RF-250

RAYTHEON

250 Watt FM Transmitter

Incorporating the NEW

CASCADE

Phase Shift Modulation

YOU CAN GET ALL OF THESE

11 IMPORTANT FEATURES

ONLY FROM RAYTHEON

1 **Simplified circuit design** through the Cascade system gives stability and efficiency to Raytheon FM.

2 **Direct crystal control,** independent of modulation, gives positive and automatic control of the mean carrier frequency. No complicated electronic or mechanical frequency stabilizers are used. A single high quality crystal does the job.

3 **An inherently lower noise level** is achieved by Cascade Phase Shift Modulation which adds the phase shift of six simple stages. No single complicated stage, nor a large number of multipliers with resulting high noise level, is necessary.

4 **Very low harmonic distortion**—less than 1.0% from 50 to 15000 CPS with 100 KC frequency deviation.

5 **A built-in tuning meter,** conveniently located on front panel, allows the operator to check *any* circuit, instantly, *while on the air.*

6 **Conservatively operated circuits** assure a high fidelity signal without program interruption over long periods of continued operation. Normal life of all tubes and components is materially increased; annoying replacements are reduced to a minimum.

7 **No expensive special tubes.** The modulator unit uses only inexpensive receiver type tubes of proven reliability.

8 **Simple, very fast tuning.** Periodic circuit tune-ups, although rarely necessary, are easily accomplished in two or three minutes, and the transmitter requires virtually no adjustment between service periods. All circuits are stable—require no critical adjustments. No external measuring instruments are ever needed.

9 **Lasting economy.** A Raytheon transmitter not only costs less to purchase but through increased operating efficiency you continue to save daily on power costs. Advanced engineering design plus modern styling guarantee your satisfaction for many years.

10 **Easy to service.** Excellent mechanical layout, vertical type chassis and full height front and rear doors make servicing both fast and easy.

11 **Unit construction.** There is no obsolescence to Raytheon FM Transmitters. This 250 watt transmitter is also the basic exciter unit for all higher powers and later you can add an amplifier to give any increased power you desire. All units are perfectly matched in size, styling and colors.

RAYTHEON

Excellence in Electronics

Schematic Diagram of the RAYTHEON 250 Watt FM Transmitter RF-250

Simplicity and straightforward circuit design are evident from the RF-250 schematic. The modulator and low frequency multiplier stages are shown within the white area.

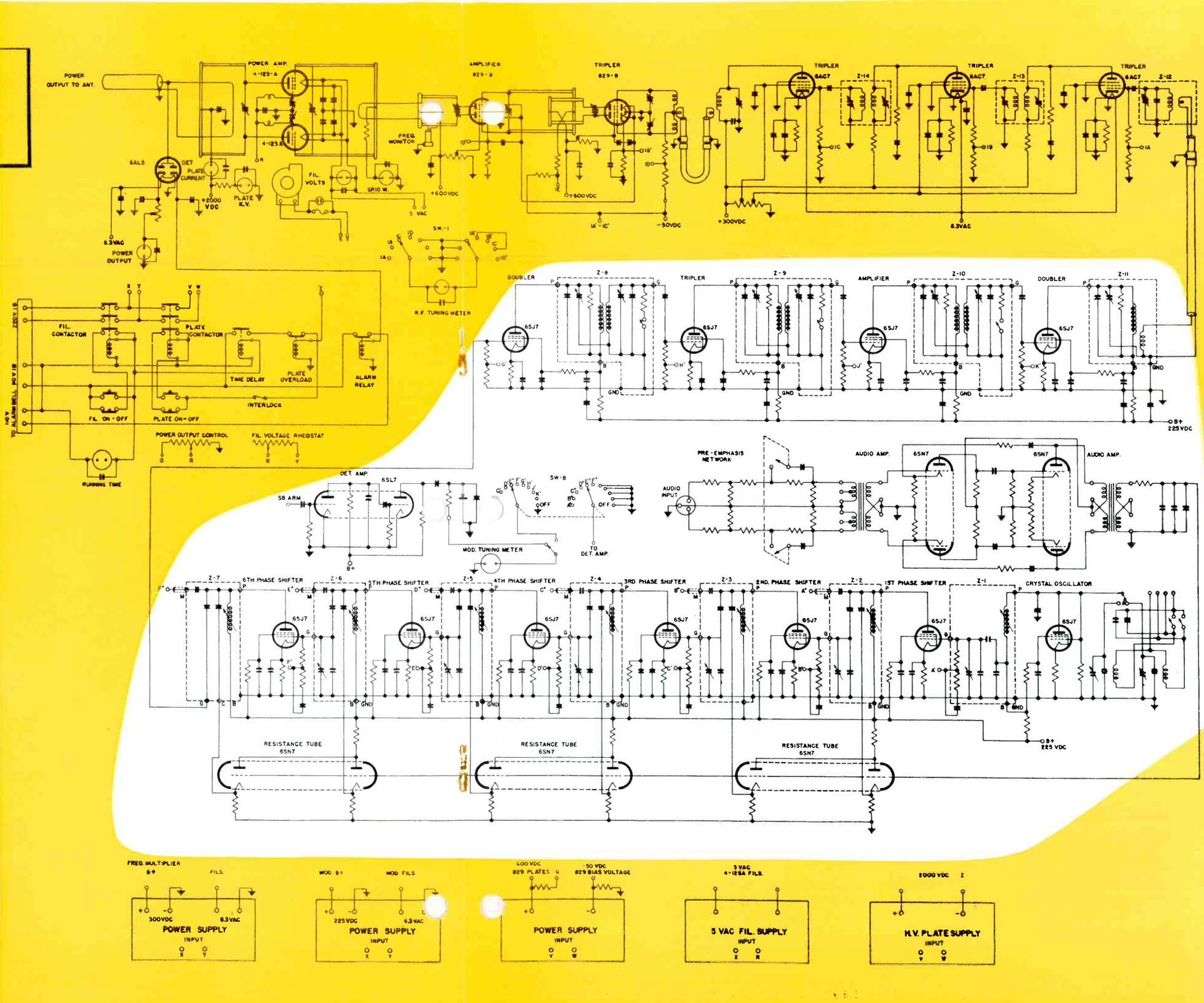
Phase shift modulation permits direct crystal control of the carrier frequency and the Cascade system makes possible direct multiplication (972 times overall) from the crystal to the final carrier frequency. The modulator chassis contains the crystal oscillator, a regular and standby crystal in temperature controlled ovens, the six cascade phase shift stages and amplifiers and multipliers which provide output at about 1.2 MC from crystal frequencies centering around 100 KC.

It should be noted that great care has been taken in all amplifier and multiplier stages to reduce to a minimum the harmonic and spurious signals which would otherwise be present. Band pass, overcoupled, double tuned circuits are used when required for good attenuation and adequate band width. Higher frequency multipliers are of the single tuned type and above 30 MC all tank circuits have linear type elements to provide high "Q" and further reduction of unwanted signals.

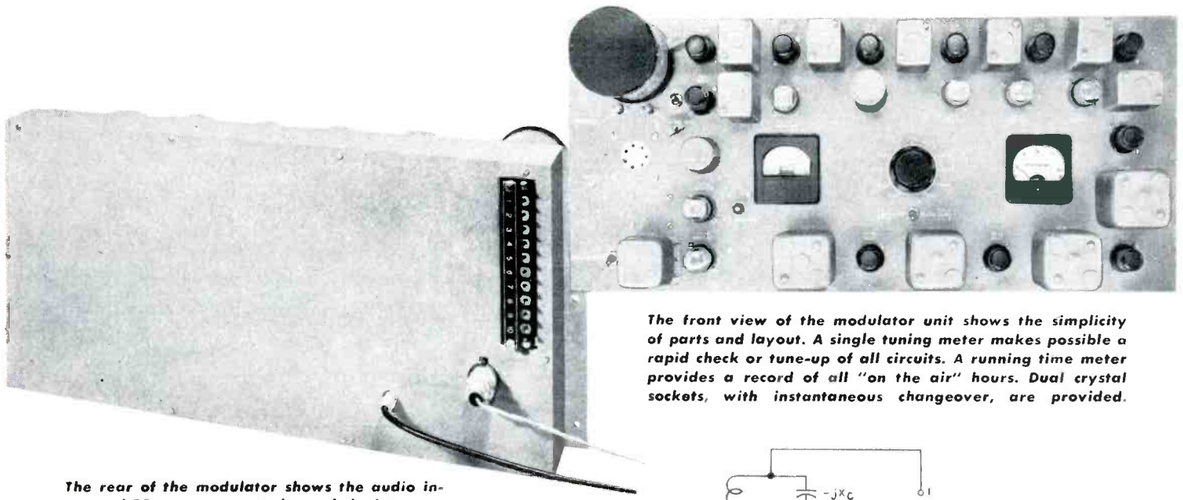
By using pentode and tetrode RF multiplier and amplifier tubes a minimum of stages are required to give increased efficiency and reliability. The RF output from the final amplifier is terminated in an end seal fitting for attaching standard 51 ohm coaxial line. A gas inlet is provided where a pressurized line is used.

Control circuits provide simple and positive protection of all operations. On those circuits subject to possible overload, such as the final amplifier power supply, circuit breaker protection is used to provide instant reoperation after the fault has cleared. Fuses with indicator lights protect other components from abnormal faults. All control circuits are arranged for interconnection with higher power units providing unified control.

Adequate metering allows instant check of all circuit operations for rapid maintenance and service checks. Rapid tube change is possible through quick-opening doors wherever shielding is employed.

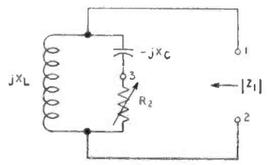


CASCADE PHASE SHIFT MODULATION



The rear of the modulator shows the audio input and RF output receptacles and the interconnecting terminal strip.

The front view of the modulator unit shows the simplicity of parts and layout. A single tuning meter makes possible a rapid check or tune-up of all circuits. A running time meter provides a record of all "on the air" hours. Dual crystal sockets, with instantaneous changeover, are provided.



Constant Impedance Network

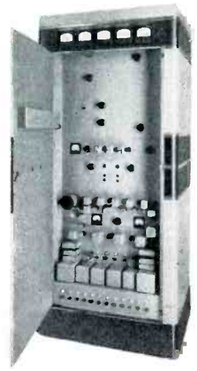
What is this entirely new CASCADE SYSTEM of Phase Shift Modulation?

Basically the Cascade Phase Shift system consists of a crystal oscillator operating at about 100 KC whose RF voltage is phase modulated by six simple phase shift networks. The six phase shift networks are in cascade for RF voltages but the audio voltages controlling them are in parallel. Thus the phase shift produced by each section is additive so that approximately six times the phase shift of a single section is obtained without multiplication of the carrier frequency. The output of the last phase shift section is then amplified and multiplied by a factor of 12 within the modulator unit. (The overall multiplication is 972 from crystal frequency to carrier frequency).

The basic constant impedance phase shift network is shown above. When X_L is made equal to $2X_C$ any variation in R_2 will have no effect upon the magnitude of the impedance across terminals 1 and 2. The phase of the output voltage will shift, however, between the limits of plus 90° and minus 90° as R_2 is either open circuited or short circuited. With R_2 open, current will flow only through X_L and must be inductive with the voltage leading the current by 90°. With R_2 short circuited and $X_L = 2X_C$, the current through X_C will be twice that through X_L and the net current will be capacitive with the voltage lagging by 90°. With R_2 at intermediate values the voltage vector will be at some intermediate angle. By replacing R_2 with the cathode to ground resistance of a vacuum tube we have a means of controlling the phase shift with audio frequency voltages. If six of these circuits with appropriate amplifier tubes are placed in cascade, and the grids of the audio controlled resistance tubes are paralleled, a six stage Cascade Phase Shifter results.

Six stages are required because the largest phase shift obtainable, with low distortion, in *any single* phase shifter is about 25° or about 13 cycles frequency change

DEVOTED TO RESEARCH AND MANUFACTURE



EASY TO OPERATE

EASY TO SERVICE

Open front view, above, shows complete metering and simplicity of controls. Each fuse has an indicator light and all are located on the front panel to give instant accessibility.

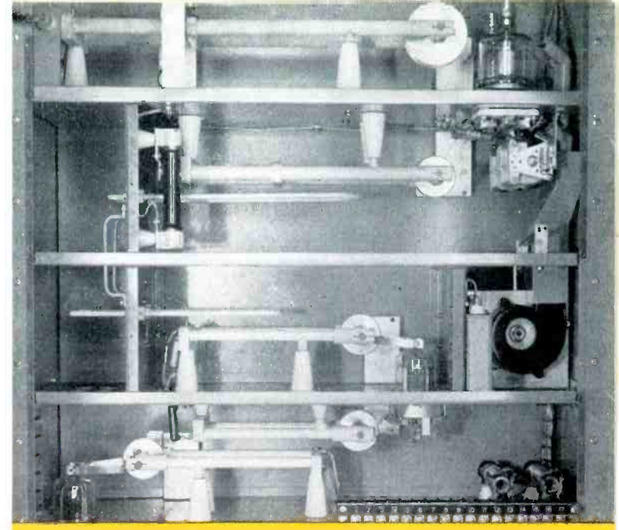
The full height rear view shown at right emphasizes the clean vertical chassis type of construction used throughout. The final amplifier, driver and tripler stages are located at the top in a completely shielded compartment. Each of these stages is further shielded from the others, giving complete stability and minimum radiation external to the cabinet. This lack of external radiation is of great importance when low level audio equipment is to be operated in close proximity to the transmitter.

Below these stages is a panel carrying additional multiplier circuits. The control panel with its switches, push-buttons and indicating lights is located at a convenient height for ease of operation.

Immediately below the control panel is the Cascade Phase Shift Modulator chassis which is described in detail on pages 6 and 7. The power supplies for the modulator and low level RF stages are just below the modulator.

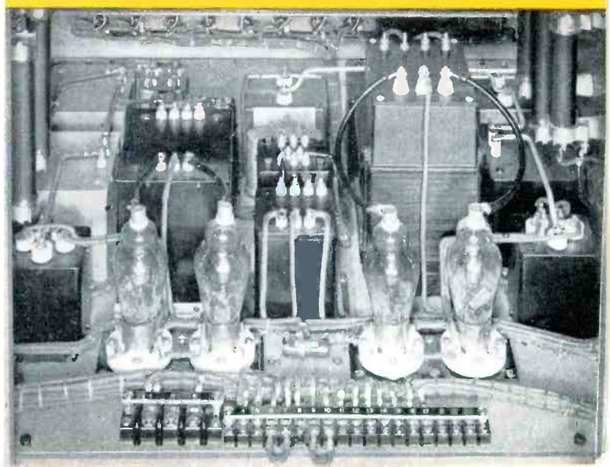
On the floor of the cabinet are located the components for high voltage power supplies, power input circuits, etc. A line voltage regulator mounted on the left side wall supplies regulated AC for the modulator power supply.

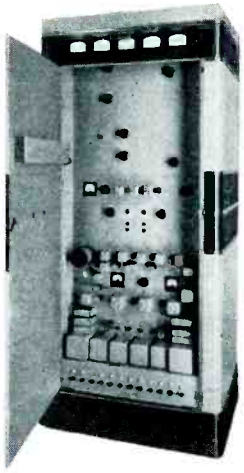
All units are readily accessible for maintenance and servicing. All components have been carefully selected to assure excellence in performance and long trouble-free service.



The view above shows the linear type tank circuits used on all stages operating above 30 MC. Though more expensive than the conventional "coil and condenser" type the use of linear tanks assures stability, reliability, high efficiency, high spurious signal attenuation and ease of adjustment.

Power components are located on the bottom of the cabinet with a wiring duct for interconnection of the RF-250 with units of higher power.





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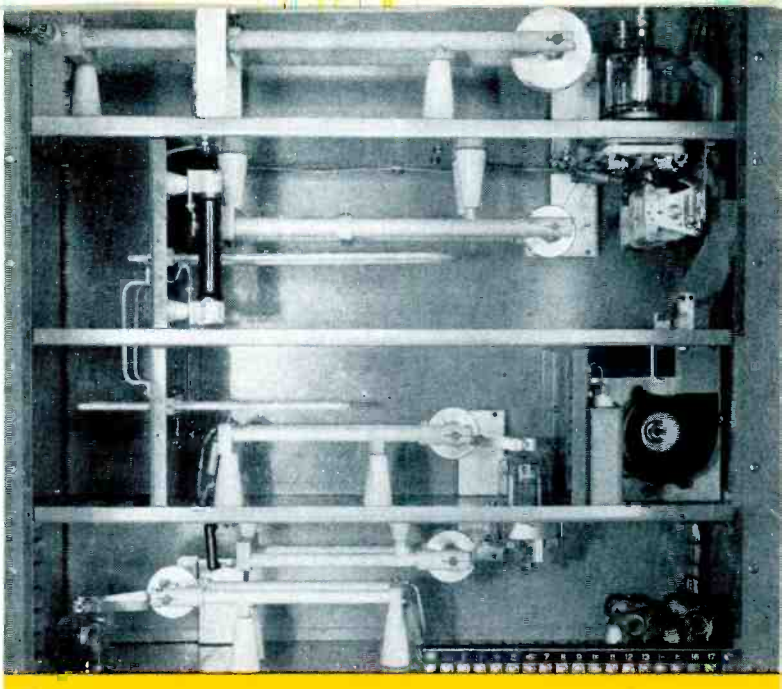

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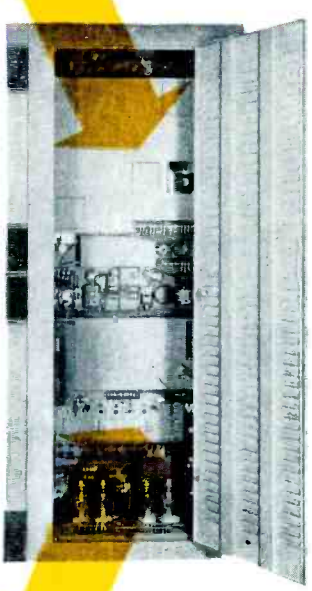

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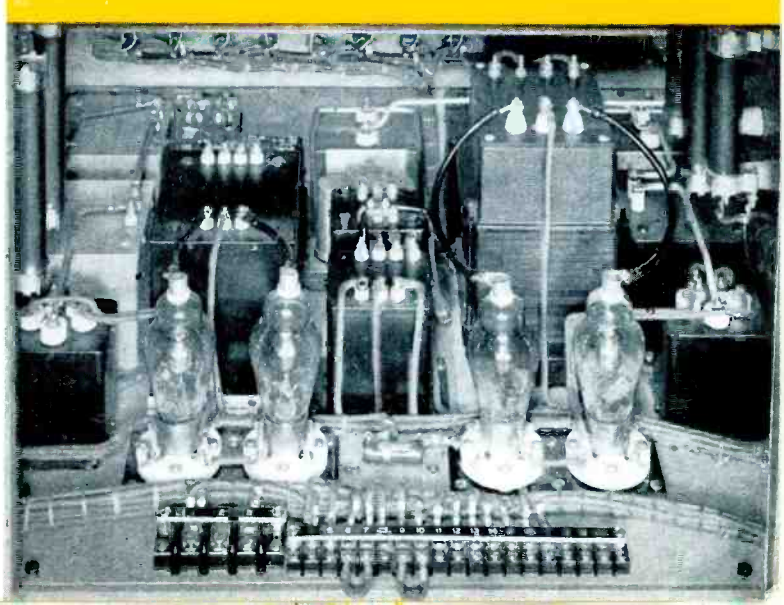

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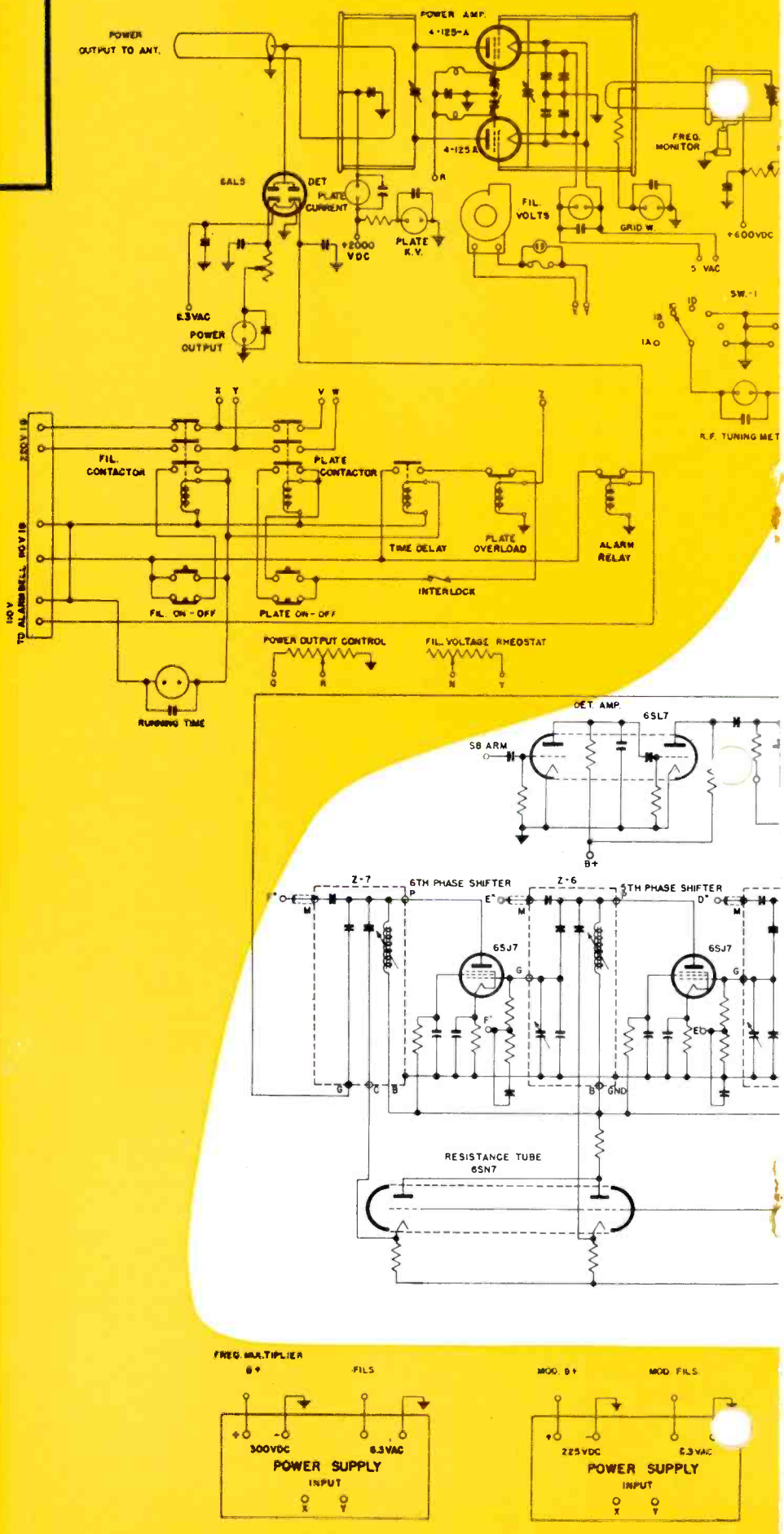

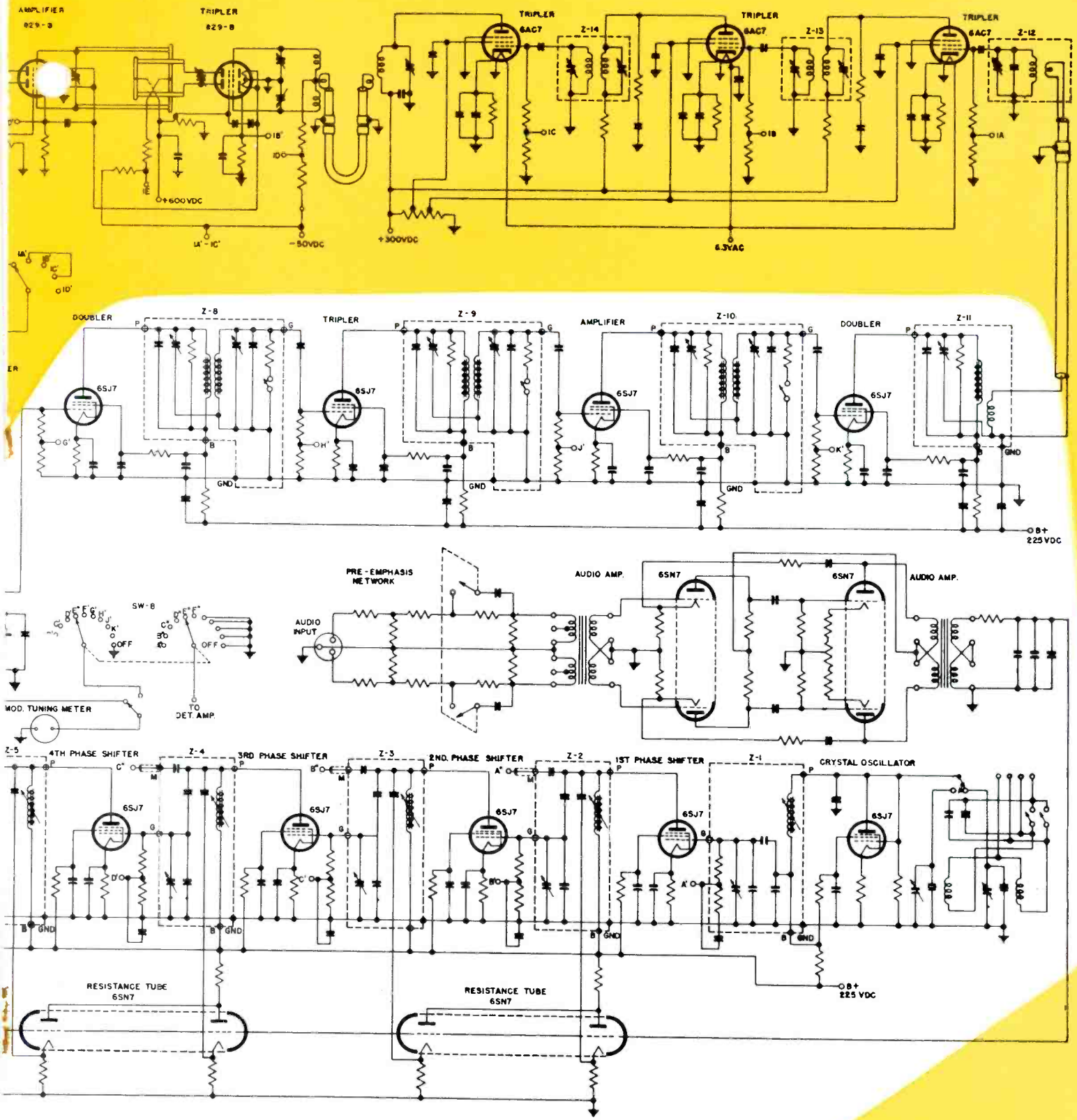
AMPLIFIER
829-B
TRIPLER
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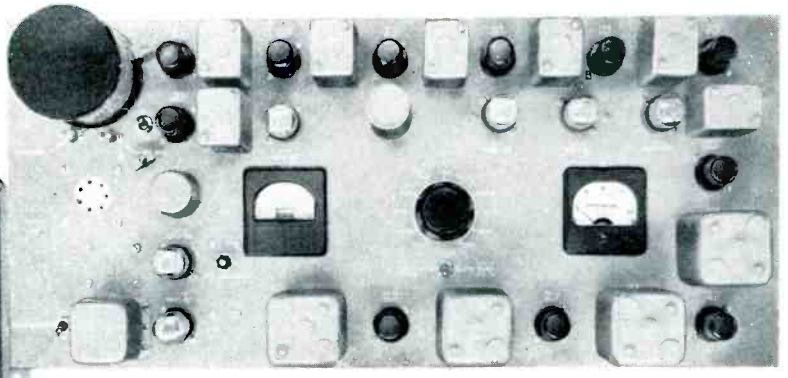
TRIPLER
6AC7
Z-14
TRIPLER
6AC7
Z-13
TRIPLER
6AC7
Z-12
+600VDC
-50VDC
+300VDC
6.3VAC
DOUBLER
Z-8
6SJ7
TRIPLER
Z-9
6SJ7
AMPLIFIER
Z-10
6SJ7
DOUBLER
Z-11
6SJ7
GND
B+
225 VDC
PRE-EMPHASIS
NETWORK
AUDIO
INPUT
AUDIO AMP.
6SN7
6SN7
AUDIO AMP.
SW-B
OFF
OFF
MOD. TUNING METER
TO
DET. AMP.
Z-5
4TH PHASE SHIFTER
Z-4
3RD PHASE SHIFTER
Z-3
2ND. PHASE SHIFTER
Z-2
1ST PHASE SHIFTER
Z-1
CRYSTAL OSCILLATOR
6SJ7
RESISTANCE TUBE
6SN7
RESISTANCE TUBE
6SN7
B+
225 VDC
600 VDC
829 PLATES
-50 VDC
829 BIAS VOLTAGE
POWER SUPPLY
INPUT
5 VAC
4-125A FILS.
5 VAC FIL. SUPPLY
INPUT
2000 VDC
H.V. PLATE SUPPLY
INPUT

CASCADE PHASE SHIFT MODULATION



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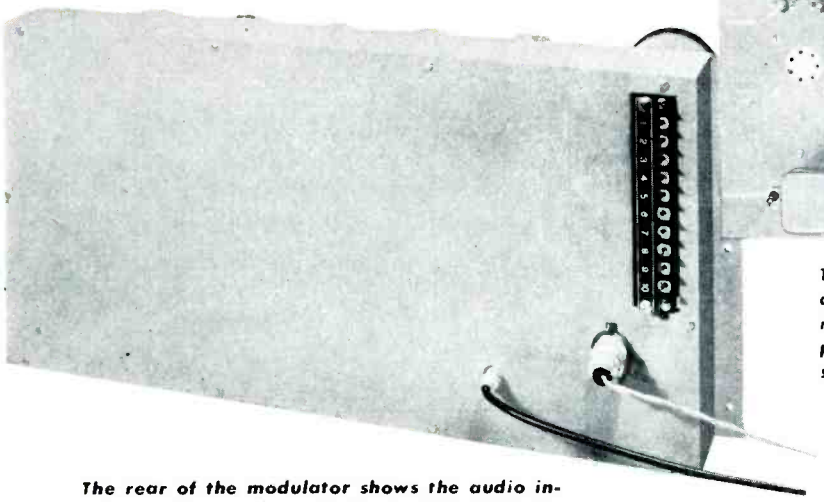

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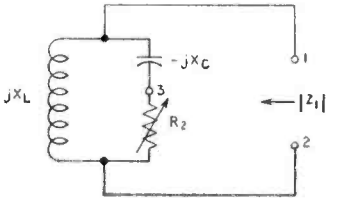

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for an audio frequency of 30 cycles. To produce the required 75 KC deviation we multiply 13 by 6 which gives 78 cycles shift produced by the six phase shift sections and again multiply by the overall multiplication (972) which follows. This gives 75.8 KC deviation.

The constant impedance type network is required to minimize amplitude modulation which, if present, increases the distortion.

The complete circuit is shown in white on the schematic diagram.

What are the advantages of the CASCADE CIRCUIT?

The Cascade Phase Shift system has many exclusive and outstanding advantages. Direct crystal control is a basic requirement for any broadcast transmitter. When this can be accomplished without an excessively high order of frequency multiplication, without the use of special purpose tubes and yet retain simplicity of circuit and components, this requirement becomes a must. All comparison oscillators, discriminators, motor controls, frequency dividers and frequency indicators are immediately eliminated. The output frequency depends only on the crystal!

Circuit simplicity permits the incorporation of a simple metering circuit which makes possible complete tune-up of the unit without the use of any external laboratory measuring equipment. This arrangement also gives very adequate maintenance and service tests which permit rapid isolation of possible faults.

Tuning is exceptionally easy: band pass circuits have push button operated damping resistors which permit simple "peaking" adjustments rather than complicated "sweep oscillator" or other means of tuning. Adequate metering is provided on all circuits beyond the modulator and all essential circuits are metered with large, easily read rectangular meters.

Linear tank circuits used above 30 MC provide high efficiency, high "Q," simple adjustment and excellent stability. Final amplifier efficiencies of from 75 to 80 per cent are easily obtained.

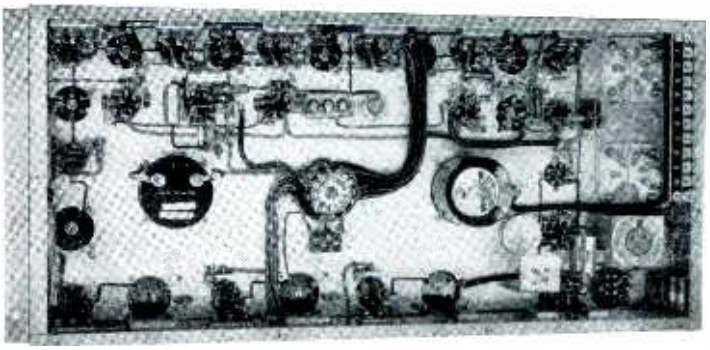
The output power control provided by a variable screen voltage on the output stage gives a complete power range from 50 to 250 or more watts without change in output efficiency. Filament voltage control is provided and a single transformer type automatic voltage regulator supplies primary power for the modulator power supply. No DC filament supplies are required and no DC voltage regulator tubes or circuits are needed.

Control circuits provide all needed starting, stopping and interlocking operations and are coordinated with higher power units for simplified control when additional power amplifiers are added.

Simplicity of tube and circuit complement makes the power consumption of this transmitter remarkably low. Line voltage variations are readily accommodated.

The mechanical construction is such that in spite of ample size and sturdy construction the unit can easily be transported through standard doors, and in passenger elevators where building top location is desired. Additional high power amplifiers may be added at any time forming a unified design of modern pleasing appearance.

The actual performance of this transmitter is conclusive proof of the sound design and advanced engineering incorporated throughout. Performance is superior to FCC and RMA requirements in all respects and simplicity and stability assure continued high quality performance over long periods with minimum maintenance and adjustment problems.



Inside view of complete modulator unit with back cover removed. The extreme simplicity of the Cascade Phase Shift circuit is well illustrated.

SPECIFICATIONS

RAYTHEON 250 WATT FM TRANSMITTER

RF-250

Output Frequency	Any specified frequency between 88 and 108 MC
Type of Emission	A-3
Power Output	50-250 watts
R. F. Output Impedance	35-70 ohms
Carrier Frequency Stability	±1000 cycles
Type of Oscillator	Direct Crystal Control
Type of Modulation	Cascade Phase Shift
Modulation Capability	±100 KC
Audio Input Impedance	600 ohms 150/600 on special order
Average Program Level	+5 VU ±2 VU
100% Modulation Level	+12 VU ±2 VU
Audio Frequency Response	50-15,000 cycles ±1 db from 1000 cycle reference
Pre-emphasis	Standard 75 micro second with removal switch
Audio Frequency Distortion:	50—15,000 cycles 1.0%
50— 100 cycles	1.0%
100— 7,500 cycles	1.0%
7,500—15,000 cycles	1.0%
FM Noise Nevel	65 db below 75 KC swing
AM Noise Level	50 db below 100% amplitude modulation

Power Line Requirements:

Voltage	208/230 three wire
Frequency	50/60 cycles
Phase	1
Regulation	5% maximum
Power Consumption	1400 watts approx.
Power Factor	87%

Mechanical Specifications

Size, with trim	height 84", width 36", depth 28"
Size, without trim	height 84", width 30", depth 28"
Weight	1200 lbs.

TUBE COMPLEMENT

Modulator Unit:

Crystal Oscillator	1 6SJ7
Phase Shifters	6 6SJ7
Resistance Tubes	3 6SN7
Multipliers	3 6SJ7
Amplifier	1 6SJ7
Audio Amplifiers	2 6SN7
Detector-Amplifiers	1 6SL7

R. F. Amplifiers:

1st Quadrupler	1 6AC7
1st Tripler	1 6AC7
2nd Tripler	1 6AG7
3rd Tripler	1 829B
Amplifier	1 829B
Output Stage	2 4-125A
300 Volt Supplies	2 5U4G
600 Volt Supply	2 866A
2000 Volt Supply	2 866A
Output Power Indicator	1 6AL5

Complete FCC filing data will be supplied upon request.

In order to incorporate constantly the finest in engineering, design and components in our Broadcast Equipment, Raytheon reserves the right to make engineering changes at any time.

RAYTHEON MANUFACTURING COMPANY

Broadcast Equipment Division

7517 North Clark Street, Chicago 26, Illinois

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