

2.1b - IF-AF MODULE - cont.

The 455 KHz signal is filtered by a 6 resonator ceramic lattice filter assembly. The normally supplied characteristics are:

- 3 db bandwidth 18 KHz
- 50 db bandwidth 40 KHz

Replacement filters for wider, narrower or steeper skirt characteristics are provided for and can be furnished from the factory as replacements or can be factory installed on special order.

The output of the ceramic filter is amplified by a type CA3053 integrated circuit. A single tuned 455 KHz transformer at the output provides additional skirt selectivity and couples to a CA3075 integrated circuit. This stage serves as a limiter, high gain IF amplifier, differential discriminator, meter amplifier and 1st audio amplifier.

The detected output from the discriminator is divided into two channels. One of these contains correct RC frequency shaping to provide de-emphasis to EIA standard contour and is coupled via the Volume Control to the CA3020A audio output amplifier. The other detected output is a two stage tuned noise amplifier utilizing type 40233 transistors, whose rectified output provides the required Squelch Control characteristics. This rectified output is utilized to switch a clamping transistor (40233) which gates the 3020A amplifier.

2.2 TRANSMITTER CIRCUITRY

2.2a - CRYSTAL OSCILLATOR/MODULATOR MODULE - The 22'er FM has provisions for 9 panel selected transmitter crystals. A separate trimmer capacitor permits adjusting each crystal to the exact frequency. Only high quality, stable crystals should be employed to achieve the precision and stability capabilities of the equipment.

ADDITIONAL TRANSMIT CRYSTALS can be furnished (.0005% tolerance from 1 to 40 degrees C ambient) at \$9.00 each. All standard 30 KC increment channels are available in stock. Alternately, crystals can be supplied by Sentry Mfg. Co., Crystal Park, Chickasha, Oklahoma 73018. Order their Stock No. #88001 plus desired output frequency. See paragraph #3 also.

A type 40246 transistor is employed as the crystal oscillator in the 8.1 MHz region and a like device is employed as an isolation stage between the oscillator and the phase modulator.

Audio output from a high impedance microphone source is preamplified by a type 2N5245 FET which then couples to a type 40233 audio stage. An adjustable potentiometer between these two stages is provided to preset gain to the desired level.

The audio output is fed to a diode clipper pair whose clipping level is controlled by the panel DEVIATION control. When this control is at

2.2a - CRYSTAL OSCILLATOR/MODULATOR MODULE - cont.

MAX (clockwise), no clipping takes place and the internal gain control permits adjustment from 0 to 15 KC or more deviation at normal voice levels. When the deviation control is retarded somewhat, clipping commences and varying degrees of FM deviation can be obtained.

Time constants before and after the clipping stage have been selected to provide extremely clean speech quality with moderate clipping while maintaining the EIA phase modulation speech contour.

The clipped audio output is coupled to a special integrated "back to back" voltage variable capacitor which, in conjunction with a high Q slug tuned coil, forms a voltage variable phase shifter at 8.1 MHz. The crystal oscillator signal (isolated) is applied across this network and the phase modulated output is limited and amplified by a CA3053 integrated circuit and transformed to low impedance as a 2 volt, 8.1 MHz phase modulated output signal.

2.2b - FREQUENCY MULTIPLIERS - Three cascaded stages employing type 12GN7A vacuum tubes provide the required frequency multiplication and power amplification for driving the final amplifier stage. In these stages the 8 MHz phase modulated signal is:

1. Tripled to 24 MHz
2. Tripled to 72 MHz
3. Doubled to 144 MHz

Double tuned band pass couplers are employed at 24 and 72 MHz. These circuits are factory aligned to cover approximately $2\frac{1}{2}$ MHz either side of the 146 MHz center frequency. The final multiplier (144 MHz doubler) is tuned by the GRID control on the front panel.

2.2c - FINAL AMPLIFIER - The 22'er FM utilizes a type 8150 vacuum tube as a Class C power amplifier with an efficient series tuned plate circuit and with low impedance, tuned link output coupling. Nominal input power is 325 volts at 180 Ma ($58\frac{1}{2}$ Watts). Typical power output of more than 30 Watts is obtained into a 50 ohm load.

2.3 POWER & CONTROL CIRCUITRY

The 22'er FM utilizes a special power supply system permitting choice of either 115 volt, 60 Hz and 12 VDC operation. Conversion from one to the other of these modes is performed by the use of the correct POWER CONNECTOR.

On 12 VDC operation, a pair of 2N2869 transistors operate as self excited switches to perform the necessary DC to AC inversion.

On both modes a bridge rectifier and associated filter components provide a 330 VDC high voltage supply for the transmitter tubes.

On AC operation a second bridge rectifier provides a Zener regulated 11 VDC source for all Solid State circuits in both receiver and transmitter.

2.3 POWER & CONTROL CIRCUITRY - cont.

On DC operation the same Zener regulator stabilizes the 11 VDC provided from the 12 volt DC system.

A single relay (3 Pole, double throw) provides normal transmit-receive (T/R) switching controlled by the PTT provisions on the microphone. The MONITOR switch disables the T/R relay permitting actuation of the lower level transmitter stages, the crystal oscillator and phase modulator module as well as the receiver. This permits monitoring ones own signal quality and deviation.

3. CRYSTAL SELECTION and ADJUSTMENT

3.1 CRYSTAL CHARACTERISTICS

The 22'er FM, when equipped with a full complement of crystals, permits stable "on-channel" transmission on 9 preset frequencies. Crystals are available from several manufacturers as well as from the Clegg factory and from the dealer from whom the equipment is purchased. Each crystal socket has an adjoining miniature trimmer capacitor which permits varying the frequency approximately 3 KHz (at the output frequency).

The specifications of the required crystals are as follows:

1. Frequency: Desired output frequency divided by 18.
For example the crystal for 146.34 MHz output is

$$\frac{146.34}{18} = 8,130.000 \text{ KHz}$$
2. Holder: HC-25/U
3. Calibration Tolerance: $\pm .002\%$ (Max)
4. Temperature Characteristics: $\pm .008$ (Max) for 0 degrees to 60 degrees Centigrade
5. Circuit Loading: 12pf parallel resonant

3.2 CRYSTAL SOURCES

Crystals complying with these specifications can be purchased from Sentry Manufacturing Co., Crystal Park, Chickasha, Oklahoma 73018. Order their Part No. 88-001 suffixed by the desired operating frequency in the two meter band.

Crystals for operation on any of the popular FM channels (30 KHz increments from 146,100 to 146,970 KHz) can be normally furnished from the factory on a "same day" delivery basis. Price per crystal is \$9.00 plus \$1.00 per order for processing and shipping.

3. CRYSTAL SELECTION and ADJUSTMENT - cont.

3.3 CRYSTAL INSTALLATION

To install or replace crystals in the 22'er FM:

1. Remove the top cover of the unit by removing the eight screws (2 on each side and 3 on the top); do not loosen speaker mounting screws.
2. The nine available crystal sockets are located on the P/C board at the front center section of the chassis.
3. Crystal sockets are numbered 1 to 9 starting at the left front and back to #5 then forward to #9. (As normally shipped from the factory, a 146.94 crystal has been installed in socket #9)
4. Install the crystals in the sequence desired in the appropriate sockets. Normally, one will find it desirable to install crystals in ascending sequence of frequency, perhaps leaving empty sockets for anticipated future channels. A particularly useful sequence of crystals compatible with the activity in many areas of the country is:

1. 146.22	4. 146.37	7. 146.82
2. 146.28	5. 146.46	8. 146.88
3. 146.34	6. 146.76	9. 146.94

5. Frequency trimming can be accomplished in several manners depending on the availability of standards. By far the most simple method is to use stations already operating on that particular channel as the frequency standard.

The procedure in this case is:

- a) Allow equipment to preheat at least 30 minutes.
- b) Tune in a signal on the desired channel on the receiver. It is desirable to listen to the activity on that channel for some time to establish the consensus as to the frequency, keeping in mind that stations slightly higher in frequency will read high on the DISCRIMINATOR meter.
- c) Carefully tune in the station selected as the standard and observe the meter setting.
- d) Switch TRANSMIT CHANNEL to the appropriate position and switch SPOT to ON position.
- e) Adjust trimmer capacitor adjacent to the crystal in use to obtain the same meter reading as in c) above.

3.3 CRYSTAL INSTALLATION - cont.

5.

f) Repeat several times if necessary. When finally accomplished properly the meter should remain at the exact same deflection for all three of the following conditions:

1. No received signal.
2. Receiving the "Standard" signal.
3. Listening to the SPOT signal.

g) The foregoing procedure allows netting to within 150 cycles or less of any reference frequency.

4. RECEIVER DIAL CALIBRATION

As shipped from the factory the 22'er FM receiver dial has been calibrated to an error of less than 10 KC at all points from 144 to 148 MHz. A screw driver trimmer capacitor has been provided to permit periodic readjustment of this calibration. This trimmer is a vertically positioned screw driver adjustment just at the rear of the front bracket of the receiver tuning capacitor. (C225)

5. OPERATING SUGGESTIONS

The Ham who moves into the world of 2 meter FM from more conventional ham activities of AM, CW or SSB will quickly find that it is a vastly different type of activity. The difference is less related to the technical factors associated with the type of modulation than it is to the philosophical difference established by the groups of Hams who pioneered channelized VHF FM in the past decade.

Many excellent articles have appeared in the various ham periodicals quite adequately describing the nature of this "hobby within a hobby". A bibliography of these articles appears at the end of this section.

Unlike most of the equipment which has been used to date by the 2 meter FM fraternity, the 22'er FM has a tuneable receiver. Heretofore, when one wanted to listen on a channel for which he was not equipped, he had to go through the expense and delay of ordering a new receive crystal (or crystals) frequently to find that the channel selected was not sufficiently interesting to justify the expenditure.

Although the receiver is continuously tuneable, it is certainly expected that the channelized type of operation will be retained for virtually all 2 meter FM operation. One must learn to consider the tuneable FM receiver not as being continuously tuneable but having the capability of tuning to all of the channels without purchasing dozens of accessory crystals. To retain this philosophy of operation, the 22'er FM transmitter section has been channelized and only crystals for the widely co-ordinated channels in current usage will be supplied from the factory.

5. OPERATING SUGGESTIONS - cont.

5.1 CHANNEL SPOTTING

The receiver tuning dial of the 22'er FM has sufficiently adequate readout accuracy to permit setting to within 10 KHz of any desired channel without resorting to any reference standard.

The SPOT, MONITOR and DISCRIMINATOR meter provide instant and self obvious means for setting the receiver precisely on any channel for which a transmit crystal has been installed.

Not quite so obvious is the use of the self contained provisions of the unit to instantly tune the receiver precisely to any repeater output frequency for which an input crystal is available. Here one first sets the receiver by direct dial readout as closely as possible to the repeater output frequency. Then, with the transmitter set to the channel corresponding to the repeater input frequency, a momentary closure of the PTT button on the microphone will trigger the repeater. The receiver can then be tuned precisely to the repeater output frequency because of the "Squelch-tail" which repeaters transmit. (That is, virtually all repeaters have a short delay in turning off after the received signal that has triggered them goes off.)

5. SERVICE INFORMATION

Fig. 1 - Block diagram

Fig. 2 - Chassis layout

Fig. 3 - 9 channel XTAL osc and phase modulator schematic

Fig. 4 - Tuner and Front end schematic

Fig. 5 - A3 - Receiver IF/AF schematic
A4 - Main Frame schematic

6.1 RECEIVER FRONT END

6.1a - FRONT END TUNER alignment should be performed by feeding the output of a sweep generator adjusted for a center frequency of 146 MHz with about ± 6 MHz width into the ANT receptacle. The front end band pass can be observed by connecting a scope at the test point provided (TP201) on the copper side of TUNER P/C board at the top of R208. See Fig. 2, component layout.

Slug tuned coils L202 and L203 should be adjusted for a flat pass band of approximately 5 MHz centered at 146 MHz. When properly adjusted an input signal of 100 MV should provide approximately .75 volts of detected signal at the test point. AGC voltage to the RF stage should be disabled by grounding the AGC lead (white wire) at C203.

6. SERVICE INFORMATION - cont.

6.2 VLO ALIGNMENT

The tuneable oscillator in the 22'er FM operates 17,450 KHz below the desired signal frequency and tunes over the range of approximately 126 to 131 MHz.

Capacitor C220 and Inductance L205 are dependently adjusted to provide this range. Neither of these should be disturbed from their original factory setting until it has been positively established that the oscillator tuning range has become seriously misadjusted. Small adjustments in RECEIVER DIAL CALIBRATION can be made with the small piston trimmer, C225 located on the main tuning capacitor C226.

When adjustment is required it is accomplished in the conventional manner of alternately adjusting C220 and L205 at opposite ends of the calibrated range. C220 is adjusted at 148 MHz and L205 at 144 MHz. L205 is varied by making very small changes in spacing between coil turns.

6.3 IF ALIGNMENT

Connect receiver to a stable unmodulated signal generator set at 147 MHz. Connect a scope with low capacity probe to TP301 on IF/AF board. Tune main dial to signal generator. Increase signal generator output until .5 volts of 455 KC IF is obtained at test point. Adjust the following for maximum output:

C211	on tuner P/C board	C308	on IF/AF board
C302	on IF/AF board	T301	on IF/AF board
C305	on IF/AF board		

Reduce signal from generator as required to maintain .5 volt at TP301. Make certain generator is in center of pass band all through alignment procedure. When properly aligned an input signal of between 6 and 25 μ v should produce the .5 volt IF signal at TP301.

6.4 DISCRIMINATOR ALIGNMENT

Connect scope to junction of R311 and R312 on bottom side of IF/AF board. With no signal input a noise signal of approximately .5 volts peak to peak will be observed. Adjusting slug of L304 will cause the displayed noise to become unsymmetrical with clipping on one side when the slug is inserted excessively and on the other side when the slug is retracted excessively. At an intermediate adjustment of the slug the noise will appear symmetrical. This is the correct slug setting.

Adjust the panel meter to read mid scale (with no signal) by means of R420 at the rear chassis apron.

7. TRANSMITTER ALIGNMENT

7.1 FREQ MULTIPLIER STAGES

Connect an 8 MC sweep generator in place of FM generator by removing coax cable from terminal board at L401 and substituting cable from sweep generator. Adjust sweep generator for center frequency of 8.1 MHz and sweep width of ± 250 KHz. With scope vertical connected to TP402 adjust L402, L403, L404 and L405 for a flat pass band of approximately 200 KHz centered at 8.1 MHz.

Move scope to T/P 403 and observe that output peak can be moved across entire 200 KHz (referred to 8 MHz input) by means of C416 (grid tuning).

Remove sweeper and scope and replace coax. lead to L401.

7.2 TRANSMIT CRYSTAL OSC/MODULATOR BOARD

Insert a crystal for any channel between 146.28 and 146.53 in one of the crystal sockets. DISCONNECT ONE END OF 10 ohm resistor, R419.

Connect a VOM on TP401 and adjust both L101 and L102 for maximum DC voltage. A voltage of -1.25 volts or more should be obtained.

7.3 PHASE MODULATOR ADJUSTMENT

7.3a - Connect a scope to junction of C127 and C142. With unit on SPOT and MONITOR switch pulled out depress PTT and talk into microphone in normal operating manner. With DEVIATION control at 2/3 clockwise adjust trimmer pot R120 so speech wave form is clipped on peaks. Increase DEVIATION control to full clockwise; clipping should cease. Peak to peak voltage should be approximately 1 volt with DEVIATION at Max and decrease to .5 volt with DEVIATION at 2/3.

7.3b - Adjust unit for normal operation with a crystal for 146.94 inserted. Set to SPOT position and PULL OUT MONITOR PROVISION SWITCH on panel (part of VOLUME CONTROL, R422). Tune carrier in exactly on receiver; depress PTT on microphone. With DEVIATION control at Maximum clockwise position adjust slug in L101 for best audio quality. ONLY A SMALL ADJUSTMENT should be required.

7.4 PA NEUTRALIZATION

(Be sure R419, 10 ohms 1 watt is disconnected before making this adjustment)

Set TRANSMIT CHANNEL switch to a crystal near band center (channel 64) and adjust C416 (GRID TUNING) for maximum voltage at TP403. Connect a sensitive diode detector to the ANTENNA connector and adjust PA PLATE and LOAD capacitors for maximum indication on the diode detector meter. Then carefully adjust the neutralizing stub (CN) for MINIMUM output on diode detector meter. Readjust GRID, PLATE and LOAD controls for maximum reading. Repeat the adjustments to achieve minimum detected "leak through" in the PA stage.

7. TRANSMITTER ALIGNMENT - cont.

7.5 POWER INPUT MEASUREMENT

TP404 and TP405 are provided to measure, with a suitable VOM, the combined plate and screen current of the PA flowing through R419, 10 ohms. This current can vary from a minimum of 180 ma (1.8v across R419) to a maximum of 200 ma (2.0v across R419). If an 8150 changed in the field yields a current other than MIN/MAX limits, it has become necessary to adjust R418, 12K, 2w to set the current within these limits.

8. VOLTAGE & RESISTANCE 22'er FM

1. All DC measurements taken with a 20,000 ohms per volt VOM.
2. All resistance measurements (power off and capacitors discharged) taken with the + side of the ohmmeter connected to chassis.

8.1 XLO/AF PCB MODULE FM - A1

1. Volume control knob pulled out and set to max. CCW, thereby opening S402.
2. SPOT switch to ON.
3. DEVIATION control to max. CCW.
4. Microphone removed.

ITEM	+VDC	RDC	ITEM	+VDC	RDC
Q 101 E	1.7v	1k	Q 104 E	0.4v	330 ohms
B	1.1v	9.5k	B	0.9v	5.5k
C	10.0v	850 ohms	C	4.0v	6k
Q 102 E	0.9v	680 ohms	IC 101,		
B	1.1v	9.5k	1 & 8	0v	9.5k
C	10.0v	850 ohms	-2	2.8v	2k
Q 103 S	1.5v	1.2k	-3	GND	0
G	0v	1 MEG	-4	2.2v	560 ohms
D	5.0v	1k	-5	5.7v	2.5k
			-6	10.0v	700 ohms
			-7	3.0v	1k

8.2 Tuner and Front End Module FM - A2

1. SPOT switch to OFF.
2. No signal input

ITEM	+VDC	RDC	ITEM	+VDC	RDC
Q 201-1	9.6v	120 ohms	Q 202-2	1.4v	33k
-2	1.8v	42k	-3	0	0
-3	0	0	-4	0.85v	250 ohms
-4	1.0v	82 ohms	Q 203 E	0.5v	1k
Q 202-1	10.0v	220 ohms	B	1.0v	2.2k
			C	8.0v	1k

7. TRANSMITTER ALIGNMENT - cont.

7.5 POWER INPUT MEASUREMENT

TP404 and TP405 are provided to measure, with a suitable VOM, the combined plate and screen current of the PA flowing through R419, 10 ohms. This current can vary from a minimum of 180 ma (1.8v across R419) to a maximum of 200 ma (2.0v across R419). If an 8150 changed in the field yields a current other than MIN/MAX limits, it has become necessary to adjust R419, 12K, 2w to set the current within these limits.

8. VOLTAGE & RESISTANCE 22'er FM

1. All DC measurements taken with a 20,000 ohms per volt VOM.
2. All resistance measurements (power off and capacitors discharged) taken with the + side of the ohmmeter connected to chassis.

8.1 XLO/AF PCB MODULE FM - A1

1. Volume control knob pulled out and set to max. CCW, thereby opening S402.
2. SPOT switch to ON.
3. DEVIATION control to max. CCW.
4. Microphone removed.

ITEM	+VDC	RDC	ITEM	+VDC	RDC
Q 101 E	1.7v	1k	Q 104 E	0.4v	330 ohms
B	1.1v	9.5k	B	0.9v	5.5k
C	10.0v	850 ohms	C	4.0v	6k
Q 102 E	0.9v	680 ohms	IC 101,		
B	1.1v	9.5k	1 & 8	0v	9.5k
C	10.0v	850 ohms	-2	2.8v	2k
Q 103 S	1.5v	1.2k	-3	GND	0
G	0v	1 MEG	-4	2.2v	560 ohms
D	5.0v	1k	-5	5.7v	2.5k
			-6	10.0v	700 ohms
			-7	8.0v	1k

8.2 Tuner and Front End Module FM - A2

1. SPOT switch to OFF.
2. No signal input

ITEM	+VDC	RDC	ITEM	+VDC	RDC
Q 201-1	9.6v	120 ohms	Q 202-2	1.4v	33k
-2	1.8v	42k	-3	0	0
-3	0	0	-4	0.85v	250 ohms
-4	1.0v	82 ohms	Q 203 E	0.5v	1k
Q 202-1	10.0v	220 ohms	B	1.0v	2.2k
			C	8.0v	1k

8. VOLTAGE & RESISTANCE 22'er FM - cont.

8.4 MAIN FRAME FM - A4 - cont.

<u>ITEM</u>	<u>VDC</u>
V 401 -1	4.2v
-2	0
-3	GND
-4 & 5	12 VAC
-7	320v
-8	90v
-9	GND
V 403 -1	5.8v
-2	0
-3	GND
-4 & 5	12 VAC
-7	330v
-8	135v
-9	GND
TP 402	-1.2v

<u>ITEM</u>	<u>VDC</u>
V 402 -1	3.8v
-2	0
-3	GND
-4 & 5	12 VAC
-7	330v
-8	100v
-9	GND
TP 401	-1.2v
V 404 -1	12 VAC
-2	GND
-4	GND
-5	220v
-6	GND
-8	220v
-9	GND
-10	0
-11	12 VAC
-12	12 VAC
TP 403	-1.75v

Plate Cap

350v Full Load

PARTS LIST

e.t. Clegg associates inc.

TITLE: 22'er FM

ITEM	DESCRIPTION	CLEGG P-N	ITEM	DESCRIPTION	CLEGG P-N
A1	XLO/AF PCB MODULE All capacitors are disc ceramic in pf. unless otherwise specified.		C141	0.05 mfd +80-20% 16v	102-100
			42	0.01 mfd Z5U +80-20%	102-069
C101	1-6 pf Piston NPO	116-119		DIODES	
2	1-6 pf Piston NPO	116-119	CR101	VARICAPS, MATCHED PAIR	144-001
3	1-6 pf Piston NPO	116-119	2	IN4005 SIL RECT	142-002
4	1-6 pf Piston NPO	116-119	3	IN4005 SIL RECT	142-002
5	1-6 pf Piston NPO	116-119	4	IN4005 SIL RECT	142-002
6	1-6 pf Piston NPO	116-119		INDUCTORS	
7	1-6 pf Piston NPO	116-119	L101	15 μ hy SLUG-TUNED	182-022
8	1-6 pf Piston NPO	116-119	2	3 μ hy SLUG-TUNED	182-011
9	1-6 pf Piston NPO	116-119		TRANSISTORS	
C110	15 NPO 5%	100-114	Q101	40246	200-004
11	15 NPO 5%	100-114	2	40246	200-004
12	15 NPO 5%	100-114	3	2N5245	200-012
13	15 NPO 5%	100-114	4	40233	200-006
14	15 NPO 5%	100-114			
15	15 NPO 5%	100-114	IC101	CA3053	201-002
16	15 NPO 5%	100-114		RESISTORS	
17	15 NPO 5%	100-114		All resistors are in ohms, $\frac{1}{4}$ watt and 10% unless otherwise specified.	
18	15 NPO 5%	100-114			
19	68 NPO 5%	100-122			
C120	68 NPO 5%	100-122			
21	2200 Z5F 20%	101-011			
22	33 NPO 5%	100-117			
23	2200 Z5F 20%	101-011	R101	12k	220-123
24	2.2 NPO +.25pf	100-104	2	68k	220-683
25	2200 Z5F 20%	101-011	3	120 ohms	220-121
26	3.0 NPO 5%	100-023	4	1k	220-102
27	1.0 mfd ELECT. 15VDC	107-003	5	68k	220-683
28	2200 Z5F 20%	101-011	6	120 ohms	220-121
29	2200 Z5F 20%	101-011	7	12k	220-123
C130	220 Z5F 10%	101-001	8	680 ohms	220-681
31	390 Z5F 10%	102-095	9	56k	220-563
32	.01 mfd Z5U +80-20%	102-069	R110	22k	220-223
33	0.1 mfd +80-20% 16v	102-101	11	33k	220-333
34	220 pf Z5F 10%	101-001	12	2.7k	220-272
35	5.0 mfd ELECT. 15VDC	107-004	13	1k	220-102
36	5.0 mfd ELECT 15VDC	107-004	14	6.8k	220-682
37	5.0 mfd ELECT 15VDC	107-004	15	82 ohms	220-820
38	50.0 mfd ELECT 15VDC	107-005	16	10k	220-103
39	5.0 mfd ELECT 15VDC	107-004	17	1 MEG	220-105
C140	.001 mfd FEED THRU	106-001	18	1.2k	220-122

PARTS LIST

e.t. Clegg associates inc.

TITLE: 22'er FM

ITEM	DESCRIPTION	CLEGG P-N	ITEM	DESCRIPTION	CLEGG P-N
	RESISTORS, cont.		C216	470 S. MICA 5%	104-134
R119	3.9k	220-392	17	270 Y5F	102-086
R120	10k VAR THUMBWHEEL	240-028	18	2-17 TRIMMER	116-116
21	56k	220-563	19	12 NPO 5%	100-113
22	6.8k	220-682	C220	22 NPO 5%	100-116
23	120 ohms	220-121		"SERIES 24"	
24	330 ohms	220-331			
25	5.6k	220-562	C221	NOT USED	
26	12k	220-123	22	15 NPO 5%	100-114
27	22k	220-223	23	10 N750 5%	100-701
28	12k	220-123		"SERIES 25"	
29	4.7k	220-472			
R130	47k	220-473	C221	2.7 N750 +.25pf	100-707
XY1	SOCKET, XTAL	290-504	22	8.2 NPO 5%	100-111
thru			23	8.2 NPO 5%	100-111
XY9				BOTH SERIES	
I101	PILOT LAMP #1891	150-102	C224	2-6 PISTON NPO	116-117
A2	TUNER & FRONT END MODULE All capacitors are disc ceramic in pf. unless otherwise specified.		25	5.5-24.5 MAIN TUNE	110-038
			26	2.5 NPO +.25pf	100-105
			27	.05 mfd +80-20% 16v	102-100
C201	5.6 NPO 5%	100-109		DIODES	
2	470 Z5F 10%	101-010	CR201	ZENER 9.1v 10%	143-000
3	470 Z5F 10%	101-010		INDUCTORS	
4	2200 Z5F 20%	101-011	L201	AIR WOUND	182-042
5	1.5 COMPOSITION 10%	100-004	2	SLUG-TUNED	182-035
6	0.82 COMPOSITION 10%	100-003	3	SLUG-TUNED	182-035
7	2200 Z5F 20%	101-011	4	TOROID	190-001
8	5.6 NPO 5%	100-109	5	AIR WOUND "OSC"	182-041
9	470 Z5F 10%	101-010		TRANSISTORS	
C210	2200 Z5F 20%	101-011	Q201	40673	200-002
11	6-25 N750 TRIMMER	116-115	2	40673	200-002
12	22 NPO 5%	100-116	3	2N3563	200-011
13	.05 mfd +80-20% 16v	102-100		RESISTORS	
14	12 NPO 5%	100-113		All resistors are in ohms, $\frac{1}{4}$ watt and 10%	
15	0.1 mfd +80-20% 16v	102-101			

PARTS LIST

e.t. Clegg associates inc.

TITLE: 22'er FM

ITEM	DESCRIPTION	CLEGG P-N	ITEM	DESCRIPTION	CLEGG P-N
A2	RESISTORS, cont. unless otherwise specified.		C310	2200 Z5F 20%	101-011
			11	0.1 mfd +80-20%	102-101
			12	0.1 mfd +80-20%	102-101
			13	0.1 mfd +80-20%	102-101
R201	68k	220-683	14	0.1 mfd +80-20%	102-101
2	120k	220-124	15	0.1 mfd +80-20% 16v	102-101
3	330k	220-334	16	110 S. MICA 5%	103-117
4	82 ohms	220-820	17	110 S. MICA 5%	103-117
5	82 ohms	220-820	18	2200 Z5F 20%	101-011
6	33k	220-333	19	.05 mfd +80-20% 16v	102-100
7	180 ohms	220-181	C320	.01 mfd Z5U +80-20%	102-069
8	120k	220-124	21	0.1 mfd +80-20% 16v	102-101
9	470 ohms	220-471	22	2200 Z5F 20%	101-011
R210	180 ohms	220-181	23	2200 Z5F 20%	101-011
11	330 ohms	220-331	24	1.0 mfd ELECT. 15v	107-003
12	680 ohms	220-681	25	.05 mfd +80-20% 16v	102-100
13	18k	220-183	26	150 JF 10%	101-000
14	2.7k	220-272	27	150 JF 10%	101-000
15	1k	220-102	28	33 NPO 5%	100-117
			29	.05 mfd +80-20% 16v	102-100
	TUNING DIAL		C330	0.1 mfd +80-20% 16v	102-101
	SERIES 24		31	.05 mfd +80-20% 16v	102-100
	143.4 - 148 MHz	329-002	32	.01 mfd Z5U +80-20%	102-069
			33	0.1 mfd +80-20% 16v	102-101
	TUNING DIAL		34	.05 mfd +80-20% 16v	102-100
	SERIES 25		35	50 mfd ELECT. 15v	107-005
	145.9 - 148 MHz	329-003	36	25 mfd ELECT. 25v	107-023
A3	IF/AF PCB MODULE		37	5.0 mfd ELECT. 15v	107-004
	All capacitors are disc ceramic in pf. unless otherwise specified.		38	0.1 mfd +80-20% 16v	102-101
			39	1.0 mfd ELECT. 15v	107-003
C301	47 NPO 5%	100-120	C340	2200 Z5U 20%	101-011
2	6-25 N750 TRIMMER	116-115	41	1.0 mfd ELECT. 15v	107-003
3	0.82 COMPOSITION 10%	100-003	42	50 mfd ELECT. 15v	107-005
4	47 NPO 5%	100-120	43	0.1 mfd +80-20% 16v	102-101
5	6-25 N750 TRIMMER	116-115			
6	0.39 COMPOSITION 10%	100-001		DIODES	
7	47 NPO 5%	100-120	CR301	1N34A	141-001
8	6-25 N750 TRIMMER	116-115	2	1N34A	141-001
9	0.1 mfd +80-20% 16v	102-101	FL301	"SERIES 24"	
				+13 KC @ -3 db	266-003
			FL301	"SERIES 25"	
				+9 KC @ -3 db	266-004

PARTS LIST

e.t. Clegg associates inc.

TITLE: 22'er FM

ITEM	DESCRIPTION	CLEGG P-N	ITEM	DESCRIPTION	CLEGG P-N
A2	RESISTORS, cont. unless otherwise specified.		C310	2200 Z5F 20%	101-011
			11	0.1 mfd +80-20%	102-101
			12	0.1 mfd +80-20%	102-101
			13	0.1 mfd +80-20%	102-101
R201	68k	220-683	14	0.1 mfd +80-20%	102-101
2	120k	220-124	15	0.1 mfd +80-20% 16v	102-101
3	330k	220-334	16	110 S. MICA 5%	103-117
4	82 ohms	220-820	17	110 S. MICA 5%	103-117
5	82 ohms	220-820	18	2200 Z5F 20%	101-011
6	33k	220-333	19	.05 mfd +80-20% 16v	102-100
7	180 ohms	220-181	C320	.01 mfd Z5U +80-20%	102-069
8	120k	220-124	21	0.1 mfd +80-20% 16v	102-101
9	470 ohms	220-471	22	2200 Z5F 20%	101-011
R210	180 ohms	220-181	23	2200 Z5F 20%	101-011
11	330 ohms	220-331	24	1.0 mfd ELECT. 15v	107-003
12	680 ohms	220-681	25	.05 mfd +80-20% 16v	102-100
13	18k	220-183	26	150 JF 10%	101-000
14	2.7k	220-272	27	150 JF 10%	101-000
15	1k	220-102	28	33 NPO 5%	100-117
			29	.05 mfd +80-20% 16v	102-100
	TUNING DIAL		C330	0.1 mfd +80-20% 16v	102-101
	SERIES 24		31	.05 mfd +80-20% 16v	102-100
	143.4 - 148 MHz	329-002	32	.01 mfd Z5U +80-20%	102-069
			33	0.1 mfd +80-20% 16v	102-101
	TUNING DIAL		34	.05 mfd +80-20% 16v	102-100
	SERIES 25		35	50 mfd ELECT. 15v	107-005
	145.9 - 148 MHz	329-003	36	25 mfd ELECT. 25v	107-023
A3	IF/AF PCB MODULE		37	5.0 mfd ELECT. 15v	107-004
	All capacitors are disc ceramic in pf. unless otherwise specified.		38	0.1 mfd +80-20% 16v	102-101
			39	1.0 mfd ELECT. 15v	107-003
C301	47 NPO 5%	100-120	C340	2200 Z5U 20%	101-011
2	6-25 N750 TRIMMER	116-115	41	1.0 mfd ELECT. 15v	107-003
3	0.82 COMPOSITION 10%	100-003	42	50 mfd ELECT. 15v	107-005
4	47 NPO 5%	100-120	43	0.1 mfd +80-20% 16v	102-101
5	6-25 N750 TRIMMER	116-115			
6	0.39 COMPOSITION 10%	100-001		DIODES	
7	47 NPO 5%	100-120	CR301	1N34A	141-001
8	6-25 N750 TRIMMER	116-115	2	1N34A	141-001
9	0.1 mfd +80-20% 16v	102-101	FL301	"SERIES 24"	
				+13 KC @ -3 db	266-003
			FL301	"SERIES 25"	
				+9 KC @ -3 db	266-004

PARTS LIST

e.t. Clegg associates inc.

TITLE: 22'er FM

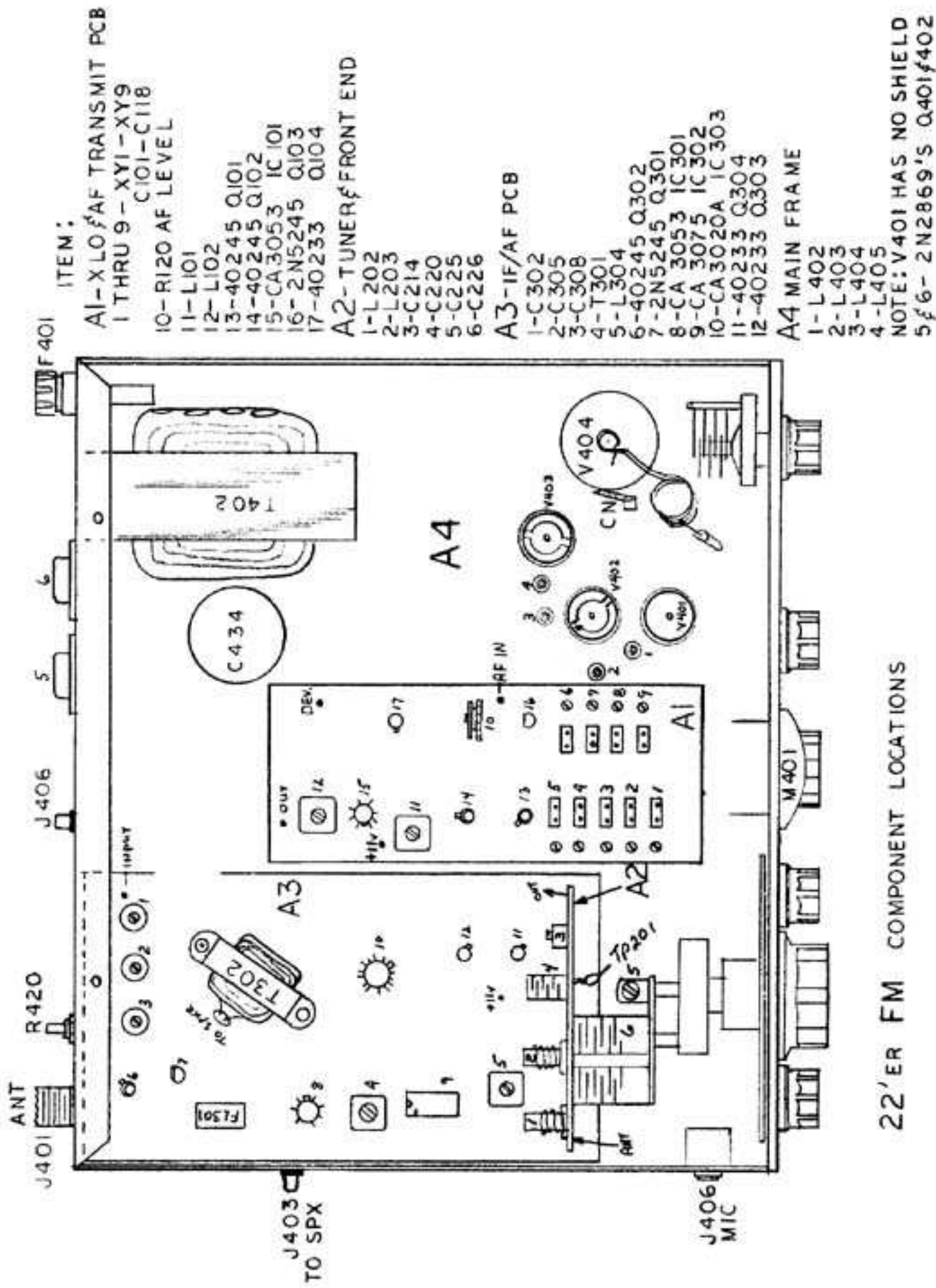
ITEM	DESCRIPTION	CLEGG P-N	ITEM	DESCRIPTION	CLEGG P-N
A4	MAIN FRAME, cont.		L405	SLUG-TUNED	182-031
C417	2200 Z5F 20%	101-011	6	RFC 1.8 μ hy	190-017
18	470 Z5F 10%	101-010	7	AIR WOUND TAPPED (GRID)	182-043
19	470 Z5F 10%	101-010	8	RFC	190-004
C420	470 Z5F 10%	101-010	9	RFC 1.8 μ h FIL CHOKE	190-010
21	.01 mfd 75U +80-20%	102-069	L410	RFC 1.8 μ h FIL CHOKE	190-010
22	3-10 AIR TUNE	110-035	P405	AC POWER CONN. 15 POSI-	
23	3-10 AIR TUNE	110-035		TIONS	292-022
24	0.82 COMPOSITION 10%	100-003	P405	DC POWER CONN. 15 POSI-	
25	2200 Z5F 20%	101-011		TIONS	292-022
26	.01 mfd 75U +80-20%	102-069	M401	0-1 ma SCALE BLACK	
27	470 Z5U 150 VAC	101-012		BACKGROUND	409-006
28	470 Z5U 150 VAC	101-012		TRANSISTORS	
29	25 mfd ELECT. 25v	107-023	Q401	2N2869/301 PNP GERMAN-	
C430	300 mfd ELECT. 25v	107-006		IUM POWER	200-019
31	25 mfd ELECT. 25v	107-023	Q402	2N2869/301 PNP GERMAN-	
32	.01 mfd 75U +80-20%	102-069		IUM POWER	200-019
33	.01 mfd 75U +80-20%	102-069	F401	3 AG - 3A, 125v SLO-BLO	
34	80-40-20 mf 450v	108-002			160-024
35	2000 mfd 25v	107-008	F402	3 AG - 15A, 32v	160-025
36	2500 mfd 15v	107-007		RESISTORS	
37	470 Z5F 10%	101-010		All resistors are in	
38	470 Z5F 10%	101-010		ohms, $\frac{1}{2}$ watt and 10%	
39	470 Z5F 10%	101-010		unless otherwise	
C440	1000 FEED THRU	106-001		specified.	
41	1000 FEED THRU	106-001	R401	12k	223-123
42	.02 mfd 75U GMV	102-056	2	150 ohms	223-151
43	.02 mfd 75U GMV	102-056	3	68k, 2w	227-683
J401	UHF COAXIAL	291-101	4	330 ohms	223-331
2	PHONO, RCA TYPE	293-003	5	33k	223-333
3	PHONO, RCA TYPE	293-003	6	1k	223-102
4	2 CIRCUIT EXT. PHONES	510-001	7	120 ohms	223-121
5	15 POSITION CINCH	292-021	8	56k, 2w	227-563
6	2 CIRCUIT MIKE	510-002	9	330 ohms	223-331
7	PHONO, RCA TYPE	293-003	R410	39k	223-393
K401	3 FORM C 12v	172-004	11	1k	223-102
	(SPDT RELAY)		12	120 ohms	223-121
	INDUCTORS		13	27k, 2w	227-273
L401	RFC 15 μ hy	190-032	14	180 ohms, 2w	227-181
2	SLUG-TUNED	182-015			
3	SLUG-TUNED	182-036			
4	SLUG-TUNED	182-031			

PARTS LIST

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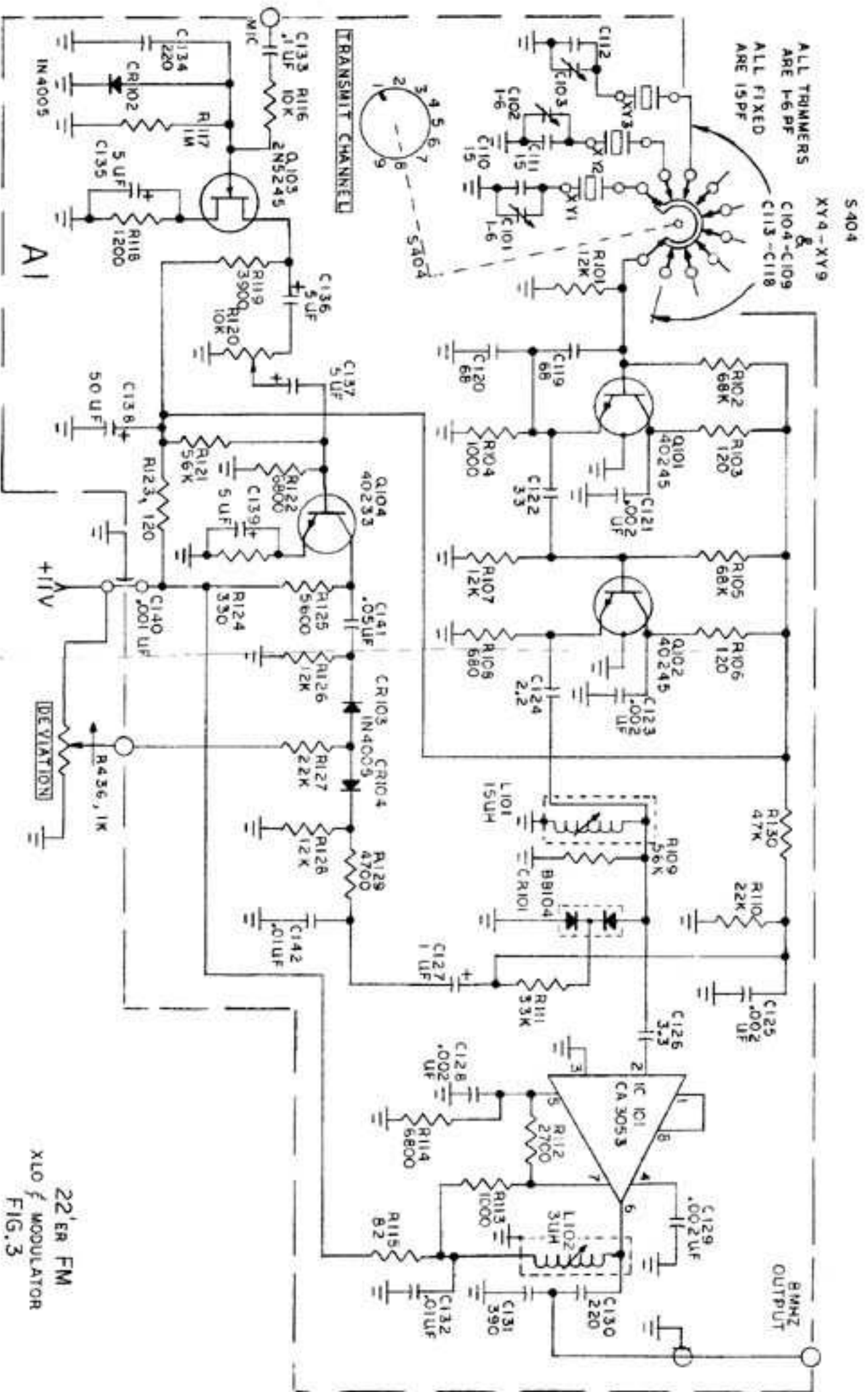
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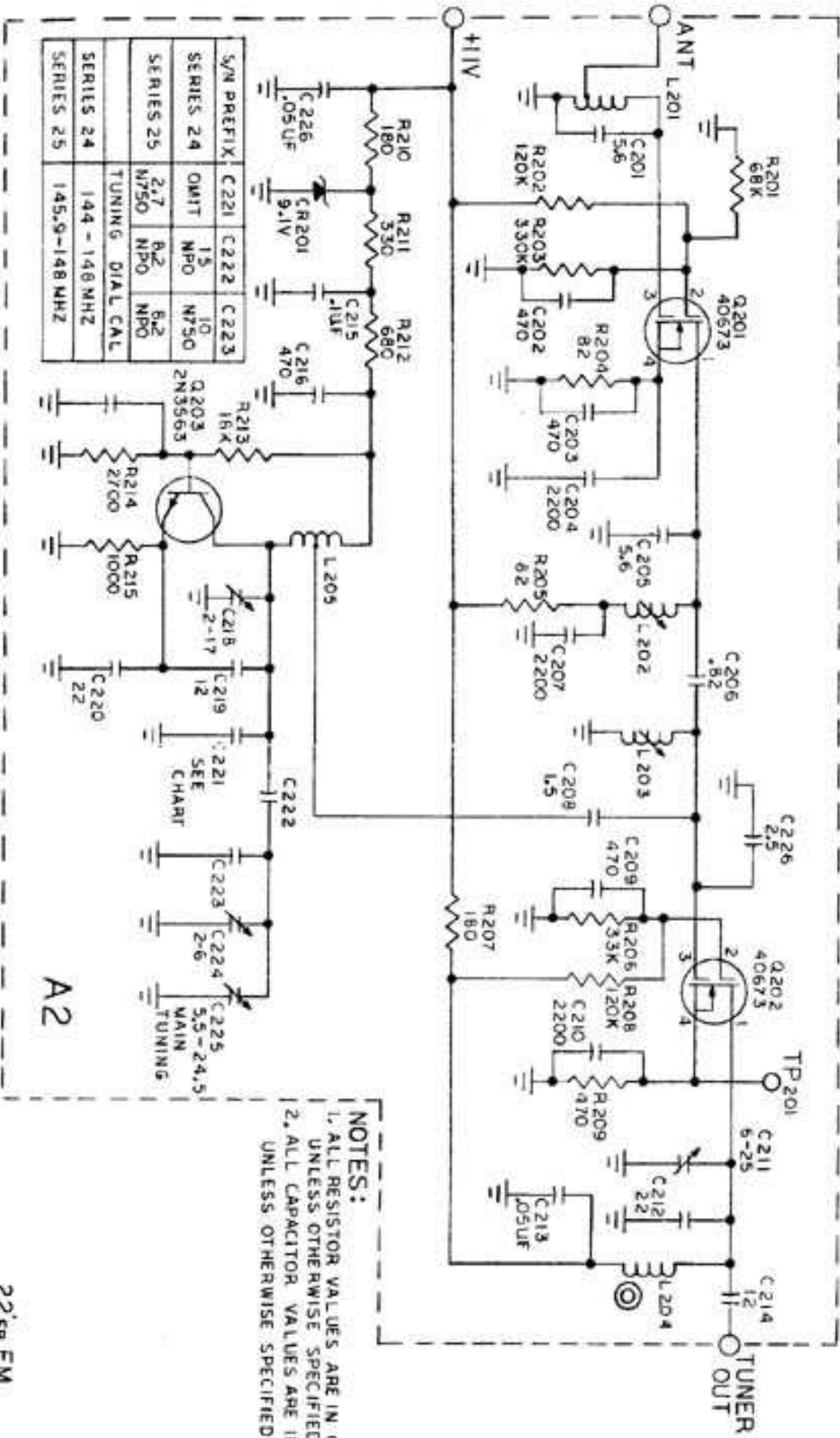
ITEM	DESCRIPTION	CLEGG P-N	ITEM	DESCRIPTION	CLEGG P-N
A4	MAIN FRAME, cont.			DIODES	
R415	330, 1w	225-331	CR401	IN 4005 SIL	142-002
16	39k	223-393	2	IN 34A GERMANIUM	141-001
17	1k	223-102	3	IN 34A GERMANIUM	141-001
18	12k, 2w	227-123	CR404)		
19	10 ohms, 1w	225-100	thru)	IN 4005 SIL	142-002
R420	2.5k, "MTR SET"	241-013	CR411)		
21	8.2k	223-822	CR412	ZENER 11v 10%	143-002
22	25k, "VOLUME"	241-006	CR413	IN 4005 SIL	142-002
23	47 ohms, 1/2w	220-470			
24	25k, "SQUELCH"	241-005			
25	12k	223-123			
26	75 ohms, 10w, W.W.	233-001			
27	8.2 ohms	223-082			
28	8.2 ohms	223-082			
29	75 ohms, 10w, W.W.	233-001			
R430	47k, 2w	227-473			
31	47k, 2w	227-473			
32	15 ohms, 2w	227-150			
33	5.0 ohms, 5w, W.W.	232-001			
34	1k	223-102			
35	47k, 2w	227-473			
36	1k	241-012			
	SPEAKER 3.2 ohms 1 oz	610-001			
	PHONO JUMPER	510-017			
S401	DPST Part of R424	241-005			
402	SPST Part of R422	241-006			
403	2 POL 2 POS	172-005			
404	1 POL 9 POS	272-007			
T401	AIR WOUND	182-044			
T402	POWER TRANSFORMER	601-011			
V401	12GN7A	211-013			
2	12GN7A	211-013			
3	12GN7A	211-013			
4	8150	218-004			



22' ER FM COMPONENT LOCATIONS

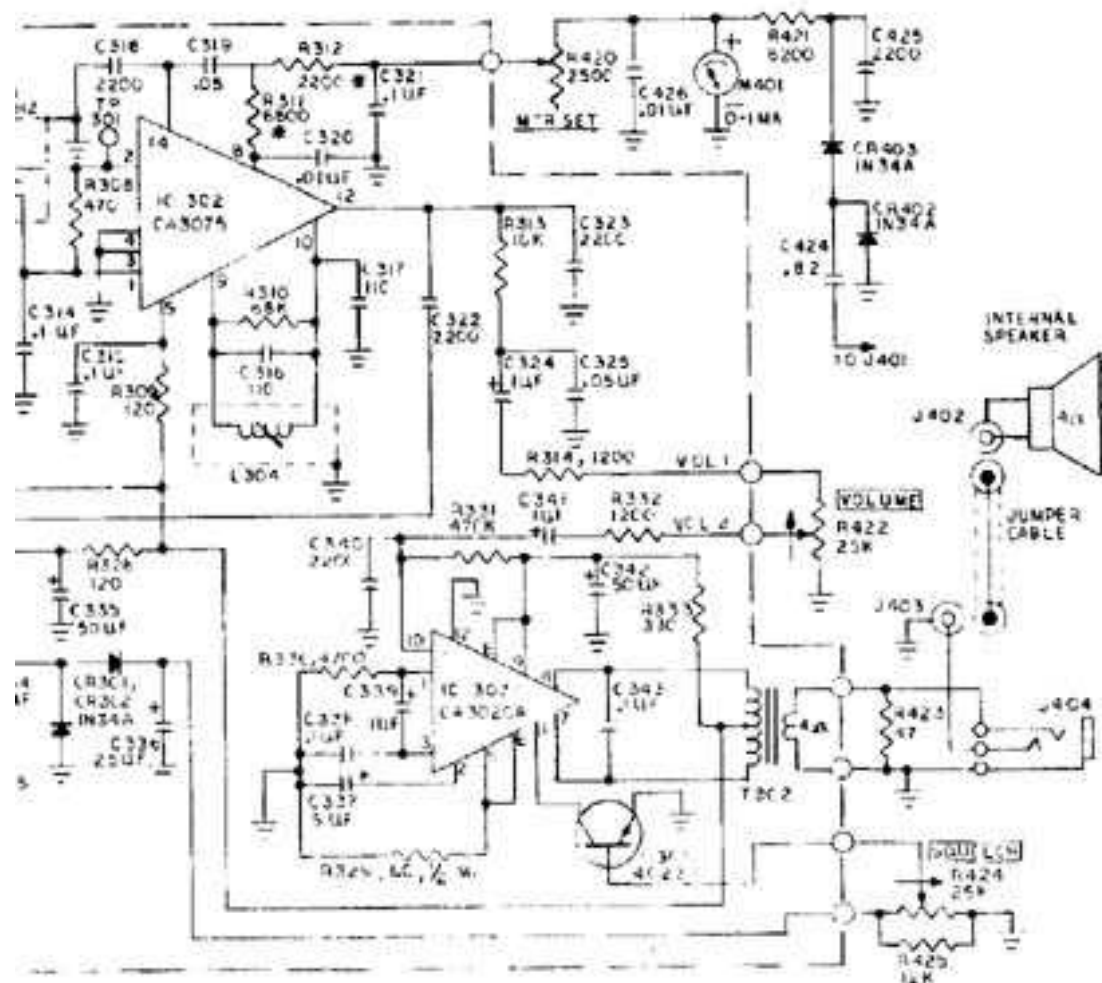
FIG.2





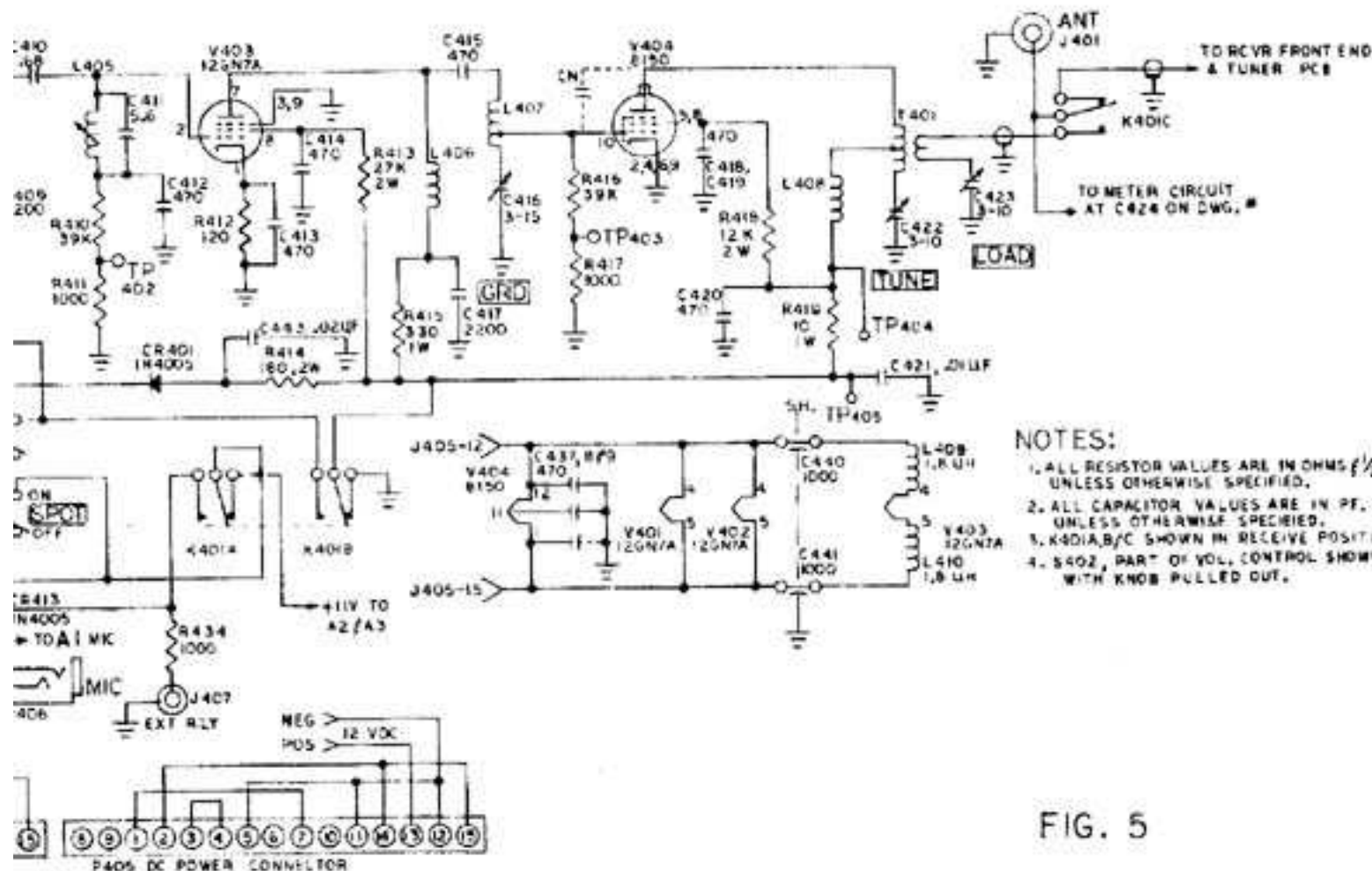
NOTES:
 1. ALL RESISTOR VALUES ARE IN OHMS $\frac{1}{4}$ W.
 UNLESS OTHERWISE SPECIFIED.
 2. ALL CAPACITOR VALUES ARE IN PF.
 UNLESS OTHERWISE SPECIFIED.

22ER FM
 TUNER/FRONT END
 FIG.4



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS & $\frac{1}{2}$ W UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES ARE IN PF. UNLESS OTHERWISE SPECIFIED.



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS $\frac{1}{2}$ W UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES ARE IN PF. UNLESS OTHERWISE SPECIFIED.
3. K401A/B/C SHOWN IN RECEIVE POSITION.
4. S402, PART OF VOL. CONTROL SHOWN WITH KNOB PULLED OUT.

FIG. 5



22'er FM TRANSCEIVER



There's a hot new performer on the 2 meter FM scene these days, as Clegg's "22'er FM" Transceiver with 60 watt, 9 channel transmitter and continuously tuneable solid-state receiver, makes its bow.

Designed for maximum "state-of-the-art" performance, the FM 22'er is a completely self-contained package including 115 VAC and 12 VDC power supplies. Deviation is front panel adjustable from 2 to 15 kHz. The receiver is equipped with a mechanical filter for 60 dB adjacent channel rejection with less than .15 uv for 20 dB quieting. All internal circuits are broad banded for instant channel change of more than 1 MHz. Individual trimmers for each transmitter channel permit absolute netting with low cost 8 MHz crystals. The "22'er FM" also has provisions for P/L and Tone Burst as well as Spot and "talk-on-frequency" facilities.

Ask your dealer for a demonstration today. You'll hear 2 Meter FM at its finest.

e.t. Clegg associates, inc.

LITTELL ROAD, EAST HANOVER, N. J. 07936 • PHONE: (201) 887-4940

OWNER'S OPERATING AND MAINTENANCE MANUAL

CLEGG 22'er - FM

1. CONTROLS, CONNECTORS and INDICATORS

1.1 POWER CONNECTORS

Series 24 and 25 FM transceivers are provided with two separate power connectors. One connector is supplied with a conventional AC line cord for 115 VAC operation and the other for DC operation.

The DC power connector is factory wired with all necessary jumpers. The two battery leads of sufficient current carrying capabilities, being supplied by the user, must have a wire size with a maximum RDC of .02 ohms or less per length. For example, 1000 feet of #12 AWG copper = 1.619 ohms (information taken from wire tables) thus 100 feet of #12 = .161 ohms and at 10 feet, one length of #12 AWG has an RDC of .016 ohms. These two leads are wired to the DC connector so that pin #13 is the positive pole of the 12 VDC system and pin #12 is the negative pole and vehicle ground. BE CERTAIN TO OBSERVE THESE POLARITIES.

1.2 PANEL CONTROLS

1.2a - MAIN TUNING DIAL is the large dual speed knob and associated dial scale at the left of the panel. This dial controls RECEIVER TUNING ONLY. The special DUAL SPEED feature permits rapid tuning between band extremities while providing a smooth mechanical band spread of a limited segment of the band.

Series 24 transceivers are supplied with a dial that contains the full 2 meter band coverage from 143.4 to 148.3 MHz. It is calibrated in 100 KHz increments and readable to 25 KHz.

Series 25 transceivers have a restricted coverage dial that is calibrated in 30 KHz "channel" designations and tunes from 145.9 to 148.2 MHz.

1.2b - VOLUME CONTROL serves in the conventional manner as an audio gain control for the receiver. (SEE MONITOR SWITCH - 1.2e)

1.2c - SQUELCH CONTROL/POWER ON-OFF SWITCH - This control, when advanced to the furthest counter-clockwise position, removes all operating power from the unit on both 115 VAC and 12 VDC installations.

When advanced through the ON-OFF detent, the receiver will immediately function. When advanced about 90 degrees further clockwise, the SQUELCH system will mute the receiver in the absence of any received signal. When advanced fully clockwise, the receiver will remain muted

1.2 PANEL CONTROLS - cont.

1.2c - SQUELCH CONTROL/POWER ON-OFF SWITCH - cont.

except when signals of modest strength are being received.

1.2d - SPOT-SWITCH - This switch actuates the crystal oscillator and low level stages of the transmitter while leaving the receiver in its normal operating condition. It is intended to permit spotting one's own crystal channel on the receiver.

1.2e - MONITOR SWITCH - This switch is ganged with the VOLUME control. The switching action is accomplished by pushing or pulling the VOLUME CONTROL KNOB in or out. When the knob is pulled outward from the panel the TRANSMIT-RECEIVE relay is deactivated. To monitor one's own modulation:

1. Pull the MONITOR SWITCH outward.
2. Turn SPOT SWITCH to ON.
3. Set TRANSMIT CHANNEL SWITCH to any of the 9 available positions for which a crystal has been installed. (As shipped from the factory, a crystal for 146.94 will normally have been installed in position #9.)
4. PUSH the PTT button on the microphone and tune in the signal and observe your own modulation.

1.2f- DEVIATION CONTROL is used to adjust the peak deviation of the transmitted signal. When advanced fully clockwise, the deviation will normally be about 10 KHz with little or no speech clipping. As the control is retarded, the transmitter deviation will be reduced smoothly to essentially zero at the counter clockwise extreme. An internal audio gain control is located on the CRYSTAL OSC/PHASE MODULATOR printed circuit board on the front center portion of the chassis. This control has been factory pre-set to provide about 8 db of speech clipping when the panel mounted DEVIATION control is set at 2 o'clock. Approximately 7 KHz deviation will be achieved. (More detailed information on the adjustment and calibration of these controls can be found at paragraph 7.3.)

1.2g - TRANSMITTER TUNING CONTROLS - Three panel controls provide for tuning the transmitter output stage for maximum output. These are captioned GRID, TUNE and LOAD. All three are adjusted for maximum deflection on the RELATIVE OUTPUT Meter while in the Transmit mode. Once maximized at any frequency, they will not normally require readjustment unless a frequency change of more than 500 KHz is made or when an antenna change is made. (Typically, all three controls can be peaked near 146.5 MHz and all of the 146-147 MHz range can be operated without further adjustment.

1.3 PANEL METER

The panel meter serves dual purposes.

- a. Transmitter Relative Output

1.3 PANEL METER - cont.

b. Receiver Discriminator Current

The switch over from Transmit to Receive metering is accomplished automatically.

On Transmit, the meter will normally indicate about mid scale for 30 Watts of RF Power output into a 50 ohm load.

On Receive, the meter will also read about center scale when no signal is being received. When tuning through the frequency of a received signal the meter will move in both directions from it's no signal reading. When an FM signal is properly tuned the meter will be approximately mid way between these two excursions and very close to the no signal reading. The following easily remembered rule will make correct receiver tuning a simple process. WHEN THE SIGNAL BEING RECEIVED IS HIGHER THAN THE FREQUENCY TO WHICH THE RECEIVER IS TUNED THE METER WILL READ HIGH.

The DISCRIMINATOR meter simplifies adjustment of transmitter crystal frequencies to any known standard signal as described later.

1.4 OTHER CONTROLS AND CONNECTORS

1.4a - MICROPHONE JACK is located on the left side of the cabinet near the front edge. This jack accepts the Clegg Push-To-Talk Ceramic microphone furnished with the 22'er FM.

1.4b - SPEAKER connections are arranged so that the 22'er FM may be operated with the self contained speaker or with a suitable external speaker. To utilize the internal speaker it is merely necessary to connect the patch cable equipped with standard PHONO plugs between the two PHONO Jacks on the left side of the unit. This patch cord is supplied with the 22'er FM.

A suitable external speaker (3-4 ohm voice coil impedance) equipped with a shielded cable and phono plug may be connected to the LOWER of the two PHONO receptacles if desired.

DO NOT OPERATE THE 22'er FM WITHOUT EITHER THE INTERNAL SPEAKER OR A SUITABLE EXTERNAL SPEAKER CONNECTED!

1.4c - A conventional HEADPHONE JACK is located on the rear panel of the 22'er FM. For best performance, low impedance headphones are recommended.

1.4d - ANTENNA receptacle is a standard UHF Coaxial receptacle located on the rear panel.

1.4e - A phono connector is located on the rear panel to provide low voltage DC for control or powering of accessory devices such as the

1.4 OTHER CONTROLS and CONNECTORS - cont.

1.4e - cont.

Clegg T/R BOOSTER. This connector is "hot" when the 22'er FM is in the Transmit mode; source is 11 volts through 1000 ohms.

1.4f - A miniature potentiometer on the rear panel is provided to permit setting the panel meter to a reference line on receive.

1.4g - FUSE POSTS are located on the rear panel. The upper fuse is for 115 VAC line protection; the lower is for 12 VDC operation. The correct fuse sizes are:

115 VAC (upper)	250 VAC, 3 amp slow blow	F401
12 VDC (lower)	28 VDC, 15 amp	F402

2. CIRCUIT DESCRIPTION

The Clegg 22'er FM employs an all solid state receiving system. The transmitter utilizes solid state circuitry for the channelized crystal oscillator and the phase modulator and microphone amplified stages. Four vacuum tubes are used in the transmitter frequency multiplication and final amplifier stages. All power supply devices are silicon diode rectifiers and zener regulators. The attached block diagram shows the function of the various active devices.

2.1 RECEIVER CIRCUITRY

The 22'er FM receiver is physically contained on two glass epoxy printed circuit boards - one of which contains the 2 meter tuneable front end with 17.450 MHz output and the other contains all of the IF, limiter, filtering, detection, audio and squelch circuitry.

2.1a - FRONT END MODULE - This section of the receiver is mounted on the frame of the main receiver tuning capacitor and includes:

1. Type 40673 Dual Gate, integrated diode protected MOSFET RF amplifier. Noise figure of less than 2.5 db is achieved on typical units.
2. Type 40673 MOSFET 1st mixer stage converting input signals to a first intermediate frequency of 17,450 KHz.
3. Type 2N3563 Tuneable oscillator covering the range of approximately 126 to 131 MHz.

2.1b - IF-AF MODULE - The 17,450 KHz 1st IF is filtered by a triple tuned band-pass coupler employing high Q toroidal coils. The 2nd Mixer utilizes a type 2N5245 JFET with output at 455 KHz. Injection is derived from a crystal oscillator at 17,905 KHz using a type 40246 bipolar transistor.