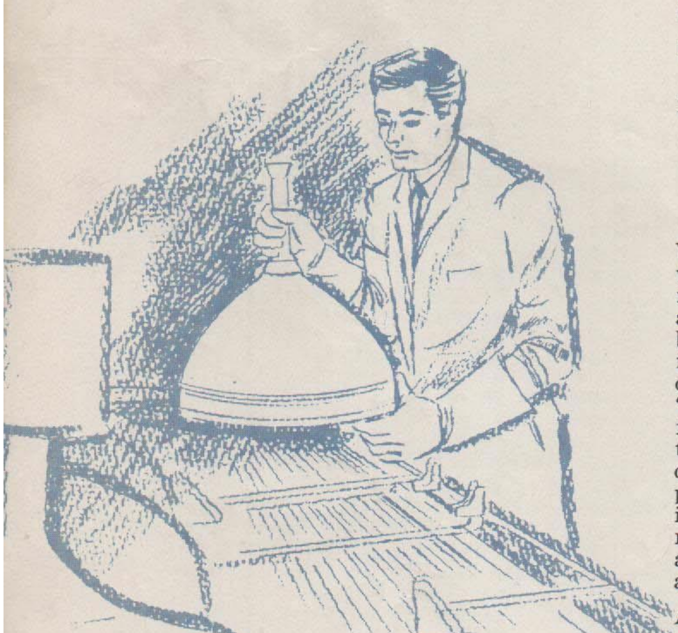
THIS IS WHAT HAPPENS TO A GUN DURING PROCESSING

It is a common occurrence to hear a tube manufacturer query a gun supplier as to why certain events are occurring with his product that have never occurred before. As far as he is concerned, no changes have been made in processing, yet the final results in the finished tube may be drastically different. In order to attempt to understand such occurrences, we must know something more of the actual physical mechanics concerned with the processing techniques employed with electron guns.

When a gun leaves the SUPERIOR ELECTRONICS plant, it has been manufactured and inspected to the highest set of standards within the industry. Essentially the gun consists of a series of metal electrode cups which have been coaxially mounted on insulating glass posts. These electrodes make up the lens system of the gun and serve to form a beam of electrons which will converge and focus at a predetermined spot. In order to form a beam of electrons, it is necessary to utilize an electron source which in this case is the commonly known "oxide coated cathode". Actually, this title is a misnomer, since the cathode is coated with alkaline earth carbonates, not oxides. It is not until the tube is processed that the cathode becomes an "oxide coated cathode". The reason for the use of carbonates lies in the fact that the oxides of the materials used are not quite as stable in air as the carbonates. They are much more hygroscopic and are therefore very easily contaminated or poisoned. During the exhaust pumping of a tube it is common practice to employ a schedule of various applied voltages to the heater of the tube in question. The purpose of applying this power is to heat the cathode through a cycle which will accomplish the following items:

1. Chemically decompose the carbonates to oxides (accompanied by the release of carbon dioxide)
2. Start a reaction between the oxides and the materials in the cathode base nickel to reduce the oxides and create free alkaline earth materials (barium, strontium and calcium). It is the availability of the first two elements to which we owe the actual phenomenon of electron emission.



While the above processes are being carried out, the vacuum system must be pumping rapidly enough to remove any of the by-products of the reactions as well as any of the gaseous material emanating from the glass bulb, screen material, aluminized layer and aquadag. It is imperative that all of these materials be removed as completely as possible, since once the cathode has been "converted", the remaining oxides have a natural affinity for most of the gases usually found inside the tube. Thus the cathode actually acts as a getter. Absorption of sufficient quantities of any of these gases can impair the previously described reducing processes and seriously inhibit the production of free electrons. The stringent requirements on pumping systems and associated temperature controls are obviously needed if we are to expect a tube to operate for any substantial length of time.

After a tube is pumped, it normally goes through a process described as "aging" or "seasoning". This process is an early stabilizing mechanism which usually involves a cathode heating schedule similar to that employed in the exhaust schedule but now coupled with applied voltages to several electrodes so that electron curent may be drawn from the cathode. Certain types of cathodes may require more, less, or none of the described aging treatment. More passive cathodes usually require cathode current in addition to heat.

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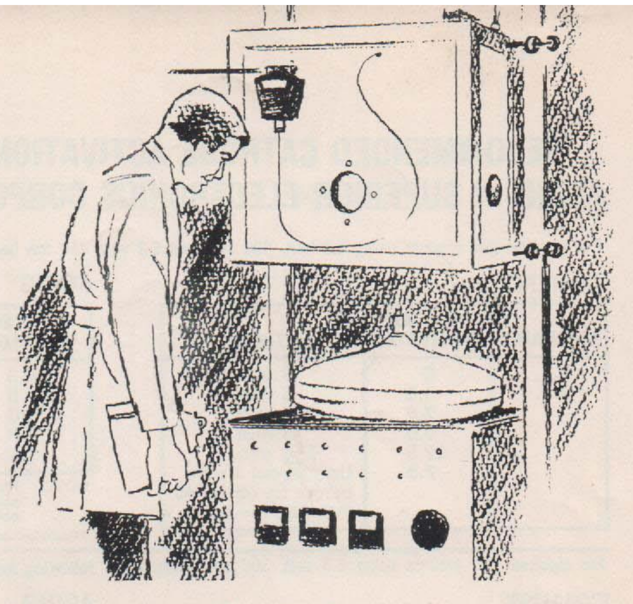


Cathodes are normally referred to as active, normal, and passive. These terms usually describe the cathode base material (nickel alloy) from a purity standpoint, i.e., the most passive alloys have the least impurity content while the most active cathodes have the highest ratio. These mentioned impurities are partially those types that act as chemical reducing agents and are necessary for the creation of high quantities of free electrons. Unfortunately, the presence of large amounts of these impurities can lead to undesirable side effects such as heavy sublimation, interface resistance and inter-electrode leakages. More passive cathodes are thus more difficult to process but are generally used and preferred where long life and reliability are prime requisites.

EXHAUST SCHEDULES— WHERE DO THEY COME FROM?

Given a particular type of electron gun it is undoubtedly possible to find multitudes of exhaust and aging schedules which will yield satisfactory results. This being the case, it may be of interest to examine the origin and necessity for the SUPERIOR ELECTRONICS recommended schedules. SUPERIOR ELECTRONICS CORPORATION maintains a complete facility for the manufacturing and testing of cathode ray tubes which are used in a long-range gun evaluation program. Such equipment is also used to provide some basis for establishing a recommended schedule. The equipment has been designed so that it is not of pure laboratory design but is rather a type which approaches actual field conditions.

Since the essential purpose of the schedule is to effect a chemical reaction by addition of heat, the basis for the schedule becomes the control of cathode temperature. From this point, SUPERIOR ELECTRONICS' engineers took into account items such as simplicity, effect on life, insurance against failure, and expanded the schedule to its well-known form as it appears today. It must be emphasized, however, that although attempts have been made to duplicate field conditions, no such duplication could have been exact enough to include every manufacturer's circumstances. Therefore, manufacturers should use the schedule as a starting point or guide from which they may employ modifications in order to achieve optimum results. In this manner, the individual manufacturer will compensate for many items, among them pumping speed variation, timing cycle errors, continuous cam type timing versus sequential step timing. Such modifications, even though they are necessary, should normally not require voltage changes differing from the recommended values by more than 10%.

RECOMMENDED CATHODE ACTIVATION SCHEDULES for EXHAUST and AGING of SUPERIOR ELECTRONICS CORPORATION ELECTRON GUN MOUNTS.

For electron gun mounts using 6.3 volt, 600 mA, and 6.3 volt, 450 mA heaters, the following exhaust and aging schedules are suggested:

EXHAUST

BOMBARD	VOLTAGE ON HEATER	TIME
R.F.	0	5 min.
R.F.	5.5	5 min.
	7.5	5 min.
	9.0	5 min.
	12.5	1½ min.
	7.5	Until about 1 min. before tip off (minimum time—5 min.)

AGING

HEATER VOLTAGE	GRID #1 VOLTAGE	GRID #2 VOLTAGE	*ANODE VOLTAGE	TIME
6.3	0	0	0	1 min.
12.5	0	0	0	1½ min.
9.0	+5 Vdc	+150 Vdc	−100	10 min.
9.0	0	0	0	10 min.
6.3	0	0	0	5 min.

NOTE: For mounts using 12.6 volt, 300 mA heaters the values in the above "Heater Voltage" columns should be doubled. All other columns remain unchanged.

*Recommended for non-aluminized types only.

For electron gun mounts using 6.3 volt, 300 mA heaters, the following exhaust and aging schedules are recommended:

EXHAUST

BOMBARD	VOLTAGE ON HEATER	TIME
R.F.	0	5 min.
R.F.	5.5	5 min.
	7.5	5 min.
	10.0	5 min.
	13.5	1½ min.
	7.5	Until about 1 min. before tip off (minimum time—5 min.)

AGING

HEATER VOLTAGE	GRID #1 VOLTAGE	GRID #2 VOLTAGE	*ANODE VOLTAGE	TIME
6.3	0	0	0	1 min.
13.5	0	0	0	1½ min.
10.0	+5	+150	−100	20 min.
6.3	0	0	0	5 min.

*Recommended for non-aluminized types only.

For electron gun mounts using the low power 2.35 volt and 2.68 volt heaters, the following exhaust and aging schedules are suggested:

EXHAUST

HEATER CURRENT

BOMBARD	2.35 VOLT HEATER	2.68 VOLT HEATER	TIME
R.F.	0	0	3 minutes
off	705 mA	600 mA	1 minute
R.F.	0	0	3 minutes
off	770 mA	620 mA	1 minute
off	Tip off	Tip off	

Note: Bombarding coil should be designed and located to keep RF above cage grid.

AGING

HEATER VOLTAGE

2.35 VOLT HEATER	2.68 VOLT HEATER	TIME
2.8	3.6	2 minutes
4.1	4.8	2 minutes
3.9*	4.6*	25 minutes

*Positive G1 voltage of 5-10 Vdc may be applied during this step to assist in cathode stabilization.

All listed heater voltages refer to measurements directly at the tube leads. Power supply meters should be regularly calibrated against such readings to compensate for among other things line drops, oxidation, loose connections, high contact or switch resistance.

If it becomes necessary to re-age any finished tubes because of improper processing or aging, it is suggested the hot shot values of heater voltage be increased 4 to 6% of the values recommended in the schedule.

During R.F. bombardment, Grid #1 temperature for 70° and 90° types should reach 775-800°C. For 110°-114° types, Grid #1 should reach 750-775°C. In all cases care should be exercised in locating the bombarder coils so that they do not extend below the bottom of Grid #1 in order to prevent undue heating of the stem leads and resulting cracked seals.

For mounts using 8.4 volt 450mA heater, the following exhaust and aging schedules are suggested:

EXHAUST

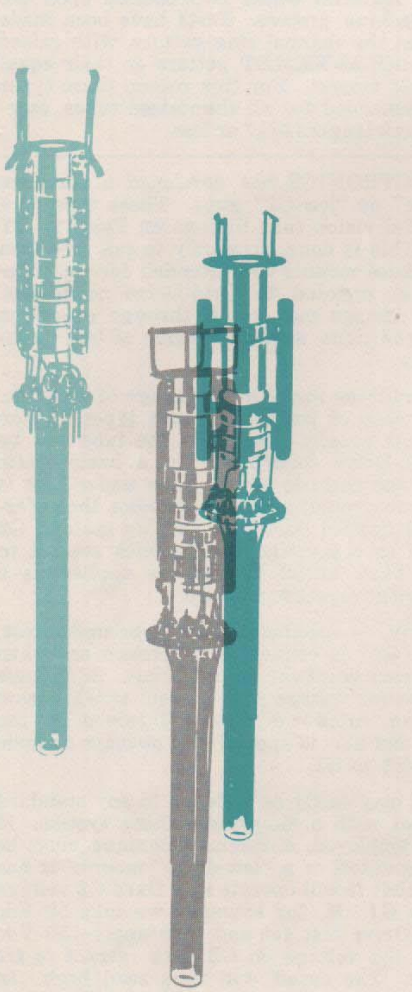
BOMBARD	VOLTAGE ON HEATER	TIME
R.F.	0	5 min.
R.F.	7.3	5 min.
	10.0	5 min.
	12.0	5 min.
	16.7	1½ min.
	10.0	Until about 1 minute before tip off (minimum time—5 min.)

AGING

HEATER VOLTAGE	GRID #1 VOLTAGE	GRID #2 VOLTAGE	*ANODE VOLTAGE	TIME
8.4	0	0	0	1 min.
16.7	0	0	0	1½ min.
12.0	+5	+150	−100	10 min.
12.0	0	0	0	10 min.
8.4	0	0	0	5 min.

*Recommended for non-aluminized types only.

TELEVISION PICTURE TUBE GETTERS



Getters are used in cathode ray tubes for the purpose of cleaning up gases that remain in the tube after pumping, and as a "keeper", adsorbing gases slowly released from tube parts during shelf and service life. Getters are effective in the adsorption of oxygen, nitrogen, hydrogen, carbon dioxide, and water vapor. They do not adsorb the inert gases helium, argon, neon, krypton, and xenon. Ordinary care should be taken in the handling of getters to see that they are not contaminated by grease, oil or other contaminants. If the getters have already been mounted on guns, the guns can be kept in a moderately heated cabinet without undue harm to the getter. The main thing is to avoid exposure of the getter to moisture or contaminating atmosphere.

Bar types or pellet types are generally used on non-aluminized and aluminized tubes where flashing is done towards the neck of the tube. Some bar type getters are preformed at 30°, 45° or 90° to direct the flash upward along the neck and into the tube. These types are generally used in aluminized tubes only. Each bar getter yields about 12 mgs. of vaporized barium when flashed for ten to twelve seconds. The time of flashing with this type getter should not exceed fifteen seconds because of the danger of burning through the getter bar. Normally flashing is done with "pancake" or oval R.F. coils positioned on each side of the neck, with each getter in the field of a coil. These getters are of the endothermic variety and flash at temperatures of approximately 1050°C.

The channel ring types of getters are made in two varieties:

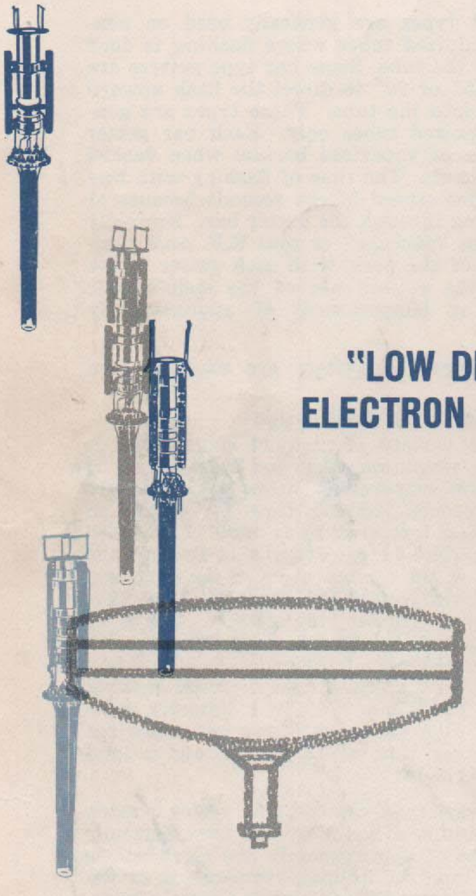
a. Endothermic b. Exothermic

a. The endothermic variety of channel ring getter is made using barium aluminum alloy and this variety is used for high barium evaporation yields. They require approximately 25 seconds flashing time for maximum yield, and the flashing temperature is 1050°C., as with the bar type getters. The danger of burning through the ring is lessened due to the configuration of the ring, and the better coupling with round R.F. coils that are normally used in flashing channel ring getters. Yields of approximately 80 mgs. can be obtained from 18mm (110°-114°) diameter channel rings of the endothermic variety if the flashing starts at 12 seconds and the total flashing time is 25 seconds. The 23mm (70°-90°) diameter endothermic getter will give yields of 85 mgs. of vaporized barium with a starting time of 12 seconds and a total flashing time of 25 seconds.

b. The exothermic variety of channel ring getter is made up of barium, aluminum, nickel alloy and they normally flash at temperatures of approximately 800°C., which is about 250°C. lower than the flashing temperature of the endothermic alloy. They yield less barium than the endothermic types when flashed but the total time of flashing is reduced to 15 to 20 seconds in order to obtain the maximum yield.

The 18mm diameter channel ring, exothermic getter will yield approximately 35 mgs. of vaporized barium with a starting time of 6 seconds, and a total flashing time of 15 seconds. The 23mm size will also yield approximately 35 mgs. of vaporized barium with the same starting time, and total time, as the 18mm size. The flashing of exothermic getters is uniform and predictable, but care must be used not to preheat this variety of getter beyond 700°C. during preliminary outgassing operations. Although the barium will not evaporate at this temperature, the free barium which is formed will act as a getter and adsorb gas that would normally be removed by vacuum pumping. Under such conditions, when the tube is sealed off and the getter flashed, the barium which has adsorbed gases will not vaporize, and the tube will be operating with a reduced amount of barium which has a tendency to shorten tube life.

Many questions have been raised as to which is the best getter to use. A getter type is selected to give the best results for a specific application. Thus, different types may be preferred by different manufacturers, depending upon the type of equipment available to them. In cathode ray tube types of a more recent design, increased emphasis has been placed upon clean, high voltage operation as well as a reduction in over-all tube length. This latter development has necessitated the use of shorter guns which require ultra-clean conditions of operation. For these guns it is extremely important to minimize the amount of getter material which is deposited upon the gun during the flashing process. Tests have been made which indicate that the channel ring getters, with raised inside shoulders such as KEMET getters or their equal are superior in this respect. For this reason these types are strongly recommended for all aluminized tubes, especially those with neck lengths 4½″ or less.



"LOW DRIVE" ELECTRON GUNS

SUPERIOR ELECTRONICS has developed a complete line of "low drive" or "low-G2" guns. These types are identified in the Television tube listings on Pages 28-37 by the footnote ▲ This is done, primarily to call attention to the fact that these mounts are intended for Cathode-Drive operation as opposed to Grid-Drive conditions. Since permanent damage may result through operation under improper conditions, some discussion of test methods is included here.

"Normal" test conditions imply a G2 voltage of 300 Vdc, or higher in the case of some 110° tube types. These "normal" conditions usually mean that the tube will be tested under Grid-Drive conditions. In a basic static CRT test circuit the cathode of the tube under test is usually connected to ground and thus becomes the reference point for all applied voltages. In this system, G2 voltage is applied as a *positive* voltage with respect to cathode, and G1 bias (cutoff voltage) is applied as a *negative* voltage with respect to cathode.

When Cathode-Drive is specified for the tube under test, the control grid (G1) is connected to ground and thus becomes the reference point for all potentials. G2 voltage is applied as a *positive* voltage with respect to G1. Beam current control (or cutoff) is now maintained by the cathode potential and bias is applied as a *positive* cathode voltage with respect to G1.

The above system may easily be included in any standard Grid-Drive test set with a simple switching system. If switching is not employed, a special technique must be used in measuring cutoff of a "low-drive" mount. It has been designed so that it will operate at a fixed G2 voltage —*with respect to G1*. If, for example, we take 50 Vdc on G2 in a Grid-Drive test set and then apply—50 Vdc to G1 for cutoff, the voltage on G2 *with respect to G1* becomes 100 Vdc. The cutoff will thus read high. In order to obtain an accurate reading, G1 and G2 potentials must be balanced so that their arithmetic *sum* equals the specified G2 voltage. For a 50 volt G2, these conditions are approximately Eg2=5-12 Vdc and Eg1= −38 to −45 Vdc for spot cutoff. "Low-drive" tubes are designed to have cutoff voltages falling in the −35 to −55 volt range which is somewhat lower than corresponding Grid-Drive guns.

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