INSTRUCTION MANUAL

TBM-4000

FM MODULATION MONITOR
FCC Type Approval 3-116
SCA MULTIPLEX MONITOR

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I GENERAL DESCRIPTION

The TBM-4000 is designed to measure frequency modulation characteristics including injection on main carrier of SCA-multiplex carriers up to 75 kilocycles in frequency. It is equipped to demodulate and monitor two SCA-mx subchannels within this frequency range, measuring their modulation percentages referred to either 5 kilocycles, or 7 1/2 kilocycles deviation for 100% modulation as selected. Also measured is the frequency of two sub-carriers as selected, and noise or crosstalk to signal ratios of at least 65 db below 100% modulation of the sub-channel.

To accomplish these functions, the TBM-4000 is divided into sections which perform as follows: The first section converts the main FM transmitter signal to a broadband IF system of 21.5 mc consisting of amplifiers and limiters which feed a special counter type FM detector for distortionless recovery of all modulation products carried by the main carrier.

This is followed by the main carrier modulation circuits which perform the following:

1) Measure main carrier total modulation up to 75,000 cycles by meter and peak flasher.
2) Measure main carrier modulation in the audio frequency range to 15,000 cycles by meter and peak flasher.
3) Measure subcarrier injection to 30% on an expanded meter scale independent of main channel audio-frequency modulation.

   This main channel monitoring circuit meets FCC Type Approval for FM modulation monitoring circuits, including meter speed and ballistics. The modulation peak indicator flashes at any pre-set level of a calibrated control. The flasher will respond to peaks having as short a duration as 10 milliseconds or less. In addition, the meter and flasher will measure either the negative or positive deviation as selected.
4) Audible monitoring of main channel audio output by amplifier and speakers.

Two subchannels may be measured with respect to their frequency, modulation percentage referred to either 5 or 7.5 kc deviation and signal to noise or signal to crosstalk ratios in db. Monitoring of the subchannels may be done by any desired combination or all of the following:

1) Percentage modulation meter.
2) Peak indication by means of a flasher.
3) Audio output for aural monitoring.
4) Subcarrier frequency meter.
5) Relay indication of subcarrier failure.
6) Crosstalk by the db scale on the modulation meter.

II TECHNICAL SPECIFICATIONS

Operating Range	Main Channel 88 to 108 mc SCA Multiplex 25 to 75 kc

Main Channel Modulation

Modulation Range	: Full scale meter deflection indicates deviation of ± 100 kc or 133% modulation. : Scale calibration indicates 100% modulation @ ± 75 kc.
Metering Accuracy	: Within 5% over entire scale (FCC standard for FM)
Meter Characteristics	: Well within FCC requirements. Pointer reaches 90% value of a modulation peak with a duration of only 70 milliseconds. Overshoot is less than 3%. Meter decays from full reading to 10% of value in 720 milliseconds.
Peak Flash Indicator	: Responds to modulation peaks with a duration of 10 milliseconds or less.
Frequency Response (Meter & Flasher)	: ± 1/2 db; 50 cps to 75 kc @ 100% modulation
Stability	: Maintained by special inverse feedback

SCA Multiplex Modulation

Modulation Range	: 100% modulation on the meter scale may correspond to deviation of ± 5 kc or ± 7.5 kc as desired. Selection is made by a front panel switch. : 133% modulation (full scale) corresponds to deviation of ± 6.67 kc or ± 10 kc.
Metering Accuracy	: Same as main channel specifications above.
Meter Characteristics	: Same as main channel specifications above.
Peak Flash Indicator	: Responds to modulation peaks with a duration of 10 milliseconds or less.
Frequency Response (Meter & Flasher)	: ± 1/2 db; 50 to 7500 cps @ 100% modulation
Stability	: Maintained by special inverse feedback

SCA Multiplex Frequency

Operating Range	: Any two SCA multiplex subcarriers between 25 kc and 75 kc by front panel selector switch.
Deviation Range	: Zero center scale is calibrated to ± 4000 cps (± .004% of 67 kc).
Accuracy	: Better than 100 cps at 67 kc.
Stability	: Maintained by crystal with .005% tolerance.

SCA Multiplex Injection

Injection Percentage	: A separate circuit and meter scale indicates the maximum allowed (FCC) modulation percentage of the main carrier by SCA subcarriers. 30% injection corresponds to about 2/3 of full scale reading.
Accuracy	: Within 5% over entire scale.

Crosstalk & Signal-to-Noise Ratio

Metering	: Reads crosstalk and S/N ratio of SCA multiplex channel to -65 db with calibrated scale and step attenuator. Measures crosstalk of main into SCA, SCA and/or stereo into SCA.

Audio

Frequency Range	: Main Channel -	Follows FCC de-emphasis curve. ± 1.0 db 50 to 15,000 cps.
	: SCA Channel -	75 microsecond de-emphasis ± 1.0 db 50 to 7500 cps.
Distortion	: Main Channel -	0.5% 50 to 15,000 cps
	: SCA Channel -	1.0% 50 to 7500 cps.
Hum & Noise	: Main Channel -	-65 db below 100% modulation @ low audio frequencies.
	: SCA Channel -	-65 db below ± 7.5 kc deviation @ low audio frequencies.

II TECHNICAL SPECIFICATIONS (cont)

General

RF Input	:	1 to 5 volts @ 50 ohms (1/2 watt max.) coaxial input.
Front Panel Indicators	:	1) Main channel modulation peak flasher (neon) 2) SCA modulation peak flasher (neon) 3) AC power (neon)
Front Panel Meters	:	1) Main channel modulation (RF input - total modulation - main channel modulation - subchannel injection) 2) Subchannel frequency (reads selected subchannel) 3) Subchannel modulation, crosstalk, S/N
Front Panel Controls	:	1) AC power on-off 2) Main channel modulation meter function switch 3) Main channel ± modulation polarity switch 4) Main channel peak modulation flasher control 5) Subchannel frequency meter function switch 6) Subchannel frequency meter calibrate control 7) Subchannel peak modulation flasher control 8) Crosstalk, S/N step attenuator 9) SCA deviation selector 5 or 7.5 kc
Rear Chassis Controls	:	RF attenuator
Outputs (front panel)	:	1) Main Hi-Z phone jack 2) SCA Hi-Z phone jack
Outputs (rear chassis)	:	1) External main channel modulation meter 2) External SCA channel modulation meter 3) Multiplex 4) Main channel audio Hi-Z 5) Main channel audio 600 ohms 6) Subchannel audio Hi-Z 7) Subchannel audio 600 ohms 8) Subchannel failure relay (for alarm)
Tubes	:	26

Types:

4-12AT7	1-6BE6	2-OA2
5-6BH6	1-6SN7	1-OB2
2-6AK5	1-6U8	3-6AB4
3-12AU7	2-5696	1-3HTF4

Diodes : 12

Types: 10-1N51 Germanium
2-5D150 Silicon

II TECHNICAL SPECIFICATION (cont)

Fuse	:	1 - 1 Amp SB-3AG
Rectifiers	:	4 type 1N2095 Silicon
Power	:	Regulated constant voltage transformer 105-125 volts, 60 cycle AC 65 watts. Gaseous regulator type tubes
Dimensions	:	Panel - standard rack 10 3/4" x 19" Chassis - 13 1/2" behind panel
Weight	:	34 lbs.

378 MHZ CRYSTAL #1
FOR 9.1 MHZ

III INSTALLATION and INITIAL ADJUSTMENT

Inspection: Upon receipt of your TBM-4000, remove it from the packing material and inspect carefully for any damage caused in transit due to rough handling or vibration. If damage is found, notify the shipping agency and advise McMartin Industries, Inc. of such action.

Location: Installation preferably should be made in a standard equipment rack or cabinet which is well connected electrically to the main station ground and away from strong RF fields created by the transmitter. The unit should be located at the transmitter to take the source directly from the transmitter. It has been designed to be deliberately insensitive. If a remote application is desired, the RF can be fed from the McMartin TBM-2500 RF amplifier, but it must be recognized that the accuracy of the subchannel readings can be influenced by multipath signal effects. Remember there are 26 tubes to keep cool, thus ventilation should be given serious consideration. Also consider source of power and the connection to the monitoring output of the transmitter.

Connections, Input: Plug AC line cord into a nominal 117 volt, 60 cps only power source.

Connect a 50 ohm coaxial cable (RG-58 or RG-8) between an RF pick-up loop and the input J1 at the monitor.

NOTE: Different readings of crosstalk may result depending on the location of the pick-up loop. A pick-up loop on the transmission line will more accurately indicate the true broadcasted signal because any non-linearity caused by standing waves will be monitored. A pick-up loop in the PA final cavity will more accurately monitor the actual transmitter performance.

CAUTION: Do apply more than 4 watts from the pick-up loop or the monitor may be damaged.

When using the TBM-4000 in conjunction with the TBM-3000 frequency monitor or other existing monitor equipment, simultaneous connection of the RF inputs from the same pick-up loop can be made with the use of a "T" connector such as the Amphenol #83-1T. Where other makes of monitors are in use, it may be necessary to incorporate a resistive pad to achieve the correct RF input level for each unit. It is known that some other manufacturer's monitors, common in the field, will create interference detrimental to the accuracy of the TBM-4000 - if, they are both connected to the same pick-up loop or RF amplifier. Separate pick-up loops or the McMartin TBM-2500 RF amplifier would eliminate this factor.

Connections, Output: There are provisions on the rear of the monitor for connecting external modulation meters - for main channel and subchannel. This meter should be connected to terminals "E" and "F" for main channel and subchannel respectively. The resistors between "E" and "F" must be removed if external meters are used.

Due to the special characteristics of these meters, they must be ordered direct from McMartin Industries, Inc.

If aural monitoring of main channel is desired, refer to the "main audio" terminal board on the rear of the chassis. For high impedance output, connect a shielded cable to terminal "D". The shield should be connected to chassis ground. (Solder lugs provided on chassis). For 600 ohm output, strap terminals "C" and "D" and connect to terminals "A" and "B".

For subchannel monitoring, make similar connections on "sub audio" terminal board.

The screw marked "alarm" on the sub meter terminal board on the rear chassis is actually a relay contact which can activate an alarm in case of subcarrier failure. See Diagram I on page 18 for a suggested alarm circuit.

The BNC connector output on the rear chassis identified as J2 contains all the modulation from the main channel through subchannels up to 80,000 cycles. This includes all components that the transmitter broadcasts, including stereo and SCA-multiplex. The J2 output is designed with two purposes in mind. First, to serve as the output to feed the McMartin TBM-4500, stereo monitor. Secondly, to serve as a means to attach specialized measuring equipment such as an oscilloscope for visual observation of the composite modulation.

Additionally, the J2 output can be used to feed a McMartin TBM-2000 thus enabling monitoring of 2 subcarriers simultaneously and continuously.

The J3 and J4 phone jacks on the front panel contains the same information as the rear chassis "D" terminal hi-impedance outputs and can be also used for aural monitoring of either main channel and/or sub-channel. These jacks can be used for earphone listening and are particularly useful for convenient connection of distortion measuring equipment.

Initial Adjustments: Turn the power on and allow the monitor to warm-up for 1/2 hour to allow temperature stabilization. The red neon pilot light will indicate that the power is on.

NOTE: It may be observed that the Sola power transformer operates at a high temperature. This is a completely normal condition since it functions on a core saturation principle and in no way indicates a defect or overload condition.

Place the main channel modulation meter function switch (SW-1) in the "RF Input" position. Set the RF "adjust" control on the rear chassis to midrange - approximately equal distance from either end of its rotation. The pick-up loop in the transmitter should now be adjusted so a reading of about 100% (top scale) appears on the main channel modulation meter during normal transmitter operation.

Now use the rear chassis RF "adjust" control to set the meter reading at exactly 100% on the top scale. You now have the proper voltage for operation of the monitor.

Your TBM-4000 has been carefully tuned and aligned at the factory, using extensive and comprehensive test equipment.

IV OPERATION

It is imperative that the instruction book be read thoroughly before beginning operations. Particularly note the check-out form attached to the back cover of the instruction manual. This form recaps the readings that were taken on this specific monitor for your specific requirements and should be studied carefully.

To simplify a description of the many readings which can be taken with this monitor, we will separate the functions by meter and describe each meter in detail.

CAUTION: The X-TALK, S/N switch (SW-5) must be left in 0 db position for normal operation, as setting of that switch amplifies the meter sensitivity 10 times over the previous setting and the meter can be damaged if it is allowed to function on modulation in a magnified setting.

Meter M1 Functions:

1) Place the M1 meter function switch (SW-1) in RF INPUT position. On the top scale, M1 will read the RF input voltage from the transmitter. As previously described, this level is controlled by the "RF ADJUST" control on the rear chassis. Normal meter reading is 100%. This reading should be checked daily and re-adjusted if more than 10% off of 100%.

2) Place M1 meter function switch in TOTAL MOD. position. In this position, the entire modulation contained by the transmitter will be read by the top scale. This will include all stereo and SCA subchannel information as well as main channel.

3) Turn function switch to MAIN CHAN. MOD. position. In this position all SCA subchannel information has been removed and only main carrier modulation will appear on the top scale of M1.

   NOTE: The constant injection of an SCA subcarrier has the effect of "swamping" or "loading" the dynamic characteristics of the modulation meter M1. If continuous monitoring of total modulation is unnecessary, this metering selection will provide the best indication of main channel only modulation. In the case of stereo multiplex on the main channel, it is recommended that the TOTAL MOD. selection be used.

4) When the function switch is turned to the SUB. CHAN. INJ. position, the meter M1 reads the percentage of SCA multiplex injection directly, with or without modulation, of one subcarrier on the inner expanded scale. (When the SUBCHANNEL FREQUENCY METER function switch is in the "NO. 1 SUB" position, the injection read on meter M1 will refer to the No. 1 sub. With the SUBCHANNEL FREQUENCY METER function switch in the "NO. 2 SUB" position, the injection read on meter M1 will be for the No. 2 sub.)

   Only one sub injection can be read at a time and the total subcarrier injection can be figured by adding the two injection readings together. For instance, if No.1 sub injection reads 10% and No. 2 sub injection reads 15%, total subcarrier injection will be 25%.

The individual injection readings for each subcarrier can be double checked in the following manner: Turn the M1 meter function switch to the "total modulation" position. Remove main channel modulation and all but one subchannel injection. Only one subchannel injection will remain on the top scale and you may read this figure directly. By turning on the second subchannel and removing the first subchannel, you may read the second subchannel injection on the top scale. It must be cautioned that with two subchannels on simultaneously, the individual injection figures do not add directly so that it is impossible to read total subchannel injection on the meter.

Special Note: The above alternate technique will enable measurement of a 19 kc pilot injection for stereo when all other main channel modulation and subchannel injection has been removed.

5) The main channel PEAK MODULATION control (R81) can be set at any desired point so that the high speed peak modulation indicator lamp (PL-1) will flash if modulation exceeds the referenced percentage setting.

Special Note: With normal broadcast program material on the air, it will not be uncommon for the peak flasher to light at a 100% setting while the meter M1 is averaging about 25 to 40% on peaks. The flasher will catch modulation peaks which are much too short (10 milliseconds and less) for the meter to respond to. More than occasional lighting of the peak flasher set at 100%, indicates an over-modulation condition of the transmitter.

This control is affected by the position of the M1 meter function switch. If the function switch is in the TOTAL MOD. position, the flasher references all modulation. With the function switch in the MAIN CHAN.MOD. position, the peak indicator will only flash when main channel audio modulation exceeds the referenced setting.

6) The modulation polarity switch (SW-2) may be set in either a plus or minus position. In the plus position, positive peaks above the carrier frequency will be observed by the M1 meter and the peak indicator lamp. In the minus position, negative peaks below the carrier frequency will be read.

Meter M2 Functions:

The TBM-4000 monitor has provisions for reading the frequency of two subchannels. On the front panel, they are designated as NO. 1 SUB and NO. 2 SUB. The NO. 1 SUB will refer to frequencies up to 45 kc (usually 41 kc) and the NO. 2 SUB will refer to frequencies over 45 kc. (Usually 67 kc). Thus, if a station is only using one subchannel at 67 kc, the monitor will be aligned and shipped so the NO. 1 SUB is inoperative and the NO. 2 SUB is aligned for 67 kc. Your check-out sheet identifies the subs and the crystals.

1) To use this meter, place the SUBCHANNEL FREQUENCY METER function switch (SW-7) in the NO. 1 SUB CAL. position, then adjust the METER CAL. control (R-74) for 0 setting of the meter. Turn the function switch to the NO. 1 SUB position and the meter will read the subchannel deviation from specified frequency. If the meter reads on the minus side, the subchannel is below frequency; on the plus side, the subchannel is above frequency.

2) If a second subchannel is in operation, turn the M2 function switch to the NO. 2 SUB CAL. position and reset the meter to zero, turn the function switch to NO. 2 SUB position and read the second subchannel frequency deviation from the specified frequency.

Meter M3 Functions:

Before reading the subchannel modulation, select the desired subchannel deviation to correspond to 100% on M3 (± 7.5 kc or ± 5 kc).

1) Place the DEVIATION switch (SW-3) in the desired subchannel deviation position. For example, if the desired peak deviation is ± 7.5 kc, the switch should be placed in that position.

   100% subchannel modulation on meter M3 is now the equivalent of ± 7.5 kc deviation. Subchannel modulation may now be read for whatever sub that is selected by the M2 meter function switch.

Peak Modulation Flasher: The subchannel PEAK MODULATION control (R-118) can be set at any desired point so that the high speed indicator lamp (PL-2) will flash if modulation exceeds the referenced percentage setting.

This control will only indicate modulation on the subchannel selected by the M2 function switch. The lamp will not flash for both subchannels simultaneously. Please note also that it refers to the deviation setting of either 5 or 7.5 kc for 100%.

Subchannel Noise Measurements: Normally noise readings are taken with all audio modulation removed from the main channel and all subchannels. This is desirable because modulation can introduce crosstalk which will influence the noise readings. The main carrier and subcarriers remain on without modulation and the M2 function switch should be placed to select the desired subchannel. Make certain that if your transmitter has automatic muting provisions that it is disabled for this test so that the subcarriers will remain on.

You are now ready to take the measurement and the M3 meter should register zero. Carefully turn the X-TALK, S/N function switch (SW-5) clockwise until you observe a mid-scale reading on the M3 meter. Each step increases the sensitivity of the meter by 10 db. To calculate your exact noise reading, add the switch setting to the reading on the scale. As an example: A noise reading of 43 db will be observed if the switch is turned to the -40 db position and the needle on the M3 meter rises to the -3 db mark.

Please note that the monitor is capable of reading noise figures below -65 db.

To read the noise on the alternate subchannel, return the function switch to the 0 db position and turn the M2 meter function switch to the alternate subchannel position and perform the same steps as described above.

Crosstalk Measurements: Return X-TALK, S/N function switch to 0 db position. The monitor will read crosstalk from main channel into the desired subchannel or from another sub or stereo into the desired subchannel or both. Readings can be taken as follows:

1) Remove all modulation from the subchannel into which crosstalk is to be measured.

2) Main channel into desired sub: Apply tone modulation to the main channel. A choice of 1000 cps for the modulating tone will provide a stringent test on the transmitter. With the M2 function switch in the desired subchannel position, turn the crosstalk function switch clockwise until mid-scale reading appears on the meter and calculate your crosstalk in the same manner that the noise readings were taken. It should be noted that you will never obtain a better reading for crosstalk than you have for noise.

3) Subchannel into sub: Remove modulation from the main channel and place modulation on the alternate subchannel from which you wish to measure crosstalk into the selected sub. Take readings as described previously.

4) From stereo into sub: With a desired stereo modulation on, take crosstalk reading as described previously.

5) Main and sub into sub: These readings can be taken by putting modulation on main and sub and taking readings as described previously.

Note: Crosstalk may also be checked dynamically with normal program material on the main channel instead of tones.

If the results obtained from actual crosstalk measurements are not satisfactory for good SCA operation, completely re-align the transmitter for minimum crosstalk while observing the transmitter manufacturer's recommended procedures. In most cases, there is an allowable tolerance in transmitter alignment and the selection of the proper point in this tolerance can greatly benefit crosstalk performance. Constantly observe the crosstalk reading on M3 while aligning the transmitter.

NOTE: There is a subchannel de-emphasis switch (SW-6) on the top of the chassis. In the "out" position, there is no de-emphasis on the meter circuit (M3) and in the "in" position there is 75 microsecond de-emphasis. For crosstalk readings to duplicate operating conditions of McMartin multiplex receivers in the field, the switch should be in the "in" position. Normally the switch should be in the "out position so that modulation can be read without de-emphasis.

IV OPERATION (cont)

Proof of Performance: Proof of performance frequency response and distortion measurements may be readily made on either the main channel or subchannels as desired. Preferably this is done by connecting a distortion/noise meter with a high impedance input circuit (above 20 K ohms) to the high Z terminal "D" on the rear of the chassis with the other distortion meter input lead grounded to the chassis or to the phone jacks on the front panel and following the procedures recommended by the distortion/noise meter being used. Regardless of which output connection is used THE JUMPER BETWEEN TERMINALS "C" & "D" MUST BE REMOVED for these measurements. Because of the inherent characteristics of the TBM-4000, distortion measurements may be made to less than 0.5% and noise to 70 db below 100% on the main channel. For the subchannel, these figures are 1.0% and -65 db respectively. However, it is to be remembered that provision is made for making S/N or crosstalk ratio measurements of the subchannel to more than -65 db below 100% modulation of the subchannel using the db range switch associated with M3, as described.

Special Note: When checking distortion for Proof of Performance tests, remember that the TBM-4000 responds to frequencies up to 80 kc. Harmonic distortion as measured from the TBM-4000 will often be higher than readings taken from alternate measurement sources. The reason is that they do not respond to all audio frequency harmonics.

This same condition will be present with regard to noise measurements. High frequency noise may not be passed by alternate measurement sources.

Automatic Muting: On the top of the chassis there is an automatic muting control which can be set at any desired level for automatic muting of the subchannel audio output between musical selections. This control can be set anywhere from "disabled" to 30% injection and will be shipped with the setting at 5%. This setting also controls the subchannel failure alarm.

V THEORY of OPERATION

For a detailed explanation of the operation of the TBM-4000, a specific signal will be traced through the monitor referring to the schematic. At points in the circuit where components are variable and can be aligned both in the factory and in the field, a detailed description of the procedure utilized in alignment will be incorporated.

The sampled transmitter signal (88-108 mc) is applied to the rear coax connector J1 to the RF (RF ADJUST) attenuator which furnishes a nominal 50 ohm termination for this connecting lead and allows rear chassis control of the RF voltage applied to mixer tube (V2). This sampled signal includes all modulation of the transmitter, not only main carrier but subchannel as well. The RF voltage to this connector should be between 1 and 5 volts. The maximum voltage is limited to this value by the power dissipation permissable in the RF attenuator. The 100 mc band signal is converted in V2 by heterodyning it with the output of crystal-controlled-frequency multiplier tube (V1). The frequency of the crystal is determined by this formula: $Fx = \frac{f - 21.5\ mc}{2}$. For example, a carrier of 98.5 mc has a crystal of 98.5 mc -21.5 mc = 77.0 mc divided by 2 or 38.5 mc. Since this frequency crystal will normally be oscillating at an overtone mode, L-1 is tuned to select oscillation at the 38.5 mc overtone in the first section of V1, and is tuned for oscillation at the crystal overtone, first tuning L-1 for maximum peak and then detune L-1 in a counterclockwise direction about 15% down from the peak.

The second section of V1 is a harmonic generator. L-2 is tuned to the desired 77.0 mc second harmonic which is fed to the No. 1 grid of the mixer tube V2. L-2 is tuned for maximum output of the mixer as indicated by maximum M1 meter indication when function switch is set to RF input. At the same time, L-3 and L-4 can also be tuned for maximum indication and with an FM modulation signal at 21.5 mc fed to V2; L-3, L-4, L-5 and L-6 are tuned for maximum voltage at diode D-1. This should be the point of least FM noise and minimum distortion at the output of detector D-1. Slight readjustments can be made to obtain this result.

L-3, L-4, L-5 and L-6 should never require further adjustment, they are very broadtuned.

Transmitter RF through the RF attenuator is fed to the third grid of the V2 mixer tube, heterodyning the signal at the plate to 21.5 mc which is selected by tuned circuit L-3. This is coupled to V3 which is an amplifier with 21.5 mc tuned plate circuit. L-4 is coupled to V4 which by choice of plate and screen voltage as well as control grid bias voltage, acts as a limiter. L-5 is broadbanded by resistance loading to feed V5, the second limiter. Time constants of the limiters, as well as cascading two limiters assures lowest possible noise ratio in the signal applied from V5 through L-6. L-6 is another resistance loaded broadband coupler to the high frequency counter type detector. This detector is an original design which is being patented under the name "Hedlund Detector" for its inventor and our chief engineer, Leonard Hedlund. The Hedlund detector consists of diode D-1, resistors R-17, R-18 and R-19 and capacitors C-17 and C-18.

All modulation products of the signal due to FM appear at the C-18, R-18 and R-19 junction which is coupled to V6, whose control grids are in parallel.

V6, second section, acts as a paraphase amplifier with balanced plate and cathode load resistors producing equal but 180 degrees out-of-phase voltages which are fed to modulation polarity switch SW-2. The first section of V6 divides its output and the plate feeds a rear of chassis jack J2 which can be used for several uses, including feeding a stereo-mx signal to the McMartin TBM-4500 stereo monitor. This output can also feed an oscilloscope for visual inspection of a component signal at that point.

The cathode of V6 feeds cathode follower V11a and also feeds through de-emphasis network R-37 and C-28 to V7a which in turn feeds the audio (main channel) signal output amplifier V8a.

Output of V8a provides main channel audio to terminal "D" which can feed a 20,000 ohm load or higher impedance up to 10 volts of audio. This terminal can be connected to a distortion analyzer for proof of performance measurements of frequency response (up to 20,000 cps de-emphasized) and distortion or noise ratio of the main channel. Also this signal is applied to J3 on the front panel, which may be used for headphone monitor or for convenient front panel connection of measuring equipment. If either J3 or D is so used, the 600 ohm transformer jumper between "C" and "D" must be removed on the main channel audio terminal board to eliminate the loading of the 600 ohm low impedance matching transformer. The jumper is connected for normal aural monitoring. For a 600 ohm output at a level of approximately + 8 VU, connect to terminals "A" and "B" with "C" and "D" strapped together.

The signal picked up by polarity switch SW-2 is taken to an amplifier, consisting of V7b and V8b which is the percentage modulation metering amplifier. The gain of these stages is set during calibration by degenerative feedback circuit R-29 and C-22 so that 100% modulation is indicated at the proper point. This adjustment is fairly critical and has been carefully calculated at the factory. It may require slight occasional adjustment in the field. This is done by the use of Bessel's function. Refer to page 19.

The M1 metering circuit forms the plate load of V8b. C-24 couples the audio to D-2 which rectifies the signal to drive the meter M1. Additional metering current is added during upward swings of the meter to speed up the pointer action so that with signals as short as 70 milliseconds duration the pointer will indicate better than 90% of the final peak value and corresponding values for other peak durations. The other R and C values used are to control overshoot, which is below 3% and the decay time of the meter indication when the signal is removed. Using the FCC specified meter ballistics and damping characteristics, this results in proper point action. These characteristics hold true for modulating signal frequencies from below 50 cycles to above 75 kilocycles within ± 1 db when the main channel function switch is in "total mod" position.

The meter function switch SW-1 permits metering of all modulation frequencies, including supersonic subchannel carriers when the switch is in the "total mod" position. With switch in "main channel mod" position the SCA subchannel modulation only is removed. When in "sub chan inj" position, M1 reads only the subcarrier injection on the inner expanded scale. Another position "RF input" measures the RF voltage into the monitor to assure proper monitor operation. It should read 100% when properly set.

A sample of the metering circuit signal is taken from the center arm of the Mod. Polarity switch through R-112 to the grid of V25. V25 amplifies the signal which is applied to the frequency compensating network consisting of R-75, C-58 and R-76. The signal from this network is fed through R-77 to the grid of thyratron V15. R-81 is a front panel control calibrated from 50% to 120% for setting the modulation level at which the main peak indicator will flash. R-82 is a chassis mounted control to set the calibration of R-81. The peak indicator (PL-1) will indicate the true value of modulation pulses of less than 10 milliseconds duration.

R-82 is used to set the modulation percentage scale of the peak flasher circuit V15 and PL-1 to agree with the percentage modulation reading M1. Due to aging of the thyratron tube, this setting may require slight adjustment occasionally in the field. To check the accuracy of the setting, modulate the transmitter 100% so that the meter scale M1 reads 100% for total modulation with the function switch in the total modulation position. With R-81 at 100%, check operation of the indicator lamp against the meter. The lamp should flash indicating 100% has been reached. Also make similar comparisons at several points on the percentage modulation scales to see if they track over the range of adjustment. At this same time, a check of the "total modulation" readings compared to "main channel" modulation should be made. If the flasher appears to be out of calibration, adjust R-82 until it tracks properly over the entire range of adjustment. One setting will suffice for the entire range. The tracking should be within 2% over the entire range.

If R-28 and R-82 are accurate, you may now check with the modulation polarity switch in both plus positive and minus negative positions to check the balance of the phase inverter to V6. Unbalance will usually be more noticeable at low audio frequencies and adjustment usually requires small changes of R-26 and R-27.

Fl-1 is used to trap out subcarrier frequencies so that their injection level is not registered on the percentage modulation meter when the function switch for Ml is on "main channel" modulation. Fl-1 is adjusted for a minimum indication of subcarrier when SW-1 is set to the "main channel mod" position.

Refer back to the signal coming from the cathode of V6 and going to the cathode follower of V11a. This signal passes through a high pass filter consisting of C-27 and R-56. This filter blocks the main channel audio leaving subcarriers which are applied to the grid of V11a. The filter also blocks subcarrier information below 28 kc thus removing most 19 kc stereo pilot that might be present. V11a is a cathode follower with low impedance output to match the diode mixer circuit fed by V10a or V10b.

The subchannel modulation fed to the diode mixer circuits consists of the mx subcarriers above the audio spectrum due to filtering action of the previous coupling elements. These are then converted to 455 kc center frequency by means of a crystal controlled oscillator V10a or V10b and the double diode mixer-converter associated with V10a or V10b. Provision for any two subcarrier frequencies is made by selection of crystal oscillator frequencies. These crystal frequencies are 455 kc above the desired mx subcarrier frequency. For example: At 67 kc the crystal will be 455 plus 67 or 522 kc. 42 kc uses a 497 kc crystal. The resulting mixer conversion gives in both cases a 455 kc FM modulated signal which is applied through amplifier V11b and then through broadbanded transformers T4 to V12. The "sub" selector switch SW-7 also controls crystal oscillator V9 which is operated in the "cal" positions of SW-7 to furnish a standard of frequency at 455 kc for zero adjustment of the subchannel frequency meter M2.

The crystal oscillator with proper crystal installed is tuned by T-2 or T-3, 15% down from the peak on the slow rise side.

With the SW-1 switch in the No. 1 SUB position or with the SW-1 switch in the No. 2 SUB position, adjust R-53 and/or R-54 for the null or minimum reading on subchannel injection with no subcarrier information coming from the station.

If this results in a significant change in "sub chan inj" R-63 should be re-adjusted to agree with the indication shown on Ml with SW-1 in the "total mod" position when the only modulation is that of the subcarrier.

The subcarrier signal following V12 is taken to cascaded limiter amplifiers V13 and V14. A sample of the subcarrier signal is also taken from the grid of V12 which is applied to the grid of V24. This signal is amplified by V24, rectified by D-8 to produce a voltage and is fed to modulation meter M1 in the subchannel injection position. R-63 is used to calibrate the subchannel injection and if external field adjustments are necessary, this can be accomplished by placing the M1 function switch in the "total modulation" position and then removing all main channel modulation and all but one selected subchannel injection. Inject 30% on the desired subchannel until the M1 meter reads 30% on the top scale. Now switch SW-1 to the subchannel injection position and adjust R-63 until the lower scale of meter M1 reads 30%.

After limiting at V13 and V14 the subcarrier is put through discriminator transformer T6, the secondary of which is arranged for a balanced dc output whose polarity and current value are proportional to frequency. The dc output is metered by M2 giving a direct reading in terms of the frequency deviation. R-74 is the front panel "meter cal" to provide for setting the meter to zero deviation reading by using crystal oscillator V9 as a reference frequency.

Alignment of the subcarrier amplifier-limiter circuits T-4, T-5 and T-6 require a generator at 455 kc capable of being frequency modulated by audio frequencies at 7.5 kc deviation at low distortion. T-4 and T-5 are adjusted for symetrical response at 455 kc. T-6 is adjusted for linear response above and below 455 kc. Adjustments are made to T-4 through T-6 for minimum distortion and minimum noise of the recovered audio frequency modulation, M2 still remaining at zero center indication. Less than 2% distortion should be obtained.

The output of the T-4, D-9, D-10 discriminator combination contains the audio frequencies carried by the subcarrier which are taken to filter F1-2. F1-2 is a low-pass combination filter circuit cutting off frequencies above 10,000 cycles and eliminating their effects on the audio and measuring circuits beyond the output of this filter. This pure recovered audio is fed to R-95, a chassis mounted calibration control used to set the 100% modulation point of the subcarrier. R-95 has a low value of 10 K ohms to preserve a flat frequency response and also to present the proper load to the filter. R-95 is adjusted so that 100% modulation indication is obtained on M3 for 7.5 kc deviation through the 455 kc amplifier-limiter-discriminator chain, SW-3 being in the 7.5 kc position. From the calibration control, the signal voltage passes through a de-emphasis network which may be switched in or out by SW-6. In the "in" position, the audio signal is de-emphasized 75 microseconds (standard de-emphasis) and in the "out" position the signal passes through without de-emphasis. After passing through the switch, the signal feeds to the grid of amplifier V16a. The output from V16a feeds through SW-3. SW-3 is a pad which changes the gain of the amplifier in either of two positions to correspond with either 5 or 7.5 kc deviation. The signal is then fed to the db range switch, essentially SW-5, which furnishes accurate multiples of 10 db steps of the signal voltage to the grid of V16b.

V16b feeds V17b and in turn the meter amplifier section V17a. V17a tube plate circuit is the same as that of V8b in the main channel metering section and for its operation, please refer to this section.

Signals taken from the plate of V17b are fed through C-74 and R-114 to the grid of thyratron V18 which is identical to the main channel portion, R-118 being the panel mounted modulation percentage setting control and R-119 is the chassis mounted calibration control. The flasher PL-2 calibrated control R-118 (sub peak mod) should be adjusted to agree with M3 percentage modulation indication by adjustment of chassis control R-119.

The aural monitor amplifier for the mx channels consists of a double triode tube V19 cascaded feeding to the mx audio terminal board serving the same function as the corresponding terminals on the main channel.

V20 is provided to permit automatic muting of the audio output of the SCA multiplex channel in use for an aural monitor. V20 is biased by limiter V13 when the subcarrier is being transmitted and monitored by the TBM-4000. This biasing is such that V20 controls relay RL-1. When no subcarrier is being transmitted RL-1 disables the mx monitoring amplifier to prevent amplification of "no carrier" noise. By means of R-96, the operating point may be set to operate at any desirable injection level or disabled entirely.

An additional contact is wired to "muting relay" terminal on the rear of chassis which grounds this terminal when subcarrier is being transmitted. This can be used, if desired, to operate external indicators or alarms during periods of no subcarrier to protect subcarrier service continuity.

An external modulation meter may be connected to either channel by removing the 1500 resistor on the meter terminals and connecting the proper meter (available from McMartin Industries, Inc.) in its place.

The power supply utilizes a self regulating constant voltage transformer, fused and by-passed for RF in its primary. The power on-off switch is SW-4 also in the primary. A neon type power ON pilot lamp is mounted on the front panel adjacent to the power switch. AC power requirements are approximately 65 watts.

The high voltage secondary goes to four silicon rectifiers employed for low voltage drop, high efficiency and reliability. The dc output is well filtered and then regulated by gaseous type, vacuum tube regulators to further remove noise and stabilize the operation of the instrument against line voltage changes. The two thyratron filaments are further regulated by a ballast tube.

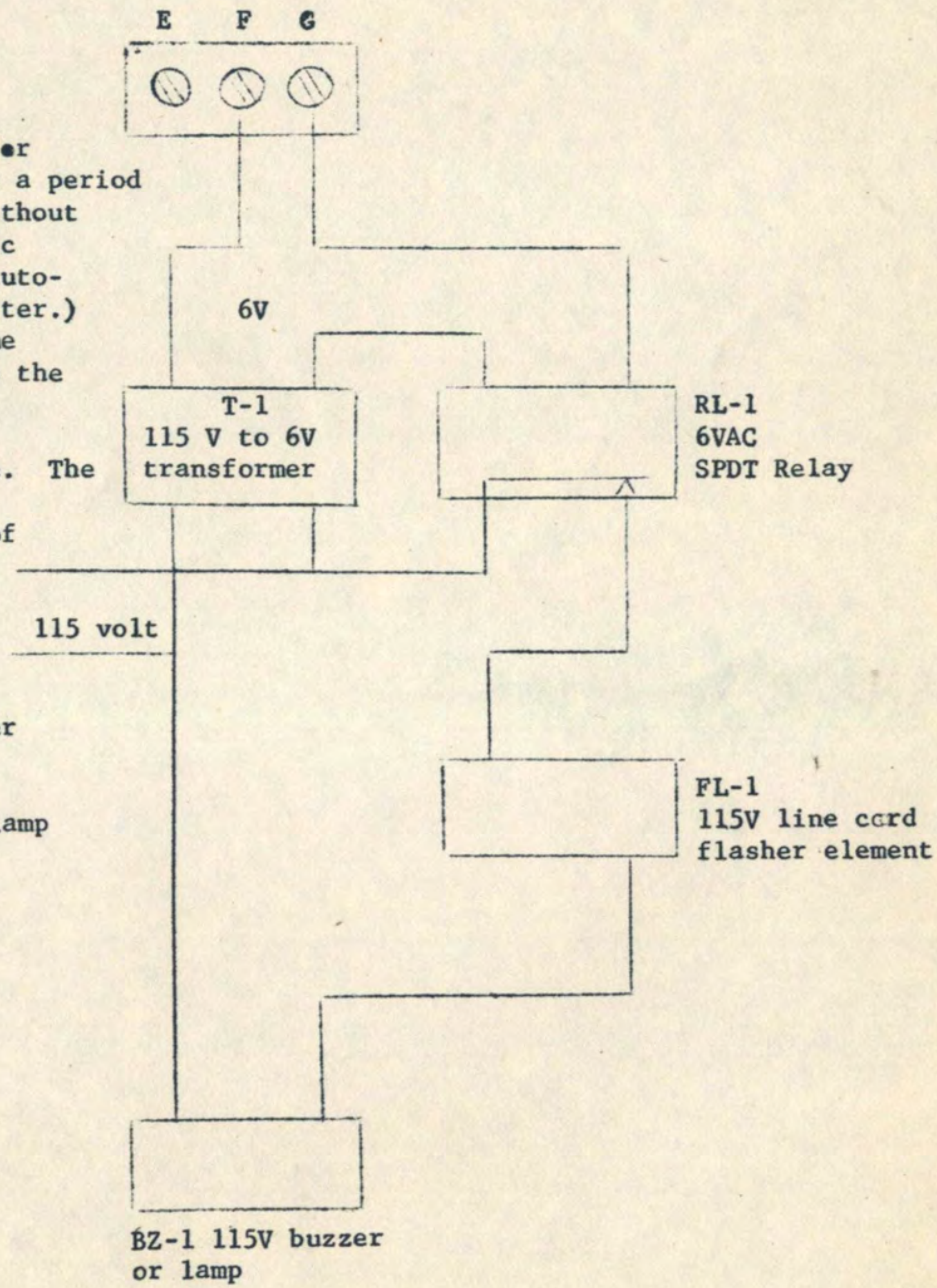
By the optimum choice of circuits and components, trouble free, long life and accuracy are assured.

After a period of time, minor calibration of the TBM-4000 may be necessary.

Subchannel Failure Alarm:

The diagram shown is designed to sound a buzzer or light a lamp when subcarrier has been absent for a period of time longer than approximately 30 seconds, without giving alarm on normal short breaks between music supplied to the subchannel. (Assuming that an automatic muting device is installed at the transmitter.) It is simple, reliable and inexpensive. The time delay of this external circuit in no way effects the normal internal automatic audio muting circuit.

Components are standard parts, locally available. The audible or lamp flashing alarm operates on and off for the duration of any subchannel failure of more than 30 seconds.



Fail-safe circuit:

PARTS:	T-1	115/6V, 1.5 amp transformer
	RL-1	6VAC SPDT relay
	BZ-1	115 VAC buzzer
	FL-1	115 V, 60 watt cord type lamp flasher unit.

Bessel's Function Modulation Calibration

In order to accurately calibrate the M1 modulation meter, adjust R-28 and for the peak flasher, adjust R-82. These adjustments are made against aural null indications as derived from the following procedure utilizing Bessel's Function:

Use a good quality, stable communications receiver with a BFO and connect the antenna input to the first limiter tube in the TBM-4000 by wrapping a few turns of wire around it. To start with, the TBM-4000 should be installed and operating normally. Turn the switch SW-1 to the TOTAL MOD position. Remove all modulation from the transmitter. Tune the communication receiver to the monitor's IF frequency, which is 21.500 megacycles. Now adjust the BFO of the receiver to give a beat note of 200-300 cycles. Now take an audio sine wave generator of known accuracy and feed it into the transmitter. Slowly increase sine wave modulation. The amplitude of the transmitter carrier and in turn the receiver beat note output will go through successive amplitude nulls. If you can hear these nulls from the receiver as they occur, you are now ready for calibration.

At this point, refer to the table of audio frequencies vs. percentage of modulation for various nulls. This table illustrates 27 different combinations for arriving at a percentage of modulation calculation. (The first null is impractical because the audio frequency would be too high).

As an example, let us select a frequency of 8,670 cycles which will give us 100% modulation when the third null is reached. Set the audio generator to 8,670 cycles and slowly increase the amplitude until the third null is reached. Stop at that point. The transmitter is now being modulated 100%. If the M1 modulation meter and peak flasher on the monitor do not read 100%, adjust R-28 and R-82 until they do.

If you wish to select a setting other than shown on the table, use the formula:

$$\text{Audio Frequency} = \frac{\text{Frequency Deviation}}{\text{Modulation Index}} \quad \text{or} \quad \frac{\text{Percentage of Modulation} \times 75{,}000}{\text{Modulation Index}}$$

The frequency deviation at 100% is $\pm$ 75 kc, and the modulation index can be selected from the table.

Caution: Remember that the accuracy of this calculation is directly related to the accuracy of the audio frequency source which modulates the transmitter.

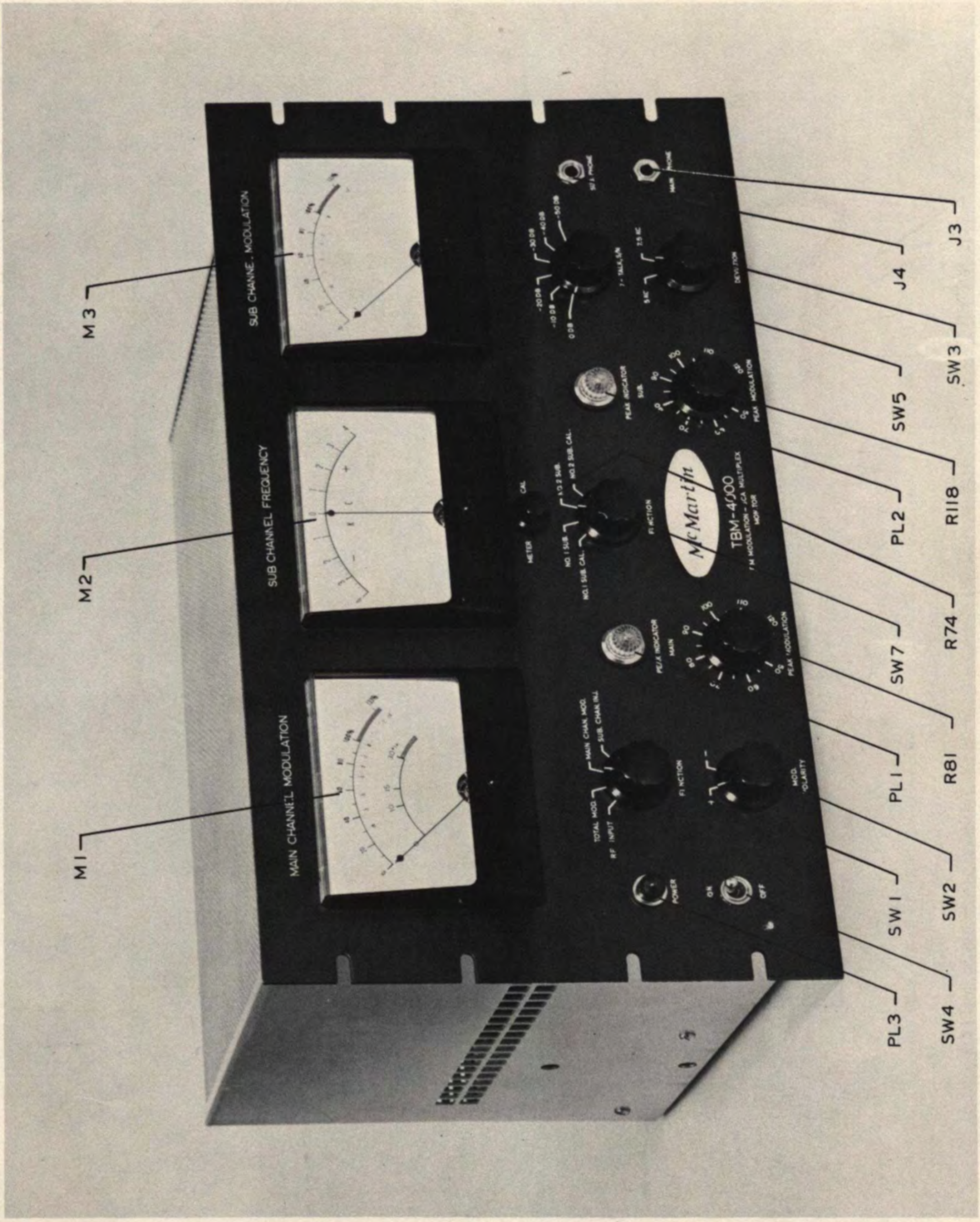
TABLE OF AUDIO FREQUENCIES vs. PERCENTAGE OF MODULATION
FOR VARIOUS NULLS
(Communication Receiver Tuned to 21.500 mc)

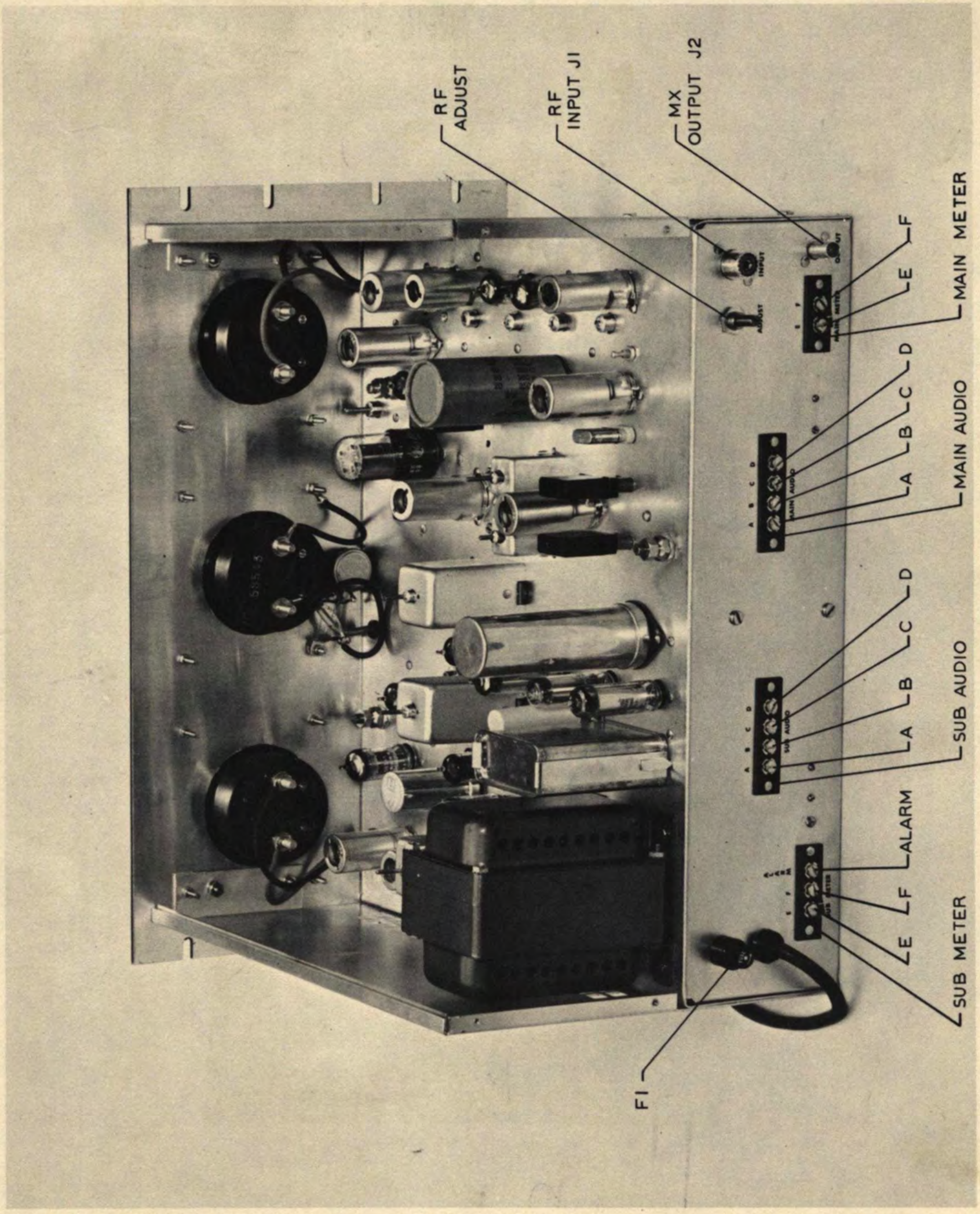
Null Number	Modulation Index	Frequency Deviation	Percentage of Modulation	Audio Frequency
2	5.520	75,000	100.0%	13,586
2	5.520	55,200	73.6%	10,000
2	5.520	27,600	36.8%	5,000
3	8.654	75,000	100.0%	8,670
3	8.654	86,550	115.4%	10,000
3	8.654	43,275	57.7%	5,000
4	11.792	75,000	100.0%	6,360
4	11.792	58,950	78.6%	5,000
4	11.792	23,550	31.4%	2,000
5	14.931	75,000	100.0%	5,023
5	14.931	74,625	99.5%	5,000
5	14.931	29,850	39.8%	2,000
6	18.071	75,000	100.0%	4,150
6	18.071	90,375	120.5%	5,001
6	18.071	28,650	38.2%	1,585
7	21.212	75,000	100.0%	3,535
7	21.212	63,636	84.8%	3,000
7	21.212	42,424	56.5%	2,000
8	24.353	75,000	100.0%	3,080
8	24.353	97,425	129.9%	4,000
8	24.353	48,675	64.9%	2,000
9	27.494	75,000	100.0%	2,727
9	27.494	82,482	109.9%	3,000
9	27.494	54,988	73.3%	2,000
10	30.635	75,000	100.0%	2,450
10	30.635	61,275	81.7%	2,000
10	30.635	30,600	40.8%	1,000

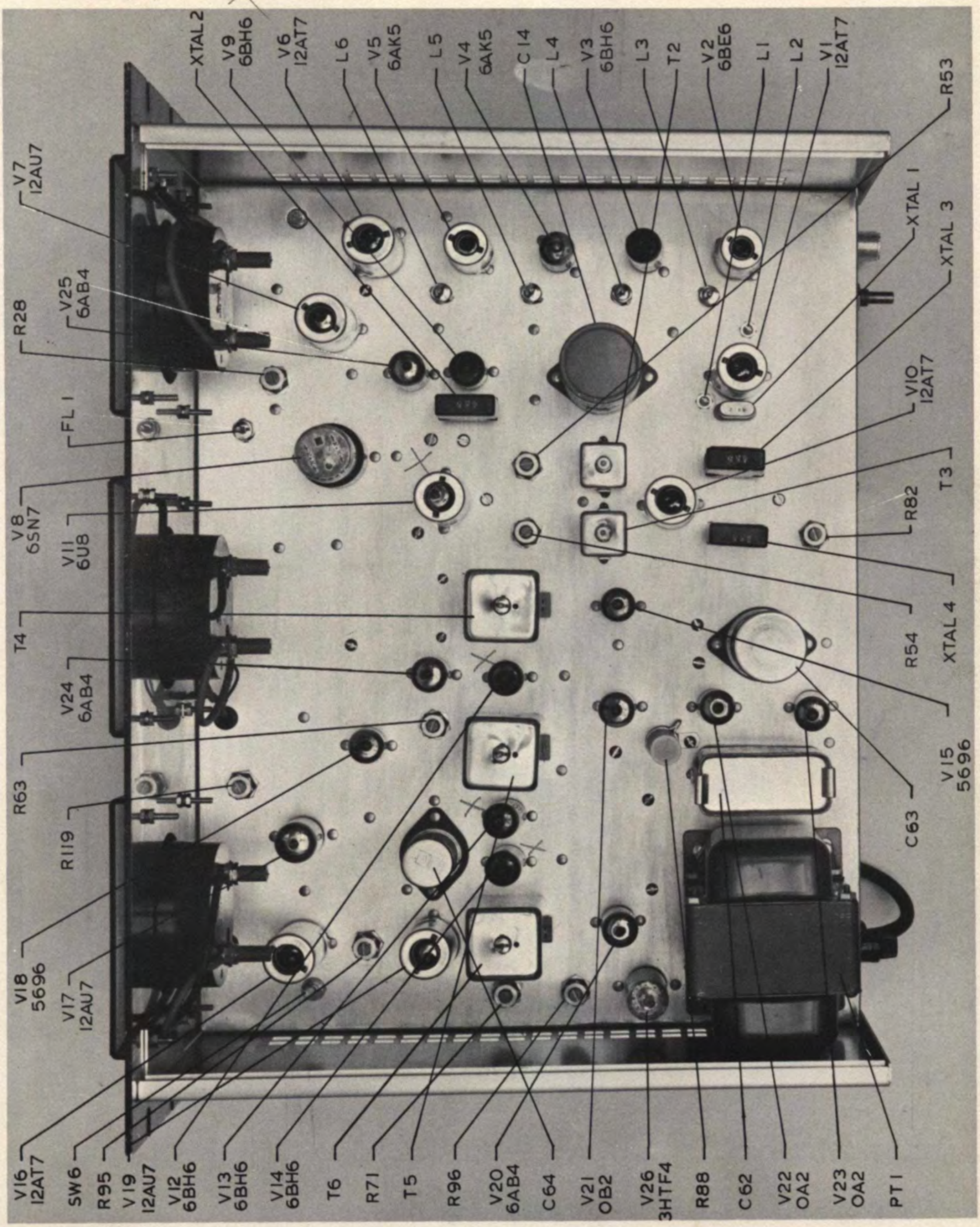
TYPICAL VOLTAGE CHART

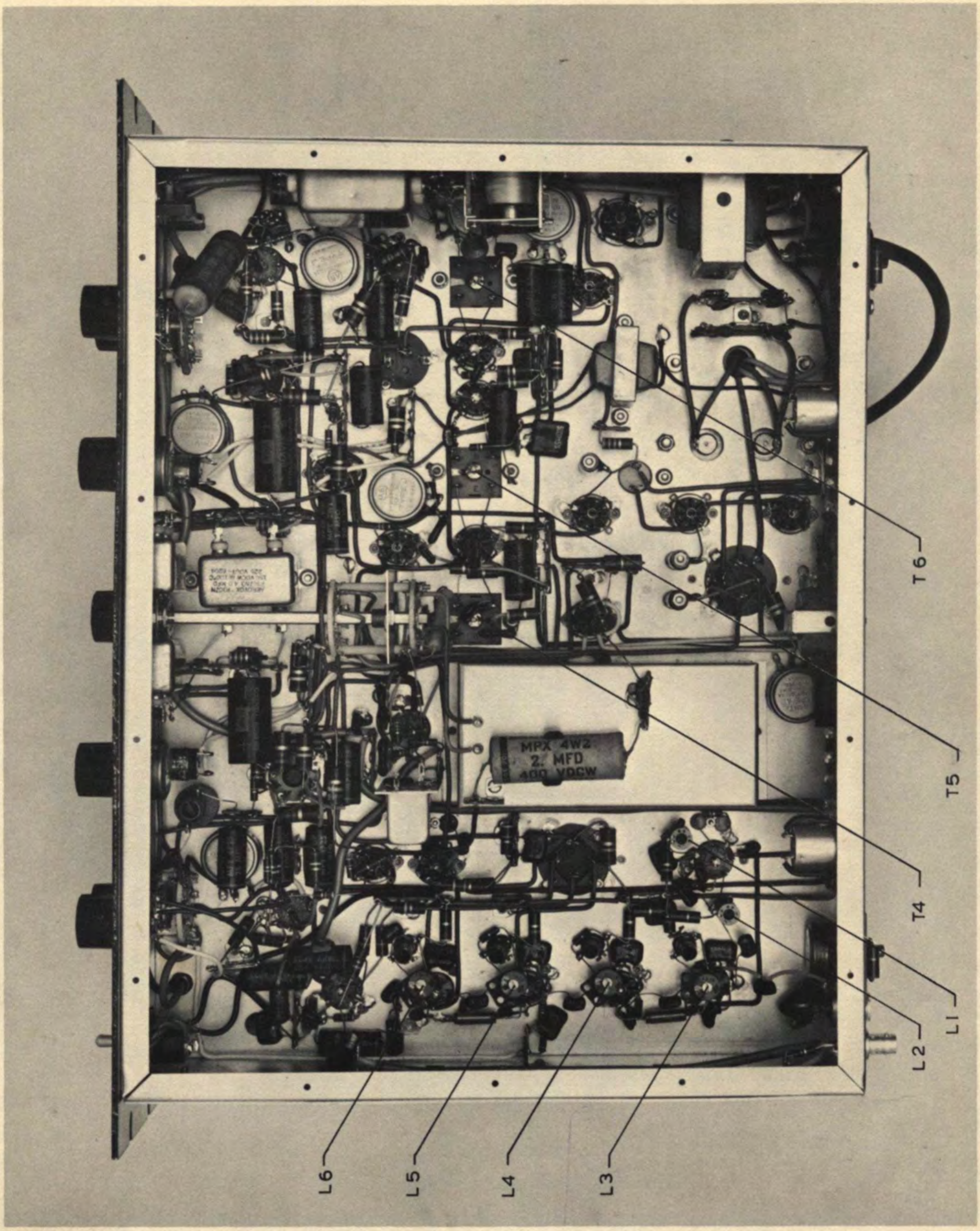
Tube	Pin # 1	2	3	4	5	6	7	8	9	Notes
V1 12AT7	100	-	-	-	-	83	*-6		5VAC	
V2 6BE6	0	1	5VAC	-	55	55	0			
V3 6BH6	0	.5	5VAC	-	70	70	0			
V4 6AK5	*-12	0	6VAC	-	60	60	0			*VTVM
V5 6AK5	*-1	0	6VAC	-	70	70	0			
V6 12AT7	55	0	2	-	-	55	0	2	6VAC	
V7 12AU7	60	0	3.5V	-	-	25	0	1	6VAC	
V8 6SN7	0	120	2	0	200	5.6	6-AC			
V9 6BH6	@1	0	-	6VAC	@ 65	@60	0			@CAL.POS.
V10 12AT7	90	*-3	0	-	-	90	*-6V	-	5VAC	
V11 6U8	108	0	68	-	6VAC	90	1	2.6V	0	
V12 6BH6	0	.7	5VAC	-	102	102	-			
V13 6BH6	#-60V	0	5VAC	-	53	8	-			#Depend. on inj.
V14 6BH6	# -2	0	5VAC	-	70	70	-			
V15 5696	0	#7	1VAC	5VAC	7	150				#Depend. on peak indicator setting
V16 12AT7	55	0	.5	6VAC	6VAC	55	0	0	-	
V17 12AU7	190	0	4.8	-	-	45	0	1	6VAC	
V18 5696	0	#/7	1VAC	5VAC	7	150				
V19 12AU7	83	0	5.3	5VAC	5VAC	145	0	2	0	
V20 6AB4	400					50	0			Unmuted
	160	0	0	5VAC	-	2V	2.2V			Muted
V21 OB2	108	-	-	-	108	-	-			
V22 OA2	300	150	150	150	300	150	150			
V23 OA2	150	0	0	0	150	0	0			
V24 6AB4	85	0	6VAC	-	0	*-.56	0			
V25 6AB4	165	0	-	6VAC	0	0	2			
V26 3HTF4 Ballast	-	6VAC	6VAC	-	-	-	.5 AC	.5 AC		

All readings taken with 20,000 ohm per volt meter except where specified.


M 3
M2
M1
J3
J4
SW3
SW5
R118
PL2
R74
SW7
R81
PL1
SW2
SW1
SW4
PL3
SUB CHANNEL MODULATION
SUB CHANNEL FREQUENCY
MAIN CHANNEL MODULATION
TBM-4500


RF ADJUST
RF INPUT J1
MX OUTPUT J2
MAIN METER
E
F
MAIN AUDIO
A
B
C
D
SUB AUDIO
A
B
C
D
ALARM
SUB METER
E
F
F1


XTAL 2
V9 6BH6
V6 12AT7
L6
V5 6AK5
L5
V4 6AK5
C14
L4
V3 6BH6
L3
T2
V2 6BE6
L1
L2
V1 12AT7
R53
XTAL 1
XTAL 3
V10 12AT7
T3
R82
XTAL 4
R54
V15 5696
C63
PT1
V23 OA2
V22 OA2
C62
R88
V26 3HTF4
V21 OB2
C64
V20 6AB4
R96
T5
R71
T6
V14 6BH6
V13 6BH6
V12 6BH6
V19 12AU7
R95
SW6
V16 12AT7
V17 12AU7
V18 5696
R119
R63
V24 6AB4
T4
V11 6U8
V8 6SN7
FL1
R28
V25 6AB4
V7 12AU7


T6
T5
T4
L1
L2
L3
L4
L5
L6
MPX 4W2
2. MFD
400 VDCW

WARRANTY

McMartin Broadcast and Audio Products are warranted to be free from defects in workmanship -- FOREVER.

At our discretion, we will exchange or repair any defective unit or component, at any time, without charge. Material and components are guaranteed for a minimum period of 90 days from the date of the original purchase. Transportation charges must be prepaid on equipment returned for warranty service.

This warranty does not extend to any of our products which have been subjected to misuse, neglect, accidents, incorrect wiring not our own, improper installation, or to use in violation of the instructions furnished by us; nor to units that have been altered outside our factory.

VIII PARTS LIST

C-1	100 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier CD-15
C-2	.001 +80 -20% 500 v disc ceramic capacitor	Radio Materials Co.
C-3	100 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier CD-15
C-4	100 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier CD-15
C-5	3000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-6	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-7	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-8	100 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-9	.001 mf ± 80 -20% 500 v disc ceramic capacitor	Radio Materials Co.
C-10	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier CD-15
C-11	47 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-12	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-13	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-14A	20 mf @350 v dcw electrolytic, twist prong, alum. can	P. R. Mallory
C-14B	40 mf @350 v dcw 4-section	P. R. Mallory Type FP
C-14C	40 mf @350 v dcw " "	P. R. Mallory
C-14D	30 mf @350 v dcw " "	P. R. Mallory
C-15	47 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier CD-15
C-16	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-17	100 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-18	10 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-19	.25 mf @400 v metalized paper tubular capacitor	Cornell-Dubilier Type MP
C-20	.25 mf @400 v metalized paper tubular capacitor	Cornell-Dubilier
C-21	.25 mf @400 v metalized paper tubular capacitor	Cornell-Dubilier

PARTS LIST (cont)

C-22	.25 mf @400 v metalized paper tubular capacitor	Cornell-Dubilier
C-23	.25 mf @400 v metalized paper tubular capacitor	Cornell-Dubilier
C-24	10 mf @450 tubular electrolytic	P. R. Mallory
C-25	4 mf @150 bathtub case, paper capacitor	Aerovox
C-26	Adjust at factory (Nominal value 4 mfd, 150 v) bathtub case, paper capacitor	Aerovox
C-27	24 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-28	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-29	.02 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-30	.25 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-31	.25 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-32	100 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-33	47 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-34	47 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-35	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-36	3000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-37	3000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-38	3000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-39	3000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-40	5000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-41	5000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-42	47 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-43	5000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-44	3000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-45	.25 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier Type MP
C-46	10 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-47	470 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-48	100 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier

PARTS LIST (cont)

C-49	.25 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-50	3000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-51	47 mmf ± 10% 500 v dipped mica capacitor	Cornell-Dubilier
C-52	.25 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-53	.25 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-54	5 mf @ 50 v tubular electrolytic miniature	P. R. Mallory Type KETA
C-55	47 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-56	470 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-57	470 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-58	910 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-59	2 mf @ 400 v metalized tubular paper capacitor	P. R. Mallory
C-60	220 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-61	220 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-62	.85 mf @ 600 VAC, alum. can, oil filled paper	Aerovox
C-63A	4 x 40/450 v twist prong electrolytic, 4 section	Sprague
C-63B	4 x 40/450 v twist prong electrolytic, 4 section	Sprague
C-63C	4 x 40/450 v twist prong electrolytic, 4 section	Sprague
C-63	4 x 40/450 v twist prong electrolytic, 4 section	Sprague
C-64A	20 mf/150 v twist prong electrolytic	P. R. Mallory
C-64B	30 mf/150 v twist prong electrolytic	P. R. Mallory
C-65	1000 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-66	1 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-67	.05 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-68	.25 @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-69	.05 mf @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-70	10 mf/450 tubular electrolytic	P. R. Mallory
C-71	4 mf 150 v bathtub case, paper capacitor	Aerovox

PARTS LIST (cont)

C-72	Adjust at factory (Nominal value 4 mf 150 v) bathtub case, paper capacitor	Aerovox
C-73	.001 mf +80 -20% disc ceramic capacitor	Radio Materials Co.
C-74	1.0 mf /200 v pup metalized paper tubular capacitor	Cornell-Dubilier
C-75	.25 @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-76	.02 @ 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-77	1 mf 200 v pup metalized paper tubular capacitor	Cornell-Dubilier
C-78	1 mf 200 v pup metalized paper tubular capacitor	Cornell-Dubilier
C-79	3000 mmf ± 5% dipped mica capacitor	Cornell-Dubilier
C-80	.25 mf 400 v metalized paper tubular capacitor	Cornell-Dubilier
C-81	Adjust at factory (nominal value 2000 mmf ± 5 500 v dipped mica	Cornell-Dubilier
C-82	1 mf 200 v pup metalized paper tubular capacitor	Cornell-Dubilier
C-83	1 mf 200 v pup metalized paper tubular capacitor	Cornell-Dubilier
C-84	100 mmf ± 10% 500 v dipped mica capacitor	Cornell-Dubilier
C-85	5000 mmfd ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-86	270 mmf ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-87	750 mmf ± 10% 300 v dipped mica capacitor	Cornell-Dubilier
C-88	.001 mf 600 v +80 -20% disc ceramic capacitor	Radio Materials Co.
C-89	.001 mf 600 v +80 -20% disc ceramic capacitor	Radio Materials Co.
C-90	.001 mf 600 v +80 -20% disc ceramic capacitor	Radio Materials Co.
C-91	750 mmf ± 10% 300 v dipped mica capacitor	Cornell Dubilier
C-92	.001 mfd +80% -20% 500 v disc ceramic capacitor	Radio Materials Co.
C-93	.001 mfd +80% -20% 500 v disc ceramic capacitor	Radio Materials Co.
C-94	10 mmfd ± 5% 500 v dipped mica capacitor	Cornell-Dubilier
C-95	150 mmfd ± 5% 500 v dipped mica capacitor	Cornell-Dubilier

PARTS LIST (cont)

R-1	100 K ± 10% 1/2 w composition carbon fixed resistor Allen-Bradley						
R-2	220 ± 10% 1/2 w	"	"	"	"	"	"
R-3	100 K ± 10% 1/2 w	"	"	"	"	"	"
R-4	220 K ± 10% 1/2 w	"	"	"	"	"	"
R-5	100 K ± 10% 1/2 w	"	"	"	"	"	"
R-6	10 K ± 10% 1 w	"	"	"	"	"	"
R-7	1 K ± 10% 1 w	"	"	"	"	"	"
R-8	220 ± 10% 1 w	"	"	"	"	"	"
R-9	10 K ± 10% 1 w	"	"	"	"	"	"
R-10	10 K ± 10% 1/2 w	"	"	"	"	"	"
R-11	68 ± 10% 1/2 w	"	"	"	"	"	"
R-12	4700 ± 10% 1 w	"	"	"	"	"	"
R-13	33K ± 10% 1/2 w	"	"	"	"	"	"
R-14	4700 ± 10% 1/2 w	"	"	"	"	"	"
R-15	10 K ± 10% 1 w	"	"	"	"	"	"
R-16	33 K ± 10% 1/2 w	"	"	"	"	"	"
R-17	4700 ± 10% 1 w	"	"	"	"	"	"
R-18	8200 ± 10% 1/2 w	"	"	"	"	"	"
R-19	120 K ± 5% 1/2 w	"	"	"	"	"	"
R-20	150 K ± 10% 1 w	"	"	"	"	"	"
R-21	10 K ± 5% 1 w	"	"	"	"	"	"
R-22	10 K ± 5% 1 w	"	"	"	"	"	"
R-23	470 K ± 10% 1/2 w	"	"	"	"	"	"
R-24	10 K ± 5% 1 w	"	"	"	"	"	"
R-25	10 K ± 5% 1 w	"	"	"	"	"	"
R-26	100 K ± 5% 1 w	"	"	"	"	"	"
R-27	100 K ± 5% 1 w	"	"	"	"	"	"
R-28	1500 ± 10% 2 w type J control carbon element					"	"

PARTS LIST (cont)

R-29	Adjust at factory (nominal value 27 K ± 10% 1/2 w) composition carbon fixed resistor	Allen-Bradley
R-30	100 K ± 10% 1 w composition carbon fixed resistor	Allen-Bradley
R-31	100 K ± 10% 1 w " " " "	" "
R-32	Adjust at factory (nominal value 680 ± 10 lw) composition carbon fixed resistor	" "
R-33	5600 ± 10% 2 w " " " "	" "
R-34	Adjust at factory (nominal value 3300 ± 10% 1/2 w) composition carbon fixed resistor	" "
R-35	33 K ± 10% 1 w " " " "	" "
R-36	Adjust at factory (nominal value 33 K ± 10% 1/2 w) composition carbon fixed resistor	" "
R-37	Adjust at factory (nominal value 75 K ± 5% 1/2 w) composition carbon fixed resistor	" "
R-38	470 K ± 10% 1/2 w " " " "	" "
R-39	2200 ± 10% 1 w " " " "	" "
R-40	150 K ± 10% 1 w " " " "	" "
R-41	100 K ± 10% 1 w " " " "	" "
R-42	15 K ± 10% 2 w " " " "	" "
R-43	100 K ± 10% 1 w " " " "	" "
R-44	270 ± 10% 2 w " " " "	" "
R-45	15 K ± 10% 2 w " " " "	" "
R-46	1500 ± 5% 1 w " " " "	" "
R-47	6.8 meg ± 10% 1/2 w " " " "	" "
R-48	10 K ± 10% 1 w " " " "	" "
R-49	47 K ± 10% 1 w " " " "	" "
R-50	47 K ± 10% 1 w " " " "	" "
R-51	220 K ± 10% 1/2 w " " " "	" "
R-52	220 K ± 10% 1/2 w " " " "	" "
R-53	2500 ohm ± 10% 2 w type J control carbon element	" "

VIII

PARTS LIST (cont)

R-54	2500 ohm ± 10% 2 w type J control carbon element	Allen-Bradley
R-55	680 ± 10% 1/2 w composition carbon fixed resistor	" "
R-56	100 K ± 10% 1/2 w " " " "	" "
R-57	10 K ± 10% 1 w " " " "	" "
R-58	33 K ± 10% 1/2 w " " " "	" "
R-59	4700 ± 10% 1 w " " " "	" "
R-60	150 ± 10% 1 w " " " "	" "
R-61	1000 ± 10% 1 w " " " "	" "
R-62	3300 ± 10% 1/2 w " " " "	" "
R-63	50 K ± 10% 2 w type J control, carbon element	" "
R-64	100 K ± 10% 1/2 w composition carbon fixed resistor	" "
R-65	10 K ± 10% 1 w " " " "	" "
R-66	100 K ± 10% 1 w " " " "	" "
R-67	47 K ± 10% 1 w " " " "	" "
R-68	100 K ± 10% 1/2 w " " " "	" "
R-69	30 K ± 5% 1 w " " " "	" "
R-70	10 K ± 10% 1 w " " " "	" "
R-71	100 K ± 10% 2 w type J control, carbon element	" "
R-72	3300 ± 10% 1/2 w composition carbon fixed resistor	" "
R-73	3300 ± 10% 1/2 w " " " "	" "
R-74	1000 ± 10% 5 w control, wire wound	Centralab
R-75	10 K ± 10% 1/2 w composition carbon fixed resistor	Allen-Bradley
R-76	15 K ± 10% 1/2 w " " " "	" "
R-77	560 K ± 10% 1/2 w " " " "	" "
R-78	100 K ± 10% 2 w " " " "	" "
R-79	75 K ± 5% 1/2 w composition carbon fixed resistor	" "
R-80	Adjust at factory (nominal value 15 K ± 10 % 1/2 w) composition carbon fixed resistor	" "

R-81	10 K ± 10% 2 w type J control, carbon element	Allen-Bradley
R-82	500 K ± 10% 2 w type J control, carbon element	" "
R-83	150 K ± 10% 2 w composition carbon fixed resistor	" "
R-84	470 K ± 10% 1/2 w " " " "	" "
R-85	470 K ± 10% 1/2 w " " " "	" "
R-86	470 K ± 10% 1/2 w " " " "	" "
R-87	470 K ± 10% 1/2 w " " " "	" "
R-88	2000 ohm @ 20 w top mount wirewound ceramic resistor	Milwaukee Resistor
R-89	Adjust at factory (nominal value 10K ± 10% 2 w) composition carbon fixed resistor	Allen-Bradley
R-90	750 @ 10 w vitreous enamel wirewound resistor	Ohmite
R-91	5000 @ 10 w vitreous enamel wirewound resistor	Ohmite
R-92	10 K @ 10 w vitreous enamel wirewound resistor	"
R-93	10 K ± 10% 1 w composition carbon fixed resistor	Allen-Bradley
R-94	33 K ± 10% 1 w " " " "	" "
R-95	10 K ± 10% 2 w type J control, carbon element	" "
R-96	500 K ± 10% 2 w type J control, carbon element	" "
R-97	3.3 meg ± 10% 1/2 w composition carbon fixed resistor	" "
R-98	100 K ± 10% 1 w " " " "	" "
R-99	1000 ± 10% 1/2 w " " " "	" "
R-100	3.3 meg ± 10% 1/2 w " " " "	" "
R-101	220 K ± 10% 1 w " " " "	" "
R-102	100 K ± 10% 1/2 w " " " "	" "
R-103	470 ± 10% 1/2 w " " " "	" "
R-104	100 K ± 10% 1 w " " " "	" "
R-105	220 K ± 10% 1/2 w " " " "	" "
R-106	Adjust at factory (nominal value 680 ± 10% 1/2 w) composition carbon fixed resistor	" "
R-107	5600 2 w 10% " " " "	" "

PARTS LIST (cont)

R-108	Adjust at factory (nominal value 3300 ± 10% 1/2 w) composition carbon fixed resistor	Allen-Bradley
R-109	33 K ± 10% 1 w composition carbon fixed resistor	" "
R-110	Adjust at factory (nominal value 33 K ± 10% 1/2 w) composition carbon fixed resistor	" "
R-111	1500 ± 5% 1 w composition carbon fixed resistor	" "
R-112	47 K ± 10% 1/2 w " " " "	" "
R-113	680 ± 10% 1/2 w " " " "	" "
R-114	470 K ± 10% 1/2 w " " " "	" "
R-115	220 K ± 10% 1/2 w " " " "	" "
R-116	100 K ± 10% 2 w " " " "	" "
R-117	Adjust at factory (nominal value 15 K ± 10% 2 w) composition carbon fixed resistor	" "
R-118	10 K ± 10% 2 w type J control, carbon element	" "
R-119	500 K ± 10% 2 w type J control, carbon element	" "
R-120	560 K ± 10% 1 w composition carbon fixed resistor	" "
R-121	15 K ± 10% 2 w " " " "	" "
R-122	680 ± 10% 1/2 w " " " "	" "
R-123	680 K ± 10% 1/2 w " " " "	" "
R-124	1500 ± 10% 1/2 w " " " "	" "
R-125	47 K ± 10% 1/2 w " " " "	" "
R-126	100 K ± 10% 1 w " " " "	" "
R-127	75 K ± 5% 1/2 w " " " "	" "
R-128	1000 ± 10% 1/2 w " " " "	" "
R-129	1000 ± 10% 1/2 w " " " "	" "
R-130	470 ± 10% 1/2 w " " " "	" "
R-131	10 K ± 10% 1/2 w " " " "	" "
R-132	470 ± 10% 1/2 w " " " "	" "
R-140	27 K ± 10% 2 w " " " "	" "
R-141	470 K ± 10% 1/2 w " " " "	" "

PARTS LIST (cont)

R-142	220 ± 10% 1/2 w composition carbon fixed resistor	Allen-Bradley
R-143	22 K ± 10% 2 w " " " "	" "
R-144	100 ± 10% 2 w " " " "	" "
R-145	68 K ± 10% 1/2 w " " " "	" "
R-146	82 K ± 10% 1/2 w " " " "	" "
R-147	1000 ± 10% 1/2 w " " " "	" "
R-148) R-149) R-150) R-151) R-152) R-153)	See SW-5	
R-154	22 K ± 10% 1/2 w " " " "	" "
R-155	100 K ± 10% 1/2 w " " " "	" "
T-1	Audio output 15 K primary, 600 ohm secondary shielded	McMartin Ind.,Inc.
T-2	Sub-carrier #1 osc. coil	" "
T-3	Sub-carrier #2 osc. coil	" "
T-4	1st 455 kc IF	" "
T-5	2nd 455 kc IF	" "
T-6	455 kc ratio detector	" "
T-7	Transformer, 6 v primary, 150 v @ 10 mA secondary	" "
T-8	Transformer, 6 v primary, 150 v @ 10 mA secondary	" "
T-9	Audio output 15 K primary, 600 ohm secondary, shielded	"
L-1	Osc. coil assembly with 10 mmf ± 10% 500 v dipped mica capacitors	" "
L-2	Doubler coil assembly with 10 mmf ± 5% 500 v dipped mica capacitor	" "
L-3	21.5 mc IF coil assembly & 3.5 mmf to 12.0 mmf capacitor & nominal value resistor 1/2 w ± 10%	" "
L-4	21.5 mc IF coil assembly 3.5 to 12.0 mmf capacitor	" "
L-5	21.5 mc IF coil assembly 3.5 to 12.0 mmf capacitor	" "

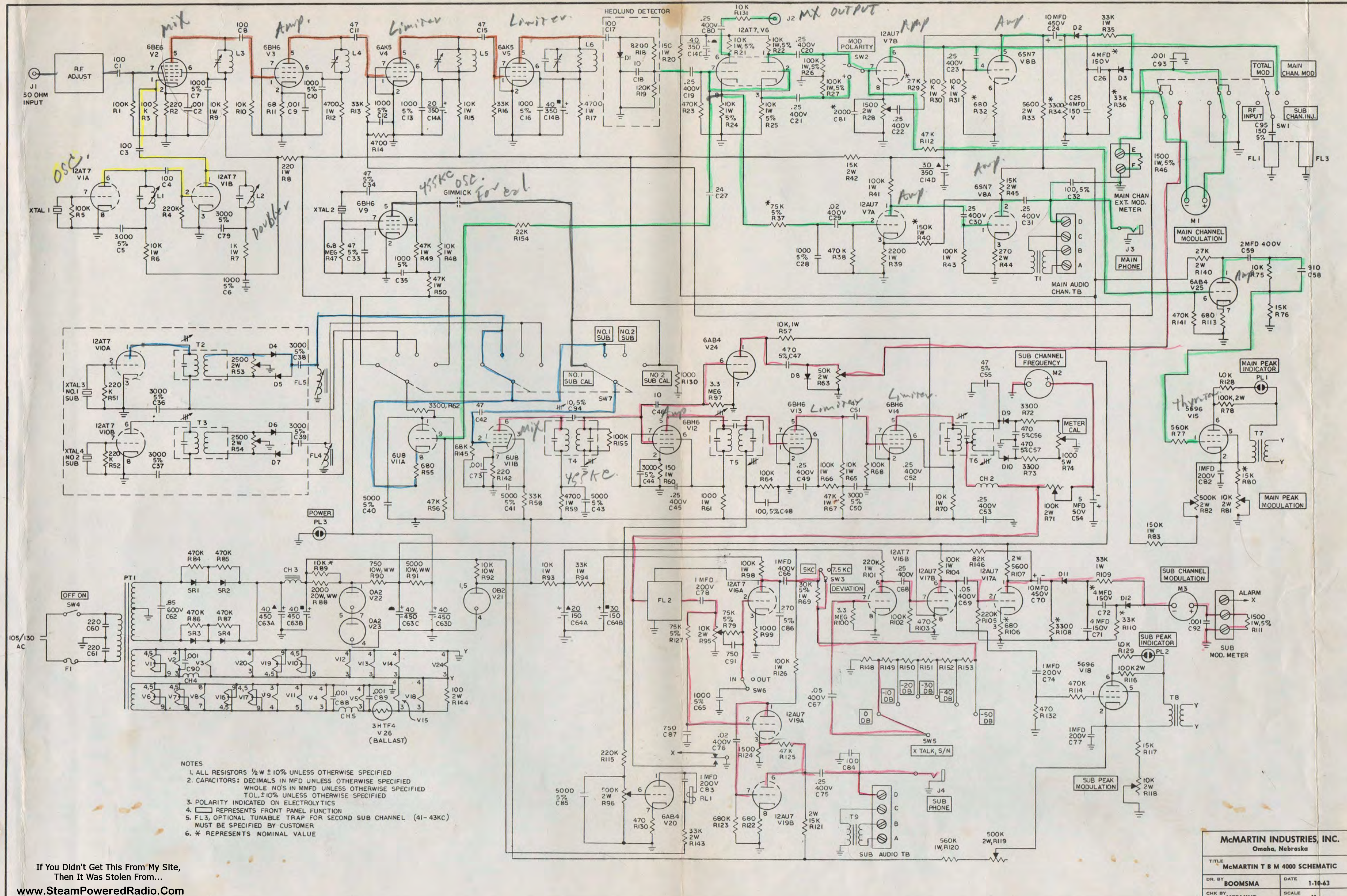
L-6	21.5 mc IF coil assembly 3.5 to 12.0 mmf capacitor	McMartin Ind., Inc.
Xtal-1	18-27 mc overtone crystal ± .005%	" "
Xtal-2	455 kc calibrate (fundamental) ± .005%	" "
Xtal-3	Subchannel 1) specified by customer	" "
Xtal-4	Subchannel 2) specified by customer	" "
D-1	SD150 silicon diode	General Electric
D-2	1N51 germanium diode	" "
D-3	1N51 germanium diode	Erie Resistor
D-4	1N51 " "	" "
D-5	1N51 " "	" "
D-6	1N51 " "	" "
D-7	1N51 " "	" "
D-8	SD150 silicon diode	General Electric
D-9	1N51 germanium diode	Erie Resistor
D-10	1N51 " "	" "
D-11	1N51 " "	" "
D-12	1N51 " "	" "
SW-1	3 pole, 4 position single wafer switch	McMartin Ind., Inc.
SW-2	1 pole, 2 position wafer switch	Centralab
SW-3	1 pole, 2 position wafer switch	" "
SW-4	SPST power switch, bat handle toggle	Cutler-Hammer
SW-5	Meter multiplier assembly Switch 2 pole, 6 position wafer R148 100 ± 1% 1/2 w precision wirewound resistor R149 216.2 ± 1% 1/2 w precision wirewound resistor R150 683.8 ± 1% 1/2 w precision wirewound resistor R151 2.162 K ± 1% 1/2 w precision wirewound resistor R152 6.83 K ± 1% 1/2 w precision wirewound resistor R153 21.62 K ± 1% 2 w precision wirewound resistor	McMartin Ind., Inc.
SW-6	SPDT toggle switch miniature	McMartin Ind., Inc.
SW-7	4 pole, 4 position, 2 wafer switch	" "

PARTS LIST (cont)

F-1	1 amp S. B. type 3 AG fuse, glass tube	Littel
FL-1	67 kc trap, tunable	McMartin Ind.,Inc.
FL-2	Lo-pass filter, 10 kc cut-off	" "
FL-3	Optional tunable trap for subchannel, specified by customer.	" "
FL-4	67 kc coil, tunable	" "
FL-5	41 kc coil, tunable (optional)	" "
M-1	Meter, 0-300 uA special, main channel mod.	" "
M-2	Meter, 25-0-25 uA special, subchannel freq.	" "
M-3	Meter, 0-300 uA special, subchannel mod.	" "
CH-1	10 mH choke	" "
CH-2	2.5 mH choke	" "
CH-3	Filter choke 6 H @ 150 mA dc	Quality Trans.
CH-4	2.5 uH RF choke	McMartin Ind.,Inc.
CH-5	2.5 uH RF choke	" "
PL-1	Main peak indicator, NE-51H	General Electric
PL-2	Subchannel peak indicator NE-51H	" "
PL-3	Pilot light assembly (neon)	McMartin Ind.,Inc.
PT-1	Power transformer, 105-130 vac (regulated plate, filament)	Sola Electric
SR-1	1N2095 silicon rectifier 600 piv @ 700 ma	P. R. Mallory
SR-2	1N2095 silicon rectifier 600 piv @ 700 ma	" "
SR-3	1N2095 silicon rectifier 600 piv @ 700 ma	" "
SR-4	1N2095 silicon rectifier 600 piv @ 700 ma	" "
RL-1	SPDT, 10 K plate circuit relay	Potter-Brumfield LB-5
V-1	12AT7	Sylvania - G. E. RCA
V-2	6BE6	General Electric
V-3	6BH6	" "
V-4	6AK5	" "

PARTS LIST (cont)

V-5	6AK5	General Electric
V-6	12AT7	" "
V-7	12AU7	" "
V-8	6SN7	" "
V-9	6BH6	" "
V-10	12AT7	" "
V-11	6U8	" "
V-12	6BH6	" "
V-13	6BH6	" "
V-14	6BH6	" "
V-15	5696	" "
V-16	12AT7	" "
V-17	12AU7	" "
V-18	5696	" "
V-19	12AU7	" "
V-20	6AB4	Amperex
V-21	OB2	"
V-22	OA2	"
V-23	OA2	General Electric
V-24	6AB4	" "
V-25	6AB4	" "
V-26	3HTF4 (Ballast)	Amperite


HEDLUND DETECTOR
MX OUTPUT
J1 50 OHM INPUT
RF ADJUST
MOD POLARITY
TOTAL MOD
MAIN CHAN. MOD
RF INPUT
SUB CHAN. INJ.
MAIN CHAN EXT. MOD. METER
MAIN CHANNEL MODULATION
MAIN PHONE
MAIN AUDIO CHAN. TB
MAIN PEAK INDICATOR
MAIN PEAK MODULATION
SUB CHANNEL FREQUENCY
METER CAL
NO. 1 SUB
NO. 2 SUB
NO. 1 SUB CAL
NO. 2 SUB CAL
POWER
OFF ON
105/130 AC
SUB CHANNEL MODULATION
ALARM
SUB MOD. METER
SUB PEAK INDICATOR
SUB PEAK MODULATION
DEVIATION
X TALK, S/N
SUB PHONE
SUB AUDIO TB
GIMMICK
3HTF4 V26 (BALLAST)
NOTES
1. ALL RESISTORS ½W ± 10% UNLESS OTHERWISE SPECIFIED
2. CAPACITORS: DECIMALS IN MFD UNLESS OTHERWISE SPECIFIED
WHOLE NO'S IN MMFD UNLESS OTHERWISE SPECIFIED
TOL. ± 10% UNLESS OTHERWISE SPECIFIED
3. POLARITY INDICATED ON ELECTROLYTICS
4. ▭ REPRESENTS FRONT PANEL FUNCTION
5. FL3, OPTIONAL TUNABLE TRAP FOR SECOND SUB CHANNEL (41-43KC) MUST BE SPECIFIED BY CUSTOMER
6. ✱ REPRESENTS NOMINAL VALUE
McMARTIN INDUSTRIES, INC.
Omaha, Nebraska
TITLE McMARTIN T B M 4000 SCHEMATIC
DR. BY BOOMSMA
DATE 1-10-63
CHK BY HEDLUND
SCALE None