MAINTENANCE

GENERAL

With ordinary care a minimum of service will be required to keep the TT-5A transmitter in operation. However, to avoid interruptions due to equipment failure during operation, a regular schedule of cleaning and inspection should be established.

It is particularly important that the equipment be kept free from dust to guard against the deposit of any substance which might be conductive. The following table lists points which should be checked in particular.

TABLE 13
RECOMMENDED CLEANING PROCEDURE

COMPONENTS	ACTION
Insulators	Use cloth dampened with carbon tetrachloride or wipe with dry cloth.
Contactors and Relays	Refer to extracts from manufacturers' bulletins on contactors.
Air Filters	The air filters on the cooling unit and rear doors of the transmitter may be cleaned several times with a vacuum cleaner or brush before it becomes necessary to wash them and replace the oily adhesive. There are commercial establishments which will clean and reoil the filter for a small fee. If desired, however, the filters may be washed in hot soapy water, rinsed and allowed to dry. Then a coating such as FILTER KOTE (Manufactured by Air Maze Corp. of Cleveland, Ohio) or SAE No. 20 motor oil must be applied. The oil may be sprayed on or the filter may be dipped into the oil. After coating, allow the filter to drain in a warm room before reinstalling.
Internal Parts of Transmitter	Use a vacuum cleaner or hand bellows for removing dust and dirt.
Internal Parts of Control Console	Except for switches, clean with vacuum cleaner or soft clean brush, particularly items such as terminal boards in monitor control section. This tends to prevent electrical noise. Contacts of attenuators in the monitor control side of the control console should be cleaned by applying "Davenoil" to the contacts and then rotating the knob. If dark streaks appear, the contacts should be wiped off and the operation repeated until the contacts are clean. After cleaning, a thin film of "Davenoil" should be applied as lubrication. No other cleaning agent should be used on the contacts. Level control potentiometers behind the panel should also be rotated occasionally to clean the contact area of any oxidation likely to cause faulty operation. Each control should be restored to its original setting after rotation. The pushbutton switches may be cleaned and lubricated using the fluid, and brush supplied with contact cleaning kit RCA stock #47050 (available on separate order). This kit includes instructions.

Lubrication of transmitter ceiling fans, blowers, and blower motors should follow the plan in Table 14. The water cooler lubrication is treated separately in Table 16.

TABLE 14
RECOMMENDED TRANSMITTER LUBRICATION
(See also Table 16)

ITEM	PERIOD	INSTRUCTIONS
Ceiling fans	Every 2000 hours	Use S-58 Non-fluid Oil (1/2 lb tubes or 1-lb cans) obtainable from New York and New Jersey Lubricant Co.; or M-6 Grease obtainable from Master Lubricant Co.; or Nerita Grease #2 (large cans only) Multi-Purpose Grease (10 oz. tubes-24 to a case) obtainable from Shell Oil Co. Remove bearing covers to lubricate fan bearings. Avoid getting dirt on bearings.
High pressure blowers (channels 7 to 13 units)	Every 2000 hours.	Same as for ceiling fans.
Small blower motors (7)	Every 500 hours.	Add several drops of SAE #10 or #20 to the wick in each of the two oil wick reservoirs.

TYPICAL METER READINGS

The following tabulation, Table 15, lists the typical meter readings for both visual and aural sections, channels 2 to 13. The notes under TUBES which follow should be referred to for additional information on the correct filament voltage for the power amplifier tubes, type 8D21.

TABLE 15
TYPICAL TRANSMITTER METER READINGS-VISUAL AND AURAL
(Taken Under Conditions of Black Picture Modulation)

CABINET NOS.	METER	UNITS	CHANNELS 2 TO 6		CHANNELS 7 TO 13	
			VISUAL	AURAL	VISUAL	AURAL
1,8	Reflectometer	-	45	30	45	30
	PA Plate Current	Amps.	1.41	1.0	1.41	1.0
	PA Plate Voltage	Kv.	5.0	4.5	5.0	4.5
2,7	PA Grid Current (varies with tube)	Ma	+4	+10	+4	+10
	PA Grid Voltage	Volts	-380	-300	-380	-300
	PA Screen Current	Ma	-40	+50	-40	+50
3,6	PA Screen Voltage	Volts	800	600	800	600
4	PA Filament Voltage	Volts	3.2	3.2	3.2	3.2
3,6	Driver Plate Current		300	180	600	450
	Driver Plate Voltage	Volts	1500	1500	1500	1500
2,7	2nd IPA Screen Current	Ma			45	20
	2nd IPA Grid Current	Ma			36	15
	2nd Tripler Cath. Current	Ma			180	150
	2nd Tripler Grid Current	Ma			9	9
	1st IPA Cath. Current	Ma			100	100
	1st IPA Grid Current	Ma			10	10
	Tripler Cath. Current	Ma		25	60	25
	Tripler Grid Current	Ma		2	2.7	2
	Doubler Cath. Current	Ma	30	20	30	20
	Doubler Grid Current	Ma	0.5	2.6	0.5	2.2
7	Crystal Oscillator Cath. Current	Ma	21		21	
1	FM Exciter Current	Ma		13		13
5	Modulator Plate Current	Ma	710		710	
	Modulator Plate Voltage	Volts	650		650	
8	1st Video Stage Current	Ma	75		75	
	2nd Video Stage Current	Ma	170		170	
	Amplifier Voltage Supply	Volts	600		600	

TUBES

GENERAL

A regular check should be made of all tubes in the equipment. Insofar as possible, tube failure should be anticipated by keeping a log of tube life and replacing tubes when indicated by the log or whenever signs of marked reduction in tube output are apparent.

As a guide for the proper operation of the 4-125A/4D21, 4E27, 4X500A, 6AS7G, and 8D21 tubes the detailed data for these tubes is included at the end of this section.

8D21 FILAMENT VOLTAGE ADJUSTMENT

Filament life of the 8D21 tubes can be conserved by operating the filament at the lowest voltage which will give the desired power output. Because the filament of this tube when operated at the tabulated value of 3.2 volts usually provides emission in excess of any requirements within ratings, it is recommended that the voltage be reduced below 3.2 volts to a value that will give adequate but not excessive emission.

The proper operating value may be found by reducing the filament voltage, with normal modulation applied to the transmitter, until a reduction in output is observed on the reflectometer. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament voltage supply, and then further increased by about 0.1 volt to allow for other variations. It is suggested that the adjustment procedure be carried out daily. However, if no significant changes in the operating voltage are found necessary the adjustment procedure can be scheduled less frequently.

During long or frequent standby periods, the 8D21 tube may be operated at decreased filament voltage to conserve life. It is recommended that the filament voltage be reduced to 80 per cent of normal during standby operations up tp 2 hours; for longer periods the filament power should be turned off.

VISUAL MODULATOR TUBE SELECTION

The Type 4E27 visual modulator tubes should be checked periodically for equal division of load. The method outlined under "Modulator Adjustments, Visual," should be followed. These tubes normally operate with the anode at a visible red color.

REGULATED POWER SUPPLIES

PA Bucking Bias Supply, Visual–The type 6AS7-G regulator tubes should be checked periodically for division of load and voltage drop as described under INSTALLATION, "Adjusting Bucking Bias Supply, Visual PA."

PA Screen Grid Supply, Visual–The Type 6AS7-G regulator tubes should be checked periodically for division of load and Voltage drop as outlined under INSTALLATION, "Adjusting Screen Grid Power Supply, Visual PA."

RECTIFIER TUBES

Spare mercury vapor tubes type 816 and 8008 should be "seasoned" and then stored in an upright position ready for immediate use.

To season the mercury vapor tubes operate each tube for a minimum of 30 minutes with only the filament voltage applied.

Take care to avoid tipping or splashing of mercury on the tube elements after seasoning. If mercury is splashed upon the elements, it will be necessary to "re-season" the tubes.

CIRCULATING WATER SYSTEM

Maintenance on the circulating water system involves the water supply itself and the associated mechanical units.

WATER SUPPLY

Keep the water tank well over half full by adding distilled water through the fill connection which is just inside the removable front cover. Tank capacity is approximately 10 gallons.

Remove the water filter strainer regularly and clean out any sludge accumulation. This operation which should be performed quite frequently during the run-in period, need be performed only periodically, thereafter.

The distilled water circulating in the system will become contaminated to some extent with use. Air finds its way into the water through various openings, and gas impurities contained in the air increase the conductivity of the water. The result is an electrolytic attack at the anode forming corrosion products such as carbonates, hydroxides, etc. Attacks of this nature will remove only minute amounts of metal and will not result in short-time deterioration of the fittings. These corrosion products, which carry the potential of the anode, are electrostatically transferred to the nearest ground point. There, after giving up their charge, they have a tendency to build up a deposit of sediment.

The anodes of the 8D21 tubes are operated at 5000 volts positive above ground. Referring to Figure 12, points "F," "G", "H", and "I" are at 5000 volts, and points "A", "B", and "C" are grounded. Good distilled water has a conductivity of about 100,000 ohms per cubic centimeter so the current flow from "G" and "F" to "C" would be less than 150 microamperes, and the current flow from "H" or "I" to "B" or "A" is less than 80 microamperes in each. The water should be changed when its conductivity falls to 50,000 ohms per cubic centimeter.

Sediment deposited will accumulate slowly at points "A", "B" and "C" and a little may deposit at "D" and "E" as these points are slightly negative with respect to "G" and "F". This deposited sediment is a very fine powder and would not be removed in an ordinary screw type water filter. Any foreign particles which may be in the water or loose in the circulating system will be electrostatically precipitated, and will accumulate with the above sediment. Thus, the apparent sediment accumulation may be greater when the station is first operated unless extreme care was taken to keep the lines clean when they were installed. The sediment will start to accumulate at the inside ends of the elbows at "A", "B", and "C" and build up inside the Saran tubing until the deposit may extend beyond the flare nuts. Continued deposits may build up and restrict water flow.

The flare nuts at points "A", "B", and "C" should be removed at intervals of 1000 to 1500 hours operating time and the deposit in the Saran tubing removed. As some deposition may occur at points "D" and "E", nuts "D", "E", "F", and "G" should be loosened, and the short lengths of tubing removed for cleaning. When replacing the flare nuts on the Saran tubing, use care that they are not tightened too tight as it is possible to cut off the flare if the nut is tightened excessively. Normally, a little over hand-tight is sufficient or approximately one-quarter to a half turn beyond hand tight. No deposit will probably be found in the tube header isolation coils as the voltages there are much lower.

The water should be circulated for a short time after the above cleaning, and then the entire system drained, removing all the old water that it is possible to remove from the system. Then refill with good distilled water. Refer to the notes on distilled water under INSTALLATION, "Water Cooling Unit."

WATER COOLING UNIT

Mechanical elements of the water cooling units will require periodic lubrication or attention as detailed in Table 16. Since either of two units may have been supplied, refer to the "MI" number on the nameplate to determine the applicable portions of Table 16.

EMERGENCY FREQUENCY CONTROL, AURAL SECTION

Provision has been made for maintaining frequency control of the aural section if the automatic frequency control system fails during program transmission. The operator will be warned of the control loss by the reaction in the carrier frequency monitor.

Tube failure may be found in some cases by switching the cathode ray tube (X119) to various stages until a lack of amplitude in the horizontal or vertical position indicates a defective stage. See Table 2 under DESCRIPTION.

Until such repairs or replacements as are necessary can be made the output carrier frequency can be controlled manually in the following manner.

Engage the motor damping disk with the tuning knob on the front end of the motor by lifting the locking spring.

Turn the motor shaft until it is lined up with the guide lines on the motor damping unit as in the normal operating position.

Adjustment of the vernier iron core in the front of T115 will usually be sufficient to bring the output frequency to its assigned value. The carrier frequency monitor will indicate when the frequency has reached its correct value.

In some cases failure of the automatic frequency control may not involve failure of any of the frequency divider stages. In this case, the assigned carrier frequency may be maintained by following the preceding steps and keeping a circle pattern on the screen of the cathode ray tube when the selector switch is in position 2.

OVERALL MAINTENANCE

The most effective method of assuring continuous satisfactory transmitter operation is to institute a regular schedule of general maintenance, recording all data on previously prepared forms so that a continuous performance record of all parts of the equipment is available. The station operating schedule and local operating conditions may affect the order of some maintenance functions, therefore, the following recommended overall schedule may be varied as experience dictates. Preceding material in this section contains more-detailed data.

TABLE 16
LUBRICATION AND MAINTENANCE CHART - WATER COOLING UNIT
(See also Table 14)

ITEM	PERIOD	INSTRUCTIONS	
		MI-19045	MI-19045A
Idler pulley bearing	Every 50 hours.	Add a drop or two of SAE #10 or #20 motor oil.	
Water pump	Every week or 10 days.	Give grease cup a single turn.	
	Every 3 or 4 months.	Refill grease cup with good grade of ball-bearing grease.	
Fan bearings	Every 2000 hours.	Add a good grade of ball-bearing grease to bearings. Do not overgrease with a pressure gun.	Add a good grade of ball bearing grease to bearings. Do not overgrease with a pressure gun.
Motor bearings and sealed pump bearing	Every 3 to 5 years.	The units will have to be taken apart and the bearings cleaned and repacked. The motor bearings are normally lifetime-sealed ball-bearings.	The units will have to be taken apart and the bearings cleaned and repacked. The motor bearings are normally lifetime-sealed ball-bearings.
V-belt drive	As needed.	Move idler pulley to eliminate excessive slack.	Move motor down to eliminate excessive slack.
V-belt replacement	As needed.	Use size A49.	Use size A34.
Pump packing	As needed.	The pump is equipped with a mechanical seal which should run for a long period without attention. This seal should run without leaking, but if a slight drip starts, the seal parts are worn and will need replacing. Normally, the leakage will increase slowly with use until it becomes excessive.	The pump is equipped with a mechanical seal which should run for a long period without attention. This seal should run without leaking, but if a slight drip starts, the seal parts are worn and will need replacing. Normally, the leakage will increase slowly with use until it becomes excessive.

TABLE 17

OVERALL MAINTENANCE SCHEDULE

DAILY
- Check filament line voltages every hour and adjust if required. - Make general inspection after shut-down. - If there have been any overloads during the day, examine the components concerned and repair or replace as necessary.
WEEKLY
- Check 8D21 Emission vs. Filament voltage and reset if required. See TYPICAL METER READINGS in this section. - Clean internal parts of transmitter, (insulators, etc.) - Make general performance checkup of: Aural transmitter - noise distortion and frequency characteristic. Visual transmitter - visual frequency and broadband characteristic. - Inspect all blowers. - Inspect all flowmeters and clean as required. See INSTALLATION. - Test all door interlocks. - Test operation of overload relays. - Check level of water in cooler unit and add distilled water if required. See CIRCULATING WATER SYSTEM, this section.
MONTHLY
- Lubricate all small blower motors per lubrication chart, Table 14. - Clean all socket contacts. - Service all relay contacts. - Check air filters and clean if necessary. - Check condition of distilled water in system. - Turn water filter "T" handle 360^{o}. - Check visual and aural monitoring circuits and levels.
QUARTERLY
- Test all spare 8D21 tubes in circuit, and tighten hose clamps on tube harness. - Operate all spare mercury vapor tubes for 30 minutes, filament only. - Make detailed inspection of every unit in transmitter with whatever tests seem advisable. - Clean air filters and blower impellers (exhaust fans and screens of ceiling fans). - Service all contactors. - Clean accumulation in Saran tubes per CIRCULATING WATER SYSTEM, this section, and change water if required.
SEMI-ANNUALLY
- Inspect all relay contacts and make replacements where required. Clean pole faces on contactors. - Test spare tubes. - Tighten all connections in transmitter. - Lubricate ceiling fans per lubrication chart. - Lubricate high-pressure blowers (driver in frames 2 and 7. channels 7 to 13) per lubrication chart, Table 14. - Inspect operation of air interlock (mercury switch) on preceding high-pressure blower. - Lubricate water cooler per Table 16. - Check outdoor air protection to water cooler intake before cold weather and for free circulation before summer.

4-125A / 4D21

VHF POWER TETRODE

TENTATIVE DATA

RCA-4-125A/4D21 is a filament type of four-electrode tube suitable for use as oscillator, amplifier, and class AB_2 modulator. It has a maximum plate dissipation of 125 watts in class C telegraph service, and can be operated with the rated maximum plate voltage of 3000 volts at frequencies as high as 120 megacycles. With reduced plate voltage, the 4D21 can be operated at frequencies up to 250 megacycles.

Having high power sensitivity and high efficiency, the 4D21 is capable of delivering large power output with small driving power. The low value of grid-plate capacitance--0.05 μμf--permits stable operation without neutralization up to about 100 megacycles if input and output circuits are adequately isolated.

Forced-air cooling of the bulb and plate seal of the 4D21 is required when it is operated near maximum ratings at frequencies above 30 megacycles. In addition, circulation of air through the perforated shell of the 5-pin base is required to cool the stem.

GENERAL DATA

Electrical:

Filament, Thoriated Tungsten:		
Voltage (AC or DC)	5	Volts
Current	6.5	Amperes
Transconductance, for plate current of 50 ma.	2450	Micromhos
Grid-Screen Mu-Factor	6.2	
Direct Interelectrode Capacitances:		
Grid No.1 to Plate *	0.05	μμf
Input	10.8	μμf
Output	3.1	μμf

Mechanical:

Mounting Position	Vertical, base up or down
Overall Length	5-7/16" ± 1/4"
Seated Length	4-11/16" ± 1/4"
Maximum Diameter	2-7/8"
Cap	Skirted Small
Base	Special Metal-Shell Giant 5-Pin

AF POWER AMPLIFIER & MODULATOR--Class AB_2 ▲

Maximum Ratings, Absolute Values:

DC PLATE VOLTAGE	3000 max.	Volts

* With no external shielding and base shell connected to ground.
▲ See page 3.

4-125A/4D21

Maximum Ratings (Cont'd):

DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	Volts
MAX.-SIGNAL DC PLATE CURRENT **	225 max.	Ma.
GRID-No.2 DISSIPATION	20 max.	Watts
PLATE DISSIPATION **	125 max.	Watts

Typical Operation with Fixed Bias:

Values are for 2 tubes

DC Plate Voltage	1500	2000	2500	3000	Volts
DC Grid-No.2 Voltage	350	350	350	350	Volts
DC Grid-No.1 (Control Grid) Voltage	-41	-45	-43	-51	Volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	282	210	178	198	Volts
Zero-Signal DC Plate Current	87	72	93	55	Ma.
Max.-Signal DC Plate Current	400	300	260	260	Ma.
Zero-Signal DC Grid-No.2 Current	0	0	0	0	Ma.
Max.-Signal DC Grid-No.2 Current	34	5	6	3.5	Ma.
Effective Load Resistance (Plate to plate)	7200	13600	22200	27700	Ohms
Peak Grid-No.1 Input Power °	5.2	3.1	2.4	2.5	Watts
Max.-Signal Power Output °°	350	350	400	520	Watts
Total Harmonic Distortion	2.5	1	2.2	1.8	Per cent

PLATE-MODULATED RF POWER AMPLIFIER—Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values:

DC PLATE VOLTAGE	2500 max.	Volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	Volts
DC GRID-No.1 (CONTROL GRID) VOLTAGE	-500 max.	Volts
DC PLATE CURRENT	200 max.	Ma.
PLATE DISSIPATION	85 max.	Watts
GRID-No.2 DISSIPATION	20 max.	Watts
GRID-No.1 DISSIPATION	5 max.	Watts

Typical Operation:

DC Plate Voltage	2000	2500	Volts
DC Grid-No.2 Voltage ♠	350	350	Volts
	50000	70000	Ohms
DC Grid-No.1 Voltage	-220	-210	Volts
Peak RF Grid-No.1 Voltage (Approx.)	375	360	Volts
DC Plate Current	150	152	Ma.
DC Grid-No.2 Current	33	30	Ma.
DC Grid-No.1 Current	10	9	Ma.
Driving Power (Approx.)	3.8	3.3	Watts
Power Output (Approx.)	225	300	Watts

**, °, °°, ♠ : See next page.

RF POWER AMPLIFIER & OSCILLATOR--Class C Telegraphy

Key-down conditions per tube without modulation

Maximum Ratings, Absolute Values:

DC PLATE VOLTAGE	3000 max.	Volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	Volts
DC GRID-No.1 (CONTROL GRID) VOLTAGE	-500 max.	Volts
DC PLATE CURRENT	225 max.	Ma.
PLATE DISSIPATION	125 max.	Watts
GRID-No.2 DISSIPATION	20 max.	Watts
GRID-No.1 DISSIPATION	5 max.	Watts

Typical Operation:

DC Plate Voltage	2000	2500	3000	. . .	Volts
DC Grid-No.2 Voltage	350	350	350	. . .	Volts
DC Grid-No.1 Voltage	-100	-150	-150	. . .	Volts
Peak RF Grid-No.1 Voltage (Approx.)	230	320	280	. . .	Volts
DC Plate Current	200	200	167	. . .	Ma.
DC Grid-No.2 Current	50	40	30	. . .	Ma.
DC Grid-No.1 Current	12	12	9	. . .	Ma.
Driving Power (Approx.)	2.8	3.8	2.5	. . .	Watts
Power Output (Approx.)	275	375	375	. . .	Watts

▲ Subscript (2) indicates that grid-No.1 current flows during a part of input cycle.

** Averaged over any audio-frequency cycle of sine-wave form.

o Driver stage should be capable of supplying the No.1 grids of the class AB_2 stage with the specified driving power at low distortion. The effective resistance per grid-No.1 circuit of the class AB_2 stage should be kept below 250 ohms.

oo With zero-impedance driver and perfect regulation, plate-circuit distortion will be as indicated. In practical circuit design, the useful power output will be several per cent less than values shown.

♦ Obtained from fixed supply or through resistor of value indicated in series with modulated plate supply.

INSTALLATION

The base of the 4D21 fits a giant 5-pin socket which provides adequate clearance for the bulb exhaust tip extending through the bottom of the base as shown in the Dimensional Outline. The socket should not apply excessive lateral pressure against the base pins. It should be mounted to hold the tube in a vertical position with base either up or down. Under service conditions involving severe vibration or shock, the tube should be protected by a shock-absorbing suspension.

The metal shell of the base should be grounded by means of spring contacts bearing against the shell. Connection to the plate cap should be flexible in order not to put strain on the plate seal.

Adequate cooling of the 4D21 is required under all operating conditions. When the operating frequency is below 30 megacycles, forced-air cooling is not required when there is adequate free circulation of air around the tube. At frequencies above 30 megacycles, forced-air cooling is required when the tube is operated at or near maximum ratings. Usually, sufficient cooling of the bulb and plate seal will be provided by a small fan or blower directed at the plate end of the tube. When shielding hampers free circulation of air through the perforated base to cool the stem, an air flow of about 2 cubic feet per minute should be directed vertically from a small nozzle toward the center hole in the ceramic insert of the base.

The filament of the 4D21 is of the thoriated-tungsten type. Under normal full-load conditions, the filament voltage should be maintained at 5 volts within ± 5 per cent.

Shielding and isolation of the input from the output circuit are necessary for stable operation in rf service. With reasonable precautions to prevent coupling, neutralization is not required up to 100 megacycles. Effective shielding between grid and plate circuits may be obtained by mounting the socket on a grounded metal plate to which is fastened spring connectors to ground the base shell. The rf impedance between grid No.2 and the filament must be kept low, usually by means of a suitable by-pass capacitor. In single-ended circuits, the plate, grid No.2, grid No.1, and filament by-pass capacitors should be returned through the shortest possible leads to a common point on the chassis. In push-pull circuits, the grid-No.2 terminal and the filament terminals of each tube should be by-passed to a common chassis point. At the higher frequencies in particular, it is essential that short, heavy leads and circuit returns be used in order to minimize lead inductance and losses.

A protective device should be used to protect both the grid No.2 and the plate against overloads, due to loss of excitation, improper circuit adjustment, or possible circuit failure.

The rated plate and grid-No.2 voltages of the 4D21 are high enough to be dangerous to the user. Care should be taken during adjustment of circuits, especially when exposed circuit parts are at high dc potential.

APPLICATION

The maximum ratings in the tabulated data for the 4D21 are limiting values above which the serviceability of the 4D21 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The 4D21 may be operated at maximum ratings up to 120 megacycles. It may be operated at higher frequencies provided the maximum plate voltage is reduced as the frequency is raised. The following table shows the highest percentage of maximum plate voltage that can be safely used up to 250 megacycles. Special attention should be given to adequate cooling at the higher frequencies.

FREQUENCY	120	150	200	250
MAX. PERMISSIBLE PERCENTAGE OF MAX. RATED PLATE VOLTAGE:				
class C plate-mod. telephony	100	84	64	-
class C telegraphy	100	80	64	56

When the 4D21 is operated with the maximum permissible plate voltage at 250 megacycles in class C telegraph service, the power output from the tube is approximately 220 watts, and the required driving power at the tube (including bias loss) is approximately 8 watts.

Grid-No.1 dissipation of the 4D21 may be calculated approximately from the following equation:

$$P_g = e_{cmp} I_c$$

where,

P_g = Grid-No.1 dissipation in watts

e_{cmp} = Peak positive grid-No.1 excitation voltage in volts

I_c = DC grid-No.1 current in amperes

The value of e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid No.1. Where no means are available for measuring e_{cmp}, the maximum grid excitation must not be greater than that which causes the power dissipated in the bias source to be 5 watts.

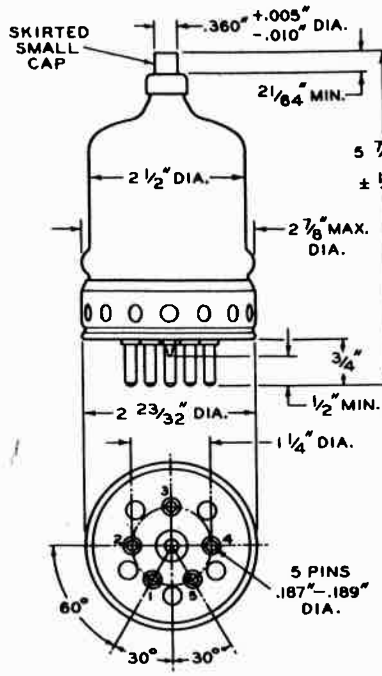
In class AB_2 audio service, the 4D21 may be operated as shown in the tabulated data. The values cover operation with fixed bias and have been determined on the basis that some grid-No.1 current flows during the most positive swing of the input cycle.

In plate-modulated class C amplifier service, the 4D21 is supplied with grid-No.2 voltage obtained either from a fixed supply or through a resistor in series with the modulated plate supply. The grid-No.2 voltage must be modulated with the plate voltage so that the ratio of plate voltage to grid-No.2 voltage remains constant. Modulation of a fixed grid-No.2 voltage supply can be accomplished either by connecting grid No.2 to a separate winding on the modulation transformer or by connecting it through a blocking capacitor to a tap on the modulation transformer or choke. With the latter method, an af choke of suitable impedance for low audio frequencies should be connected in series with the grid-No.2 supply lead. Grid-No.1 bias may be obtained by means of a grid resistor or from a combination of either grid resistor and fixed supply or grid resistor and cathode resistor. The combination of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

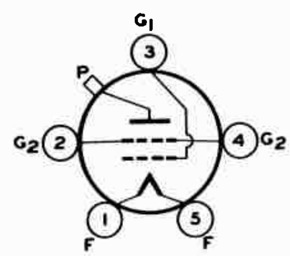
In class C rf telegraph service, the 4D21 may be supplied with grid-No.1 bias by any conventional means, except when a preceding stage is keyed; in this case, sufficient fixed bias should be used to maintain the plate current at a low value when the key is up. The grid-No.2 voltage should be obtained from a fixed low-voltage source if the 4D21 or any preceding stage is keyed.

Push-pull or parallel arrangements may be used when more radio-frequency power is required than can be obtained from a single tube. Two tubes in push-pull or parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid-No.1 bias is the same as that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits.

DIMENSIONAL OUTLINE



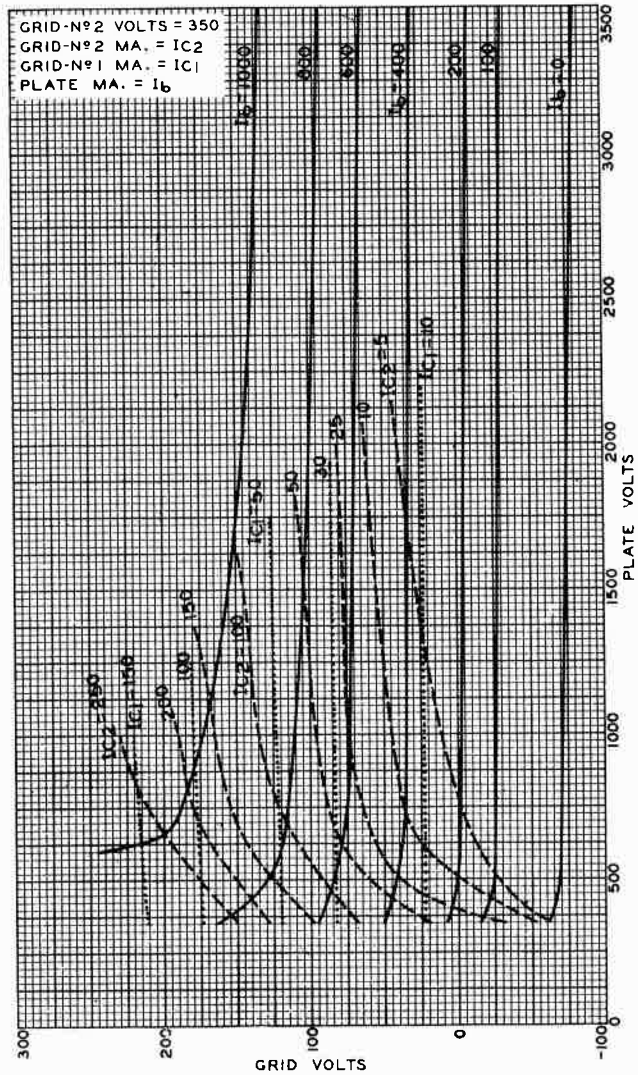
SOCKET CONNECTIONS
Bottom View



5BK

PIN 1: FILAMENT
PIN 2: GRID No.2
PIN 3: GRID No.1
PIN 4: GRID No.2
PIN 5: FILAMENT
CAP: PLATE

AVERAGE CONSTANT-CURRENT CHARACTERISTICS



4X500A

POWER TETRODE

Forced-Air Cooled

TENTATIVE DATA

RCA-4X500A is a filament type of radiator-cooled, four-electrode tube suitable for use as an rf power amplifier and oscillator. It has a maximum plate dissipation of 500 watts, and can be operated at full ratings up to 120 megacycles. Because of its design features, the 4X500A generally requires no neutralization to provide stable operation at high frequencies.

GENERAL DATA

Electrical:

Filament, Thoriated Tungsten:		
Voltage	5	volts
Current	13.5	amperes
Transconductance, for plate volts = 2500, grid-No.2 volts = 500, and plate ma. = 200	5200	micromhos
Grid No.1 to Grid No.2 Mu-Factor	6.2	
Direct Interelectrode Capacitances:		
Grid No.1 to Plate	0.05	μμf
Input	12.8	μμf
Output	5.6	μμf

Mechanical:

Mounting Position	Vertical, radiator up or down
Maximum Overall Length	4-3/4"
Maximum Diameter	2-5/8"
Terminals	See Outline Drawing
Radiator	Integral part of tube

Forced-Air Cooling:

Of Radiator . . . . . 22 min. cfm

The specified air flow at a pressure drop of 1.4 inches of water should be passed through the radiator, and should be started before the application of filament voltage.

Of Glass at Filament End of Tube . . . . . 1000 min. fpm

The glass at the filament end of tube must by cooled by passing air at the specified velocity across the filament end of tube. This air can be provided by a small fan or blower and should be supplied before applying the filament voltage.

RF POWER AMPLIFIER & OSCILLATOR—Class C Telegraphy or FM Telephony

Key-down conditions per tube without amplitude modulation

Maximum Ratings, Absolute Values:

For operating frequencies up to 120 Mc

DC PLATE VOLTAGE	4000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	500 max.	volts

Maximum Ratings (Cont'd):

DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-500 max.	volts
DC PLATE CURRENT	350 max.	ma
PLATE DISSIPATION	500 max.	watts
GRID-No.2 DISSIPATION	30 max.	watts
GRID-No.1 DISSIPATION	10 max.	watts

Typical Operation in Push-Pull Amplifier at 110 Mc:

Values are for 2 tubes

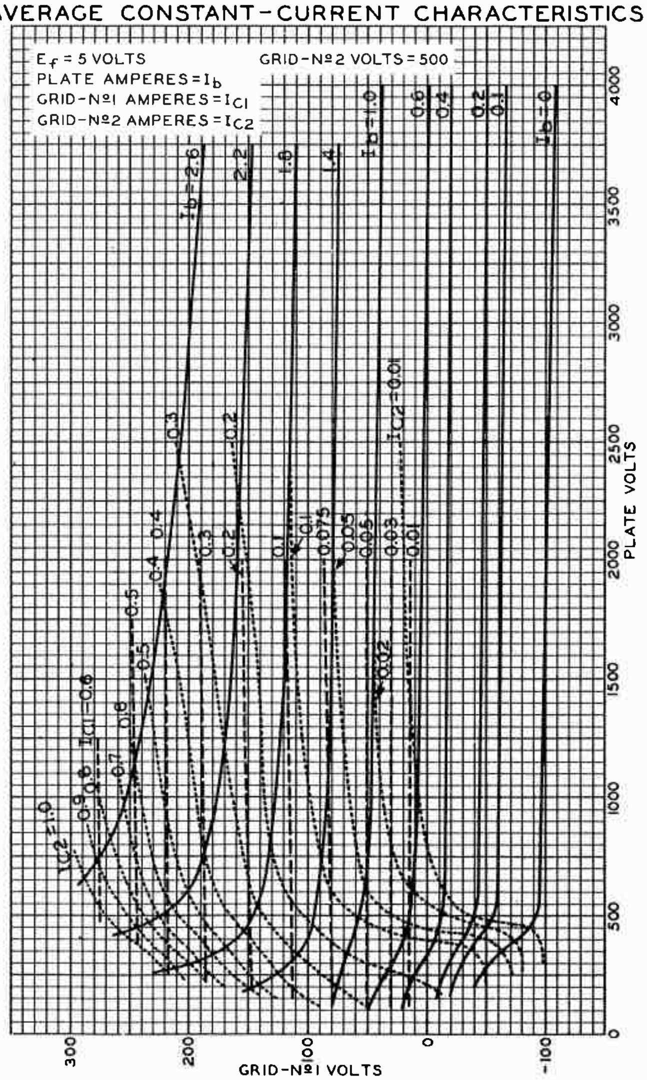
DC Plate Voltage	2500	3000	volts
DC Grid-No.2 Voltage	500	400	volts
DC Grid-No.1 Voltage	-250	-200	volts
DC Plate Current	690	600	ma
DC Grid-No.2 Current	100	95	ma
DC Grid-No.1 Current	40	45	ma
Driving Power (Approx.)	20	18	watts
Power Output (Approx.)	1300	1320	watts
Useful Power Output	1150	1180	watts

Typical Operation in Push-Pull-Parallel Amplifier at 110 Mc:

Values are for 4 tubes

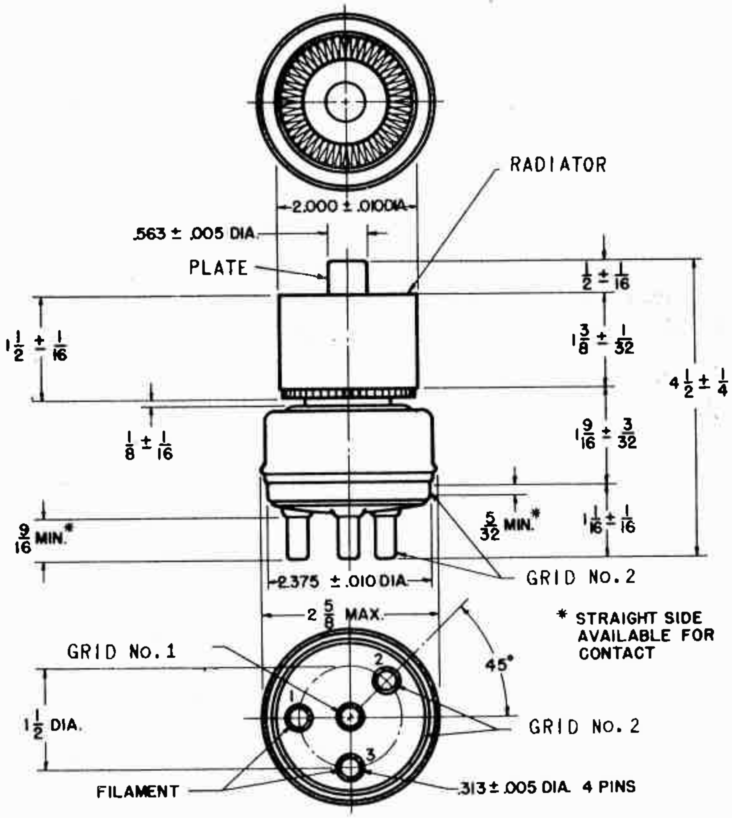
DC Plate Voltage	4000	volts
DC Grid-No.2 Voltage	500	volts
DC Grid-No.1 Voltage	-250	volts
DC Plate Current	1250	ma
DC Grid-No.2 Current	160	ma
DC Grid-No.1 Current	70	ma
Driving Power (Approx.)	50	watts
Power Output (Approx.)	3900	watts
Useful Power Output	3500	watts

AVERAGE CONSTANT-CURRENT CHARACTERISTICS



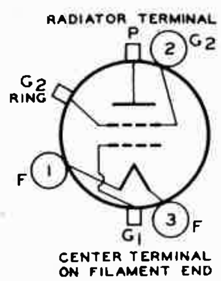
4X500A

DIMENSIONAL OUTLINE



TERMINAL DIAGRAM

PIN 1: Filament
PIN 2: Grid No.2
PIN 3: Filament
RING: Grid No.2



RADIATOR: Plate
CENTER TERMINAL ON FIL.
END OF TUBE: Grid No.1

6AS7-G

LOW-MU TWIN POWER TRIODE

TENTATIVE DATA

RCA-6AS7-G is an indirectly heated type of multi-unit tube containing two low-mu triode units. It is particularly suitable for use as a regulator tube in regulated dc power-supply units. It is also useful as a booster tube in the scanning circuit of television receivers, or in any application where a low-mu twin triode with high plate current is desired.

High load-current capability together with low tube voltage drop can be obtained by connecting the two units in parallel.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	Volts
Current	2.5	Amperes

Mechanical:

Mounting Position	Any
Maximum Overall Length	5-5/16"
Maximum Seated Length	4-3/4"
Maximum Diameter	2-1/16"
Bulb	ST-16
Base	Medium Shell Octal 8-Pin

DC AMPLIFIER

Values are for each unit

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	250 max.	Volts
PLATE CURRENT	125 max.	Ma.
PLATE DISSIPATION	13 max.	Watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	300 max.	Volts
Heater positive with respect to cathode	300 max.	Volts

Characteristics:

Plate-Supply Voltage	135	Volts
Cathode-Bias Resistor	250	Ohms
Amplification Factor	2.1	
Plate Resistance	280	Ohms
Transconductance	7500	Micromhos
Plate Current	125	Ma.

Maximum Circuit Values (for maximum rated conditions):

Grid-Circuit Resistance: For cathode-bias operation□	1.0 max.	Megohm

BOOSTER SCANNING SERVICE

Values are for each unit

Maximum Ratings, *Design-Center Values:*

PEAK INVERSE PLATE VOLTAGE*	1700 max.	Volts
PLATE CURRENT	125 max.	Ma.
PLATE DISSIPATION	13 max.	Watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	300 max.	Volts
Heater positive with respect to cathode	300 max.	Volts

Maximum Circuit Values (for maximum rated conditions):

Grid-Circuit Resistance: For cathode-bias operation□	1.0 max.	Megohm

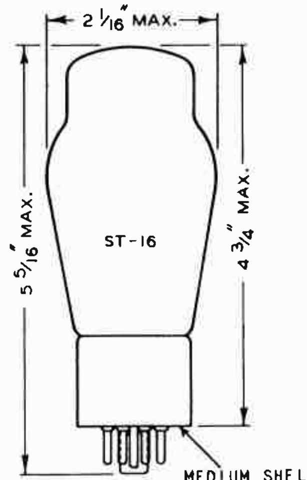
□ Operation with fixed bias is not recommended.

* The duty cycle of the peak inverse voltage pulse must not exceed 15% of one scanning cycle and its duration must be limited to 10 microseconds.

APPLICATION

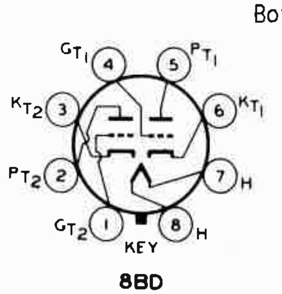
It is essential that precautions be taken in equipment design to prevent subjecting the 6AS7-G to full load-current before its cathode has reached normal operating temperature. The cathode requires approximately 15 seconds to attain normal operating temperature. Unless this precaution is observed, the cathode of the 6AS7-G will be seriously damaged if not completely ruined.

DIMENSIONAL OUTLINE



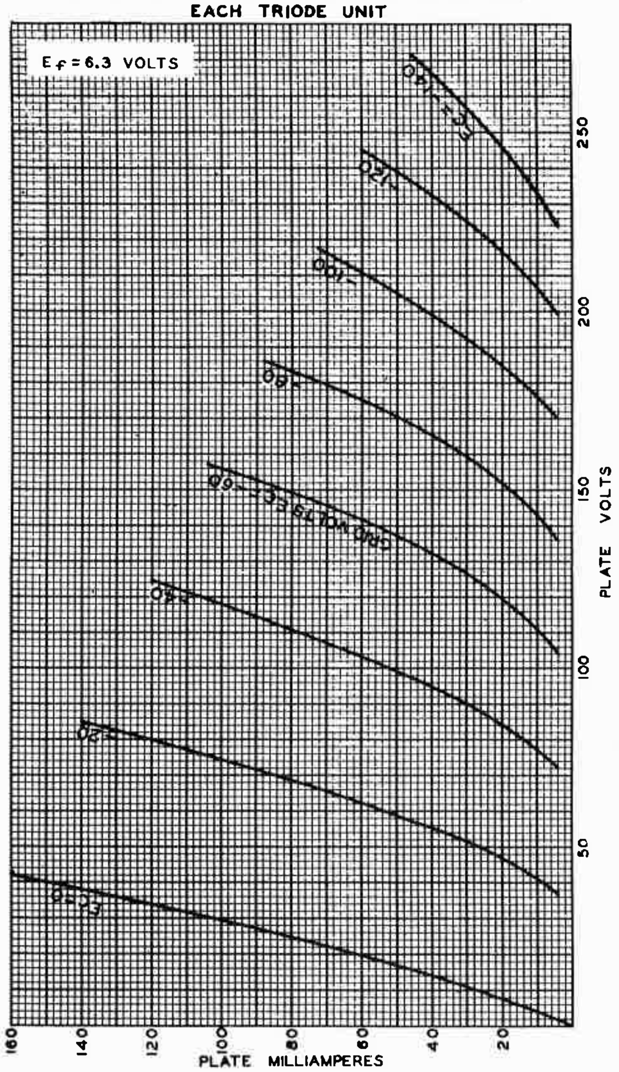
SOCKET CONNECTIONS

Bottom View



PIN 1: GRID OF TRIODE No.2
PIN 2: PLATE OF TRIODE No.2
PIN 3: CATHODE OF TRIODE No.2
PIN 4: GRID OF TRIODE No.1
PIN 5: PLATE OF TRIODE No.1
PIN 6: CATHODE OF TRIODE No.1
PIN 7: HEATER
PIN 8: HEATER

AVERAGE PLATE CHARACTERISTICS
EACH TRIODE UNIT



IMPORTANT

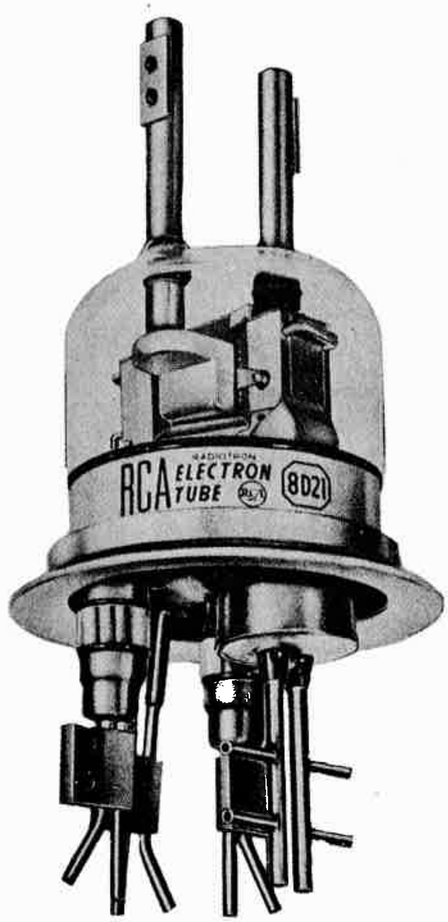
See p.5 for Information on Conserving Filament Life.

8D21

PUSH-PULL POWER TETRODE

Water & Forced-Air Cooled

RCA-8D21 is a water- and forced-air-cooled, high-power, twin tetrode of unique design intended for use as a class C rf power amplifier in television transmitters. In such service, it has a maximum plate-voltage rating of 6000 volts, a maximum total plate input of 10000 watts, and a maximum total plate dissipation of 6000 watts. It may be operated with maximum rated input up to 300 megacycles.



The 8D21 is unique in that high power capability at very high frequency is obtained by the use of a compact, high-current-density structure in which all electrodes are water cooled close to the active electrode areas.

The structure features a thoria-coated, multistrand filament; low interelectrode capacitances; excellent internal shielding between input and output circuits; internal neutralization of the small feedback capacitance to eliminate need for external neutralization; internal bypassing of screen to filament to maintain the rf potential of the screen at ground potential; and short internal leads with consequent low inductances. The overall length of the 8D21 is only about 12 inches and its maximum diameter is 5-3/4 inches.

Because of electron optical principles incorporated in its design, the 8D21 features very low current to its grids with resultant flexibility and simplification of circuit design.

GENERAL DATA

Electrical:

Filament, Thoria-Coated:		
Voltage (AC or DC)	{3.2 av. / 3.4 max.	volts / volts
Current with 3.2 volts on filament	125	amperes
Starting Current	Must never exceed 220 amperes, even momentarily	
Cold Resistance	0.0077	ohm
Grid No.1—Grid No.2 Mu-Factor	5	
Direct Interelectrode Capacitances (Each Unit):*		
Grid No.1 to Plate	**	μμf
Input	25.5	μμf
Output	6.5	μμf
Internal Grid-No.2 Bypass Capacitor (Approx.)	200	μμf

Mechanical:

Mounting Position	Plane of grid-No.1 leads horizontal and below horizontal plane of plate leads
Maximum Overall Length	12-9/32"
Maximum Diameter	5-3/4"
Terminal Connections	See Outline Drawing

Air Cooling:

Forced-air cooling of the glass envelope is required. The air flow must start with application of plate voltage, and should be directed from a 2"-diameter nozzle at the plate end of the tube so as to cool the area between the plate seals as well as the sides of the glass envelope. The air flow may be removed simultaneously with removal of plate voltage. Interlocking of the air flow with the power supplies is recommended to prevent the application of voltages to the tube without air cooling.

Air Flow	40 min.	cfm
Bulb and Seal Temperature	150 max.	°C

Water Cooling:

Water cooling of the filament block, the No.1 grids, the No.2 grids, and the plates is required. The water flow must start before application of any voltages and preferably should continue for several seconds after removal of all voltages. Interlocking of the water flow through each of the electrodes with all power supplies is recommended to prevent tube damage in case of failure of adequate water flow.

Water Flow Required:		
Filament Block (Cooling pipes connected in series)	0.1 min.	gpm
No.1 Grids (Cooling pipes connected in series)	0.1 min.	gpm
No.2 Grids	0.1 min.	gpm

Water Flow Required (Cont'd):

Plate of Each Unit:		
With dissipation of 1.5 kw	0.3 min.	gpm
With dissipation of 2.25 kw	0.4 min.	gpm
With dissipation of 3 kw	0.5 min.	gpm

Water Flow Obtained with Pressure Drop of 60 psi:

	Min.	*Max.*	
Filament Block (Cooling pipes connected in series)	0.18	0.37	gpm
No. 1 Grids (Cooling pipes connected in series)	0.18	0.35	gpm
No. 2 Grids	0.18	0.38	gpm
Plate of Each Unit	0.55	1.00	gpm
Water Pressure		100 max.	psi
Minimum Recommended		60	psi
Outlet Water Temperature		70 max.	°C

GRID-MODULATED PUSH-PULL RF POWER AMPLIFIER—Class C Television Service

Synchronizing-level conditions unless otherwise indicated; values are total for both units

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	6000 max.	volts
DC GRID-No. 2 (SCREEN) VOLTAGE	1000 max.	volts
DC GRID-No. 1 (CONTROL-GRID) VOLTAGE—White level	−1000 max.	volts
DC PLATE CURRENT (At crest of modulation)	2 max.	amperes
PLATE INPUT	10000 max.	watts
GRID-No. 2 INPUT	400 max.	watts
PLATE DISSIPATION	6000 max.	watts
GRID-No. 1 DISSIPATION	50 max.	watts

Typical Operation in Television Service up to 216 Mc—Bandwidth of 6 Mc:

DC Plate Voltage	5000	volts
DC Grid-No. 2 Voltage	800	volts
DC Grid-No. 1 Voltage:		
Synchronizing Level	−220	volts
Pedestal Level	−400	volts
White Level	−820	volts
Peak RF Grid-No. 1-to-Grid-No. 1 Voltage	1300	volts
DC Plate Current:		
Synchronizing Level	1.9	amperes
Pedestal Level	1.45	amperes
DC Grid-No. 2 Current:		
Pedestal Level	−0.025	ampere
DC Grid-No. 1 Current:		
Synchronizing Level	0.050	ampere
Pedestal Level	0.010	ampere
Driving Power (Approx.)***	300 to 500	watts
Power Output:		
Synchronizing Level	5300	watts
Pedestal Level	3100	watts

PUSH-PULL RF POWER AMPLIFIER—Class C Telegraphy or FM Telephony

Key-down conditions without amplitude modulation; values are total for both units

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	6000 max.	volts
DC GRID-No. 2 (SCREEN) VOLTAGE	1000 max.	volts
DC GRID-No. 1 (CONTROL-GRID) VOLTAGE	−1000 max.	volts
DC PLATE CURRENT	2 max.	amperes
PLATE INPUT	10000 max.	watts
GRID-No. 2 INPUT	400 max.	watts
PLATE DISSIPATION	6000 max.	watts
GRID-No. 1 DISSIPATION	50 max.	watts

Typical Operation in CW Service at 300 Mc:

DC Plate Voltage	6000	volts
DC Grid-No. 2 Voltage	800	volts
DC Grid-No. 1 Voltage°°	−275	volts
Peak RF Grid-No. 1-to-Grid-No. 1 Voltage	1350	volts
DC Plate Current	1.6	amperes
DC Grid-No. 2 Current	0.040	ampere
DC Grid-No. 1 Current (Approx.)	0.085	ampere
Driving Power (Approx.)	500	watts
Power Output (Approx.)	6500	watts

Typical Operation in FM Service up to 216 Mc:

DC Plate Voltage	4500	volts
DC Grid-No. 2 Voltage	700	volts
DC Grid-No. 1 Voltage°°	−300	volts
Peak RF Grid-No. 1-to-Grid-No. 1 Voltage	1150	volts
DC Plate Current	1	ampere
DC Grid-No. 2 Current	0.050	ampere
DC Grid-No. 1 Current (Approx.)	0	amperes
Driving Power (Approx.)	400	watts
Power Output (Approx.)	2500	watts

Maximum Circuit Value (CW or FM Service):

Grid-No. 1-Circuit Resistance	6000 max.	ohms

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Values are for each unit, unless otherwise indicated

	Note	*Min.*	*Max.*	
Filament Current	1	110	140	amperes
Input Capacitance	−	22.5	28.5	$\mu\mu$f
Output Capacitance	−	5.3	7.7	$\mu\mu$f
Plate Current	1,2	−	0.1	ampere
Plate Current	1,3	3.0	5.0	amperes
Plate Current Average of Both Units	1,3	3.35	−	amperes
Grid-No. 1 Current	1,3	0.15	+0.40	ampere
Grid-No. 1 Current Average of Both Units	1,3	−	0.25	ampere
Grid-No. 2 Current	1,3	−	1.5	ampere
Grid-No. 2 Current	1,4	−	0.15	ampere
Grid-No. 2 Current Average of Both Units	1,4	−	0.10	ampere
Peak Cathode Current	1,5	7	−	amperes

Note 1: AC filament volts = 3.2.
Note 2: With 5000 volts on plate, 800 volts on grid No. 2, and −220 volts on grid No. 1.
Note 3: With 1500 volts on plate, 800 volts on grid No. 2, and +500 volts on grid No. 1.
Note 4: With 2500 volts on plate, 800 volts on grid No. 2, and +300 volts on grid No. 1.
Note 5: Designers should limit the maximum usable cathode current to this value.

* With no external shielding.

** Grid-No. 1-to-plate capacitance is internally neutralized by the tube structure to within 0.02 $\mu\mu$f.

● Continuous Commercial Service.

*** Driving power is accounted for largely by circuit losses and is less at lower frequencies. In practical, grid-modulated circuit design with damping resistors, the indicated driving power, depending on frequency, is required to take care of the losses in the damping resistors, the circuit losses, and the tube driving power.

°° Obtained from combination of fixed bias and 2500- to 3000-ohm grid resistor.

INSTALLATION

The *serial number* which identifies each individual 8D21 and which should be used in any correspondence concerning the tube, is stamped on the structure within the glass envelope between the plate terminals. Other numbers stamped externally on the tube are for purposes of manufacturing records only.

In *transportation and storage* of the 8D21, care should be taken to protect the tube from rough handling that would damage the metal-to-glass seals or other parts. The 8D21 is supported within its shipping container so that it will not come in contact with the sides of the container during shipment. It should be stored in the container with the plate terminals down and should be protected from moisture and extreme temperature changes.

While the tube is being removed from its container, it should be lifted by grasping both filament-pipe assemblies near the mounting flange, or by grasping one filament-pipe assembly and the grid-No. 2-pipe assembly near the mounting flange.

under no circumstances should the 8D21 be handled by the grid-No. 1-pipe assembly. After the tube is removed from its container, it should be handled by the bulb or mounting flange. The weight of the 8D21 packed for shipment is approximately 12-1/2 pounds; unpacked, approximately 4-1/2 pounds.

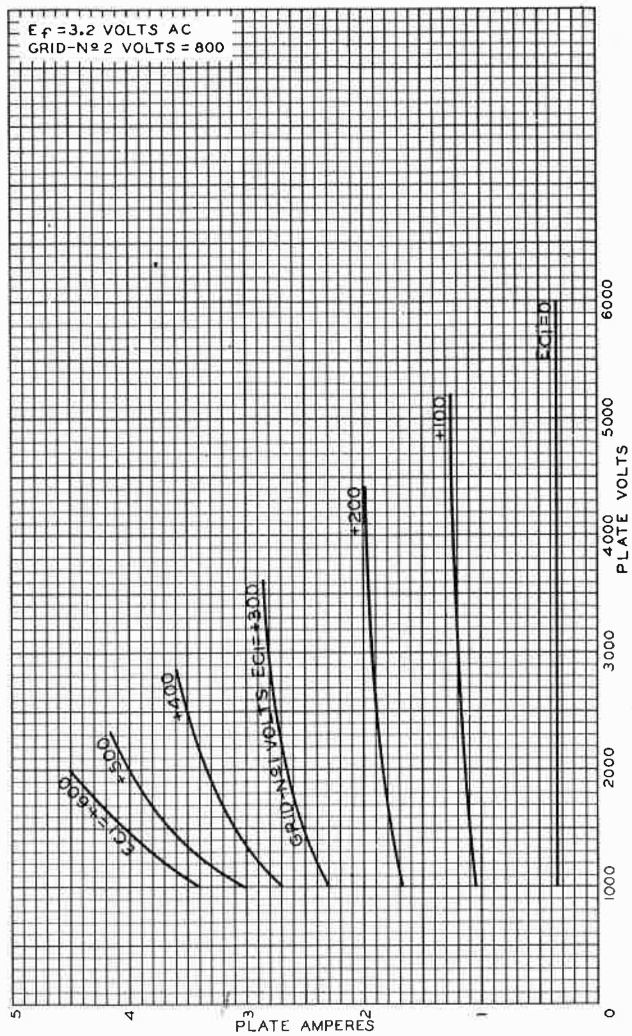


Fig. 1 - Average Plate Characteristics for Each Unit of Type 8D21.

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, any foreign material clinging to it should be removed. After the tube has been tested and before it is placed in storage, its cooling pipes and the ducts in the tube electrodes should be blown free of water. Care should be taken to prevent any foreign matter from entering the cooling pipes at any time. As a safeguard, it is recommended that during storage the 8D21 be completely enclosed in a container made of Pliofilm, or equivalent, and then sealed.

Mounting of the 8D21 requires the use of a mechanism to engage the mounting flange and clamp it firmly to hold the tube in a horizontal position with the plane of the grid-No. 1 leads horizontal and below the horizontal plane of the plate leads. Care should be taken to prevent vibration from being transmitted to the tube. Vibration of the tube and its associated circuit may cause undesired modulation of the signal output. Circuit elements adjacent to the tube terminals should put no strain on the terminals.

Extreme care should be taken to assure that no strain is placed on the seals when connecting or disconnecting the water hoses and the electrical connections to the tube. Particular care must be exercised with the grid-No. 1 seals. The grid-No. 1-pipe assembly should be supported with one hand while attaching or detaching the water hoses with the other.

The *water-cooling system* consists, in general, of a source of cooling water, a feed-pipe system which carries the water to the filament blocks, the No. 1 grids, the No. 2 grids, and the plates of the tube, and provision for interlocking the water flow through each of the electrodes with the power supplies. When the plate is at high potential above ground, the feed-pipe system should have good insulating qualities and proper design to reduce leakage current to a negligible value.

It is recommended that the water-cooling system be of the closed type utilizing distilled water to prevent the possibility of scale formation and corrosion, both of which can be expected with tap water. Scale not only restricts water flow but prevents proper transfer of heat from the tube electrode to the cooling water, while corrosion may destroy the electrodes and pipes. The water-supply system should be capable of supplying at least 2 gallons per minute at a pressure of 60 pounds per square inch at the tube.

A strainer should be provided in the water-supply line to the tube in order to trap any foreign particles likely to impair the water flow through the tube pipes. It is suggested that a strainer with an 80-mesh screen (0.005" openings) be used.

The piping system must be arranged so that the water flow through the grid-No. 1 pipes is in the direction indicated in the detail sketch of this terminal on the Outline Drawing. The grid-No. 1 pipes of tetrode unit No. 1 should preferably be connected in series with the grid-No. 1 pipes of tetrode unit No. 2 with due regard to the direction of water flow. The series connection provides simplicity and reduces the number of flow interlocks required. Similarly, the pipes to the two filament blocks should preferably be connected in series, but without regard to the direction of water flow. It is essential that the water hose used for the series connections have good insulating qualities and be of sufficient length to minimize leakage currents. The tube pipes should not support the hose connections.

Proper functioning of the water-cooling system is of the utmost importance. Even a momentary failure of the water will damage the tube. In fact, without cooling water, the heat of the filament alone is sufficient to cause serious harm. It is, therefore, necessary to provide a method of preventing operation of the

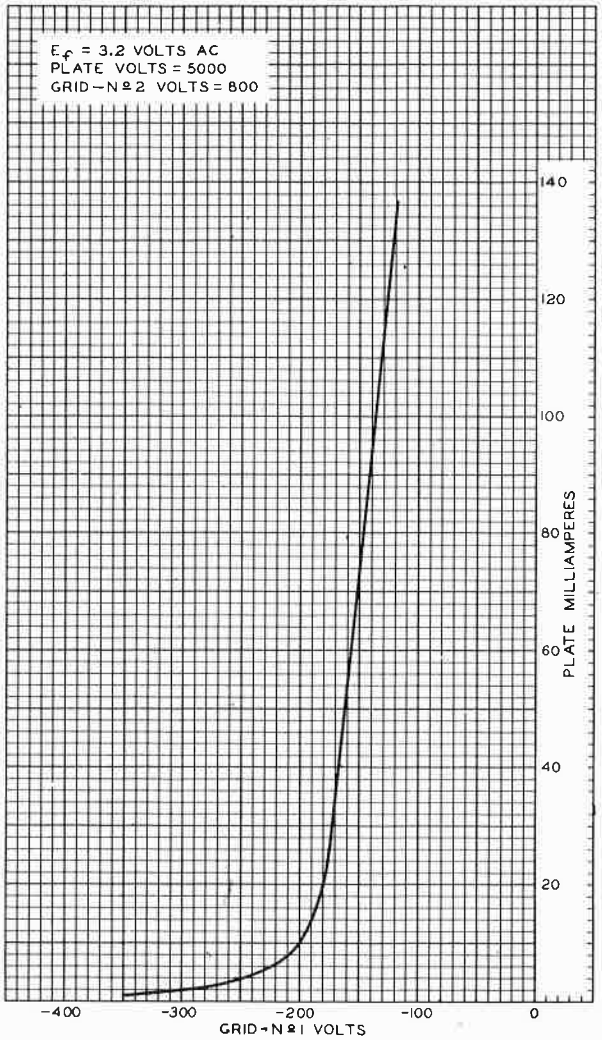


Fig. 2 - Average Characteristic for Each Unit of Type 8D21.

tube in case the water supply should fail. This may be done by the use of water-flow circuit breakers or interlocks which open the power supplies when the flow through any electrode is insufficient or ceases. The water flow must start before application of any voltages and preferably should continue for several seconds after removal of all voltages.

The minimum water flow required through the filament blocks, the No.1 grids, the No.2 grids, and the plate of each tetrode unit, together with the recommended minimum and allowable maximum pressure for such flow, is given in the tabulated data. The minimum and maximum flow obtained with a pressure of 60 pounds per square inch is also shown in the tabulated data. The use of an outlet water thermometer and a water flow meter at each of the outlets is recommended. Under no circumstances should the temperature of the water from any outlet ever exceed 70°C.

If occasion arises where any of the cooling pipes becomes clogged, the tube should preferably be removed from the circuit before attempting to dislodge the foreign material. Then, use water or compressed air at a pressure not exceeding 100 pounds per square inch to try to dislodge the foreign material in a direction opposite to that of the normal water flow through the clogged pipe. If compressed air is not available, compressed gases, such as nitrogen or oxygen, may be used provided the pressure is limited to 100 pounds per square inch. Should this procedure fail to clear the pipe, write Adjustment Dept., Radio Corporation of America, Harrison, N.J., for instructions, giving complete details.

An approximate value of the plate dissipation which should not exceed the value shown under Maximum Ratings in the tabulated data, may be calculated from the following equation

$$P_{watts} = n(t_o - t_i) \times 250$$

in which t_i is the temperature of the cooling water at the inlet in degrees Centigrade, t_o is the temperature of the water at the outlet in degrees Centigrade, and n is the number of gallons per minute of flow.

An *air-cooling system*, interlocked with the power supplies, is required to cool the glass envelope of the 8D21. This system consists of a blower and an air duct having a 2"-diameter nozzle. The air flow from the nozzle should not be less than 40 cubic feet per minute, and should be directed at the plate end of the tube so as to cool the area between the plate seals as well as the sides of the glass envelope. The temperature of the seals and of the bulb should not exceed 150°C at the hottest point. The temperature of the plate seals and of the bulb may be measured either with a thermocouple or with temperature-sensitive paint, such as Tempilac. The latter is made by the Tempil Corporation, 132 West 22nd Street, New York, N.Y., in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of 1 per cent.

The air-cooling system should be electrically interconnected with the filament and high-voltage supplies to prevent the application of voltages to the tube without air cooling. The air flow must start with the application of plate voltage, and may be removed simultaneously with removal of the plate voltage. Precautions should be taken to insulate the air-cooling system from the tube or circuit parts which may be at high potential.

The *thoria-coated filament* in the 8D21 is of the multi-strand type and is designed for dc or single-phase ac operation. The filament is arranged so that the strands in one leg furnish the electron emission for one tetrode unit, while those in the other leg furnish electron emission for the other tetrode unit. The strands of each leg are recessed in slots in a focusing block through which water is circulated by means of two water pipes. These two pipes are electrically and mechanically connected together by a lug which serves as the terminal for one leg of the filament. Similarly, the two pipes for the other block are connected together by a lug which serves as the terminal for the other leg of the filament. The two terminals are identified in the Outline Drawing as Filament Terminal "A" and filament Terminal "B".

The filament connectors should make firm, large-surface contact with the filament lug terminals in order to prevent heating by the high filament current. The filament-connection leads should not be taut, but should allow for some movement in order to prevent placing any strain on the filament pipes.

The filament of the 8D21 should be operated at constant voltage rather than constant current and must be allowed to reach normal operating temperature before plate and screen voltages are applied. The filament heating time is about 5 to 10 seconds depending on the type of filament starter employed. A suitable voltmeter should be permanently connected directly across the filament lug terminals so that the filament voltage will always be known.

Filament life of the 8D21 can be conserved by operating its filament at the lowest voltage which will give the desired power output. Because the filament of this tube when operated at the tabulated value of 3.2 volts provides emission usually in excess of any requirements within ratings, it is recommended that the filament voltage be reduced below 3.2 volts to a value that will give adequate but not excessive emission for any particular application. The proper operating value may be found by reducing the filament voltage, with normal modulation applied to the transmitter, until a reduction in output is observed. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament-voltage supply, and then further increased by about 0.1 volt to allow for other variations. It is suggested that the adjustment procedure be carried out daily. However, if no significant changes in the operating voltage are found necessary, the adjustment procedure can be scheduled less frequently. Good regulation of the filament voltage is in general economically advantageous from the viewpoint of tube life.

During long or frequent *standby periods*, the 8D21 may be operated at decreased filament voltage to conserve life. It is recommended that the filament voltage be reduced to 80 per cent of normal during standby operation up to 2 hours; for longer periods, the filament power should be turned off.

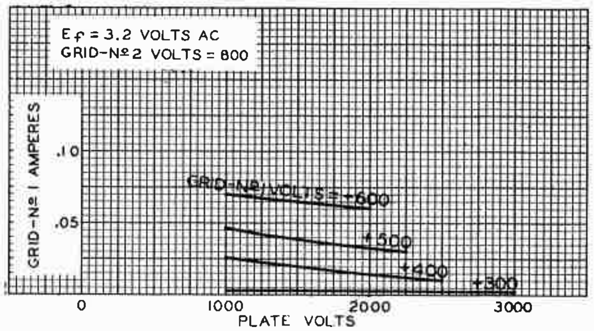


Fig. 3 - Typical Characteristics for Each Unit of Type of 8D21.

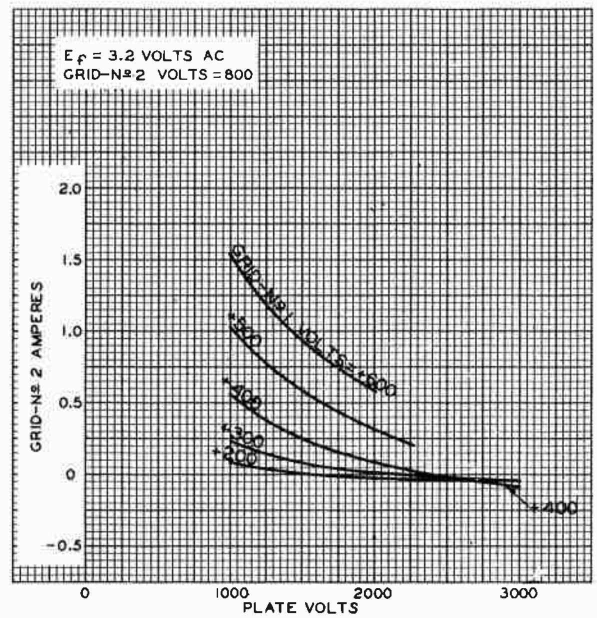


Fig. 4 - Typical Characteristics for Each Unit of Type 8D21.

When direct current is used, the polarity of the filament leads should be reversed every 500 hours of operation.

A *filament starter* should be used to raise the filament voltage gradually in order to limit the high initial surge of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance or reactance out of the circuit, a high-reactance filament transformer, or a simple rheostat. A combination of the last two methods is usually most desirable. Regardless of the method of control, it is important that the filament current never exceed, even momentarily, a value of 220 amperes.

The *grid-No.1 terminals* for the two tetrode units of the 8D21 are identified on the Outline Drawing. Electrical connection should be made to the solid end of each terminal by a suitable grip connector. Do not solder connections to these terminals.

Circuit returns from the No. 1 grids, the No. 2 grids (connected together within tube and brought out to a single terminal), and plates should be made to the mounting flange or to filament terminal "B" which is electrically connected to the mounting flange.

The *grid-No.2 (screen) voltage* should be obtained from a source of good regulation. The plate voltage should be applied before or simultaneously with the grid-No.2 voltage; otherwise, with voltage on grid No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation. A dc milliammeter should be used in the grid-No.2 circuit so that its current can be measured and the dc power input determined.

The *grid-No.2 current* is a very sensitive indication of plate-circuit loading and rises excessively (often to the point of damaging the tube) when the tube is operated without load. Therefore, care should be taken when tuning the 8D21 circuit under no-load conditions to prevent exceeding the grid-No.2 input rating of the tube.

The *plate-supply lead* common to both plates should be provided with a time-delay relay to delay application of plate voltage until the filament has reached normal operating temperature.

Protective devices should be used to protect not only the plates but also the No.2 grids against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the common ground lead of the plate circuits should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The time required for the operation of the relay and circuit breakers should be about 1/10 second and not more than 1/6 second.

A protective device in the grid-No.2 supply lead should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

When an 8D21 is first placed in service, care should be taken to see that the water- and air-cooling systems are functioning properly. The tube should then be operated without plate or screen voltage for 5 minutes at rated filament voltage. After this initial preheating schedule, the tube should be operated at approximately one-half the usual plate and screen voltages for 15 minutes. Full plate and screen voltages may then be applied and the tube operated under normal load conditions for a period of 1 hour or more. It is recommended that spare tubes be given the preheating and initial-operation treatment every 3 months. This procedure will insure that only good tubes are carried in stock.

When a new circuit is tried or when adjustments are made, the plate voltage and the screen voltage should be reduced to approximately one-half the rated values to prevent damage to the tube and associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooling water or the glass bulb, the plate and screen voltages may be raised in steps to the desired values. Adjustments should be made at each step for optimum operation.

The rated plate and screen voltages of the 8D21 are extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

APPLICATION

The *maximum ratings* in the tabulated data for the 8D21 are limiting values above which the serviceability of the 8D21 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute value will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The 8D21 may be operated with maximum rated input up to 300 megacycles.

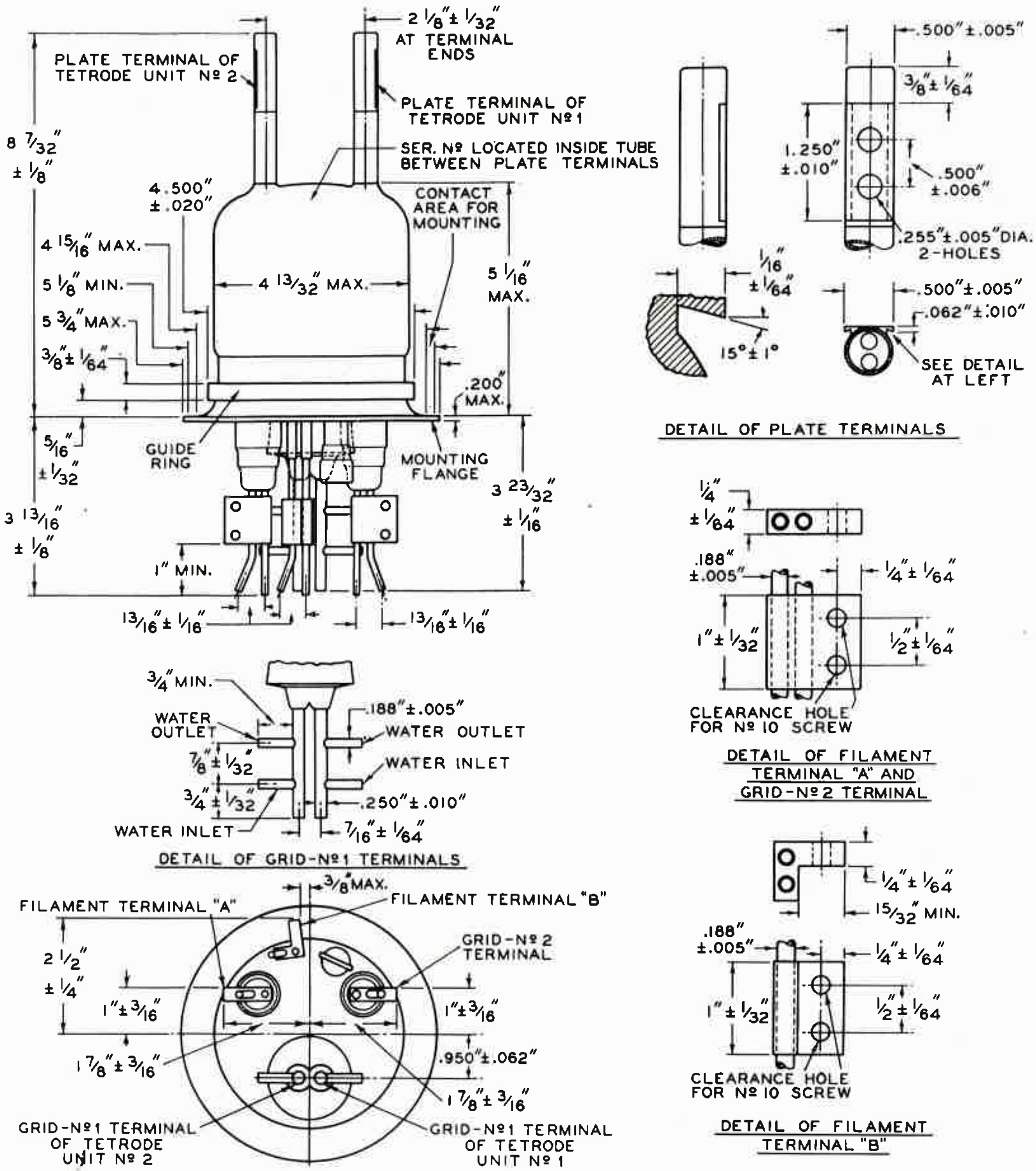
In *grid-modulated class C rf power amplifier service,* the 8D21 is supplied with unmodulated rf grid-No.1 voltage and with a video-modulated grid-No.1 voltage. The grid-No.2 voltage should be obtained from a source of good regulation.

In *class C rf power amplifier service,* the 8D21 should be supplied with grid-No.1 bias by a combination of fixed bias and a 2500- to 3000-ohm grid resistor. The grid-No.2 voltage should be obtained from a well-regulated voltage source.

REFERENCE

Federal Communications Commission, *"Standards of Good Engineering Practice Concerning Television Broadcast Stations"*, Superintendent of Documents, U.S. Government Printing Office Washington 25, D.C.

DIMENSIONAL OUTLINE



TUBE SYMBOL

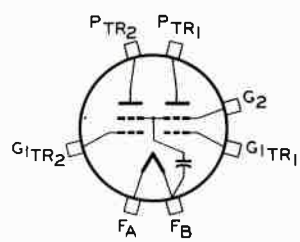
For Terminal Connections, See Outline Drawing

F_A : FILAMENT

F_B : FILAMENT & MOUNTING FLANGE

G_{1TR_1} : GRID No. 1 OF TETRODE UNIT No. 1

G_{1TR_2} : GRID No. 1 OF TETRODE UNIT No. 2



G_2 : GRID No. 2 OF TETRODE UNITS No. 1 & No. 2

P_{TR_1} : PLATE OF TETRODE UNIT No. 1

P_{TR_2} : PLATE OF TETRODE UNIT No. 2

TIPS ON USE OF THE RCA-8D21

The following material supplements the preceding instructions and data on the 8D21 tube and is compiled to help television station engineers properly utilize the RCA-8D21 Push-Pull Power Tetrode for optimum performance.

The "dos" and "don'ts" are those with which every operating engineer should be thoroughly familiar in order not to damage the 8D21 through improper operation.

DO

Test New 8D21's Immediately Upon Receipt

Give New 8D21's the Recommended "Break-In" Treatment

Use Care in Attaching Water Hoses and Electrical Connections

Use Distilled Water for Cooling

Be Sure That Adequate Water Flow is Maintained

Clean Water-Supply Filter at Regular Intervals

Be Sure That Air Flow to Glass Envelope is Adequate and Properly Distributed

Clean Blower at Regular Intervals

Keep 8D21's Clean

Allow 8D21's to Warm Up Prior to Day's Operation

Operate Filament at Lowest Possible Voltage

Blow 8D21's Free of Water and Enclose in Plastic Cover Before Placing in Storage

Operate Spare 8D21's Every 3 Months

DON'T

Don't Handle 8D21's by the Grid-No. 1 Pipe Assembly

Don't Use Tap Water for Cooling

Don't Allow Cooling Water to Become Contaminated

Don't Operate 8D21's with Full Voltage on Plate and Grid No. 2, or with Full Excitation, Until Proper Loading Conditions Have Been Obtained

DESIGN FEATURES OF THE 8D21

RCA-8D21 has been designed specifically for use as a highly stable, high-gain, broadband television transmitting tube. It is capable of efficient operation as a linear or grid-modulated amplifier with full input at frequencies as high as 300 megacycles per second.

The 8D21 is a good broadband tube because it has an unusually high "figure of merit," i.e., ratio of filament emission current to plate-to-plate capacitance.

High emission is provided at very low heating power by a new type of electron emitter consisting of thorium oxide on tantalum ribbon.

High power capability at very high frequency is achieved through the use of a compact, high-current-density structure in which small electrodes are water cooled close to the active areas where heat is generated. The small electrodes make possible low interelectrode capacitances. As a result, operation at frequencies as high as 300 megacycles per second is readily accomplished with open-type tank circuits, and without having to "bury" the tube in a cumbersome, inaccessible, concentric-line structure.

Water cooling of the electrodes is accomplished efficiently by high-velocity water streams. The linear velocity of the water in the streams may be in the order of 25 feet per second - a value sufficiently fast to remove instantaneously any steam or vapor bubbles that may form in the cooling ducts. The water flow required for each 8D21 is only about 2.4 gpm at the relatively low pressure of 60 psi.

The 8D21 makes possible the stability required in the modulated amplifier stage of television transmitters - stability many times greater than that required in any other type of service. The stage must not merely be kept below the point of oscillation caused by feedback; it must be kept many fold below this point to avoid severe distortion of the bandpass characteristic. Such an operating condition is achieved with the 8D21 because its pushpull tetrode construction provides: excellent internal shielding between input and output circuits; internal neutralization of the small feedback capacitance; internal bypassing of grid No. 2 to filament to maintain the rf potential of grid No. 2 at ground potential; and short internal leads with consequent low inductances. These features eliminate the major causes of input-output feedback.

Because of electron optical principles incorporated in its design, the 8D21 has high power gain, grid-current characteristics which permit video modulation of either the excitation or grid-No. 1 bias with a reasonably low value of video voltage, and a substantially linear amplitude characteristic in the synchronizing region - all necessary attributes of a good linear or modulated amplifier tube for television service.

TESTING A NEW 8D21

Each 8D21 is thoroughly tested before shipment. However, to insure that the tube has not been damaged in transit, it should be tested (see "Break-In" Treatment) upon receipt in the equipment in which it is to be used. Should there be any evidence of damage in transit, a "bad order" report should immediately be filed with the transportation company.

After the required adjustments have been made and the tube is operating normally to give the desired output, it is suggested that the readings of the meters and flow indicators as well as the control settings be logged before the tube is placed in storage. Then, in the event of an emergency tube change, the tube can be put in service quickly.

WATER-COOLING REQUIREMENTS

A few simple precautions will prevent the introduction of particles at some point in the water system between the filter and the tube. Inspect rubber hoses when changing tubes, for bits of rubber loosened by pipe ends that have become rough or sharp in service. When such is the case, carefully smooth the pipe ends with a fine file and/or crocus cloth.

When changing the water and before flushing the tube, use a pipe cleaner to remove any deposit from the ends of the tube pipes and the hose ends. This procedure will prevent any deposit from being carried into the tube when it is flushed. If tap water is used for flushing, always follow with a distilled-water flush to prevent any chlorine in the tap water from remaining in the tube. The presence of chlorine greatly increases the corrosion rate of the pipes and ducts in the tube. Therefore, never allow chlorinated water to enter the water system.

TUBE CLEANLINESS

As with other high-voltage, high-frequency equipment, it is essential that the glass bulb and other external parts of the 8D21 be kept free from accumulated dirt to minimize surface leakage and the possibility of arc-over. Make it a regular practice to wipe dirt from the glass bulb and other external parts of the tube about twice a month or more frequently, if necessary, to keep the tube clean.

"BREAK-IN" TREATMENT

Before a new 8D21 is placed in service or set aside as a spare, or after a tube has been in prolonged storage, it should be given the following treatment, preferably in the visual power amplifier:

Step 1: With no other voltages on tube, apply 3.0 volts to the filament for 10 minutes.

Step 2: Increase filament voltage to 3.2 volts, and apply about 2800 volts to the plates, 700 volts to the No. 2 grids (screens), and -600 volts bias to the No. 1 grids.

Step 3: Adjust the excitation to give a plate current of 100 to 200 milliamperes. Output loading should be maintained at normal broadband response.

Step 4: Decrease the grid-No. 1 bias or increase the excitation until a plate current of about 500 milliamperes is obtained. Allow tube to operate at this value for 5 minutes.

Step 5: Reduce plate current to a value between 100 and 200 milliamperes. Then apply full voltage to the plates and to the No. 2 grids, and operate at a plate current of 250 to 300 milliamperes for 10 minutes.

Step 6: Gradually increase the plate current over a period of 10 minutes until the visual "black-level" value, or the aural "carrier-level" value, is obtained. Operate the tube at this point for about 10 minutes. Modulation may then be applied.

OPERATION WITHOUT PROPER LOADING

When the transmitter is being tuned after a tube is installed, or when major circuit adjustments are made, reduce the plate voltage, the grid-No. 2 voltage, and the excitation as much as possible consistent with the practicality of making the adjustments. After adjustment to give proper loading for the 8D21, normal operating voltages and excitation may be restored. Failure to observe this procedure may result in serious tube or circuit damage because of high peak voltages resulting from improper loading.

GRID AND SCREEN CURRENTS

The negative grid-No. 1 and grid-No. 2 (screen) currents often observed in 8D21 operation are normal and do not indicate an inferior tube. They are caused by secondary electron emission from the No. 1 grids and the No. 2 grids. Since the magnitude of such emission is affected by slight changes in the surfaces of the No. 1 and No. 2 grids, the value of the grid-No. 1 current and the value of the grid-No. 2 current may vary considerably between individual tubes, or during the life of a tube. Accordingly, these currents should not be used for determining the proper conditions of loading, particularly when the currents are negative. Plate current and power output are the proper indicators of operating conditions.

MICROPHONICS

While microphonics in the 8D21 are normally at a low level, it may be desirable in video service to reduce still further microphonics resulting from the tube or associated grid-No. 1 circuit. The reduction can be accomplished by increasing the amount of grid-No. 1-circuit damping and by careful tuning of the circuit. The damping should not be increased to the point where the driver tubes will operate at higher than rated plate current. It is sometimes observed that when the grid-No. 1 circuit is tuned, the point at which microphonics disappear from "white level" does not coincide with that at "black level." In such cases, tuning to achieve the desired results at "white level" will result in a good picture, since microphonics are ordinarily not observable in the darker portions of the picture.

Avoid operating the water circulating system at abnormally high pressure. Such operation will cause excessive water turbulation in the tube passages with a resultant increase in microphonics. The following readings of the pressure gauge in the transmitter will normally give adequate flow through the tube:

Cooler Location	Pressure Gauge Reading-psi
On Floor With Transmitter....................	70 to 75
On Floor Below Transmitter....................	65 to 70

TUBES WITH DIMINISHED OUTPUT

When an 8D21 will no longer deliver adequate power output in video service, it will ordinarily be satisfactory for service in the sound transmitter. Transferring 8D21's under such conditions will greatly extend their useful life.

STORAGE AND OPERATION OF SPARES

Before an 8D21 is placed in storage, its cooling pipes and the ducts in the tube electrodes should be blown free of water. Removing all water prevents the possibility of voltaic action in the pipes and ducts with resultant corrosion. After the tube is dry, wrap and seal it in the original wrapping material or similar plastic film to prevent any foreign matter from entering the water pipes. Then place the 8D21 in the shipping container with the plate terminals down. During storage, the tube should be protected from moisture and extreme temperature changes.

As in the case of all large power tubes, no 8D21 should remain in storage for more than 3 months. It should be operated in rotation with other 8D21's in order to keep it free from traces of gas which may be liberated during prolonged storage. This procedure of rotating 8D21's in service will insure that only good tubes are carried in stock.