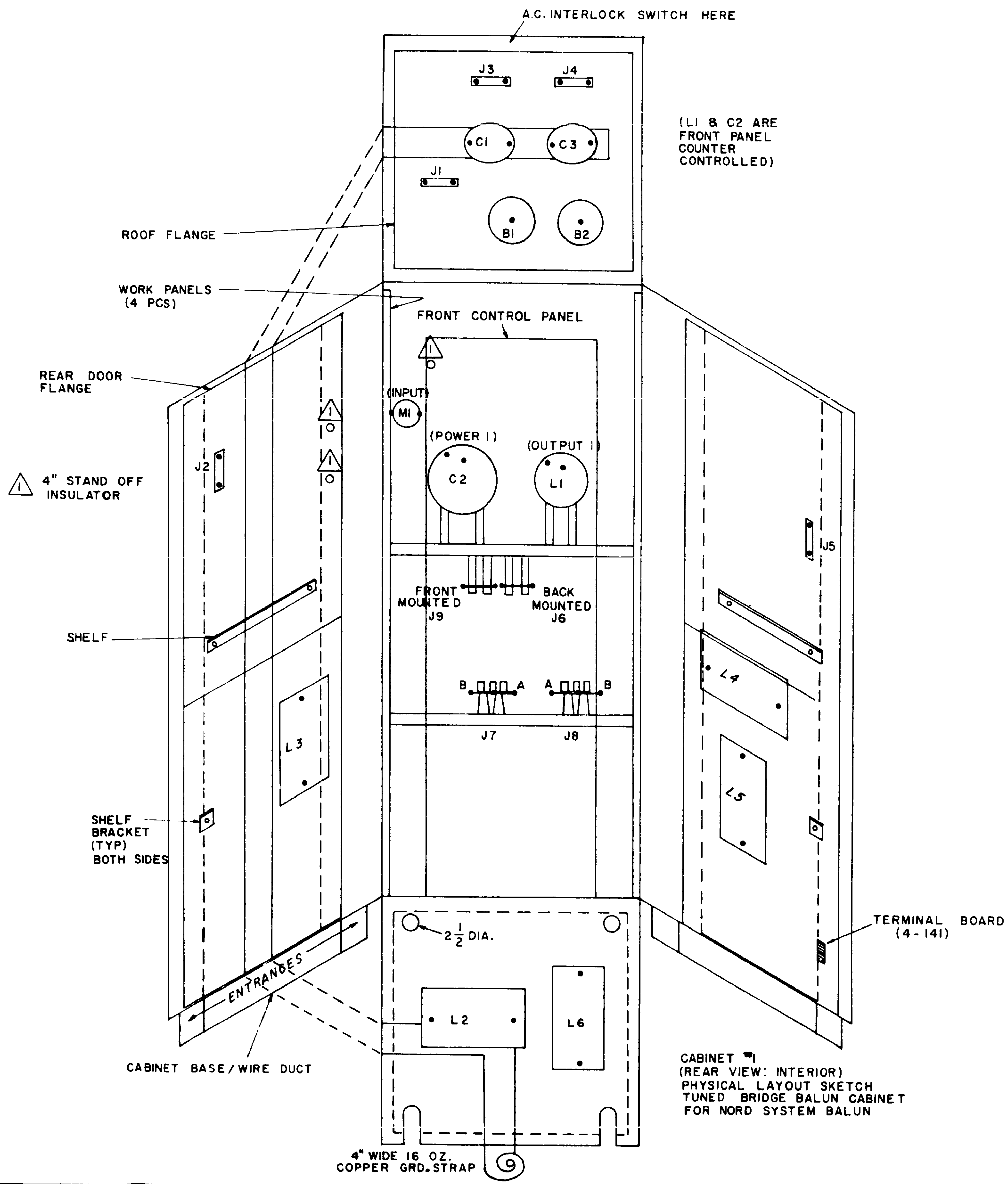
FREQ. KHz	VEEDER COUNTER SETTINGS				CAPACITORS REQ. X INDICATES IN USE						INDUCTORS REQUIRED X INDICATES IN USE												TABULATION OF J-PLUG ASSEMBLIES X INDICATES: PLUG INSERTED																							
	OUTPUT 1 (L1)	POWER 1 (C2)	OUTPUT 2 (C5)	POWER 2 (L7)	C1	C2	C3	C4	C5	C6	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	J1	J2	J3	J4	J5	J6	J7A	J7B	J8A	J8B	J9	J10	J11	J12	J13A	J13B	J14A	J14B	J15	J16	J17	J18	J19	

CALABRATION CHART TUNED BRIDGE BALUN TB-LF (50-150) 600/50-20 D0102B

MULTRONICS, INC.

REVISIONS

ZONE	SYM.	DESCRIPTION	DATE	APPROVAL
—	A	REDRAWN FROM "C" SIZE TO "D" SIZE	11-2-66	



CABINET #1
(REAR VIEW: INTERIOR)
PHYSICAL LAYOUT SKETCH
TUNED BRIDGE BALUN CABINET
FOR NORD SYSTEM BALUN

TUNED BRIDGE BALUN CABINET MI-27626-B (R-LINE MODEL)
EXTERIOR DIMENSIONS:
84" HIGH x 34" WIDE x 32 1/2" DEEP
INTERIOR DIMENSIONS:
80" HIGH x 32" WIDE x 30 DEEP

REQD	PART NO.	ITEM	DESCRIPTION	MATL OR MFR	MATL SPEC OR CAT NO	CKT SYM	UNIT WT	ZONE

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DEC — FRACT — ANG — RMS FIN —
MATERIAL
FINISH
USED ON | NEXT ASSY.

	SIGNATURE	DATE
DR	C. Bethea	1/21/64
CHK	[illegible]	[illegible]
ENGR	[illegible]	[illegible]
PROJ APPD.		

TUNED BRIDGE BALUN LAYOUT
MODEL TB-LF (50-150)
600/50-20
FOR
CONTRACT NBY 70650
U.S. NAVAL RADIO STATION (T)
LUALUALEI, HAWAII

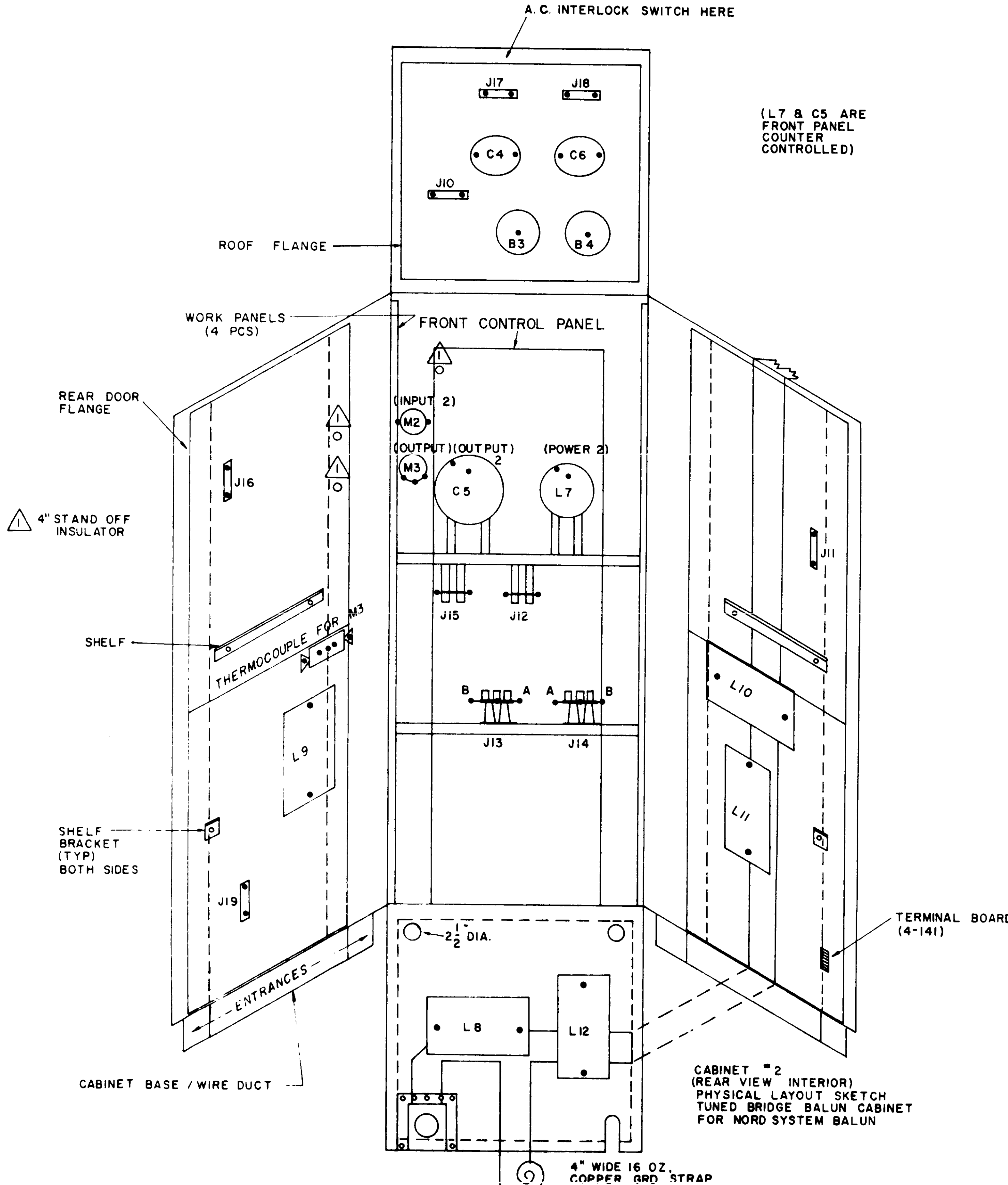
MULTRONICS, INC.

C0204 REV A

SCALE —

SHEET 1 OF 2

ZONE	SYM.	REVISIONS DESCRIPTION	DATE	APPROVAL
—	A	REDRAWN FROM "C" TO "D" SIZE	11-2-66	



(L7 & C5 ARE
FRONT PANEL
COUNTER
CONTROLLED)

TUNED BRIDGE BALUN CABINET MI-27626-B (R-LINE MODEL)
EXTERIOR DIMENSIONS:
84" HIGH x 34" WIDE x 32 1/2" DEEP
INTERIOR DIMENSIONS:
80" HIGH x 32" WIDE x 30" DEEP

CABINET #2
(REAR VIEW INTERIOR)
PHYSICAL LAYOUT SKETCH
TUNED BRIDGE BALUN CABINET
FOR NORD SYSTEM BALUN

REQ'D	PART NO	ITEM	DESCRIPTION	MATL OR MFR	MATL SPEC OR CAT NO	CKT SYM	UNIT WT	ZONE

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	
SIGNATURE	DATE
DR C.B.	9/21/64
CHK	9/ /64
ENGR	
TITLE	TUNED BRIDGE BALUN LAYOUT MODEL TB-LF(50-150) 600/50-20 FOR CONTRACT NBY 70650 U.S. NAVAL RADIO STATION (T) LUALUALEI, HAWAII
COMPANY	MULTRONICS, INC.
DWG NO.	C0204
REV.	A
SHEET	2 OF 2

COMPONENTS LIST

TUNED BRIDGE BALUN

MODEL TB-LF (50-150) 600/50-20
50 KHz-150 KHz (20 KW)
600 ohm (bal.) - 50 ohm (unbal.)

(applied to schematic #D0102)

DESIGNATION	QUANTITY	DESCRIPTION	MANUFACTURER
		JACKS	
J7,8,13 &14	4	J-Plug Assembly #C0017 (3 terminal)	Multronics,Inc.
J's	15	J-Plug Assembly #C0016-1 (2 terminal)	Multronics,Inc.
		METERS	
M1	1	0-8A RF 3" (ES) Model 308	Weston
M2	1	0-8A RF 3" (ES) Model 308	Weston
*M3	1	0-30A RF 3"(ES) Model 308	Weston

* External thermocouple instrument

DESIGNATION	QUANTITY	DESCRIPTION	MANUFACTURER
		INDUCTORS	
*L1	1	107uh, 15A #M107-15V	Multronics,Inc.
L2	1	79 uh, 20A #M79-20	Multronics,Inc.
L3	1	107uh, 20A #M107-20	Multronics,Inc.
L4	1	107uh, 20A #M107-20	Multronics,Inc.
L5	1	79uh, 20A #M79-20	Multronics,Inc.
L6	1	107uh, 20A #M107-20	Multronics,Inc.
*L7	1	107uh, 15A #M107-15V	Multronics,Inc.
L8	1	79 uh, 20A #M79-20	Multronics,Inc.
L9	1	107uh, 20A #M107-20	Multronics,Inc.
L10	1	107uh, 20A #M107-20	Multronics,Inc.
L11	1	79 uh, 20A #M79-20	Multronics,Inc.
L12	1	107uh, 20A #M107-20	Multronics,Inc.

* Indicates front panel counter controlled component ("0 set" counter with inductor in its full counterclockwise position; to give increasing reactance with increasing numerals)

DESIGNATION	QUANTITY	DESCRIPTION	MANUFACTURER
		CAPACITORS	
C1	1	.0047 MFD (15KV, 30A) #2857-52	Cornell Dubilier
*C2	1	100-5000MMFD (7.5KV, 125A) #VMMC	Jennings
C3	1	.0091 MFD (12KV, 39A) #2885-52	Cornell Dubilier
C4	1	.0047 MFD (15KV, 30A) #2857-52	Cornell Dubilier
*C5	1	100-5000 MMFD (7.5KV, 125A)#VMMC	Jennings
C6	1	.0091 MFD (12KV, 39A) #2885-52	Cornell Dubilier

* Indicates front panel controlled ("0 set" these counters, with capacitor at its full counterclockwise position; to give increasing reactance with increasing numerals)

DESIGNATION	QUANTITY	DESCRIPTION	MANUFACTURER
		BOWL INSULATORS	
B's	4	Bowl Insulator #135-15-1	E. F. Johnson

GUARANTEE

This equipment is guaranteed against defects in material, workmanship, or manufacture for a period of one year from the date of delivery. Our obligations under this guarantee are limited to repairing or replacing any item which shall prove, by our examination, to be thus defective, provided the item is returned to the factory for inspection with all transportation charges paid. Before returning any item believed to be of defective material, workmanship or manufacture, a detailed report must be submitted to the company giving exact information as to the nature of the defect. The information shall include, in as much detail as possible, all subject material listed under instructions for replacement of parts. Upon receipt of the report by the company, detailed instructions as to how the equipment is to be returned will be issued. Do not return any material until instructed to do so by the company.

Multronics, Inc.
5712 Frederick Avenue
Rockville, Maryland 20852
U.S.A.

MULTRONICS, INC.