Collins Broadcast transmitters

and accessories

5.50

FROM MIKE TO ANTENNA

This catalog is prepared for your convenience in selecting transmitting equipment that will best meet your requirements. The transmitters, phasors, antenna tuners and accessories shown and described are engineered for reliability, high fidelity, economy and convenient operation. The mate to this catalog, *Collins Speech Equipment*, is available upon request.

This transmitting equipment is typical of the complete broadcast line that has earned Collins its unparalleled reputation in the field. Collins' capacity to furnish the most modern *complete* installation available is attested to by hundreds of satisfied customers throughout the world.

We will be happy to work with you on the overall specifications of your individualized equipment. By obtaining your full requirements from Collins, you get not only the best individual units for your purpose, but also the assurance that you have an integrated system with superior overall performance.

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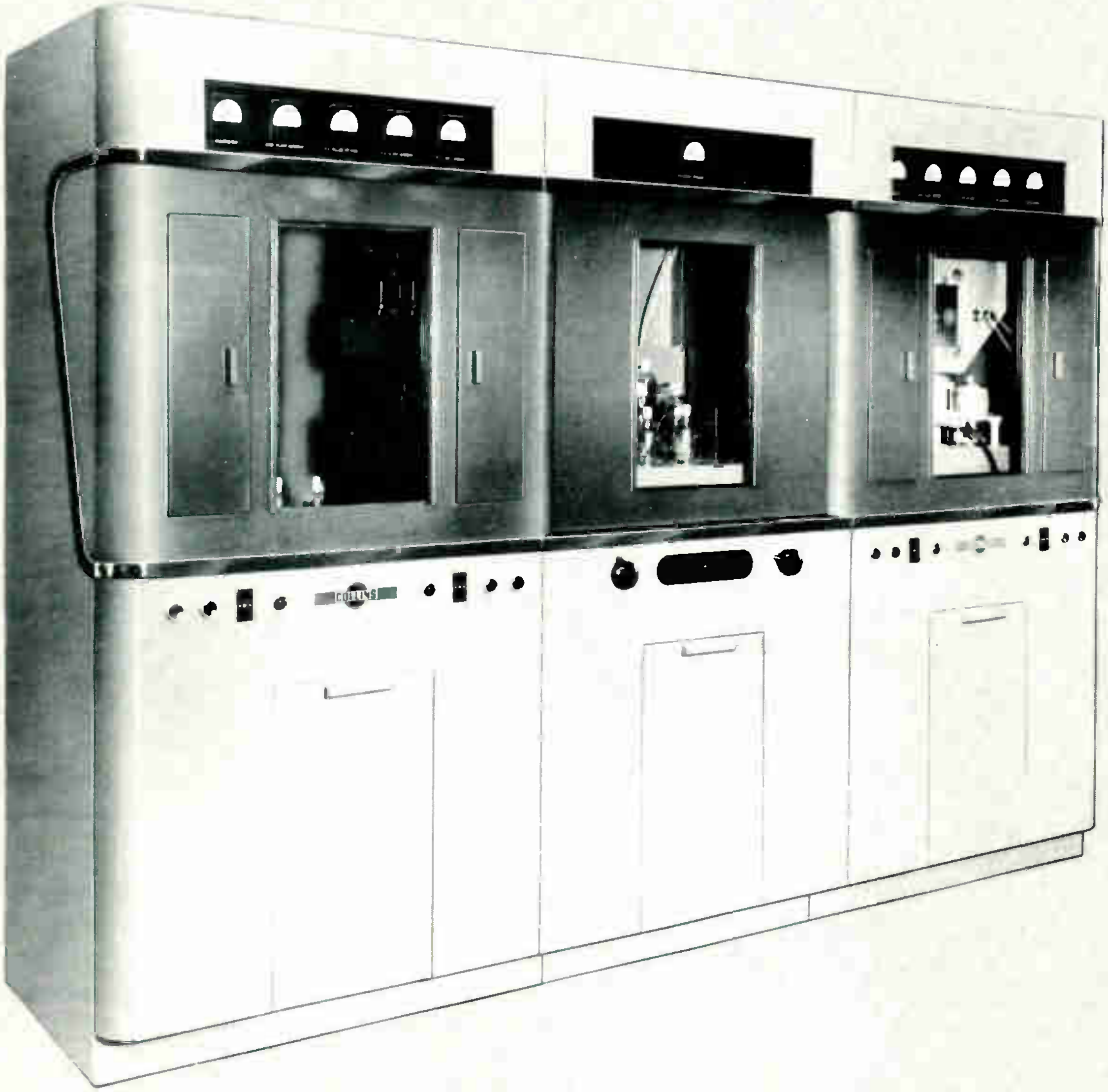


COLLINS 21E/M 5/10 KW BROADCAST TRANSMITTER

The 5,000 watt 21E and 10,000 watt 21M are straight-forward electrically and mechanically designed transmitters that permit operation not only in the standard broadcast band but on short wave as well. They are supplied for any frequency from 540 kilocycles to 18 megacycles. The 21E/M occupies only 21 square feet of floor space. A convenient power increase package can convert the 5kw 21E into a 10kw 21M overnight.

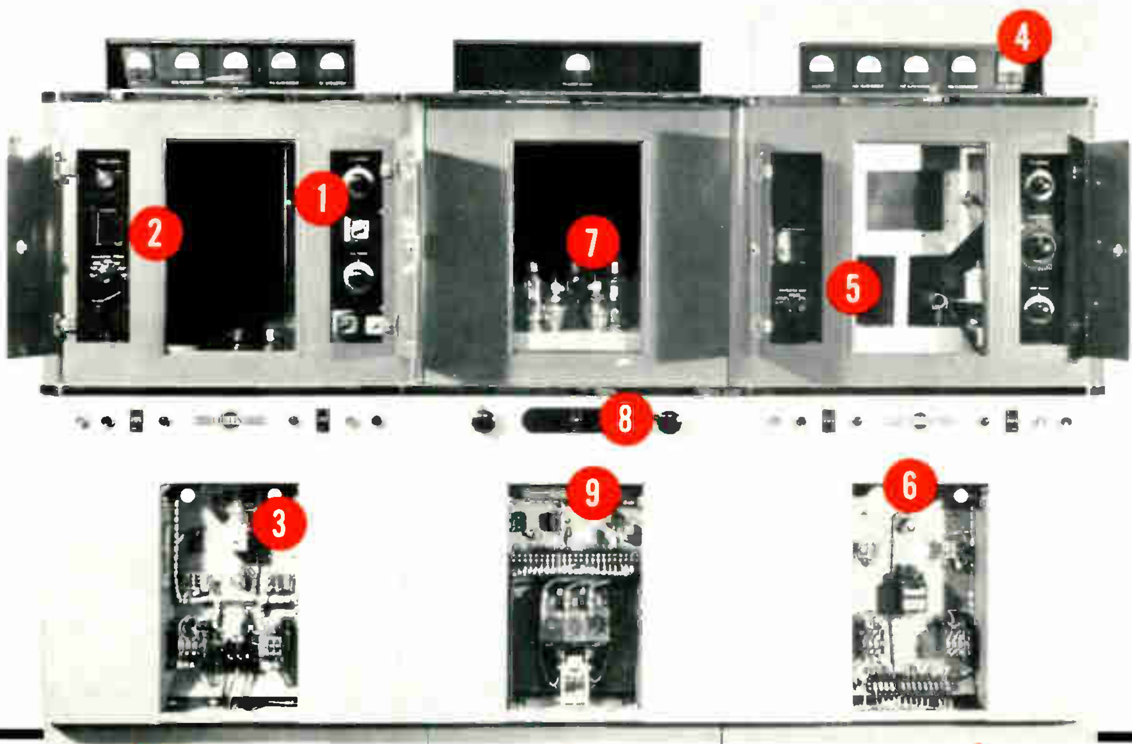
Dependability, long-life and savings in size and weight are achieved by taking advantage of the improved performance offered by modern tubes and components and the use of simplified circuitry. All transformers and reactors are of the dry type, eliminating the concrete vault required with earlier transmitters using oil-filled components.

The 21E/M is easily serviced and maintained, thus keeping lost air time to a minimum. Full view of all tubes is provided through plate glass windows and all important circuits are metered. Access to relays and contactors for inspection and adjustment may be gained while on the air by the easy removal of access covers on the front of equipment. A removable section at the top front of each cabinet exposes the meter panels for cleaning and maintenance. All other components are accessible through the rear doors or rear access panels. These doors are equipped with both ac primary interlocks and high voltage shorting switches for the protection of operating personnel.

21E/M TRANSMITTER

5/10,000 Watt AM — front view, doors off

1. Driver cabinet operating controls
2. Driver cabinet audio chassis
3. Driver cabinet relay enclosure
4. Power amplifier cabinet meters
5. Power amplifier modulators
6. Power amplifier relay enclosure
7. Power supply cabinet rectifier tubes
8. Power supply cabinet operating controls
9. Power supply cabinet relay enclosure

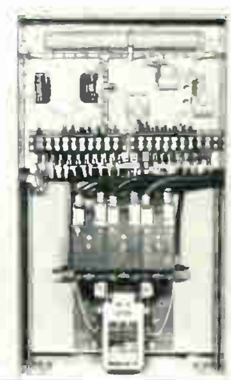


DRIVER CABINET AUDIO CHASSIS

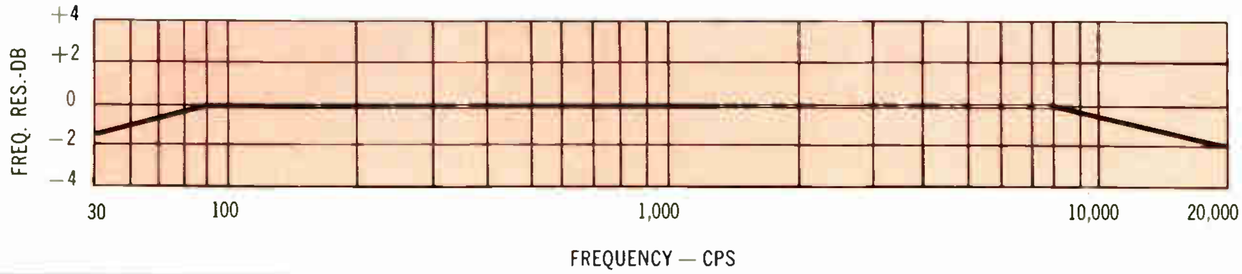
MODULATOR TUBES

POWER RECTIFIERS

RELAY ENCLOSURE



21E AUDIO FREQUENCY RESPONSE



OPERATING CONTROLS

The control circuits feature flexibility, operating convenience and optimum equipment protection. Pushbutton control of filament and plate power is provided. If desired, the pushbutton and indicating light circuits may be extended to a remote position.

Automatic sequencing is supplied; pressing the final amplifier plate "on" button causes all filament, bias and plate voltages to be applied in correct sequence and with the proper time delays. Pressing the filament "off" button instantly removes all power except that applied to the blower motor, which continues to run for a period adjustable up to 5 minutes, and then shuts off.

AUDIO

The input to the audio system consists of a terminating pad that feeds the primary of the audio input transformer. The first audio stage employs pentode-connected 6SJ7 tubes in a push-pull Class A amplifier. Type 4-125A tubes are used in the push-pull Class A audio driver. The 4-125A audio drivers are resistance coupled to the grids of a pair of 3X3000A1, push-pull, Class AB_1 modulator tubes. Approximately 12 db of feedback is provided from plates of the modulator tubes to grids of the first audio stage.

THERMAL TIME DELAY

In keeping with the modern circuitry of these transmitters, a thermal time-delay circuit is employed. The time-versus-temperature cooling curve of this circuit closely approximates the cooling characteristics of the rectifier and amplifier filaments, thereby giving the delay circuit the ability to select the proper time interval after a carrier interruption of any given length. The cold-start delay period can be adjusted for any value between 15 and 45 seconds. However, when a short carrier interruption occurs, the delay circuit allows only enough time for the filaments to reach operating temperature before the transmitter can be returned to the air. After an instantaneous power interruption the carrier can be returned to the air immediately.

METERING

Meter panels are tilted at an angle for ease of operation and observation of transmitter performance. The following circuits are metered:

> RF line current, final amplifier plate voltage, final amplifier plate current, modulator plate current, final amplifier grid current, back modulator cathode current, front modulator cathode current, back final amplifier cathode current, front final amplifier cathode current, RF driver line current, RF driver plate voltage, RF driver plate current, audio driver cathode current, RF driver grid current, 807 cathode current, 807 grid current, 6SJ7 cathode current, 6SJ7 grid current, crystal oscillator cathode current, audio amplifier cathode current and ac filament primary voltage.

The top panel on the front of each cabinet can be removed by releasing two screws.

HIGH LEVEL MODULATION

Class AB_1 high level modulation is used with Eimac 3X3000A1 tubes. These tubes are physically interchangeable with the 3X2500A3 tubes used in the final amplifier but have performance characteristics ideal for audio use. With Class AB_1 operation, the audio driver transformer and its attendant problems are eliminated.

OVERLOAD RELAYS

Adjustable overload relays are furnished for the RF driver, audio driver, power amplifier and modulator stages. An overload in the RF driver or audio driver stages removes all plate voltages. An overload in the power amplifier or modulator stages causes plate power to be removed and reapplied. If the overload has cleared, the equipment then remains on the air in normal operation. However, if the overload persists or if a second overload occurs within a four-second period, the plate voltage is removed and must be reapplied manually.

POWER SUPPLIES

Plate voltage for the modulator and final amplifier is furnished by a common high voltage supply. Bias for the modulator and final amplifier is provided by a common low voltage supply. Plate voltage for the audio driver and RF driver is supplied by a common power supply. A separate low voltage supply feeds the audio driver screens as well as the plates and screens of the other RF and audio tubes. A second bias supply provides approximately 100 volts for the audio driver and RF driver bias and lesser voltage for the other biasing throughout the transmitter.

VOLTAGE CONTROL

Filament voltage adjustment control, high-low power control, and a high voltage breaker control are located on the front of the center cabinet just below the window. The magnetic high voltage breaker removes the primary voltage automatically upon a heavy overload in the transformer primary circuit and can be reset immediately after the overload is cleared.

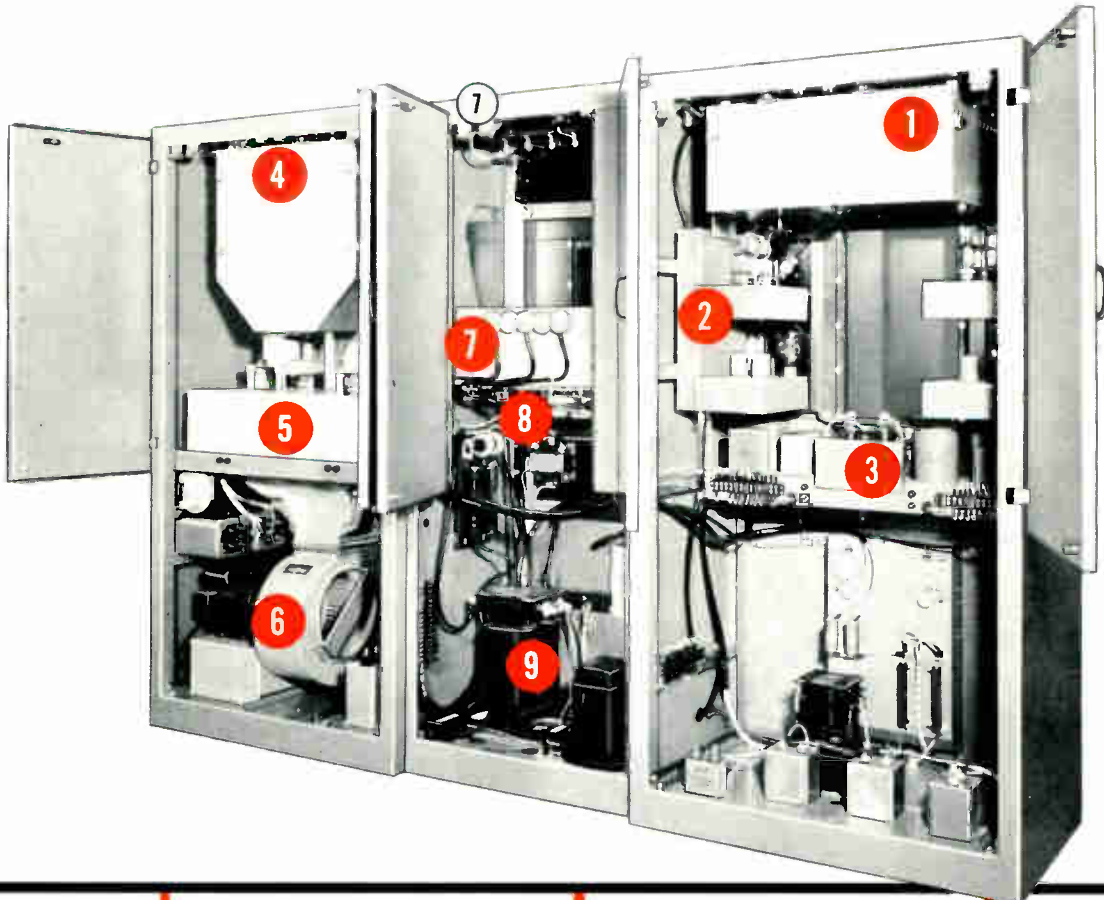
RELAY ACCESSIBILITY

By removing the clip-in flush panels on the lower front of the transmitter cabinets, power circuit equipment is readily accessible. All controls are available for adjustment while the transmitter is in operation.

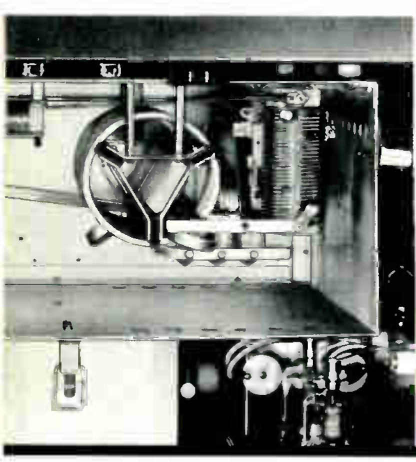
21E/M TRANSMITTER

Rear view — doors off

1. Driver cabinet output network
2. Driver cabinet RF chassis
3. Driver cabinet low voltage power supply
4. Power amplifier output network
5. 21M power amplifier RF chassis
6. Power amplifier cabinet blower
7. Power amplifier cabinet interlocks
8. Power supply cabinet rectifier chassis
9. Power supply cabinet modulation transformer

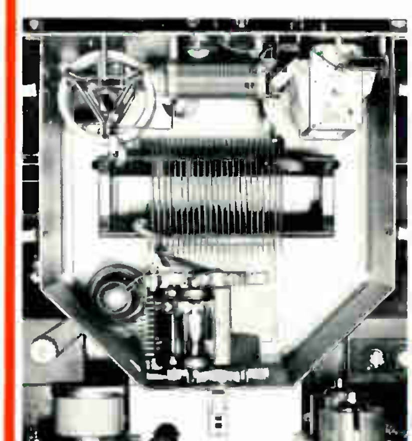


DRIVER OUTPUT NETWORK

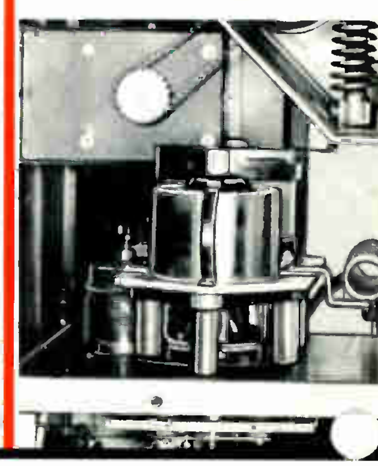


DRIVER RF CHASSIS

POWER AMPLIFIER OUTPUT NETWORK



21M POWER AMPLIFIER RF CHASSIS



SHIELDING

The entire RF network is double shielded to reduce spurious radiation. RF circuits are completely independent of the cabinet proper. Quality materials and components assure long life with trouble-free operation.

FREQUENCY CONTROL

As a result of major advances in crystal stability and oscillator design, the 21E/M Transmitter has eliminated the use of a crystal oven and its associated thermostats, relays and other controls. A highly perfected oscillator design — in conjunction with extremely stable, low temperature coefficient crystals — has resulted in exceptionally good frequency stability. There are provisions for mounting two crystals on the RF chassis, with one of the two always available in a stand-by condition. Crystals are easily selected by means of the crystal selector switch behind the right hand control panel.

All RF circuits of the 21E/M are straightforward and trouble-free. The oscillator, buffer and RF driver plate circuits are contained within shielded plug-in units located behind the right front access door of the driver cabinet. For frequencies in the AM broadcast band, the oscillator employs a resistive load. Because the 21E/M is also available for high frequency applications, provisions are included for replacing the resistor with a tuned tank circuit for frequency doubling. A frequency monitor connection is brought out from the grid circuit of the driver amplifier.

The RF output network consists of a pi section followed by an L section and is designed to feed into impedances between 50 and 72* ohms. Harmonics are greatly attenuated in this network. There is a minimum of fundamental frequency loss between the power amplifier and transmission line.

*Other impedances are available on special order.

DRIVER POWER SUPPLIES

The driver unit has separate power supplies for high voltage, low voltage and bias. The high voltage supply employs two type 872A half-wave mercury vapor rectifiers in a single-phase, full-wave circuit. It supplies dc voltage for the plates of the audio drivers and the plates and screens of the RF driver tubes.

The low voltage supply uses two type 866A half-wave mercury vapor rectifiers in a single-phase full-wave circuit to provide dc voltage for plates and screens of the low power stages and for screens of the audio driver tubes. The bias supply employs a 5U4G high vacuum rectifier in a single-phase, full-wave circuit. It supplies bias to the 807 amplifier, audio driver, and RF driver amplifier tubes, and dc voltage for the arc-suppression circuit.

OUTPUT NETWORK

In the RF output network of the 21E/M, a high degree of harmonic attenuation has been accomplished and the network loss between the final stage and the transmission line has been minimized. The entire RF network is double shielded to reduce spurious radiation and all RF circuits are completely independent of the cabinet proper.

ARC PROTECTION

Another feature is the arc-suppression circuit, which protects the final amplifier and RF driver tank circuits against arcs to ground due to lightning or other causes. Should such an arc occur, this circuit removes plate power until the arc is extinguished, then returns the equipment to normal operation.

COOLING SYSTEM

Cabinet ventilation in the final amplifier is obtained through a blower in the base of the cabinet, providing quiet, trouble-free cooling for all components and tubes. The blower produces a high capacity at a quiet, low speed and continues to run for an adjustable period of up to five minutes after power removal. Ventilation in the other two cabinets is provided by means of circulating fans.

21E/M TRANSMITTER

Specifications—Complete Schematic center foldout

FREQUENCY RANGE: 540 — 1600 kc standard, frequencies to 18 mc available

POWER OUTPUT: 21E — 5500/1100 Watts
5500/550 Watts on order

21M — 10,600/5500 Watts
— 10,600/1100 Watts on order

FREQUENCY STABILITY: Better than ±5 cps (Typical — Better than ±2 cps)

AUDIO FREQUENCY RESPONSE: Within ±1.5 db from 30 to 12,000 cps (Typical — Within ±1.5 db from 30 to 15,000 cps)

DISTORTION: Less than 3% from 50 to 10,000 cps for 95% modulation, including all harmonics up to 16 kc. (Typical — Less than 3% from 30-15,000)

RESIDUAL NOISE LEVEL: 60 db or more below 100% modulation.

CARRIER SHIFT: Less than 3% (Typical value less than 2%)

RF OUTPUT IMPEDANCE: 40/600 ohms on order

AUDIO INPUT IMPEDANCE: 150/600 ohms

AUDIO INPUT LEVEL: +10 dbm, ±2 db, 600 ohms input with built-in input pad. With the input pad removed, −5 dbm is sufficient for 100% modulation. 150 ohm connection of input transformer is possible when desired.

AMBIENT TEMPERATURE RANGE: Up to 45° C

ALTITUDE RANGE: Sea level to 6,000 feet

POWER SOURCE: 208/230 v, 3 phase 50/60 cps; 50 cps on special order

WEIGHT: 21E — Approximately 2,700 lbs.
21M — Approximately 3,000 lbs.

DIMENSIONS: 105¼″ wide, 76″ high, 28″ deep (Plate transformer extra)

POWER DEMAND (APPROXIMATE):

*5,000 Watts Output	Power (KW)	Power Factor (%)
5,000 watts		
Output — No Modulation	12.8	90.0
— 30% Modulation	13.8	90.0
— 100% Modulation	18.5	90.0

*10,000 Watts Output	Power (KW)	Power Factor (%)
10,000 watts		
Output — No Modulation	21.2	90.5
— 30% Modulation	23.6	90.1
— 100% Modulation	32.8	91.5

TUBE COMPLEMENT:

21E		21M
1 6AU6	Crystal Oscillator	1 6AU6
1 6SJ7	Buffer or Multiplier	1 6SJ7
1 807	Amplifier	1 807
2 4-125A	Driver	2 4-125A
1 3X2500A3	Final Amplifier	2 3X2500A3
2 6SJ7	Audio Amplifier	2 6SJ7
2 4-125A	Driver Amplifier	2 4-125A
2 3X3000A1	Modulator	2 3X3000A1
1 5U4G	Exciter Bias	1 5U4G
2 866A	Final Amplifier Bias	2 866A
2 866A	Low Voltage Plate	2 866A
2 872A	Intermediate Plate	2 872A
6 872A	High Voltage Plate	6 575A

*21E capable of 5,500 Watts Output, 21M capable of 10,600 watts output

COLLINS 300J-2, 550A-1, 20V-2 TRANSMITTERS

300J-2
250/100 Watt AM Transmitter

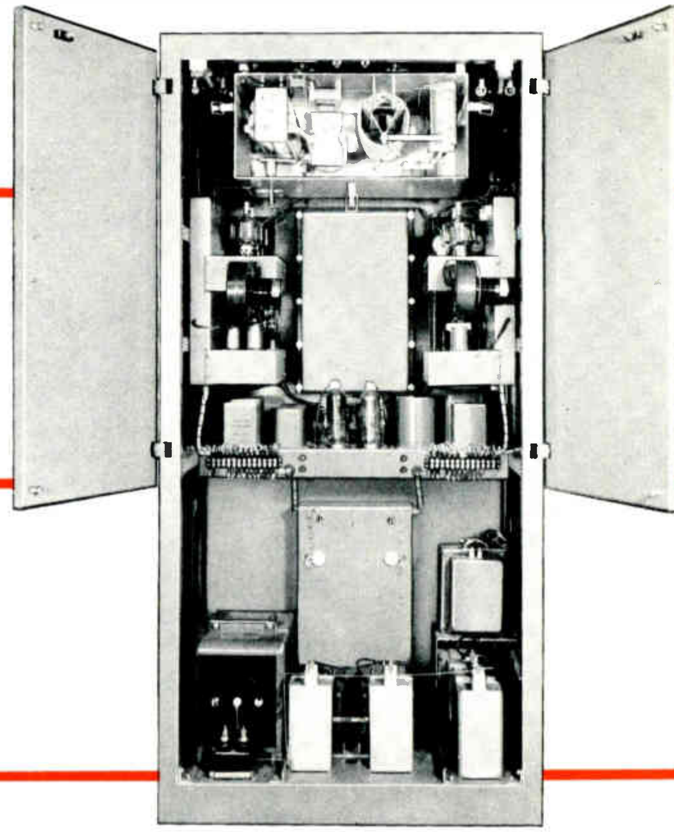
Facilities for reduction to 100 watts are standard equipment. Overnight conversion to 500/250 watts or 1,000/500 watts, with Collins power increase package.

550A-1
500/250 Watt AM Transmitter

Facilities for reduction to 250 watts are standard equipment. Overnight conversion to 1,000/500 watts, with Collins power increase package.

20V-2
1,000/500 Watt AM Transmitter

Facilities for switch-operated reduction to 500 watts are standard equipment. Reduction to 250 watts is also available on order.



Rear view, open

The 300J-2, 550A-1 and 20V-2 Transmitters are basically alike except for output power. The following text applies to all three. Differences in specifications related to power output are shown in individual specifications on page 13.

Collins 20V, 300J, 550A transmitters give continuous high fidelity broadcast operation at any specified frequency in the band from 540 to 1600 kilocycles or in any of the high frequency broadcast bands. All materials and components are of highest quality and promote long life and trouble free operation.

OUTSTANDING FREQUENCY CONTROL

A very high percentage of transmitter frequency instability problems and oscillator failures have been directly traceable to the crystal oven, thermostat and associated equipment. Collins has, through a major advance in crystal stability and oscillator design, eliminated the use of crystal ovens and associated thermostats, relays and circuit complexities.

Extremely stable low temperature coefficient crystals and the highly perfected oscillator produced frequency stability well within the FCC specifications of ±20 cycles.

Two crystals are employed with one of the two always available in a standby position. A selector switch provides instant choice of either crystal while the transmitter is in operation.

HIGH EFFICIENCY TUBES — only 7 types

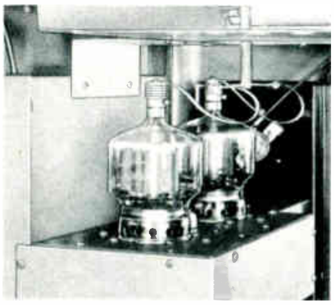
High efficiency, high gain type 4-400A tetrode tubes are used in both the modulator and the power amplifier. Extremely conservative operation is obtained with very low driving power, which simplifies the overall circuitry.

Oscillator Chassis

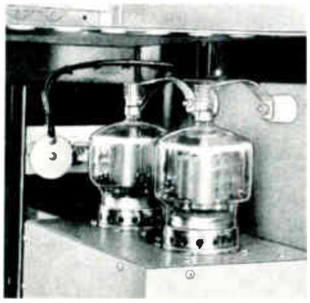
Only seven different tube types are used, resulting in fewer tube replacements to meet FCC requirements.

4	4-400A	2-Final Amplifier 2-Modulator
1	807	Drive Amplifier
3	6SJ7	1-Buffer Amplifier 2-Audio Amplifier
1	6AU6	Crystal Oscillator
2	872A	High Voltage Rectifier
2	866A	Low Voltage Rectifier
1	5U4G	Bias Rectifier

Cabinet ventilation is obtained through a fan on lower back panel. In addition, individual blowers mounted on RF and modulator chassis provide quiet, trouble-free cooling for all components and tubes.



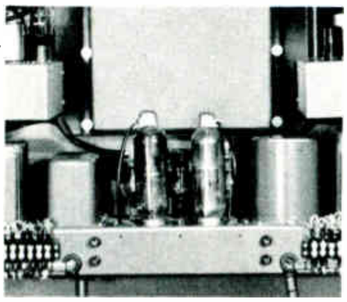
Final RF amplifier



Modulator stage

POWER SUPPLIES

One heavy duty high voltage power supply is used for the modulator and final amplifier. A separate low voltage supply feeds the modulator screen grids, as well as the plates and screen grids of the other RF and audio tubes. The bias supply provides approximately 100 volts for the modulator and power amplifier bias and lesser voltages for other biasing throughout the transmitter.



Power supply

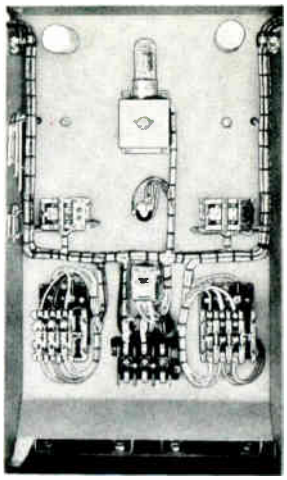
THERMAL TIME DELAY RELAY

An instantaneous interruption of line voltage will result in no delay in returning to the air. A thermal time delay circuit automatically selects the proper delay period after short carrier interruptions. This thermal time delay relay allows return to the air at the earliest possible moment, cutting off-the-air time to a minimum number of seconds.

CONTROLS

Momentary type filament and plate power start-stop switches are located on the front of the transmitter.

When the filament 'On' button is pressed, the filaments, blowers, bias supply and plate time delay circuit are immediately energized. At the end of the filament warm-up cycle the filament pilot light will glow, indicating readiness for application of high and low plate voltages. Manual operation of the plate button on the front of the transmitter will energize these power supplies and the plate pilot light will glow its indication of full operating conditions.



Relay panel

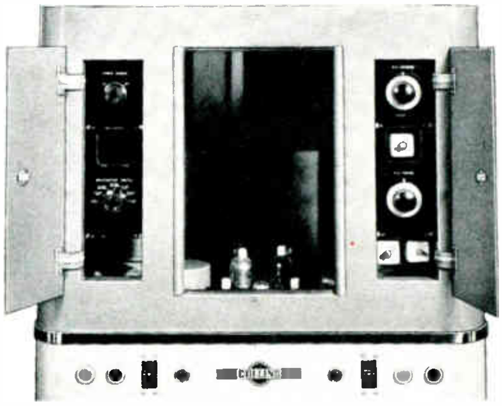
If desired, the transmitter can be started by simply pressing the plate 'On' button. Filament, bias and plate power will then be applied in correct sequence and with the proper time delay. Pressing the filament 'Off' button de-energizes all circuits.

Filament and control circuits and the high voltage plate supply are protected by toggle-type magnetically operated circuit breakers.

Individually adjustable overload relays are provided for the modulator and final amplifier stages. These relays are connected so that an overload removes plate power and the equipment must be renergized manually.

Tuning controls on the left side of the front window are High-Low Power switch, Multimeter switch, Modulator Bias adjustments and Audio Balance control.

Tuning controls on the right side of the front window are PA Plate Tuning, PA Loading, Crystal Selector switch, Crystal Frequency Trimmers, RF Driver Audio Hum Balance and RF Final Amplifier Audio Hum Balance. All of the above controls are available for adjustment while the transmitter is in operation. AC power circuit equipment is readily accessible by removing the clip-in flush panel in the



Front panel controls

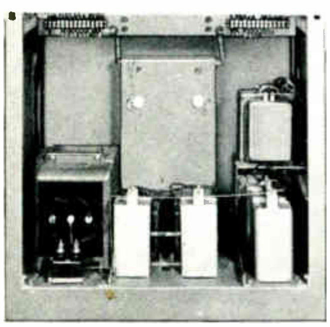
lower center of the transmitter front. No neutralization adjustments are necessary for operation at any frequency in the standard broadcast band.

PERSONNEL PROTECTION

Personnel protection is provided by automatic door interlocks and gravity operated shorting bars. After the interlocks have opened, the gravity bars ground the high voltage and discharge the large filter capacitors.

ARC PROTECTION

The lightning and arc-over protective kit, now supplied as standard equipment on the 20V-2, 300J-2, 550A-1 Transmitters will safeguard tubes and tank components by interrupting the high voltage and low voltage plate supply primaries in event of a short circuit or flash-over in the transmitter RF output circuit. The protective relay has one set of contacts which are normally closed. The relay coil is connected in series with the monitor coil. The end of the monitor coil that connects to the relay is isolated from ground for dc by removing the ground connection and substituting a bypass capacitor. The transmitter bias supply is used as a convenient voltage source for operation of the relay. When an arc-over occurs in the power amplifier output tuning network, due to lightning or any other cause, the ionized path produced by the RF voltage in the arc-over has a sufficiently low dc resistance to complete the relay coil circuit and energize the relay. As the relay operates, it removes high voltage from the transmitter and stops the arc-over. When the arc-over no longer exists there is no path to ground for the dc relay coil current, and the relay returns to its normal position. The relay removes arc-over conditions from the output network and returns the transmitter to normal operation so quickly that usually only the click of the transmitter relays will notify the transmitter operator that an arc-over has occurred.



Blower and Filter

MODULATION

A simplified modulator design and advanced circuitry has resulted in a more compact, efficient modulator. This transmitter can be safely operated at 100 per cent *sinewave* modulation without fear of breakdown. Conservative ratings, highest quality components and high efficiency cooling all contribute to the modulation capability of the transmitter. Exceptionally low audio distortion is obtained.

METERING

For ease of operation and observation of transmitter performance the following circuits are metered: RF line current, final amplifier plate current, final amplifier plate voltage, modulator cathode current, final amplifier grid current, 807 RF driver cathode current, 807 grid current, 6SJ7 buffer cathode current, 6SJ7 grid current, 6SJ7 audio driver cathode current and 6AU6 crystal oscillator cathode current. The meter panel is tilted at an angle for operating convenience.

MONITOR CONNECTIONS

Readily accessible coaxial monitor connections are provided for both modulation and frequency monitors. In addition, a direct monitor speaker connection is provided to allow on-the-air monitoring from the transmitter. A monitor amplifier system also may be fed from this termination.

OUTPUT NETWORK

A high degree of harmonic attenuation has been accomplished. The entire RF network is double shielded to reduce spurious radiation. All RF circuits are completed independent of the cabinet proper.

CABINET

All tubes are visible through the front window and all tuning controls are located on the front of the transmitter.

One vertical door, located on each side of the front window, provides access to the various controls and adjustments. The filament and plate power switches and their association indication lights are located below these doors on the front of the transmitter.

Double doors on the rear of the cabinet provide instant access to the interior of the equipment.

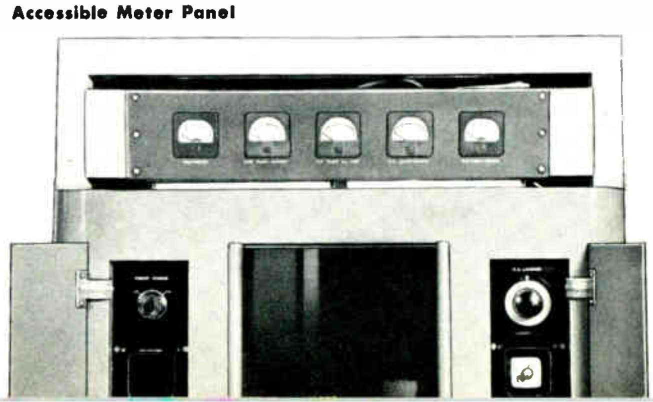
A "clip-in" panel below the window covers the compartment in which the time delay circuits, the plate relay and the primary terminal block are located.

The top panel on the front of the transmitter can be removed by releasing two screws.

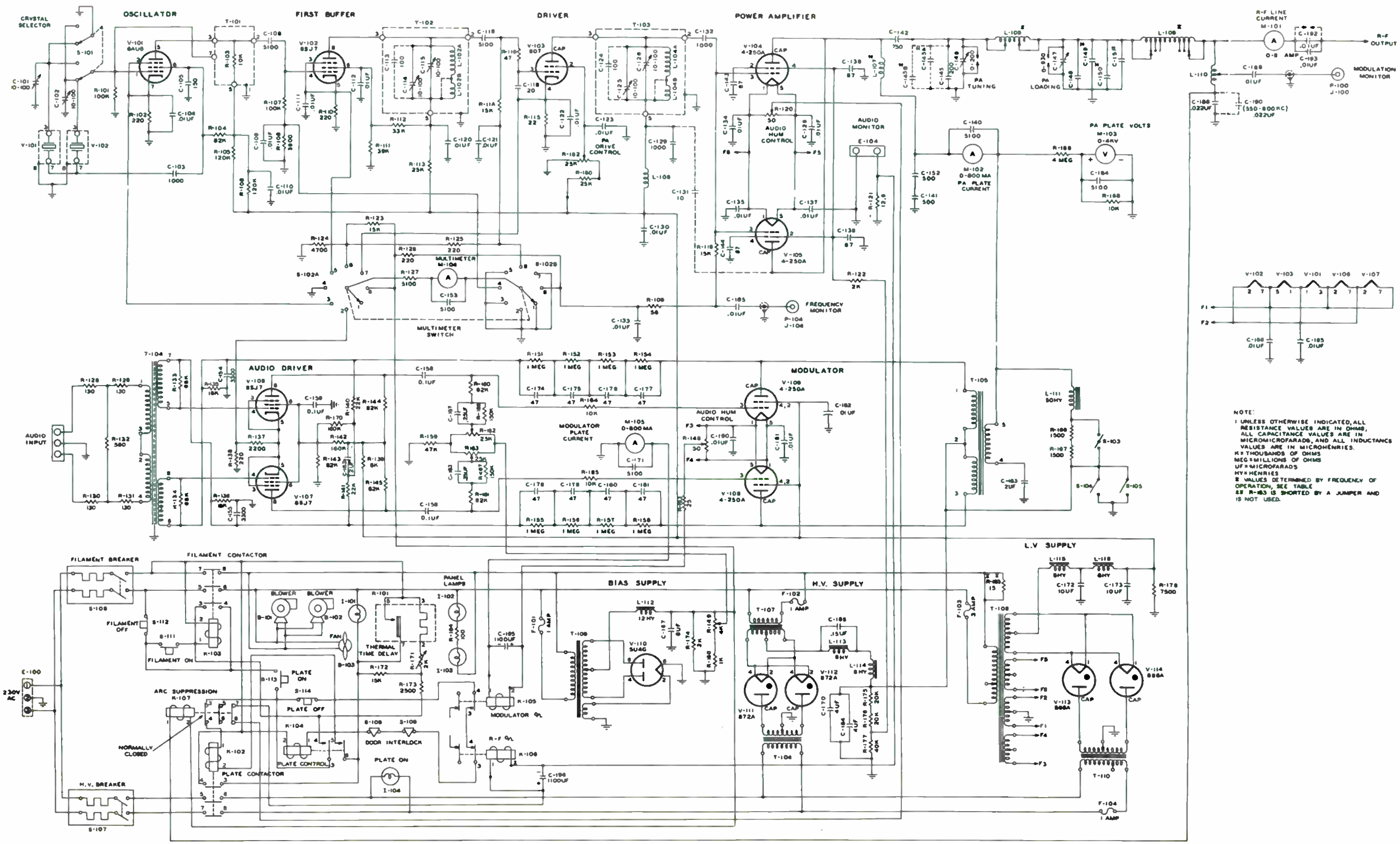
This ruggedly constructed cabinet is finished in an attractive high gloss two-tone grey enamel. Streamlined polished chrome syling adds to the modern appearance.

Cooling — adequate cooling is provided by the large blower and filter assembly housed in the lower rear panel of the transmitter . . . plus the two auxiliary blowers shown on page 10.

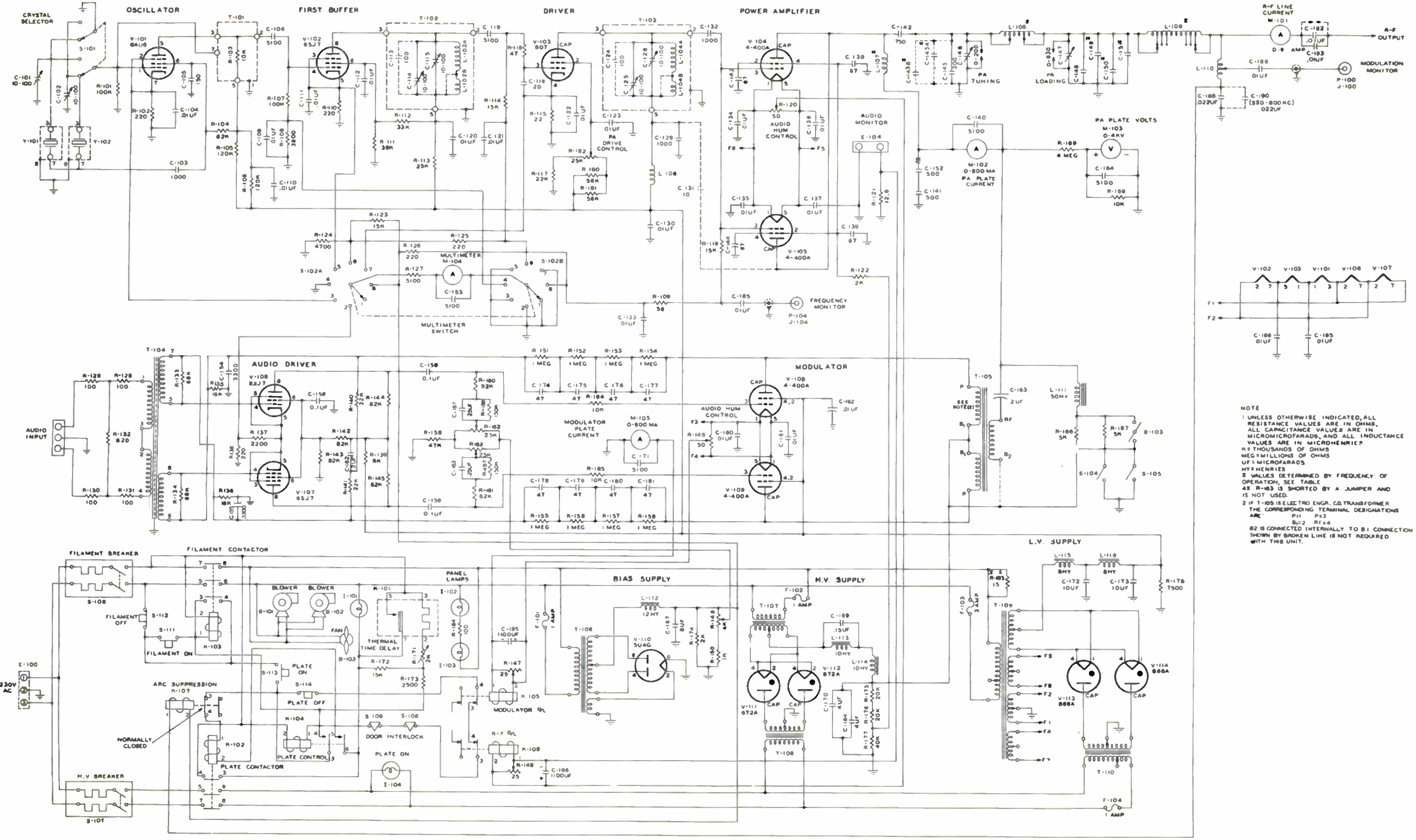
Accessible Meter Panel



550-A SCHEMATIC DRAWING



20V-2 SCHEMATIC DRAWING



NOTE

1 UNLESS OTHERWISE INDICATED, ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN MICROMICROFARADS, AND ALL INDUCTANCE VALUES ARE IN MICROHENRIES
K = THOUSANDS OF OHMS
MEG = MILLIONS OF OHMS
UF = MICROFARADS
HY = HENRIES
※ VALUES DETERMINED BY FREQUENCY OF OPERATION, SEE TABLE
4※ R-183 IS SHORTED BY A JUMPER AND IS NOT USED.

2 IF T-105 IS ELECTRO ENGR. CO. TRANSFORMER THE CORRESPONDING TERMINAL DESIGNATIONS ARE: P=1 P=3 B1=2 RF=4
B2 IS CONNECTED INTERNALLY TO B1 CONNECTION SHOWN BY BROKEN LINE IS NOT REQUIRED WITH THIS UNIT.

and accessories →

COLLINS 37M

FM Ring Antennas

STREAMLINED SIMPLICITY

The Collins 37M Series Ring Antenna consists of only two basic parts: (1) radiating rings and (2) connecting inter-ring transmission line. Any number of rings, either odd or even, may be employed, providing maximum flexibility in available power gains for the requirements of the particular installation.

Only one inter-element transmission line is required to feed all rings in a multiple-element array. The individual radiating rings are identical mechanically and electrically. They are both shunt fed and mechanically supported by this single interconnecting feed line, which consists of modified lengths of standard RMA specification rigid coaxial transmission line of suitable size for the transmitter power being employed. The 37M terminates in a standard RMA 51.5 ohm flange connection on the bottom element of the array for coupling directly to the transmission line.

LOW WEIGHT AND WINDLOADING

Because of the simplicity of its electrical and mechanical design, the 37M is so light and compact that the resulting dead weight and windloads are reduced to a previously unknown low for FM antennas. The aerodynamic simplicity and low weight of the 37M are achieved through the elimination of massive radiating elements, complex external multiple-line feed systems, bulky supporting structures and unwieldy multiple-element units in the individual radiating section. Greater efficiencies can be obtained and savings made in new tower costs, erection time and maintenance expense. The 37M is unexcelled for maximum power gain at low weight and windloads.

METHOD OF MOUNTING

Two advantageous methods of mounting the 37M Antenna are available to the FM broadcaster: (1) Side mounting of the array on a corner leg of the tower offers definite advantages. Towers, either guyed or self-supporting, which previously have been considered incapable of supporting *any* FM antenna will in nearly all cases handle the Collins side mounting 37M. Towers which support top mounting television antenna arrays increase their usefulness with the addition of a side mounting 37M array. Any number of rings may be side mounted, obviating the necessity of modifying the top of the tower or disturbing in any way the tower lighting equipment, top mounting TV radiator or the tower proper.

(2) The top or pole mounting design is available on special order for installation on towers where no TV antenna is present or planned. This style of mounting provides the maximum in height and coverage. The light weight and windloading of the top mounting array allow erection on most guyed and self-supporting towers without extensive tower modification.

INSTALLATION EASE

The unique characteristics of light weight and electrical-mechanical simplicity make the 37M easy and quick to erect. There are no extraordinarily heavy hoisting problems, and many hours of erection time may be saved. Support brackets are specially fabricated for each installation to match the tower and mounting arrangement specified by the purchaser, thus minimizing erection problems at the site.

MECHANICAL STABILITY

Another important advantage of the 37M is the inherent mechanical stability of the tower, transmission line, and antenna assembly. Undue oscillating and weaving of the tower and antenna are eliminated by the low weight and windload, which result in reduced strain on the supporting structure as well as reduction in tower maintenance costs.

CIRCULAR RADIATION PATTERN

The horizontal radiation pattern of the 37M is essentially circular for both top mounting and side mounting arrays. A maximum deviation of only 1 db is obtained in the top or pole mounted arrangement, while the circular pattern of the side mounted array will generally equal that of the top mounted antenna. The extent of deviation from a circular pattern in the side mounted antenna is normally minor and is dependent on the type and size of tower on which the antenna is mounted. Under the most unfavorable tower conditions the side mounted pattern has proved to be entirely acceptable.

HIGH GAIN

One of the most outstanding features of the Collins FM antenna is the availability of high power gains. The flexibility of the number of rings, either odd or even, which may be used, provides a power gain to meet the requirements of each installation.

LOW VSWR

The voltage standing wave ratio of the 37M can be maintained at better than 1.1 to 1 because of the inherent high stability of the tuning system. Adequate bandwidth virtually eliminates detuning effects caused by changes in atmospheric conditions.

AMPLE POWER CAPACITY

Antenna arrays mounted on 1⅝" or 3⅛" line are available for handling transmitter powers up to 20 kw. There is a 37M to meet your particular power and gain requirements.

DE-ICING PROVISIONS

The compactness and simplicity of the 37M Antenna allow the maximum efficiency in ice and sleet removal. Each ring may be equipped with an internally mounted heating unit which consists of a cartridge type element inside each of the tuning condenser plates and an additional flexible heating element extending the full circumference of the inside of the ring. The absence of large masses of metal makes de-icing of the 37M an efficient and practical operation while the operating costs of de-icers are reduced to minimum.

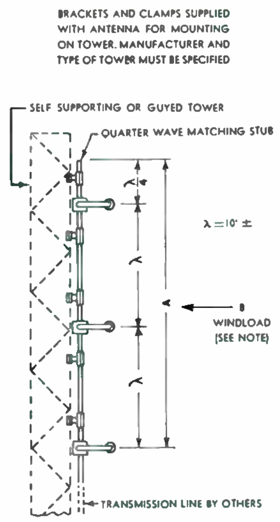
ECONOMY

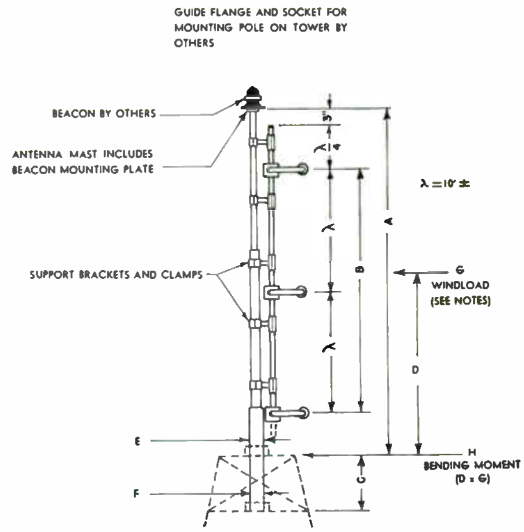
Among the economies unique in the 37M are:

- Low initial cost
- Highest gain at low weight and windloading
- Reduction in new tower costs
- Can be side mounted on existing light weight towers
- Lower erection costs
- Reduced maintenance expense

ENGINEERING DATA

Collins 37M Series FM Antennas



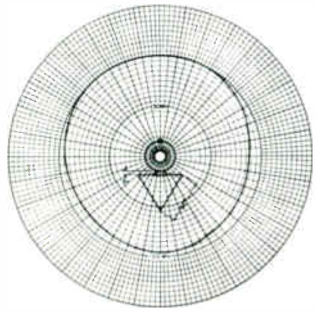


SIDE MOUNTING

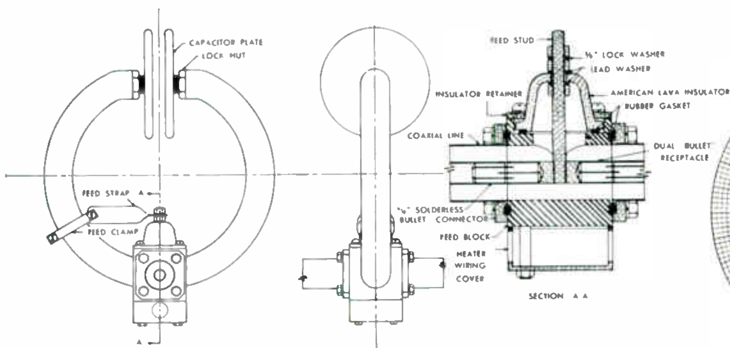
Collins Type	No. of Rings	Power Gain	Field Gain	A Feet	On $1\frac{5}{8}$" Line B	On $1\frac{5}{8}$" Line Weight	On $3\frac{1}{8}$" Line B	On $3\frac{1}{8}$" Line Weight
37M-1	1	.9	.95	2-6±	24	23	32	46
37M-2	2	2.0	1.41	12-6±	68	55	100	100
37M-3	3	3.0	1.73	22-6±	114	86	170	175
37M-4	4	4.1	2.02	32-6±	160	119	240	240
37M-5	5	5.2	2.28	42-6±	206	152	310	305
37M-6	6	6.3	2.51	52-6±	252	185	380	370
37M-7	7	7.3	2.70	62-6±	298	218	450	435
37-M-8*	8	8.4	2.90	72-6±	344	251	520	500

TOP MOUNTING

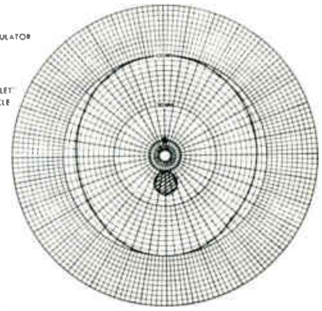
Collins Type	No. of Rings	Pwr. Gain	A Ft.	B Ft.	C Ft.	On $1\frac{5}{8}$" Line D Ft.	E Dia.	F Dia.	G Lbs.	H Ft.-Lbs.	Dead Wt.	On $3\frac{1}{8}$" Line D Ft.	E Dia.	F Dia.	G Lbs.	H Ft.-Lbs.	Dead Wt.
37M-1	1	.9	6		3	4-7	$3\frac{1}{8}$"	$3\frac{1}{8}$"	50	230	223	4-7	$3\frac{1}{8}$"	$3\frac{1}{8}$"	68	312	250
37M-2	2	2.0	16	10±	4	10	$4\frac{1}{2}$"	$4\frac{1}{2}$"	239	2,390	305	12-3	$4\frac{1}{2}$"	$4\frac{1}{2}$"	291	3,565	360
37M-3	3	3.0	26	20±	7	14-5	$6\frac{5}{8}$"	$6\frac{5}{8}$"	403	5,803	736	14-4	$6\frac{5}{8}$"	$6\frac{5}{8}$"	486	6,950	825
37M-4	4	4.1	36	30±	10	19	$7\frac{5}{8}$"	$7\frac{5}{8}$"	564	10,716	1169	18-9	$7\frac{5}{8}$"	$7\frac{5}{8}$"	678	12,713	1290
37M-5	5	5.2	46	40±	12	23	$8\frac{5}{8}$"	$7\frac{5}{8}$"	747	17,181	1652	22-8	$9\frac{5}{8}$"	$9\frac{5}{8}$"	919	20,769	2128
37M-6	6	6.3	56	50±	14	27-2	$9\frac{5}{8}$"	$8\frac{5}{8}$"	951	25,867	2285	26-7	$10\frac{3}{4}$"	$9\frac{5}{8}$"	1173	31,260	2770
37M-7	7	7.3	66	60±	15	31	$10\frac{3}{4}$"	$8\frac{5}{8}$"	1175	36,425	3218	31-3	$10\frac{3}{4}$"	$8\frac{5}{8}$"	1388	43,375	3485
37M-8*	8	8.4	76	70±	16-6	34-9	$11\frac{3}{4}$"	$9\frac{5}{8}$"	1417	49,241	4051	34-8	$12\frac{3}{4}$"	$11\frac{3}{4}$"	1696	58,682	4650



Typical Side Mounting radiation pattern 100 mc, 12" diameter ring on side on Wincharger tower



FREQUENCY RANGE VERSUS LOOP DIAMETERS
Diameter varies from 11" to 14" depending upon frequency and line size



Typical Top Mounting radiation pattern 100 mc, 12" diameter ring on 10" diameter pole.

81M PHASORS

Directional Antenna Equipment

Collins entry into the complete directional antenna equipment field was the result of a desire to improve design, delivery and pricing of the equipment.

The Company maintains a research and development department which devotes its full efforts to the design and manufacture of phasing and tuning equipment that will meet critical operating parameters with a minimum of maintenance and adjustment.

By instituting its own design and construction, Collins can offer fastest possible delivery, maintain its famous standard of quality and sell at the lowest possible cost.

Whether your requirement is for a complete directional system or replacement of a control unit, your station will profit from Collins design for your individual needs. Engineered into each installation are easily adjusted networks, highest stability, adequate voltage and current safety factors and maximum economy.

A customer's requirements as specified by his consulting engineer are strictly adhered to and *designs are submitted for approval* before construction is started.

POWER DISTRIBUTION

Distribution of power to towers in a directional antenna array can be accomplished in a number of ways. The power divider in Collins 81M equipment is usually a resonant tank circuit consisting of a large fixed coil tapped with smaller variable coils for power adjustment. An alternate design uses a group of variable coils, each one feeding a tower; this group then becomes the tank coil of the circuit.

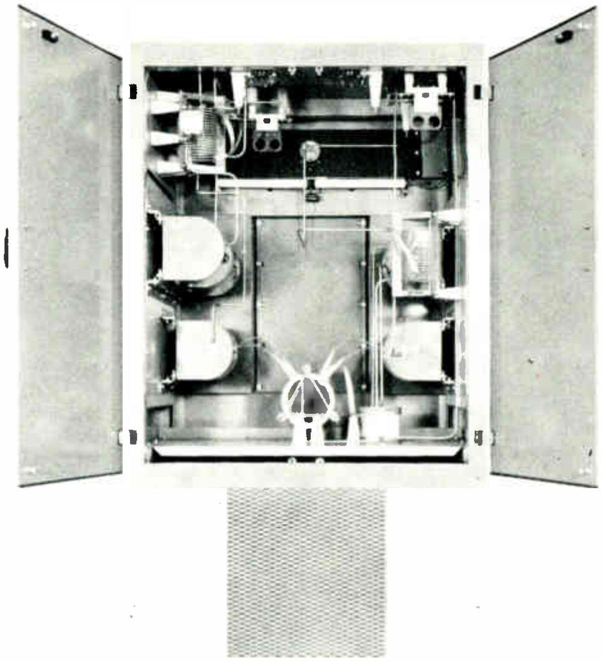
For 1 kw or lower, the capacitive arm of the tank circuit is a capacitor and variable coil connected in series. The variable coil provides tuning adjustment by varying the overall negative reactance in this branch of the tank.

In higher powers, the tank capacitance branch is fixed, the tank coil is tapped and the entire tank fed by an input 'T' network. This provides a means of trimming the tank reactance and of transforming the tank impedance to a satisfactory value.

PHASE SHIFT

Phase shifting networks are 'T' designed, with variable coils mechanically connected in tandem for the series arms and a coil and capacitor in series for a shunt arm. Wherever possible, 90° networks — capable of being adjusted ±30° from the design value — are supplied.

Wherever a phase shift network is not required, a series variable coil and capacitor are used to supply variation of + 20° around 0° setting. They are used for trimming phase shift of current in the towers with which they are used.



ABOVE, 1 kw phasor with rear doors open. AT RIGHT, 1 kw two-tower phasor installed with Collins 20V-2.

ANTENNA COUPLING

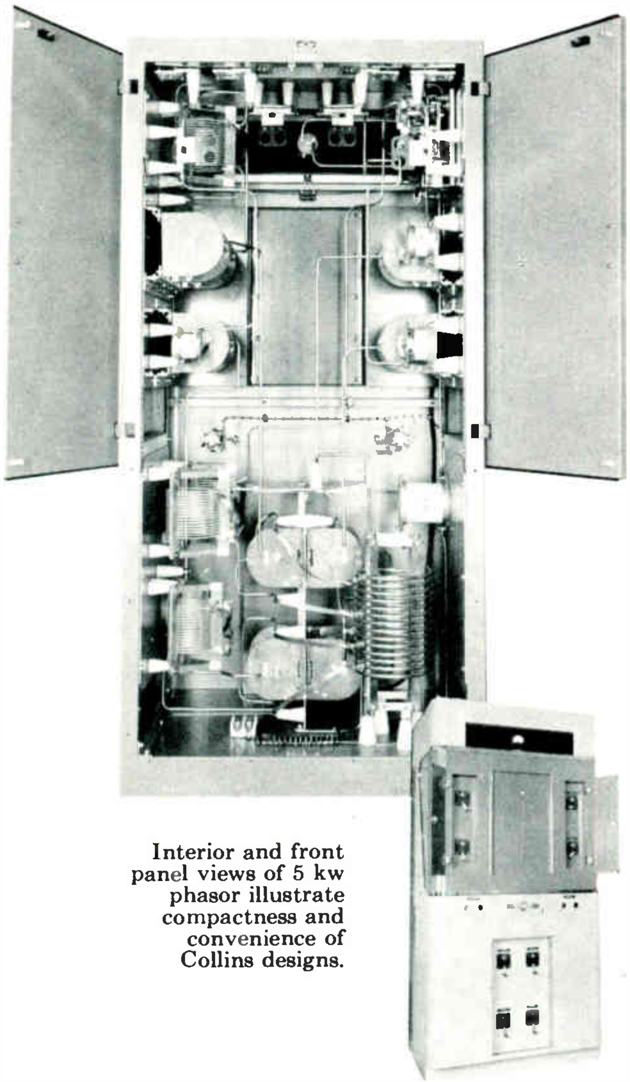
'T' networks are also used for impedance matching and phase shift. The network providing 90° of phase shift wherever possible has sufficient latitude of adjustment to match the transmission line impedance to any value within a range of impedances, including all possible values of calculated base operating impedance.

SWITCHING

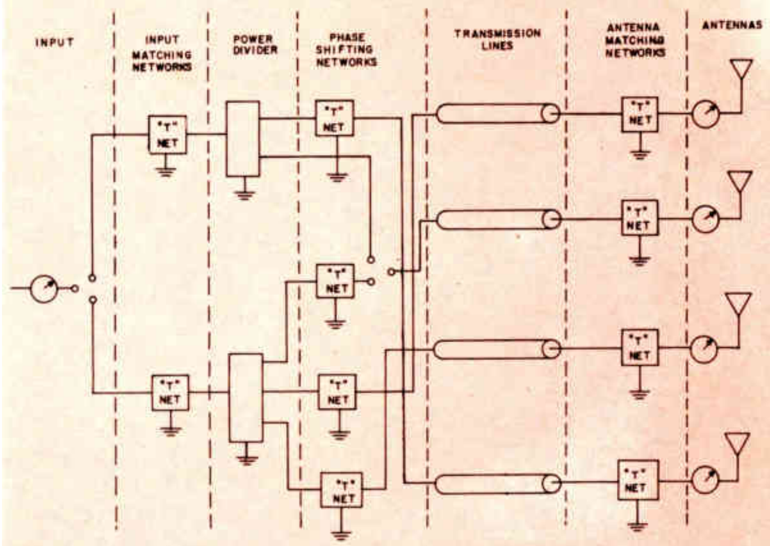
Switching of circuits for day and night operation or directional and non-directional operation is accomplished by impulse-type, toggle-operated RF relays, energized by push button switches on the front panel. The push button automatically removes the plate voltage of the transmitter before pattern switching and restores it when switching is completed. Interlocks on the cabinet doors also remove the plate voltage when doors are opened.

CONTROLS

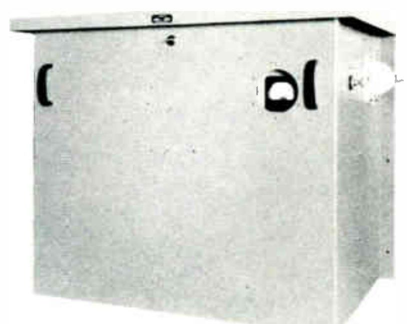
Amplitude and phase adjustment controls are recessed counter dials which assure accurate resetability. In complex arrays requiring additional



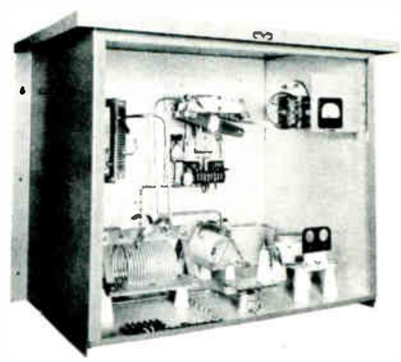
Interior and front panel views of 5 kw phasor illustrate compactness and convenience of Collins designs.



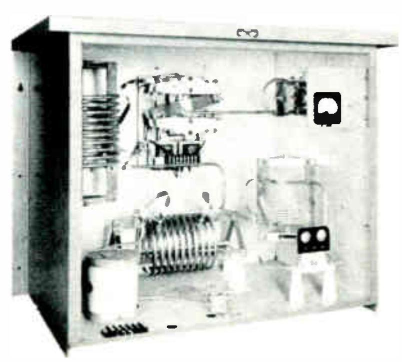
Typical block diagram of Collins directional antenna installation.



Weatherproof antenna tuner housing.



Antenna tuner for towers 1 and 3 in four-tower array of 5 kw station.



Antenna tuner for towers 2 and 4 in four-tower array of 5 kw station.

controls, the counter dials are recessed behind a tilt-out panel in the middle of the lower half of the cabinet.

COMPONENTS

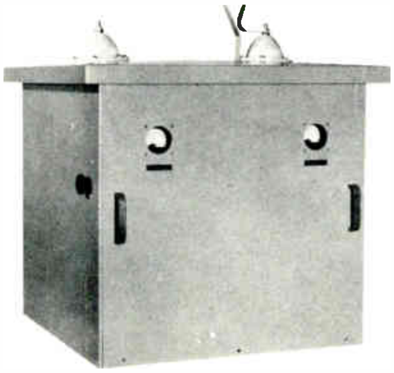
Power dividing circuits and phase shift networks utilize heavy edge-wound copper ribbon inductors and ceramic cased mica capacitors. Vacuum capacitors are used where made necessary by high circulating currents.

Plated $\frac{5}{16}$" copper tubing is used for all RF busses and insulation is steatite or Mycalex.

Input and output connections are provided at the top of the phasing cabinet unless otherwise specified. Special terminations are provided for solid dielectric cables in both the phasing cabinet and antenna coupling units. An input common point RF ammeter is supplied, along with line current meter jacks. Antenna current meters have make-before-break switches, which can be operated without opening the cabinet door on the weatherproof coupling units.

ADDITIONAL ACCESSORIES

42E ANTENNA TUNER



These are specially constructed units to match a vertical radiator to an unbalanced transmission line. The electrical circuit is arranged in the form of either a T section low-pass filter or other configuration depending upon the particular application. The use of a T section allows operation over a wide range of antenna impedances without changing the circuit configuration. Line current and antenna current meters are provided as is a current transformer for a remote meter. A horn gap furnishes lightning protection. The 42E is housed in a sturdy weatherproof cabinet constructed of heavy-gauge welded steel. All components are easily accessible upon removal of the front cover, which is simply lifted upward and outward. Meters are read through two windows in the housing. The meter shorting switch can be operated from the outside. The transmission line and antenna connections are made by insulated feed-through bushings on the roof of the cabinet. The unit is supplied complete with an 8-foot length of 3″ diameter pipe for mounting on a concrete base. Overall dimensions are 27″ wide, 27¾″ high, 27″ deep. It weighs 117 pounds and has a gray finish.

TOWER LIGHTING CHOKES

These chokes provide thorough isolation of power lines from the RF field. They are encased in all-weather housings or supplied as open units complete with mounting brackets and terminals. The three Collins types are: 23C-1, 500-watt single phase; 23D-1, 1500-watt single phase, and 23E-1, 3,000-watt three phase. Each weighs 20 pounds.

142A SHUNT MATCHING NETWORK

The 142A cancels reactance for matching shunt-fed antennas to a transmission line. The 142A is housed the same as the 42E Tuner, except that only one meter and one tuning inductor are supplied. The unit includes a static drain choke and transformer for a remote antenna current meter. The dimensions and approximate weight are identical with the 42E. The 412A Units are designed to fit varying requirements and when making an inquiry or placing an order the following information should be supplied:

1. Transmitting frequency
2. Transmission line impedance
3. Tower height
4. Distance to tower feeder tap from ground
5. Distance from base of tower to tuning or matching unit
6. Transmitting power

AM, FM TOWERS

Collins furnishes a wide selection of both self-supporting and guyed antenna towers to meet the requirements of any AM or FM installation.

Towers are normally supplied with a protective coating of rust inhibitive paint prior to shipment, although they can be supplied with a galvanized finish at a slightly higher price. Galvanized is recommended in locations where the tower will be subjected to salt air spray, extreme humidity or other corrosive conditions. The finish coat is normally supplied by the tower erector and is in keeping with CAA requirements.

All hardware, fittings, guy insulators, anchor steel and base insulator (where required) are supplied with each tower. The applicable FCC (CAA) lightning kit and wiring also is provided.

Collins can arrange for trained installation crews who specialize in tower erection. They handle all details, including lighting, ground systems installation, etc. Since tower erection is handled by subcontractors, different erectors are employed in various areas and quotations will be supplied upon request.

Specially constructed towers, shunt-fed radiators and towers used to support FM antennas will also be quoted on request.

CLARK 108 PHASE MONITOR

The 108 Phase Monitor provides an indication of the phase relations in directional antenna systems, and is tailored for the particular installation. It usually incorporates provision for indicating the relative amplitudes of the currents in the various antennas, as well as the phase relation.

FREQUENCY RANGE: 100 kc to 2 mc.
PHASE ANGLE RANGE: 0° to 360°
MONITORING ACCURACY: 1 degree
RESOLUTION: ½ degree
RF INPUT IMPEDANCE: 50 to 70 ohms nominal
RF VOLTAGE RANGE: 1 to 7 v
TUBES: 2-6AU6, 2-OB3, 1-5Y3, 3-6AL5
POWER REQUIREMENTS: 105-125v, 80 w
DIMENSIONS: 14″ x 19″ x 7°
WEIGHT: 20 lbs.

CLARK 120-D FIELD INTENSITY METER

The 120-D (formerly WX-2D) is a light weight instrument for the measurement of a wide range of radio signal intensities in the broadcast band. It is also effective for interference studies at low signal strengths and for close-in measurements on directional arrays.

FREQUENCY RANGE: 540 to 1600 kc
FIELD INTENSITY RANGE: 10 mv meter to 10v meter
ACCURACY OF ATTENUATORS: 2%
OUTPUT INDICATOR: Direct reading panel meter
ANTENNA: Shielded, unbalanced loop
POWER REQUIREMENTS: Batteries 5-1½v, 2-67½v (provisions for external supply)
DIMENSIONS: 9″ high, 13″ wide, 5¾″ deep
WEIGHT: 12½ lbs. with batteries

CLARK 121 ACCESSORY UNIT

The 121 is designed as a companion unit to the 120D (also WX-2A, WX-2B, WX-2C and WX-2D).

The principal function is its ability to operate 1 ma recorders of the Esterline Angus type to give a permanent record of field strength. It can also be used as a general purpose recording and monitoring amplifier when a high input impedance is desired and 5 vdc is available.

INPUT REQUIRED: Approximately 5 vdc
OUTPUT: 1 ma into loads up to 2,000 ohms
SPEAKER: 4″ panel mounted
POWER SOURCE: 117 v 50/60 cps or 6 vdc
POWER INPUT: 15 wac or 2.5 adc
SIZE: 12½″ x 6½″ x 4½″
WEIGHT: 10 lbs.

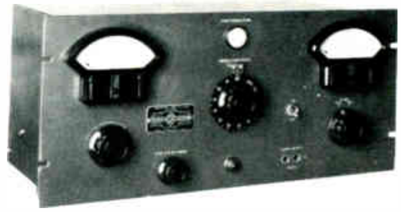
1181-A FREQUENCY DEVIATION MONITOR

The 1181-A gives direct indication of magnitude and direction of the frequency deviation of an AM transmitter. The monitor input is obtained from the transmitter output.

Positive indication of either transmitter carrier or monitor crystal oscillator is provided.

FREQUENCY RANGE: .5 to 2.0 mc
CRYSTAL: Supplied with unit. Specify frequency on purchase order
DEVIATION RANGE: ±30 cps
DIMENSIONS: 19″ wide, 15¾″ high, 13″ deep, for rack mounting
POWER SOURCE: 105-125 or 210-250 vac, 50/60 cps 125 w

1931-A AM MODULATION MONITOR



Operating in the frequency range of 0.5 to 8 mc, the 1931-A measures percentage modulation on either positive or negative peaks, indicates overmodulation, monitors program level, measures carrier shift when modulation is applied and measures transmitter audio frequency response.

DIMENSIONS: 19″ wide, 8¾″ high, 10″ deep for rack mounting
POWER SOURCE: 105-125 vac, 50/60 cps, 50 w

REMOTE ANTENNA CURRENT METERING KIT

This kit consists of a meter, thermocouple, meter mounting bracket and 15 feet of shielded pair wire. It is used to remotely read antenna current at the transmitter. A thermocouple is supplied to work in conjunction with the RF current transformer in Collins 42E tuning units. When ordering, specify type of tuner, base current of tower, base resistance or complete description of antenna system. This kit can be installed at the factory prior to transmitter shipment (at no additional charge for installation) or ordered as a kit for customer installation.

MISCELLANEOUS METERS

All popular sizes and ranges of RF and DC meters are also available.

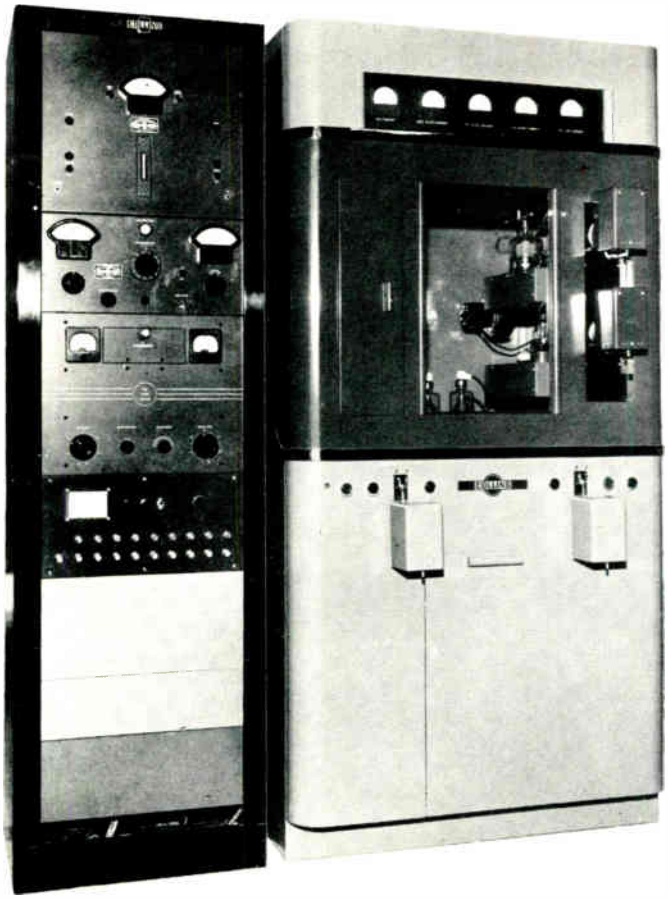
FISHER-PIERCE 63305C BEACON LIGHT CONTROL

This photo-electric lighting control turns tower lights on at sunset and off at sunrise at predetermined levels of north sky illumination. It operates on 105-130 volts, has a contact rating of 30 amps and is supplied in a weatherproof housing. Approximate shipping weight is 10 lbs.

COPPER GROUND WIRE AND STRAP

Collins supplies No. 10 bare copper ground wire (31.8 ft. per lb.), 2″ x .032″ copper ground strap (4.02 ft. per lb.) and 4″ x .032″ copper ground strap (2.01 ft. per lb.). Also available is Truscon 8′ x 24′ expanded copper mesh ground screen.

ADDITIONAL ACCESSORIES Cont.



RUST REMOTE CONTROL SYSTEMS

Collins supplies remote control systems consisting of self-contained transmitter and control units, equipment for obtaining frequency and modulation monitor readings, and accessory units coordinated on "building block" principles.

These are tubeless dc systems that can control normal transmitter requirements such as switching program lines, adjusting plate or filament voltage, operating a line variac, CONELRAD switching, operation of power contactors, metering of voltages and currents, loading and tuning, turning transmitter on or off, tower lights and metering of same.

If future requirements call for additional capacity, accessory units may be wired into the system. No additions or alterations are needed to the basic units.

All Collins transmitters can be equipped with remote control at the factory or in the field.

Three systems are available: the Rust C System, D System, and F System.

C SYSTEM

The C System is recommended for single transmitter non-directional stations, as well as two- and three-tower, single pattern directional operations, for which the capacity of ten two-direction (20 total) control functions and nine meter readings is ample. It features complete accessibility, reliability and easy installation with plug-in interconnecting cables supplied.

D SYSTEM

The D System is a new large capacity system using time-tested, reliable Rust circuitry. It is designed with built-in reserve capacity to handle future requirements for added transmitters or directional remote operation. Features include compact and accessible construction with drop-down hinged panels, low power consumption and no tubes. The D System can control a total of 50 functions and remotely read 24 meter readings.

F SYSTEM

This new and improved unit is similar to the C System, which has given outstanding service in hundreds of broadcast stations. It too is recommended for single transmitter non-directional stations for which the capacity of ten control functions and nine meter readings is ample.

Remote control system quotations for your particular application can be supplied upon request.

TRANSMISSION LINES

Collins can supply both open wire and coaxial transmission lines. These are available in a range of impedances and power-handling values to meet all commercial broadcast applications.

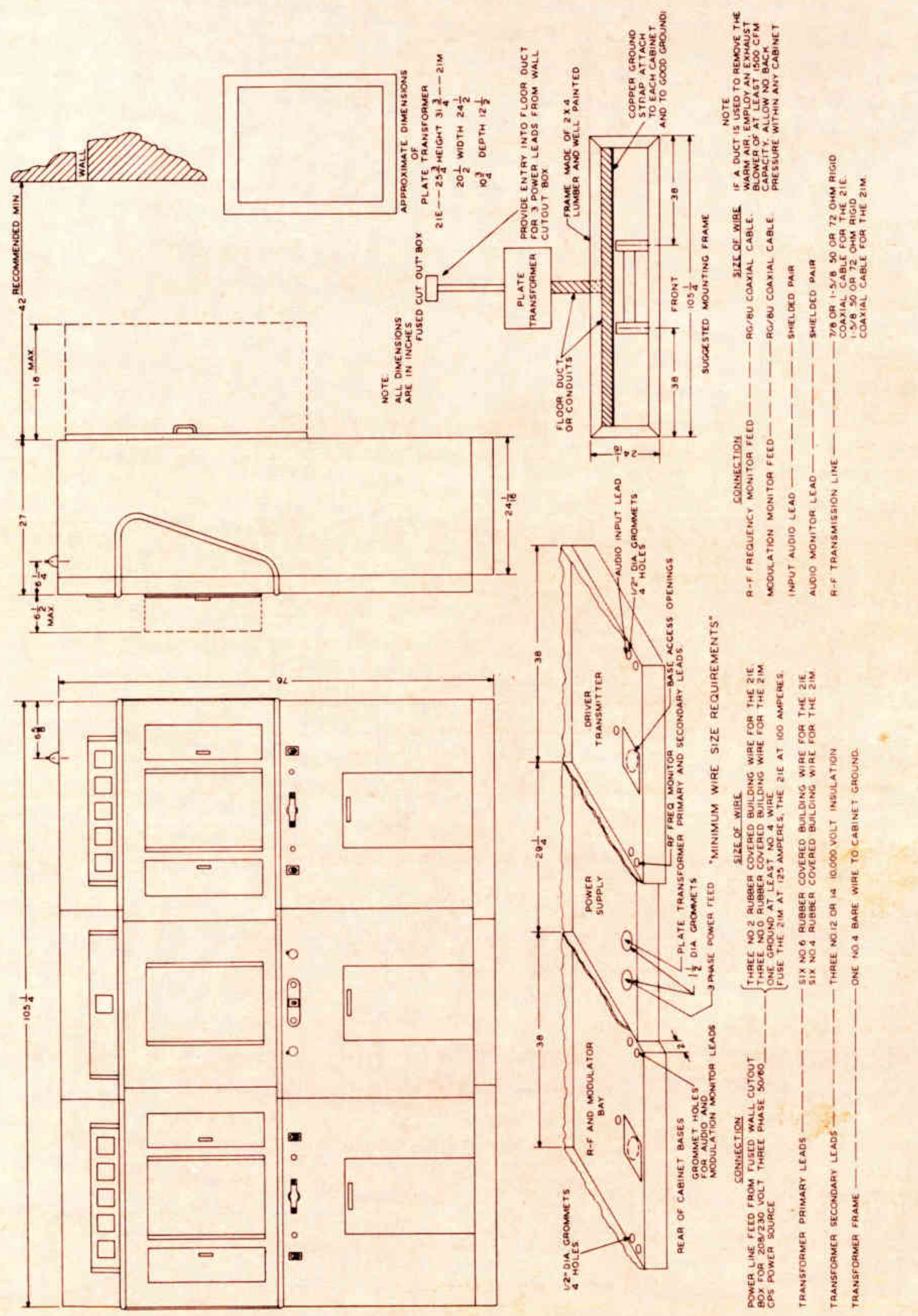
Coaxial lines are offered in flexible, semi-flexible and rigid types. The solid-dielectric, flexible or semi-flexible lines are suitable for powers up to and including five kilowatts. For higher powers, gas or air dielectric rigid lines are recommended.

Prices and detailed specifications for any broadcast application are available upon request.

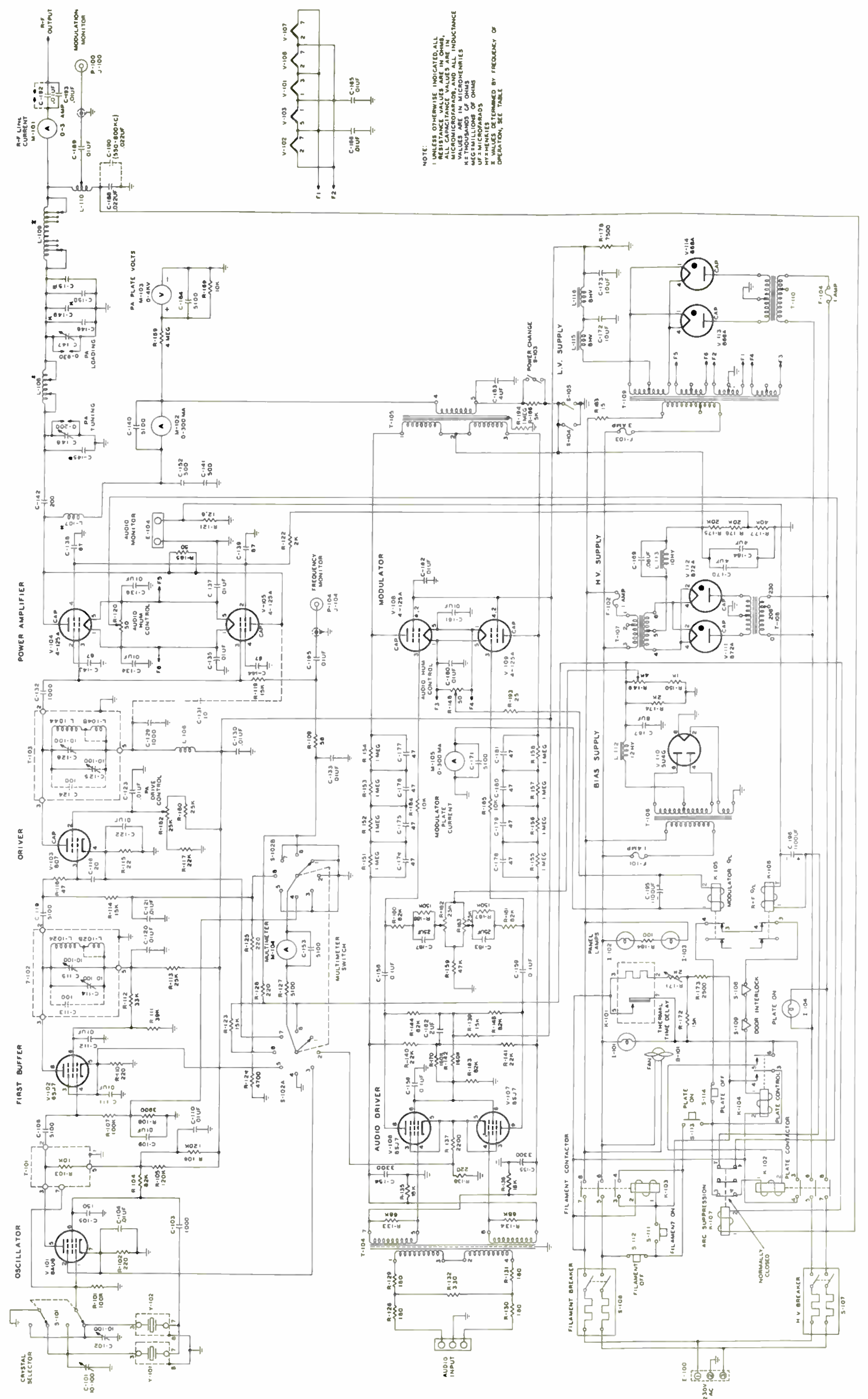
NOTE
1. COMPONENTS MARKED WITH AN ASTERISK(*) ARE CHANGED FOR 10KW OPERATION, OR CHANGE WITH FREQUENCY.
2. COMPONENTS SHOWN WITH BROKEN LINES ARE ADDED FOR 10KW OPERATION.
3. UNLESS OTHERWISE INDICATED ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES ARE IN MICROMICROFARADS.

21 E/M COMPLETE SCHEMATIC

21E/M INSTALLATION DRAWING



300J-2 SCHEMATIC DRAWING



Specifications

300J-2

COMPLETE SCHEMATIC ON PAGE 16

FREQUENCY RANGE: 540-1600 kc standard. Frequencies to 24 mc available.

POWER OUTPUT: Nominal 250/100 watt. (Actual 275/110 watt).

FREQUENCY STABILITY: Better than ±5 cps (Typical — ±2 cps).

AUDIO FREQUENCY RESPONSE: Within ±1½ db from 30 to 12,000 cps. (Typical ±1.5 db from 30-15,000).

AUDIO FREQUENCY DISTORTION: Less than 3% from 50-10,000 cps for 95% modulation, including all harmonics up to 16 kc. (Typical — Less than 3% from 30-15,000).

RESIDUAL NOISE LEVEL: 60 db or more below 100% modulation.

CARRIER SHIFT: Less than 3%, 0-100% modulation (Typical — Less than 2%).

RF OUTPUT IMPEDANCE: 40/600 ohms on order.

AUDIO INPUT IMPEDANCE: 600/150 ohms.

AUDIO INPUT LEVEL: +10 dbm ±2 db, pad input.

AMBIENT TEMPERATURE RANGE: Up to 45° C.

ALTITUDE RANGE: Sea level to 6,000 feet.

POWER SOURCE: 208/230 v, single phase 50/60 cps.

POWER DEMAND:

0% modulation	1,000 watts
30% modulation	1,250 watts
100% modulation	1,400 watts

(90% Power Factor)

WEIGHT: Approximately 900 lbs.

DIMENSIONS: 38″ wide, 76″ high, 27″ deep.

Specifications

550A-1

COMPLETE SCHEMATIC ON PAGE 17

FREQUENCY RANGE: 540-1600 kc standard. Frequencies to 18 mc available.

POWER OUTPUT: Nominal 500/250 watt. Actual 550/275 watt. (550/125 watt on order.)

FREQUENCY STABILITY: Better than ±5 cps. (Typical — Better than ±2 cps).

AUDIO FREQUENCY RESPONSE: Within ±1.5 db from 30 to 12,000 cps. (Typical — ±1.5 db from 30 to 15,000 cps).

AUDIO FREQUENCY DISTORTION: Less than 3% from 50-10,000 cps for 95% modulation, including all harmonics up to 16 kc. (Typical — Less than 3% from 30-15,000).

RESIDUAL NOISE LEVEL: 60 db below 100% modulation.

CARRIER SHIFT: Less than 3%, 0-100% modulation. (Typical — Less than 2%).

RF OUTPUT IMPEDANCE: 40/600 ohms on order.

AUDIO INPUT IMPEDANCE: 150/600 ohms.

AUDIO INPUT LEVEL: +10 dbm ±2 db, pad input.

AMBIENT TEMPERATURE RANGE: Up to 45° C.

ALTITUDE RANGE: Sea level to 6,000 feet.

POWER SOURCE: 208/230 v, single phase 50/60 cps.

POWER DEMAND (at 550 watts output):

0% modulation	2300 watts
30% modulation	2370 watts
100% modulation	2840 watts

(83% Power Factor)

WEIGHT: Approximately 1,050 lbs.

DIMENSIONS: 38″ wide, 76″ high, 27″ deep.

Specifications

20V-2

COMPLETE SCHEMATIC ON PAGE 18

FREQUENCY RANGE: 540-1600 kc standard. Frequencies to 18 mc available.

POWER OUTPUT: Nominal 1,000/500 watt. Actual 1100/550 watt. (1100/275 Watt on order)

FREQUENCY STABILITY: Better than ±5 cps (Typical — Better than ±2 cps).

AUDIO FREQUENCY RESPONSE: Within ±1.5 db from 30 to 12,000 cps. (Typical — ±1.5db from 30 to 15,000 cps).

AUDIO FREQUENCY DISTORTION: Less than 3% from 50-10,000 for 95% modulation, including all harmonics up to 16 kc. (Typical — Less than 3% from 30-15,000).

RESIDUAL NOISE LEVEL: 60 db or better below 100% modulation.

CARRIER SHIFT: Less than 3%, 0-100% modulation. (Typical — Less than 2%).

RF OUTPUT IMPEDANCE: 40/600 ohms on order.

AUDIO INPUT IMPEDANCE: 150/600 ohms.

AUDIO INPUT LEVEL: ±10 dbm ±2 db, pad input.

AMBIENT TEMPERATURE RANGE: Up to 45° C.

ALTITUDE RANGE: Sea level to 6,000 feet.

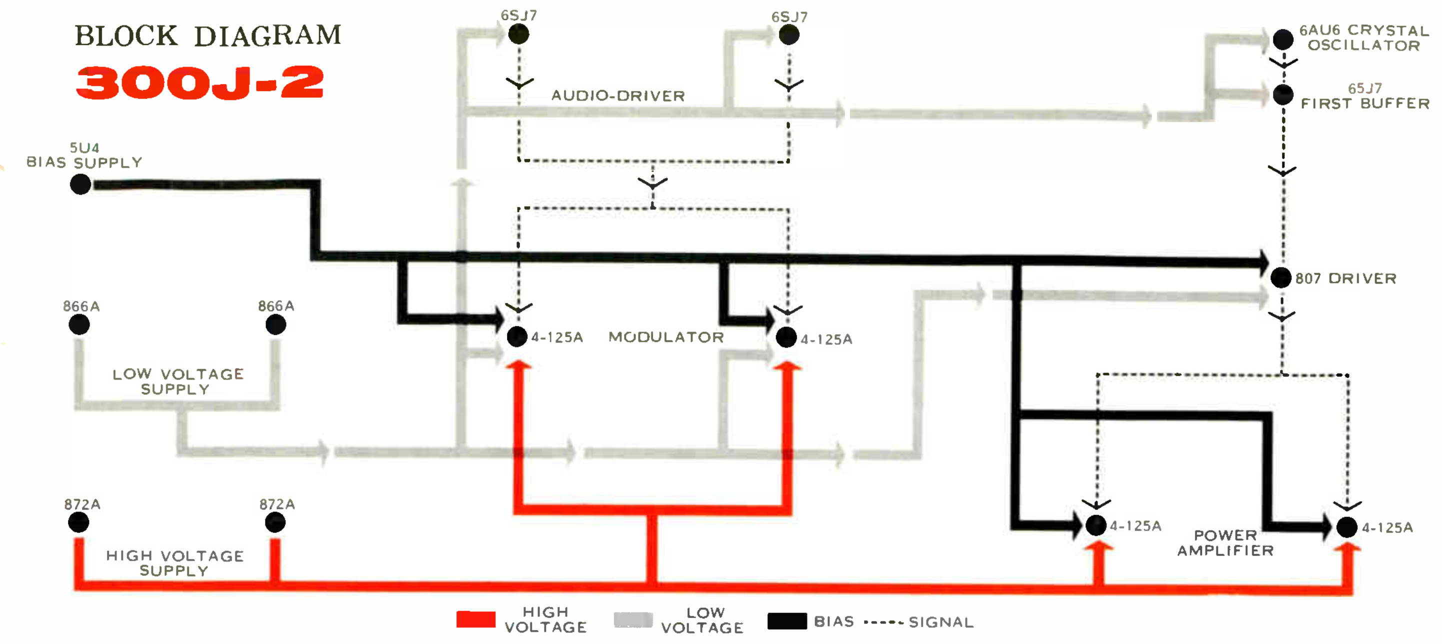
POWER SOURCE: 208/230v, single phase 50/60 cps.

0% modulation	2950 watts
30% modulation	3250 watts
100% modulation	4150 watts

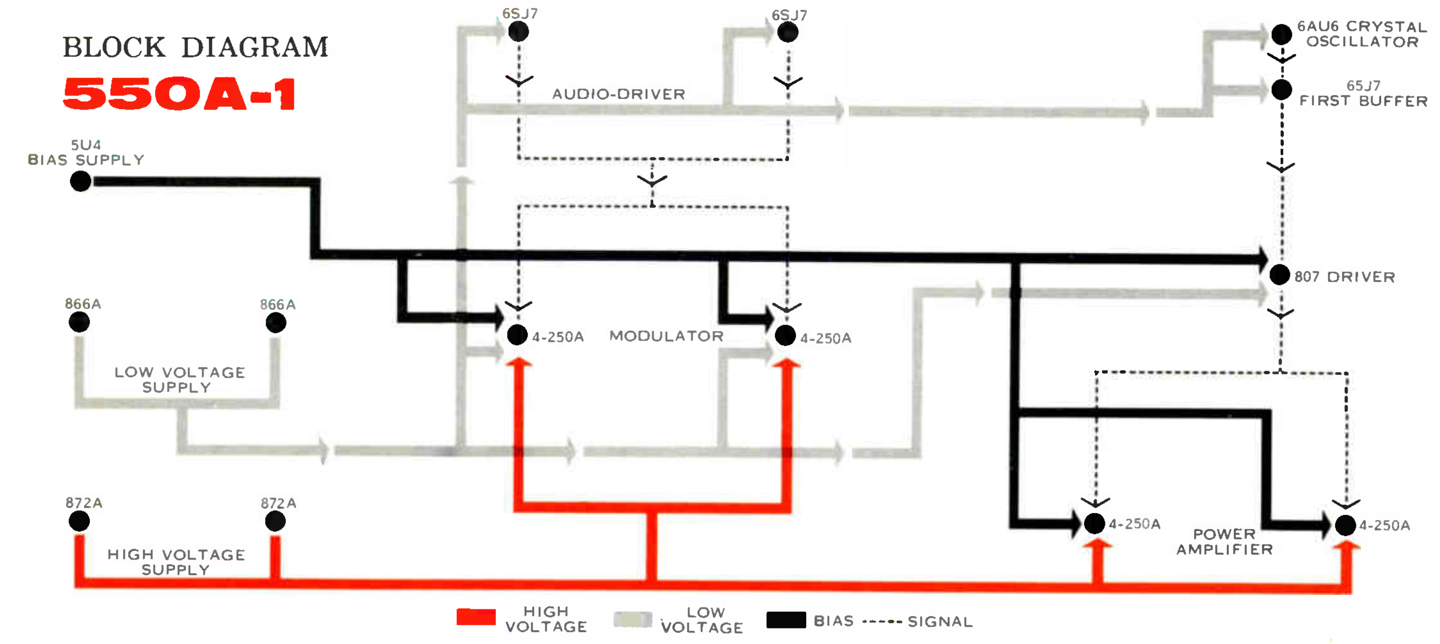
WEIGHT: Approximately 1,150 lbs.

DIMENSIONS: 38″ wide, 76″ high, 27″ deep.

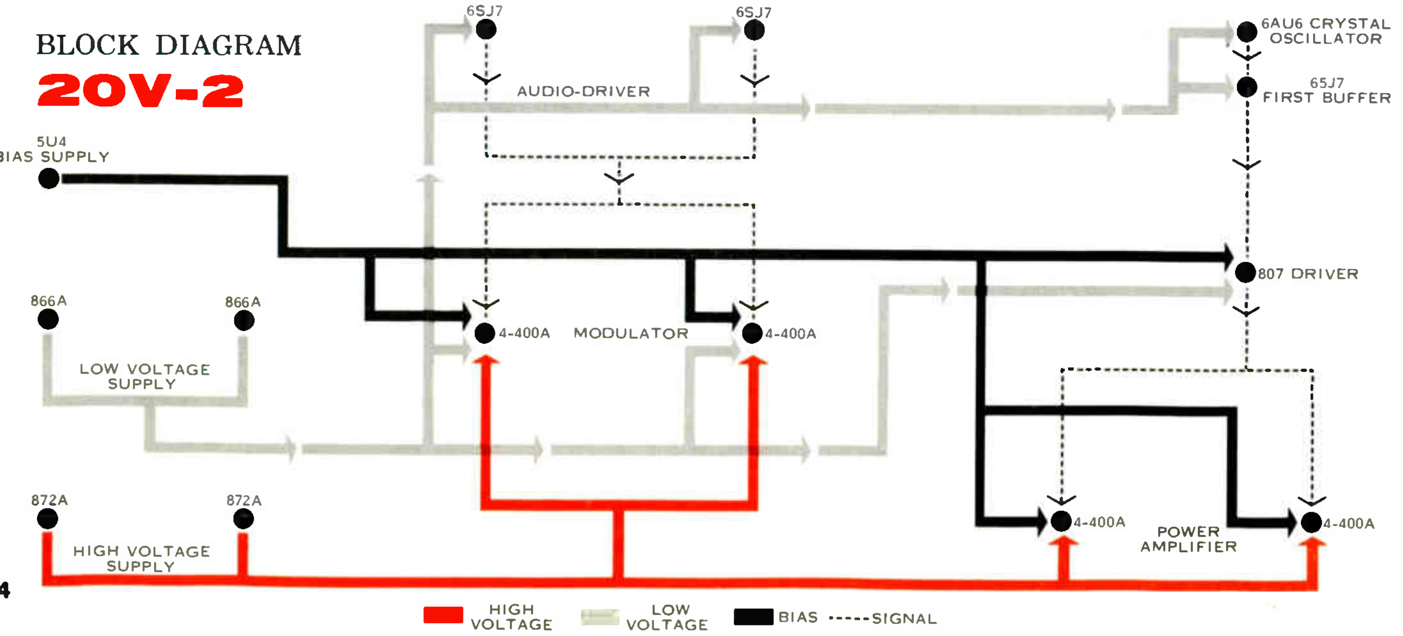
BLOCK DIAGRAM
300J-2



BLOCK DIAGRAM
550A-1

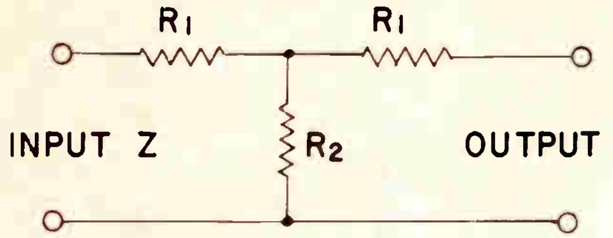


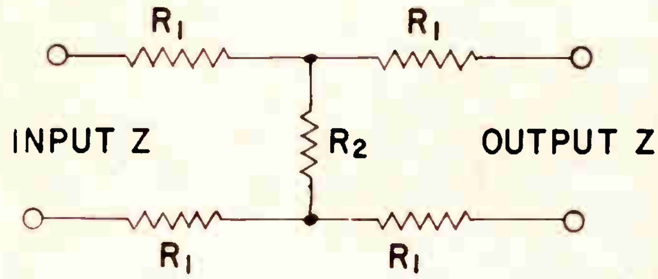
BLOCK DIAGRAM
20V-2



ATTENUATOR NETWORK

Input and Output Z=600 Ohms

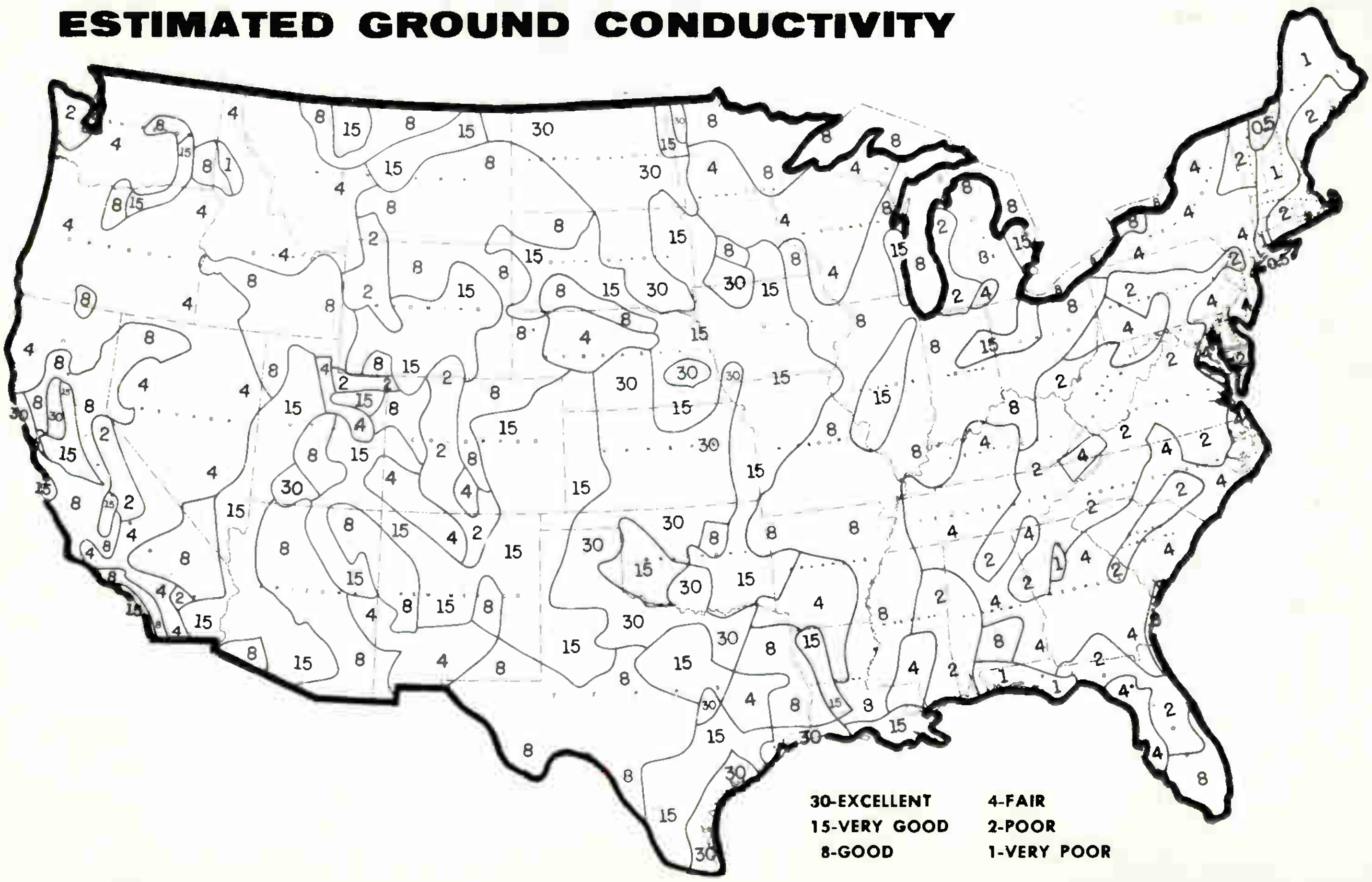


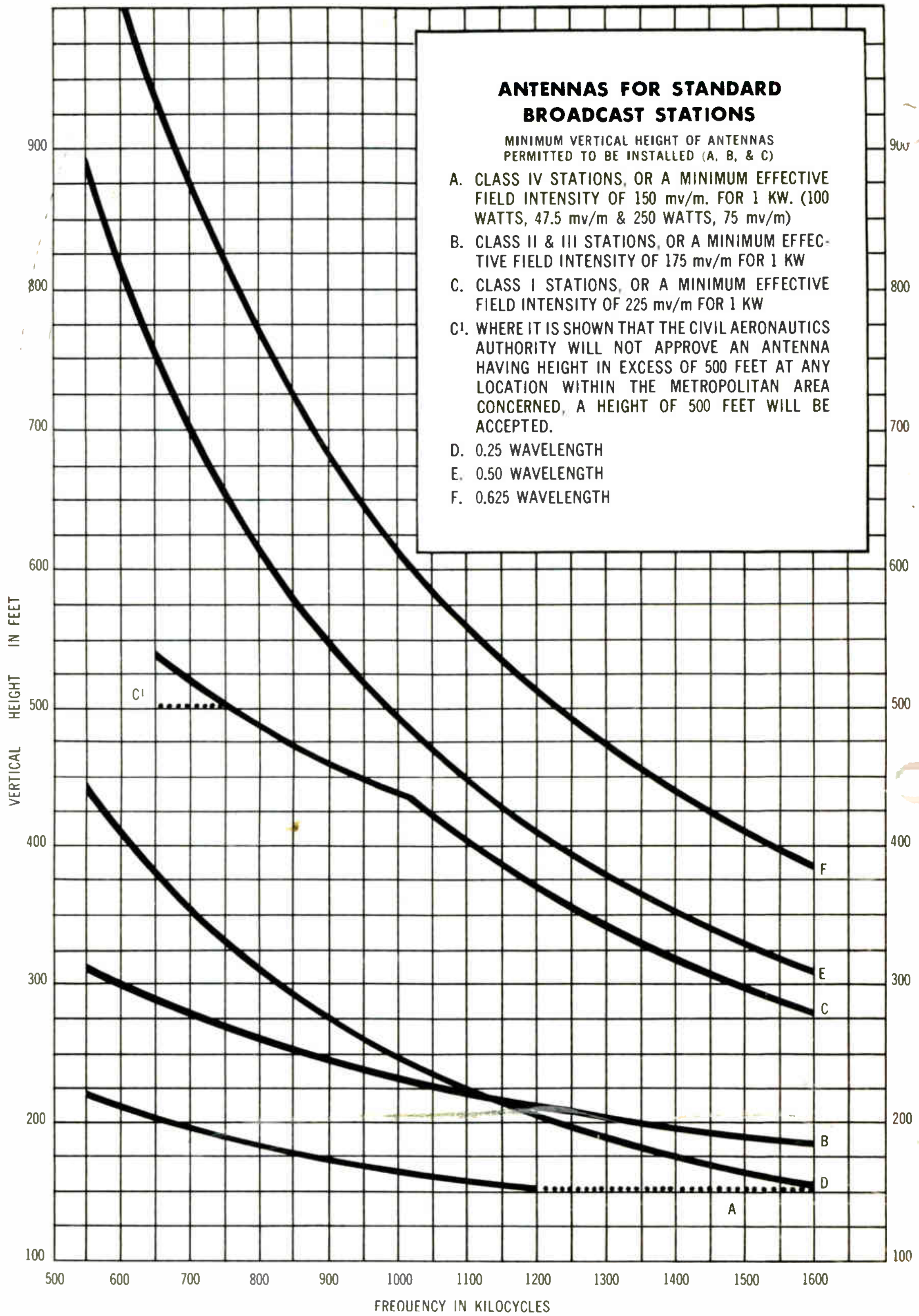


DB LOSS	R_1	R_2	DB LOSS	R_1	R_2
0.5	17.2	10464	16	435.8	195.1
1	34.5	5208	17	451.5	172.9
2	68.8	2582	18	465.8	152.5
3	102.7	1703	19	479.0	136.4
4	135.8	1249	20	490.4	121.2
5	168.1	987.6	22	511.7	95.9
6	199.3	803.4	24	528.8	76.0
7	229.7	685.2	26	542.7	60.3
8	258.4	567.6	28	541.1	47.8
9	285.8	487.2	30	563.0	38.0
10	312.0	421.6	32	570.6	30.2
11	336.1	367.4	34	576.5	24.0
12	359.1	321.7	36	581.1	19.0
13	380.5	282.8	38	585.1	15.1
14	400.4	249.4	40	588.1	12.0
15	418.8	220.4			

DB LOSS	R_1	R_2	DB LOSS	R_1	R_2
0.5	8.6	10464	16	217.9	195.1
1	17.25	5208	17	225.7	172.9
2	34.4	2582	18	232.9	152.5
3	51.3	1703	19	239.5	136.4
4	67.9	1249	20	245.2	121.2
5	84.1	987.6	22	255.9	95.9
6	99.7	803.4	24	264.4	76.0
7	114.8	685.2	26	271.4	60.3
8	129.2	567.6	28	277.0	47.8
9	142.9	487.2	30	281.6	38.0
10	156.0	421.6	32	285.3	30.2
11	168.1	367.4	34	288.3	24.0
12	179.5	321.7	36	290.6	19.0
13	190.3	282.8	38	292.5	15.1
14	200.2	249.4	40	294.1	12.0
15	209.4	220.4			

ESTIMATED GROUND CONDUCTIVITY





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