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Standard Broadcast Transmitters

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The most recent decade has probably witnessed more dramatic and unusual changes in AM transmitters than has occurred during the four past decades of AM Broadcasting. It is the intent of this chapter to present as much factual information as possible on the more important changes. Specific examples of these advanced designs with respective benefits will be discussed.

The following are some of the most impressive innovations found in transmitters presently being delivered by transmitter manufacturers.

Transistors

The use of transistors as important functional elements has increased in AM transmitters. This trend is certain to continue. Compared to tubes, transistors have inherent advantages of higher reliability, more linear operating characteristic, low power consumption, and reduced extraneous circuit elements which makes them desirable for audio and RF circuits.

High Plate Efficiency Circuitry

This method of increasing plate conversion efficiency is presently used by two manufacturers and is proving an important innovation from the standpoint of longer tube life and increased modulation capability.

Askarel Filled Modulation Transformers

Within the last few years, several transmitter manufacturers have employed Askarel filled modulation transformers virtually eliminating modulation transformer failures. While there is nothing new about Askarel filled modulation transformers, it is included in this discussion of advances because its use provides all of the advantages of an oil filled transformer without eliminating many of the advantages of a dry type. Its size is very nearly the same as the dry type because it takes advantage of many of this decade's improvements in insulating materials.

Pulse Duration Modulation

A modulation technique which develops the audio power required to modulate a conventional Class C RF amplifier by recovering the audio signal from a pulse train whose duty cycle varies with the amplitude of the modulating signal. The technique allows utilization of high efficiency Class D service for the modulator versus low efficiency linear service as employed in conventional high level modulators.

Progressive Series Modulation

A high efficiency form of series modulation which includes two active pass elements in series with the RF amplifier stage. One pass element provides positive peak modulation, while the other modulates the RF in the negative direction. The technique requires no modulation transformer or reactor and no filter reactor. The technique is particularly applicable in solid-state transmitters to amplitude modulate Class D solid-state power amplifiers.

MODULATION SYSTEMS

The following types of modulation systems are employed in broadcast transmitters at this time. They are considered separately from discussions of respective transmitters so the transmitters themselves may be evaluated on their individual merits without the confusion of simultaneously evaluating modulation systems.

Screen Grid Modulation

In this method the screen grid potential of tetrode PA tubes is varied with the modulating signal by direct coupling of the modulator stage to the screen grid.

Screen grid modulation is also called Efficiency Modulation because the conversion efficiency of the modulated PA stage varies with the modulation. At carrier conditions where the plate voltage swing is only one-half maximum the conversion efficiency is 33 percent whereas at 100 percent modulation, the plate voltage swing is maximum and the efficiency is approximately 80 percent or which is comparable to the conversion efficiency of a Class C amplifier.

The advantages of Screen Grid Modulation are low audio power requirements, no large audio transformers or reactor, and capability for addition of overall feedback to the modulated stage for improved fidelity.

Phase to Amplitude Modulation

In this system, the phase of the RF signal is modulated with the audio signal at low levels to two similar amplifier chains in such a manner that when the phase is advancing in one chain, it is retarding in the other. The resultant outputs then are combined in the load to produce an amplitude modulated signal.

At carrier level, the phase of the outputs of the two RF channels are adjusted 135° out of phase. During modulation the phase shift of both amplifier chains are linearly varied with the modulation signal plus and minus 22½° above and below the carrier condition, but in opposite direction from each other. If the amplitudes are equal, then at 100 percent negative modulation the two chains are 180° different in phase and therefore cancel. Similarly, on 100 percent positive peaks the two chains are 90° apart in phase.

Because of the shifting phase relationship between the two output tubes, the load impedance of each tube varies widely during modulation. In order to maintain reasonably constant efficiency of the modulation cycle, the RF driver stages of the two amplifier chains are also modulated.

Conventional Methods

The most common modulation system is still high-level plate modulation. Few changes have occurred in these tried and tested systems except for the use of pulse duration modulation. Increasing emphasis is being placed on positive modulation percentages greater than 100 percent. One hundred percent negative amplitude modulation peak is when the carrier amplitude becomes zero. Positive peak modulation is then reference to negative peaks so that 100 percent positive peak modulation occurs when the positive excursion of the modulation signal equals the negative excursion at 100 percent. Consequently, any positive excursion greater than the negative swing is defined to be more than 100 percent positive modulation.

Note: Modulation percentage relates to carrier amplitude at the instant of modulation. This means that any percentage of modulation applied to the positive swing of the carrier must consider the carrier shift present at that instant. For example, if a transmitter modulating 100 percent on negative peaks had a 5 percent carrier shift, then 100 percent positive peaks would indicate only 90 percent when referred to the carrier amplitude before modulation occurred.

Pulse Duration Modulation (PDM)

The simultaneous requirement for low cost, broad frequency response, low distortion and high efficiency has resulted in a modulation system which utilizes a new approach for obtaining the audio power for high level plate modulation. The new modulation system (PDM) obtains its improved performance by operating a modulator tube in series with an RF power tube. High efficiency is obtained by operating the modulator tube in a saturated switching mode, or Class D.

The amplitude of the audio signal is determined by the percentage of time the modulator tube is conducting (duty cycle). The tube current is a square wave function whose duty cycle (pulse width) is varied as a function of audio amplitude. A 70 kHz square wave is presently used in one system.

The fundamental component of the square wave is filtered leaving the amplified audio and a dc component which is the modulated plate voltage for a Class C final amplifier.

Progressive Series Modulation (PSM)

In solid-state AM transmitters the use of series modulators is attractive due to their simplicity and the ability to divide the modulation circuitry into sections to be used with similarly divided RF amplifier modules. In addition, a series modulator can be designed that is dc coupled, yielding improved transient response, automatic power control, and the ability to change between two operating powers without carrier interruption.

To improve the efficiency of the technique, two pass elements are used instead of one. One element modulates the carrier in the negative direction, the other in the positive direction. This reduces the time that each pass element is conducting and thus reduces the power dissipated in each device. During carrier conditions, for example, only one device conducts, supplying a lower voltage to the RF amplifier. The other device is in a quiescent state and only conducts during positive modulation conditions that require higher applied voltage.

The result of this technique is the simplicity of Class B modulation, the performance of a simple series modulator and good efficiency.

CONTINENTAL ELECTRONICS 317C 50 kw TRANSMITTER

The 317C transmitter employing tetrodes, 4CX35000C, in both the carrier and peak tube positions with screen modulation of both tubes results in a highly efficient transmitter.

A 90° phase lag network connects the plates of the two PA tubes together and a similar arrangement is used on the grids. One tube supplies all of the power output for carrier conditions while the second tube becomes operative only to supply peak power during positive modulation. Both tubes operate in a Class C mode. A positive bias is applied to the screen of the carrier tube and a small negative bias to the screen of the "peak" tube. In this way the "carrier" tube is modulated negatively during the negative half of the modulation cycle, while the "peak" tube is modulated upward during the positive half of the modulating cycle.

Plate voltage does not increase with positive modulation so a higher plate voltage than usual, 16 kv, is used to increase plate efficiency. The high efficiency of the PA plus the low modulating power required results in a high overall efficiency for the 317C. See Table 1.

The Continental 50 kw transmitter is self-contained except for a housing which contains the high voltage plate transformer, a Wye-Delta switch, and a plate voltage regulator.

A simplified schematic of the 317C transmitter is shown in Fig. 2.

Fig. 1. Front view of the Continental 317C 50 kw Transmitter (Courtesy Continental Electronics Co.).

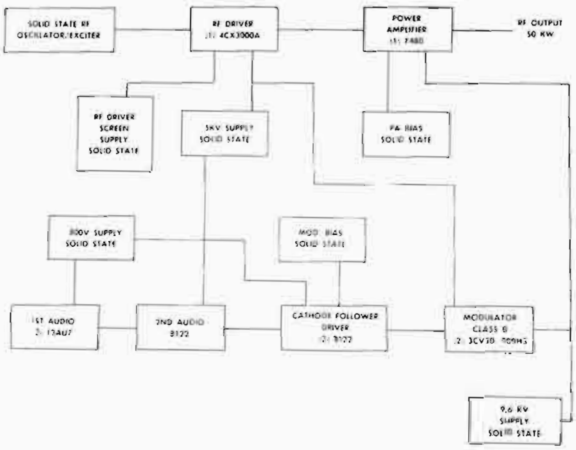

Fig. 2. Simplified schematic Continental 317C Transmitter (Courtesy Continental Electronics Co.).

HARRIS MW-50 TRANSMITTER

The Harris MW-50 transmitter features high level plate modulation employing pulse duration modulation (PDM). The transmitter is air cooled and uses only 5 tubes and is self contained in two cubicles with the exception of external high voltage power supply.

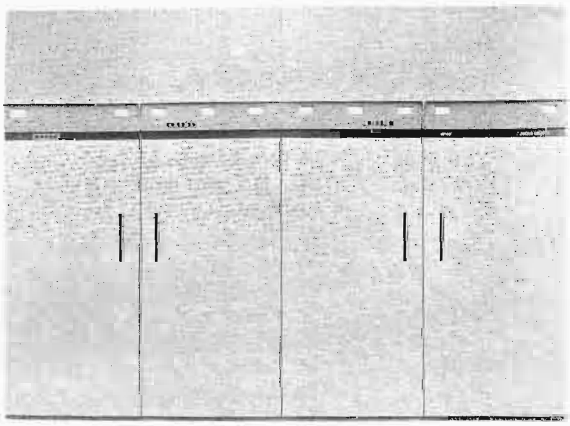

Fig. 3. Front view Gates VP-50 50 kw Transmitter (Courtesy Gates Radio Co.).

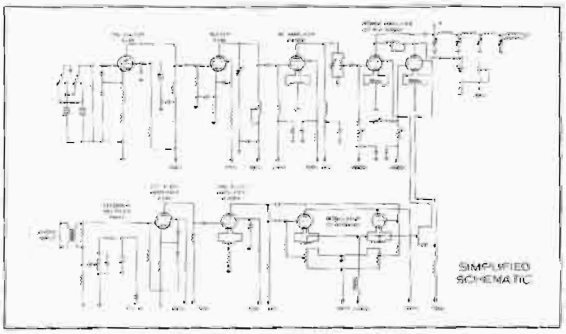

Fig. 4. Block diagram-Gates VP-50 Medium Wave Transmitter (Courtesy Gates Radio Co.).

The RF power amplifier employs a 4CX35000 operating Class C and is modulated by audio voltages developed by another 4CX35000 operating in Class D switching mode as a pulse amplifier.

The modulation method employed allows reproduction of complex modulation waveforms representative of highly-processed audio.

The modulator driver and RF driver tubes are 4CX1500A's. All lower level stages are solid state.

Control and protective circuits limit plate voltage applied to the RF power amplifier during an overload condition to 10 milliseconds duration and provide fault indication. VSWR protection and metering is employed.

A block diagram is shown in Fig. 4.

THE RCA BTA-50H1 TRANSMITTER

This 50 kw broadcast transmitter uses the phase-to-amplitude modulation system called "Ampliphase" by RCA. It is an air-cooled transmitter using 6697 tubes in the final of each 25 kw RF amplifier chain. The RF chains each share a common oscillator using an 807 tube which drives a variable resistance type of phase modulator.

A drive regulator samples the audio signal, amplifies and couples it to the grids of the second IPA stage. It consists of two 6A67s and four 807 tubes. It varies the drive to the final amplifiers to assure maximum plate efficiency over the complete audio cycle and contributes to overall linearity.

Fig. 5. Front view of the RCA BTA-50H1 50 kw Transmitter (Courtesy RCA Broadcast Products Division).

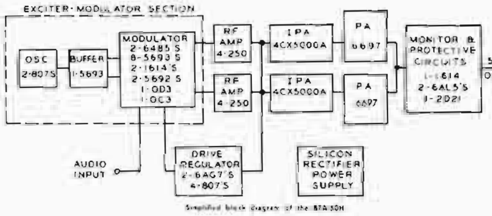

Fig. 6. Simplified Block diagram RCA BTA-50H1 Transmitter (Courtesy RCA Broadcast Products Division).

TABLE 1

Specifications of 50 kw Transmitters

	Continental 317C	RCA BTA-50H1	Gates MW-50
Physical Data			
Height	78"	84"	78"
Width	144"	181"	144"
Depth	54"	63"	48"
Weight	6600 lbs.	12000 lbs.	6445 lbs.
PA Tubes	(2)4CX35000C	(2)6697	(1)4CX35000C
Type of Modulation	Screen Grid	Phase to Amplitude	Pulse Duration
Type of Cooling	Forced Air	Forced Air	Forced Air
Power Consumption			
0% Mod	82 kw	94 kw	80 kw
AVG% Mod	92 kw	100 kw	87 kw
100% Mod	120 kw	130 kw	110 kw
Performance			
A.F. Response	±1.5dB 30–10K	±1.5dB 30–10K	±1.5dB 30–10K
A.F. Dist.	3%	3%	3%
A.F. Noise	−60 dB	−60 dB	−60 dB
Carrier Shift	Less than 3%	Less than 5%	Less than 2%
VSWR Protection	Yes	Yes	Yes
External Components	Power Transformer	Wall mounted Switch gear and Dist. Transformer Plate Transf.	H.V. Power Supply Wall mounted Circuit Breaker

Control circuits in the BTA-50H1 provide a choice of single button or step by step starting, automatic timing and sequencing of starting operations. Fault location is provided by indicating flags on each of the overload relays plus a system of lamps to indicate the status of the interlocks. A reflectometer is provided to protect the transmitter against abnormal loads.

An installation consists of four cubicles making up the main transmitter, wall mounting switch gear, and three high voltage plate transformers.

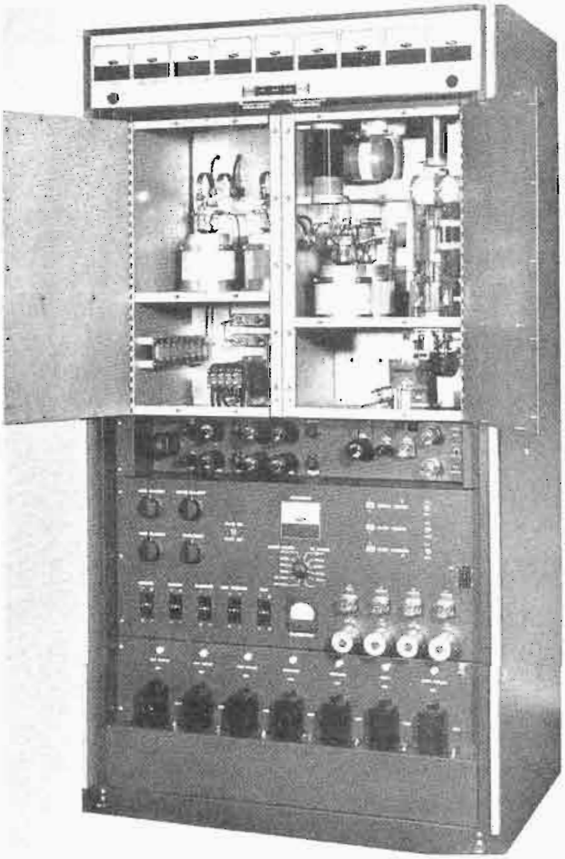

Fig. 7. Front view AEL AM-15KA 15 kw Transmitter with doors open (Courtesy American Electronic Laboratories, Inc.).

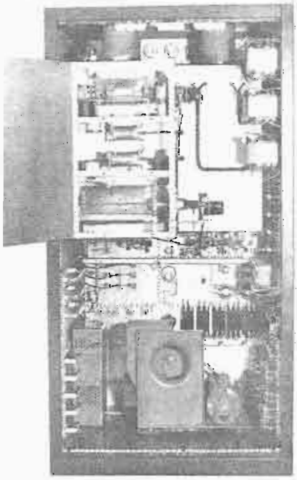

Fig. 8. Rear view AEL AM-5KA 5 kw Transmitter with door removed (Courtesy American Electronic Laboratories, Inc.).

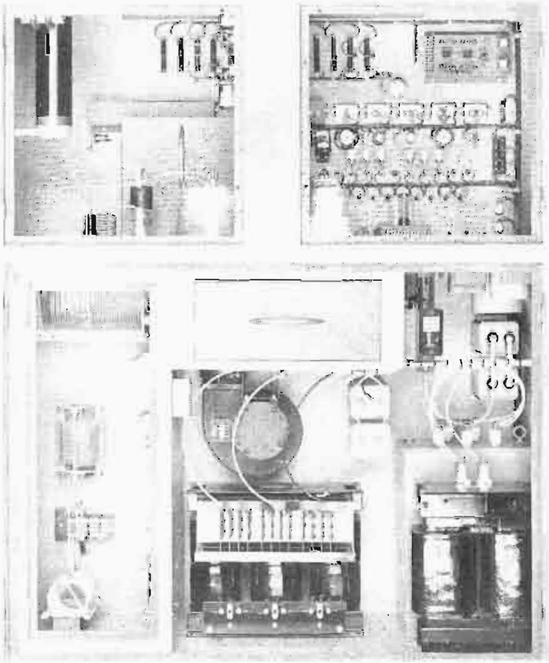

Fig. 9. Rear view Model FB-10J Bauer.

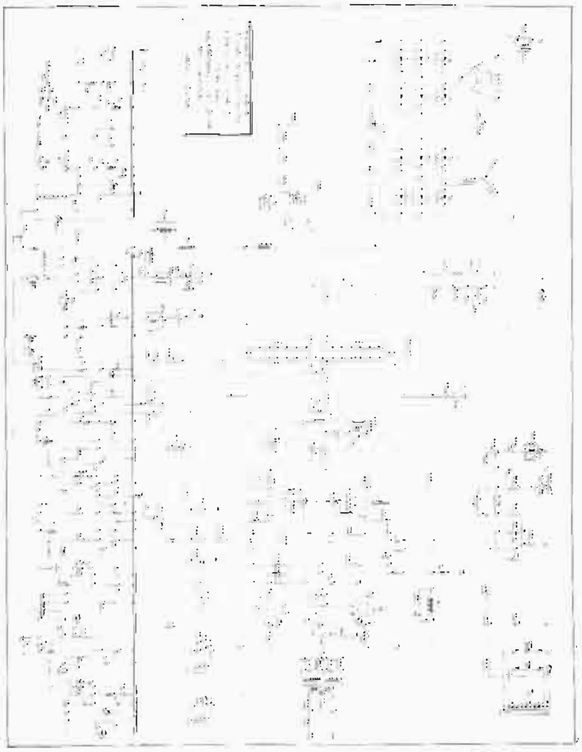

Fig. 10. Simplified schematic Bauer FB-10J Transmitter.

5 AND 10 kw TRANSMITTERS

Presently there are several (6-8) manufacturers of 5 and 10 kw AM transmitters. Of these, six maufacturers make a single transmitter adding only a second PA tube to produce a 10 kw transmitter from a 5 kw unit. CCA and Visual use different types of tubes for the PA and modulators in their 10 kw transmitter than in their 5 kw unit. All manufacturers use silicon rectifiers in their power supplies.

Six 5 kw transmitters are self-contained, while AEL and Visual place their high voltage power supply and heavy iron cored components in a separate container. RCA has an externally mounted plate transformer for their 10 kw transmitter.

Five manufacturers use tubes throughout except for the power supply rectifiers. Collins uses solid state circuitry up to the RF driver of the final amplifier and solid state audio stages up to the modulators. The Continental and Harris 5 and 10 kw transmitters provide VSWR protection. Power reduction facilities are included in the CCA, Collins, and Harris transmitters.

The Harris 5 kw transmitter employs pulse duration modulation and incorporates only two tubes in the design. The transmitter features built-in power supplies and high efficiency.

Fig. 11. CCA AM5000D 5 kw Transmitter (Courtesy CCA Electronics Corp.).

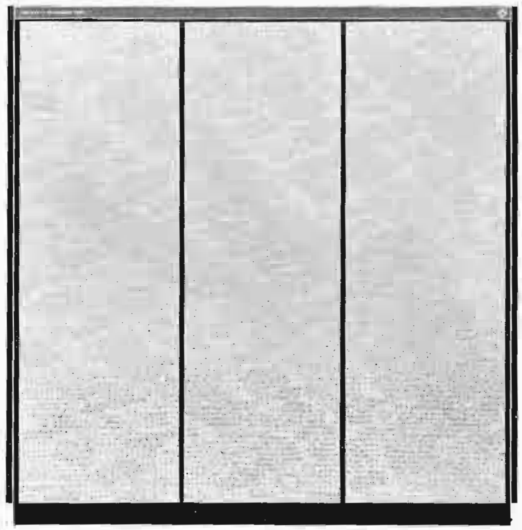

Fig. 13. Collins 830E-1 front view.

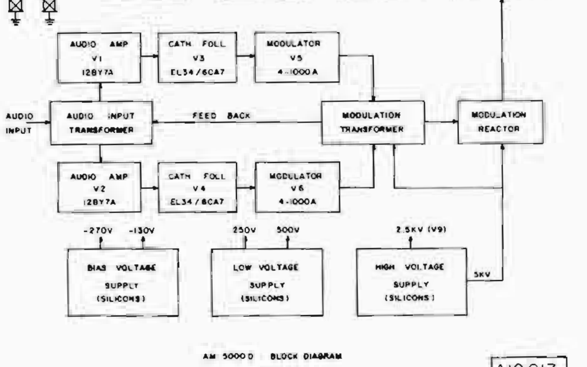

Fig. 12. CCA AN15000D block diagram.

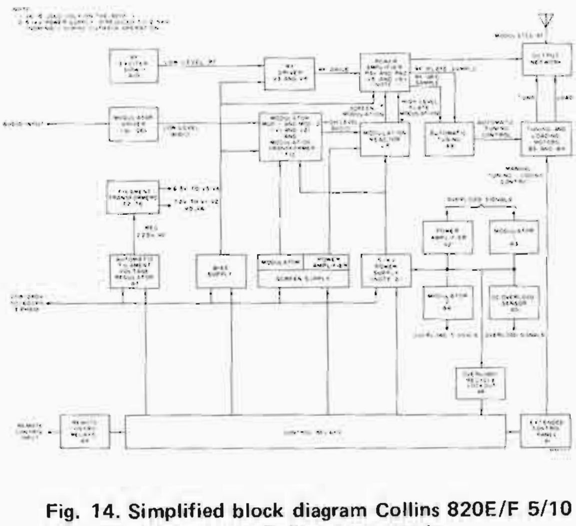

Fig. 14. Simplified block diagram Collins 820E/F 5/10 kw Transmitter (Courtesy Collins Radio Co.).

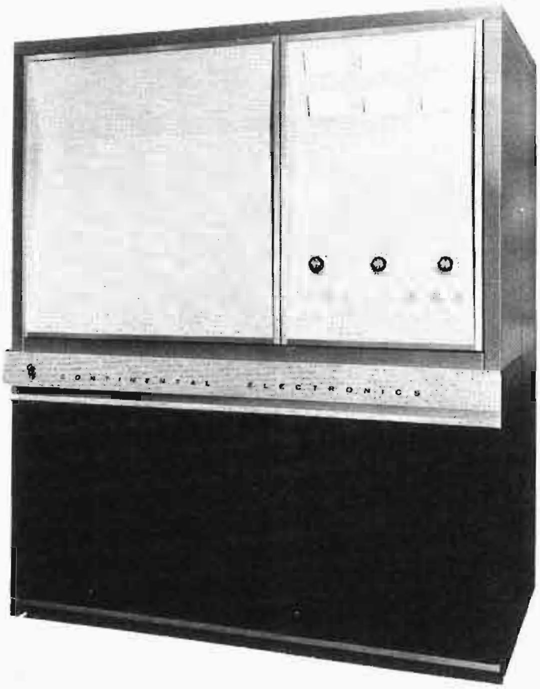

Fig. 15. Front view of the Continental 315C/316C 5 or 10 kw Transmitter (Courtesy Continental Electronics Mfg. Co.).

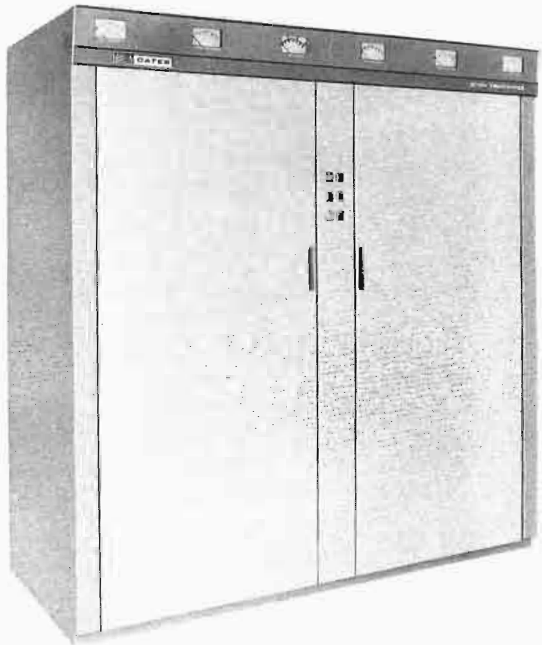

Fig. 17. Front view of the Gates BC10H kw Transmitter (Courtesy Gates Radio Co.).

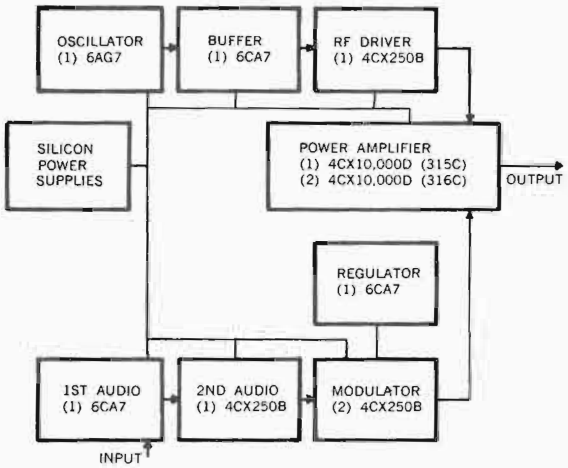

Fig. 16. Continental electronics Type 315C and 316C 5 and 10 kw Transmitters.

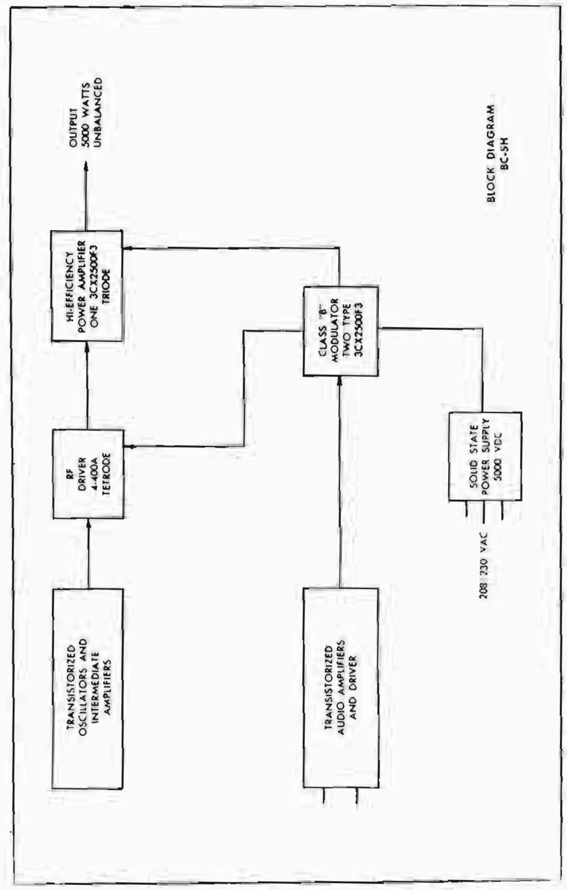

Fig. 18. Block diagram of the Gates BC-5H 5 kw Transmitter (Courtesy Gates Radio Co.).

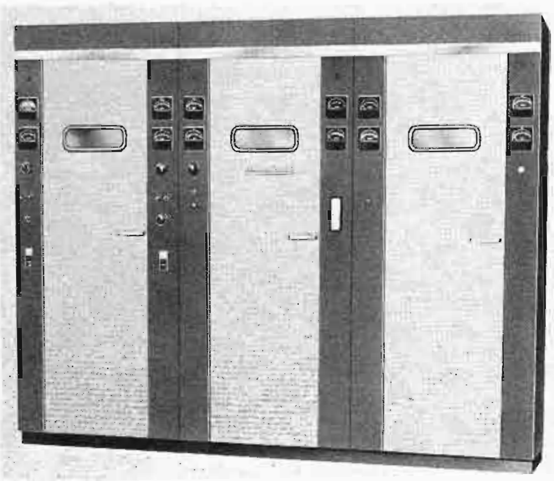

Fig. 19. Front view RCA BTA 5U1/10U1 5 or 10 kw Transmitter (Courtesy RCA Broadcast Equipment Division).

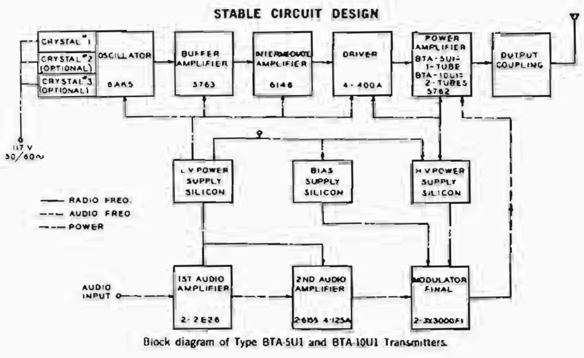

Fig. 20. Collins 820E/F1 Automatic Tuning simplified Schematic.

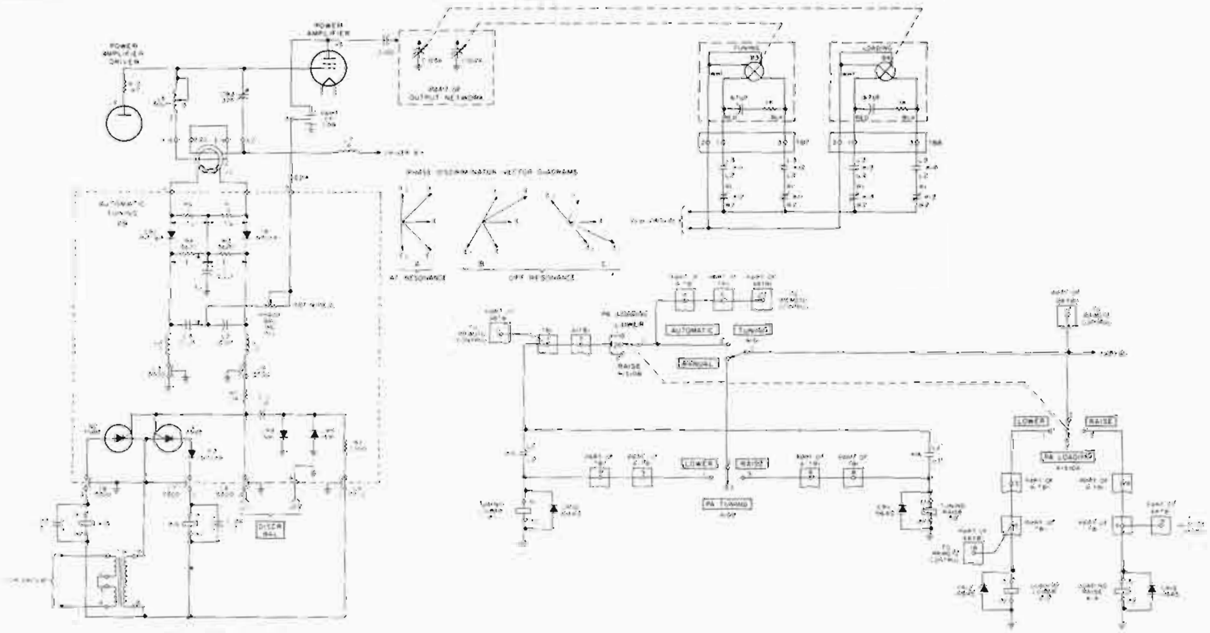

Fig. 21. Simplified schematic of a Collins automatic tuning (Courtesy Collins Radio Co.).

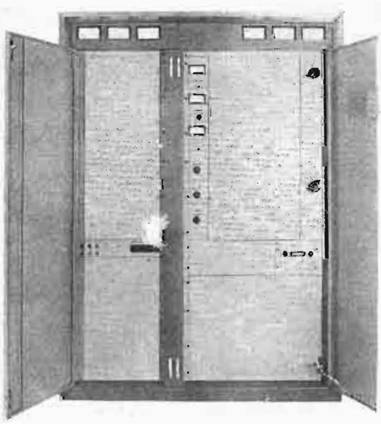

Fig. 22. Visual AM-5K-A 5 kw Transmitter (Courtesy Visual Electronics Corp.).

1000 WATT TRANSMITTERS

All 1 kw transmitters are self-contained with power reduction to either 500 watts or 250 watts as a standard feature except Visual, which accomplishes power cutback with an add-on kit. All use silicon rectifier power supplies. AEL, Bauer, Harris, and Visual provide a built-in dummy antenna. AEL, Bauer, and Collins regulate the filament voltages. Harris and RCA use bilevel modulation to improve carrier shift of their tube-type transmitters.

The Harris solid-state transmitter employs Progressive Series Modulation (PSM), which requires no modulation transformer, reactor, or filter inductor and is dc coupled.

TABLE 2

Specifications of 5 kw Transmitters

Data	AEL AM-5KA	Sparta FB-5J	CCA 5000D	Collins 820E-1	Continental 315C	RCA BTA5L1	Harris MW-5
Physical Data							
Height	76"	75"	76"	69"	78"	77"	78"
Width	57"	60"	68"	67½"	66"	70"	72"
Depth	33"	29"	32"	32"	34"	32"	32"
Weight	1500 lbs.	2000 lbs.	3500 lbs.	2000 lbs.	1900 lbs.	2500 lbs.	1250 lbs.
PA Tubes	7237	4CX5000A	3CX2500F3	4CX5000A	4CX10000	3CX5000H3(2)	3CX2500F3
Type of Mod.	Hi-Level	Hi-Level	Hi-Level	Hi-Level	Screen-Gnd	Phase to Amplitude	PDM
Power Consumption							
0% Mod	12 kw	10.6 kw	Not listed			12 kw	9.4 kVA
Avg% Mod	15 kw	12.0 kw	Not listed				
100% Mod	18 kw	15.5 kw	14.0 kw	18.5 kw	16.5 kw	18 kw	13.0 kVA
A.F. Response	±1.5 dB 50–10K	±1.5 dB 30–12K	1.5 dB 30–10K	±1.5 dB 50–10K	±1.5 dB 30–12K	±1.5 dB 30–15K	±1.0 20–10K
A.F. Distortion	2.5%	3%	2%	3%	2.5%	2.0%	2.0%
A.F. Noise	−55 dB	−60 dB	−55 dB	−60 dB	−60 dB	−60 dB	−60 dB
Carrier Shift	2%	3%	3%	3%	2%	3%	2%
External Components							

TABLE 3

Specifications of 10 kw Transmitters

	AEL AM-10KA	Bauer FB-10J	CCA AM-1000D	Collins 820F-1	Continental 316C	Gates BC10H	RCA BTA10U1	Visual AM-10K-A
Tubes Used								
Osc	12BY7A	12BY7A	12BY7A	Solid State	6AG7	Solid State	6AK5	12BY7A
1st R.F.	6146	12BY7A	6146		6AG7		5763	6146
2nd R.F.		12BY7A					6146	
3rd R.F.	4-400A	8236	4-400A	6146B(2)	4CX250B	4-400	4-400	4-400
Power Amplifier	7237(2)	4CX15000A	3CX10000A3	4CX5000A(2)	4CX10000D(2)	3CX2500F3(2)	5762(2)	3CX10000A3
1st A.F.	12BY7A(2)	EL-34(2)	6CA7(2)	Solid State	6CA7	Solid State	2E26(2)	6146(2)
2nd A.F.	6146(2) 6CB5(4)				4CX250B		4-125A(2)	
Modulator	7237(2)	4CX5000A(2)	4CX3000(2)	4CX5000A(2)	4CX250B(2)	3CX250UF3(2)	3X3000F1(2)	4CX5000A(2)
Physical Data								
Height	76"	75"	76"	69"	78"	78"	88"	76"
Width	40"	60"	68"	69"	66"	72"	116"	57"
Depth	33"	29"	32"	67-7/16"	34"	32"	32"	33"
Weight		2500 lbs.	4000 lbs.	2450 lbs.	2150 lbs.	2500 lbs.	5300 lbs.	1600
Power Consump.								
0% Mod	19 kw	19 kw	Not listed	Not listed	Not listed	18.5 kw	17.5 kw	18.9 kw
Avg% Mod	23 kw	22 kw				21.0 kw	21.0 kw	22.5 kw
100% Mod	31 kw	27 kw	28 kw	32.0 kw	30 kw	27.5 kw	26.0 kw	25.0 kw
Power Cutback	+ Accessory	+ Accessory	Included	Included	+ Accessory	Yes	+ Accessory	+ Accessory
VSWR Protect.	No	No	No	No	No	Yes	No	No
Bi Level Mod	No	No	No	No	Yes	Yes	No	No
A.F. Response	±2.0 dB 40-12K	±1.5 dB 30-12K	±1.5 dB 30-10K	±1.5 dB 50-10K	±1.5 dB	±1.5 dB 30-12K	±1.5 dB 30-10K	±1.5 dB 50-10K
A.F. Dist.	2.5%	3.0%	2.0%	3.0%	3.0%	2.5%	2.5%	2.5%
A.F. Noise	−57 dB	−60 dB	−55 dB	−60 dB	−60 dB	−60 dB	−60 dB	−55 dB
Miscellaneous	Ext. Pwr. Comp.	Self-contained	Self-contained	Self-contained	Self-contained	Self-contained	Trans. Ext.	H.V. Pwr. Mod. Trans. & Mod. Reactor External

The performance specifications of all 1 kw transmitters are comparable as can be seen from Table 4. All tube-type 1 kw transmitters are high level modulated Class C power amplifiers. The Harris MW-1 employs Class D transistor RF power amplifiers.

All tube-type transmitters except the Harris BC-1H employ tetrodes, or pentodes as in the Collins 820D-1, in the final amplifier. The BC-1H utilizes a triode.

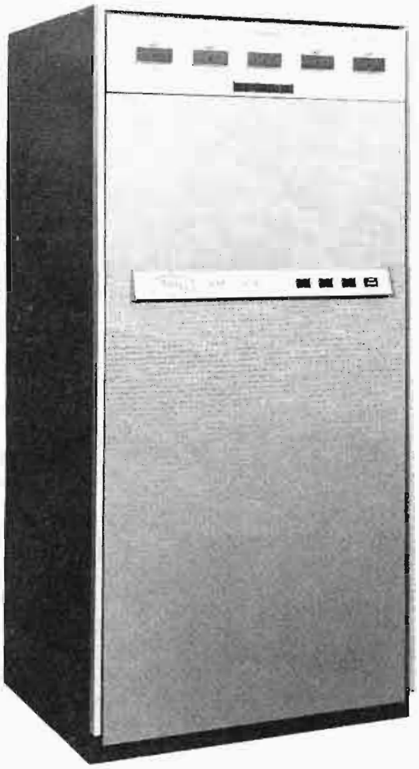

Fig. 23. AEL AM-1KA (1000 watt) Transmitter (Courtesy American Electronic Laboratories).

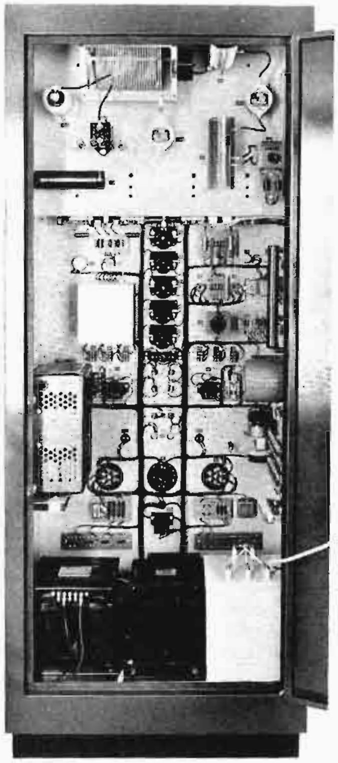

Fig. 24. Rear view, Bauer 707 (1000 watt) Transmitter (Courtesy Bauer Communications Products Division of Granger Associates).

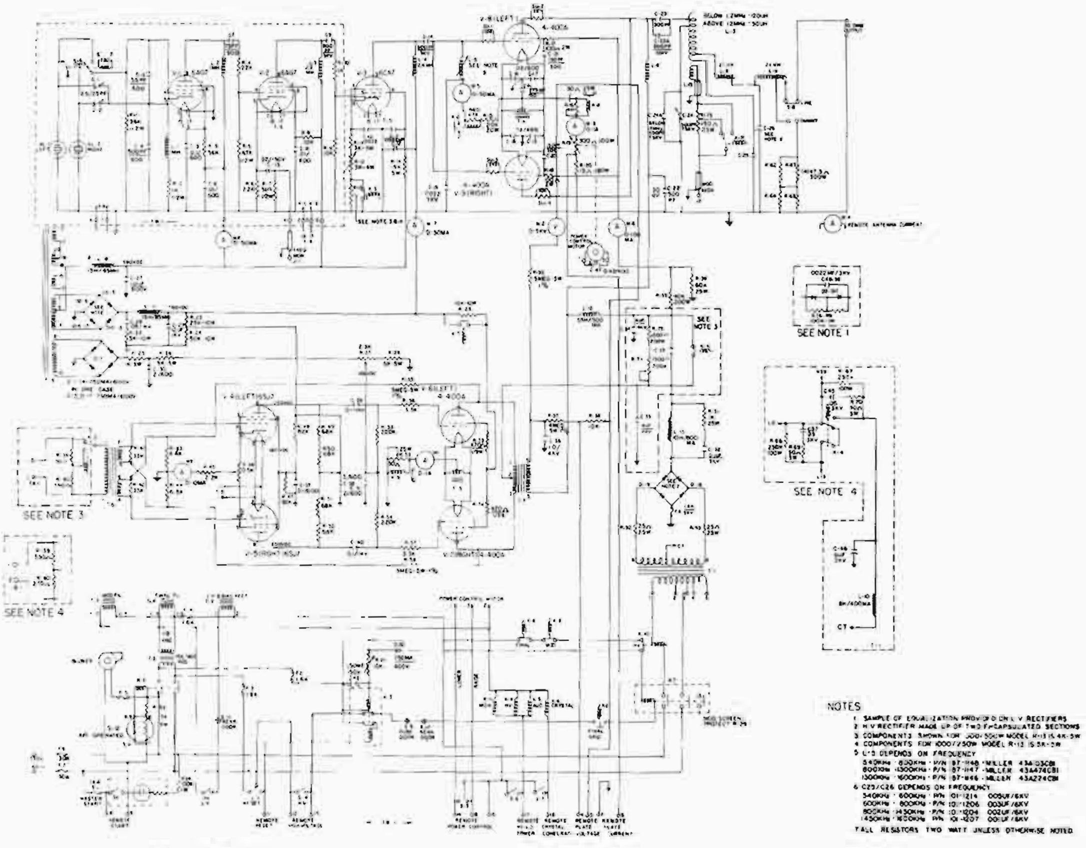

Fig. 25. CCA AML000D 1 kw Transmitter (Courtesy CCA Electronics Corp.).

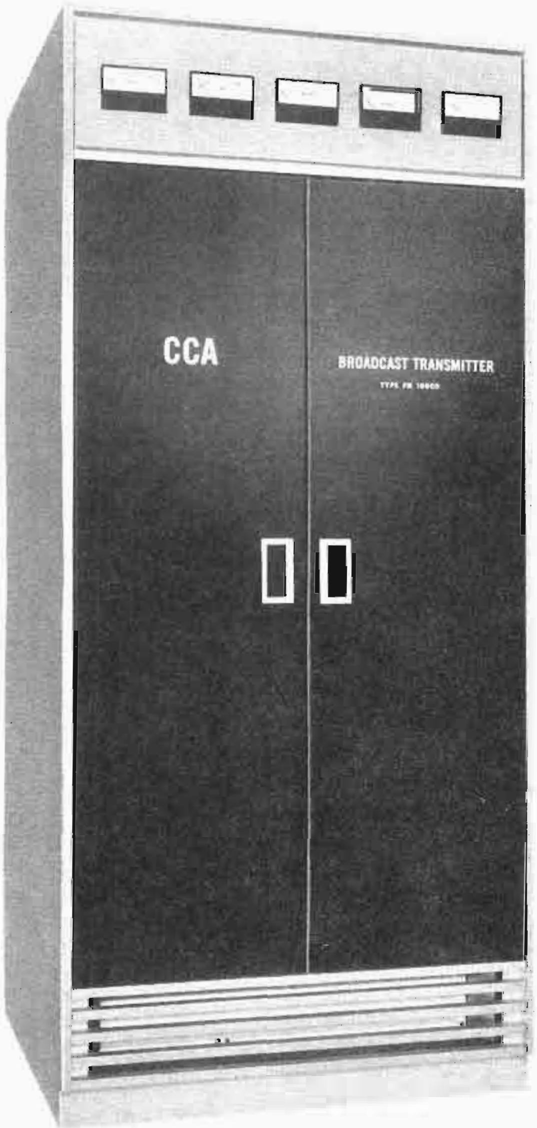

Fig. 26. CCA AM1000D 1 kW Transmitter (Courtesy CCA Electronics Corporation)

Fig. 28. Simplified block Collins 820D1 1 kw Transmitter (Courtesy Collins Radio Co.).

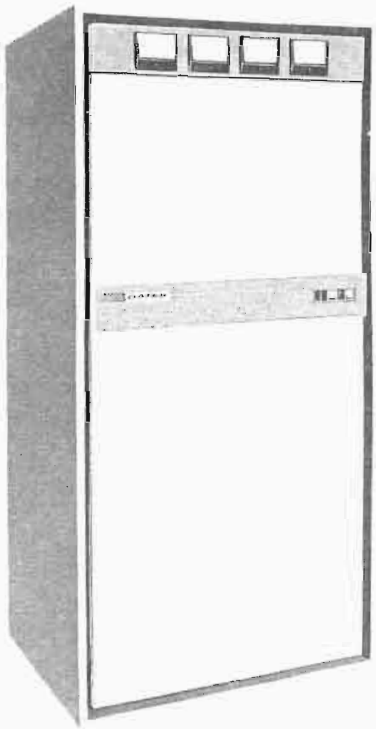

Fig. 29. Gates BCLG (1000 watt) Transmitter (Courtesy Gates Radio Co.).

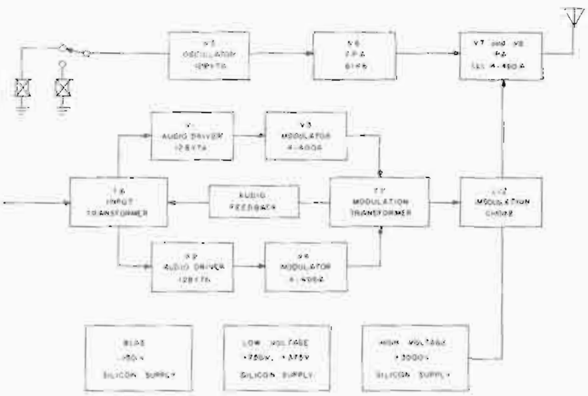

Fig. 27. CCA AM-1000D simplified block diagram.

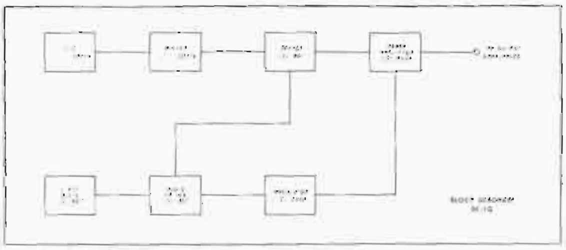

Fig. 30. Gates BC1G Transmitter (Courtesy Gates Radio Co.).

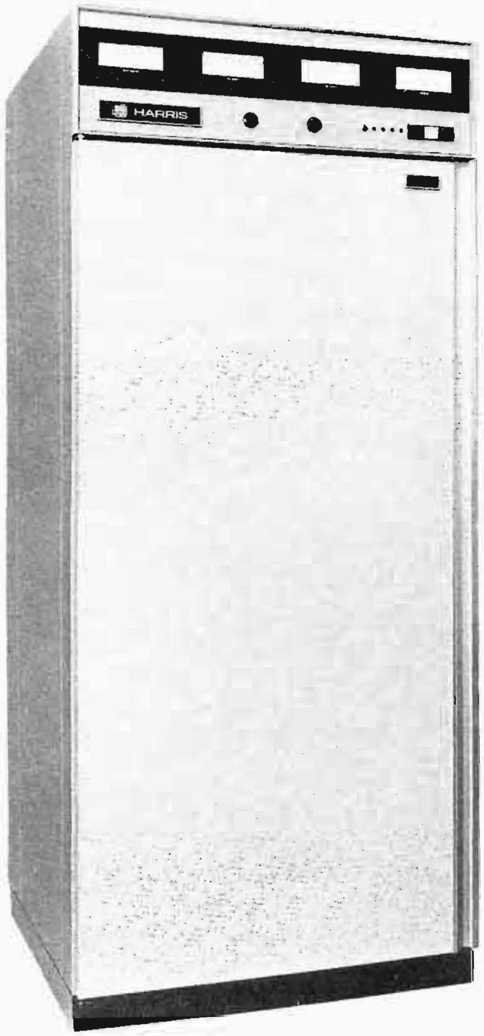

Fig. 31. Harris 1 MW-1—the world's first FCC type accepted (1000 watt) Transmitter 100% solid-state broadcast transmitter.

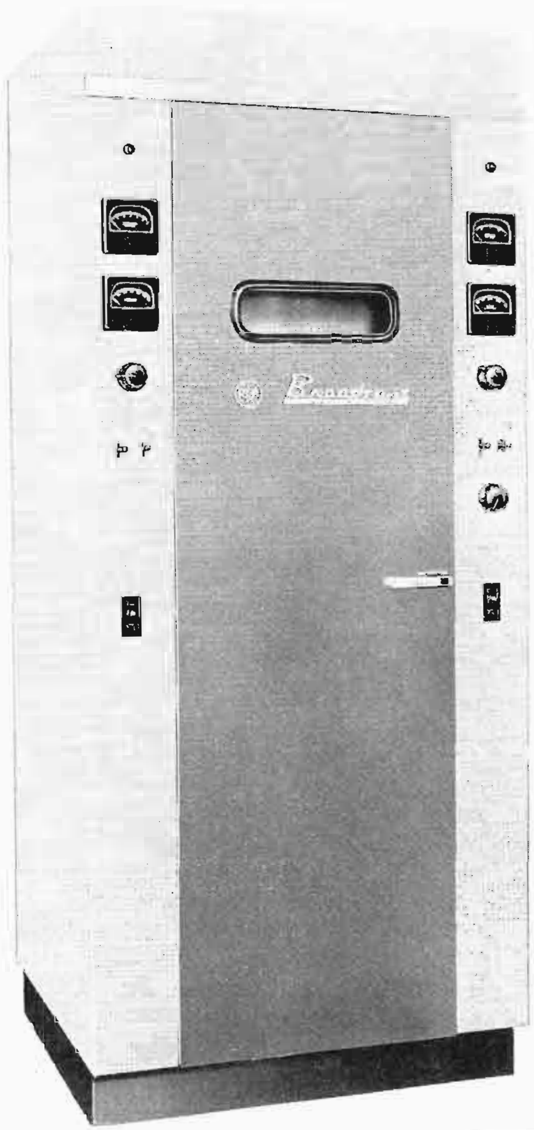

Fig. 33. RCA BTA 1R2 (1000 watt) Transmitter (Courtesy RCA Broadcast Products Division).

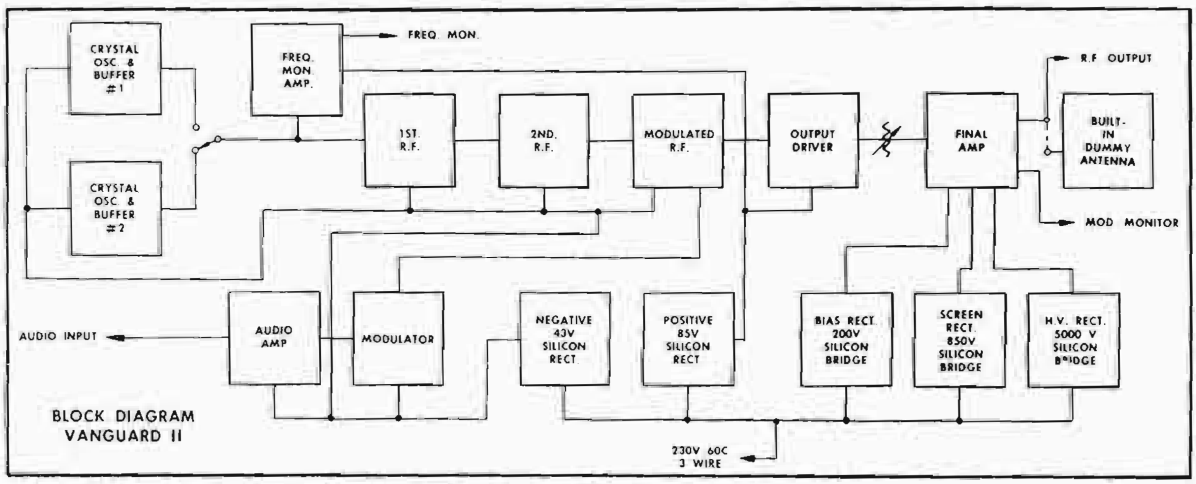

Fig. 32. Harris MW-1 block diagram.

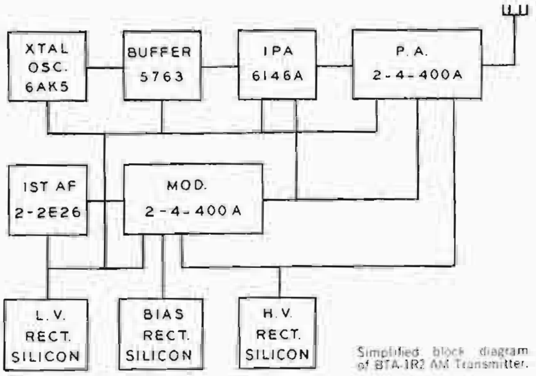

Fig. 34. Simplfieid block diagram BTA-1R2 AM Transmitter (Courtesy RCA Broadcast and Communications Products Division).

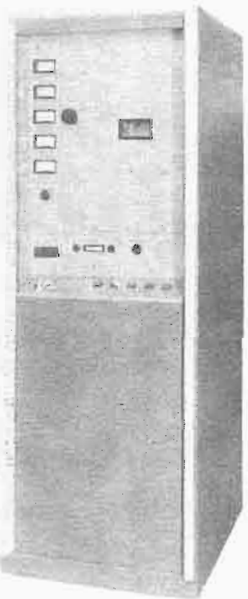

Fig. 35. Visual AM-1K-A 1 kw Transmitter (Courtesy of Visual Electronics Corp.).

COLLINS 820D-1 TRANSMITTER

One recently designed 1 kw transmitter on the market is the Collins 820D-1. It is a high-level modulated transmitter and utilizes solid state circuitry in all RF stages ahead of the PA tube, a pair of 5-500A's, and solid state audio amplifiers to drive two 5-500A modulators.

The exciter is Collins' 310W-1 presently used in their 5 and 10 kw transmitters. This exciter uses a crystal oscillator without ovens operating in the 2.1 MHz to 4.3 MHz region. The crystal controlled oscillator is frequency divided to the AM broadcast frequency with integrated circuits.

The 820D-1 transmitter output network is designed as a three node bandpass filter. The first node is tuned by a motor driven variable capacitor while loading is a fixed inductor adjustment with power output controlled by a plate voltage adjustment. The important advantage of this circuit is a symmetrical passband response which reduces distortion at the higher modulation frequencies.

A third advantage of the 820D-1 is the availability of an automatic power output control. This added accessory will sense the RF Output current to control a servo system, which adjusts the plate voltage control to hold the power output at a predetermined value.

The 820D-1 has its metering and control functions located on a separate panel which may be mounted remotely from the main transmitter chassis.

HARRIS MW-1 TRANSMITTER

The first FCC type accepted solid-state 1 kw transmitter is manufactured by Harris Corporation. This transmitter is 100% solid state, including the PA and modulator.

TABLE 4

Specifications of 1 kw Transmitters

Data	AEL AM-1KA	CCA AM-1000D	Collins 820D-1	Gates BC1H	Gates MW-1	RCA BTA-1R2	Sparta 707
Physical Data							
Height	70"	76"	69"	72"	72"	84"	75"
Width	34"	34"	41"	31½"	31½"	34"	30"
Depth	28"	32"	23-1/8"	31½"	31½"	32½"	25"
Weight	–	1000 lbs.	1100 lbs.	770 lbs.	595 lbs.	1700 lbs.	800 lbs.
PA Tube	4-400(2)	4-400(2)	5-500(2)	833(2)	N/A[a]	4-400(2)	4-400(2)
Power Consump.		100% 4000W	0% 2200W 100% 3400W	0% 2600W 100% 3850W	100% 3000W	0% 2900W 100% 3900W	0% 2900W 100% 3900W
A.F. Response	±1.5 dB 30-10K	±1.5 dB 30-10K	±2 dB 50-10K	±1.5 dB 30-12K	±1.0 dB 20-10K	±1.5 dB 30-10K	±1.5 dB 30-12K
A.F. Distortion	3% 40-10K	1.5% 100-7.5K	3% 50-7.5K	2.5% 50-10K	1.5% 20-10K	2% 50-10K	2% 50-10K
A.F. Noise	–58 dB	–55 dB	–60 dB	–60 dB	–60 dB	–60 dB	–60 dB
Carrier Shift	5%	3%	3%	3%	2%	3%	3%
Dummy Load	Yes	No	No	Yes	Yes	No	Yes

[a]Solid State Transmitter.

Series modulation of Class D transistor RF amplifiers is employed, using Progressive Series Modulation (PSM).

Output power is generated in 12 redundant modules, each of which has its own modulator. PA efficiency approaches 90% without the use of special waveshaping. Failure of one module still permits continuous operation at 1 kw. Operation is maintained at lower power with fewer modules. Fault indicators are provided to identify a failed module.

The series modulator, which is dc coupled, provides excellent transient response, dc feedback for automatic control of output power, the ability to switch between any two predetermined power levels without carrier interruption and single knob power adjustment capability over a wider range.

The transmitter features fast VSWR protection, quiet air cooling, built-in dummy load, built-in voltage regulator for brown-out protection and complete remote control capability.

VAPOR PHASE COOLING

Cooling by vapor takes advantage of the latent heat of vaporization of water. Raising the temperature of one pound of water 1°F requires one BTU; however, changing a single pound of water at 212°F to steam vapor takes 970 BTUs. Thus, vapor cooling will remove nearly 20 times as much energy as a circulating water system.

As power is applied to the tube anode, dissipation heats the water to 212°F. Further heating causes the water to boil and change to steam. This vapor is passed through a heat exchanger, where it is condensed to a liquid. The condensed water is returned to the boiler reservoir for reuse.

Water losses are compensated for by the reserve tank, which will replenish the boiler if the water level drops one-quarter inch. Tube anodes have a constant supply of water with fail-safe protection. The vapor system operates near atmospheric pressure and is fully vented.

The main advantages of vapor cooling are quieter operation, most efficient removal of heat from tubes, not dependent on blowers, and greater freedom from dust and dirt.

FORCED AIR COOLING

Many power tubes are cooled by air forced thru fins of an external anode. Each tube has specifications as to the volume of air and static pressure

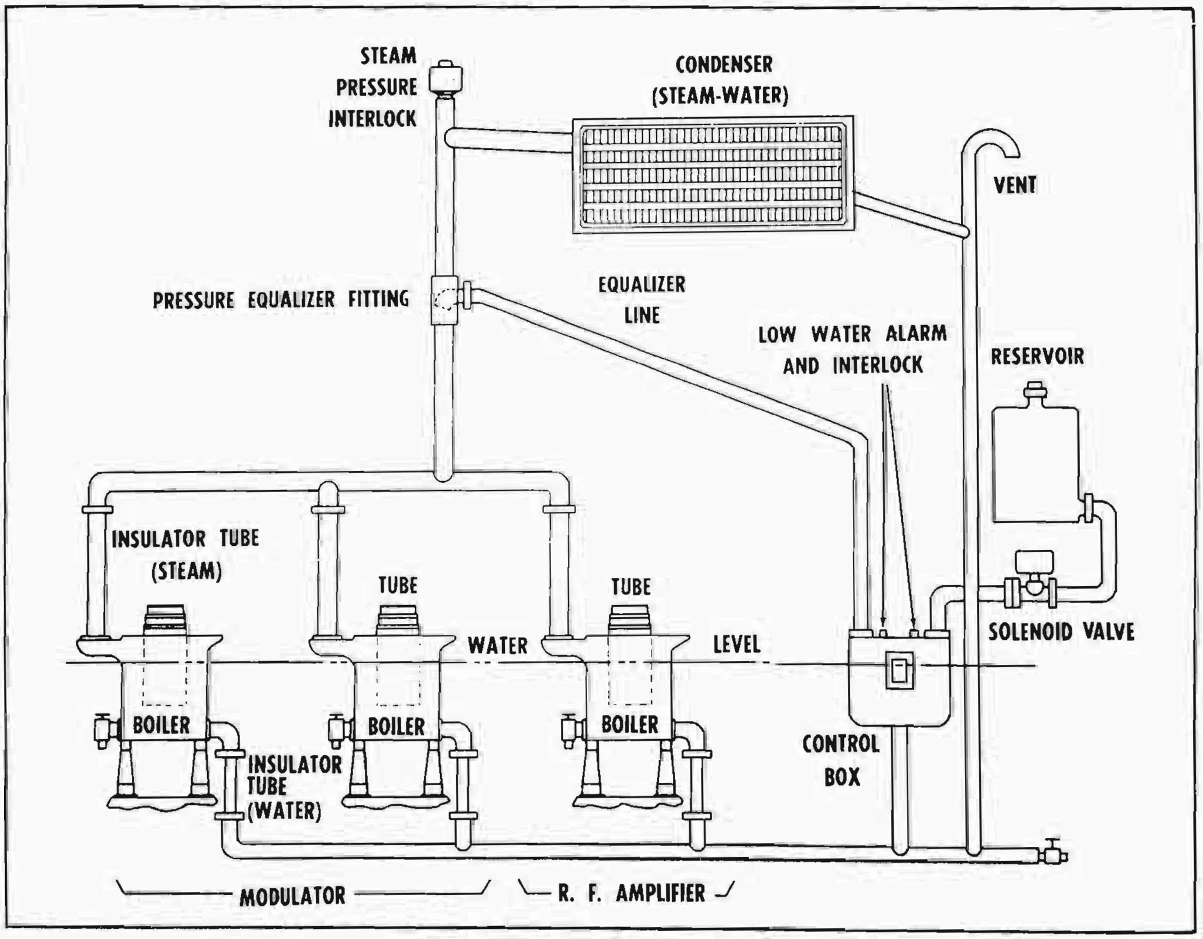

Fig. 36. Vapor phase cooling system illustration (Courtesy Gates Radio Co.).

required by the tube for a given dissipation. Fin types range from open tubes requiring large air volume at low pressure to smaller and closely spaced fins which require less air volume, but at considerably higher pressure.

The blower should not only allow for the air pressure drop of the tube, but also for ducts and air filters. Cooling efficiency decreases with altitude so that for high elevations higher capacity blowers must be used. Cooling efficiency also decreases with dust accumulation. Therefore, cleaning of the radiating fins of tubes is important.

Efficient air cooling is imperative for extended tube life.

CARE AND PROTECTION OF SILICON RECTIFIERS

Semiconductor rectifiers have almost universally replaced tube rectifiers in broadcast transmitters power supplies. Their care and protection is somewhat different than tubes so special attention should be given to them.

The rectifiers are capable of withstanding the high voltages because several diodes are connected in series. It is advisable to check individual diodes in each bank at regular intervals to insure that the full voltage capability of the rectifier is maintained.

Current carrying capacity of a given solid state rectifier depends upon the removal of heat from the diode junction. For this reason, it is important that rectifiers are kept clean where removal of heat is by air flow. It is also important that they are maintained in good thermal contact with any surface where this surface is used as a heat sink.

CARE OF TUBES

Power tubes should be inspected on arrival for shipping damage. Glass tubes should be examined around the seals for possible cracks. Filament should be checked for continuity and tests for short circuits made between the elements.

They should be placed in the transmitter for test as soon as possible. Allow 15 minutes with ON only filament voltage, then 15 minutes with reduced plate voltage, followed by a 15-minute interval with full voltage, after which modulation can be gradually applied. Residual gas may cause a virtual short circuit condition. If this occurs, reduce plate voltage and repeat break-in sequence.

Filament voltages should be maintained within the limits specified by the tube manufacturer. Some filaments, such as thoriated tungsten, may be damaged as much by under-voltage as over-voltage.

Hours of service records should be kept on each tube. Short tube life should call for an appraisal of operating conditions, both mechanical and electrical. Spare tubes should be placed in service for a day at four to six months intervals to reduce any gas accumulation.

TROUBLESHOOTING

Successful troubleshooting of any equipment follows these three steps in order given:

1. Define the problem;
2. Determine the cause of the problem;
3. Select the best solution.

The first step is usually the most difficult and is always the most important. Often, when the actual problem is determined, the other steps become automatic and easy. For example, if a resistor is burned out, this is an effect and until the problem causing the resistor to burn out is determined, the real difficulty cannot be corrected.

A very common failure in troubleshooting is treating symptoms rather than causes. Take time to determine exactly the problem and time will be saved in administering the solution.

Know the instruction book on the transmitter. Especially, understand the control circuit system of the transmitter. Knowing the sequence of the control circuit relays and their function many times provide excellent clues to the source of the problem.

Keep an accurate record of all operating voltages in the transmitter as you have measured them. These may be slightly different than those given in the instruction book.

Finally, an accurate and detailed diary or log of difficulties or unusual operating conditions together with cause and cure is extremely useful for future reference.