CATHODE TEMPERATURES DURING GUN SEAL

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INTRODUCTION:

It is quite obvious that the proximity of heat sources such as gas flames and/or electric radiant heaters near a cathode assembly during gun seal or similar operations must increase its temperature. Not so obvious, however, is the degree of temperature rise that occurs, how the rise may be influenced by the structure in which the cathode is incorporated, and most important of all, how the extent and time duration of a temperature increase can affect cathode characteristics.

The Gun Group presently is engaged in work concerning the design and development of new electron guns. Shortened varients of the present straight gun have been made and are of particular interest since one of the immediate engineering objectives is to produce a cathode ray tube having a practicable minimum face to base measurement. In addition to the attention focused on shortening the gun structures to meet the objective just mentioned, consideration has also been given to mounting the cathode and gun assembly closer to the stem press. Such an orientation may promote higher cathode temperatures. Moreover, recent modifications made on cathode assemblies such as the decrease in the size of the G_1 cup for one type and the possible adoption of an open mica-cathode structure for another type have created conditions which better the "line of sight" of a heat source during gun seal. Thus, as may be the case for changes in mount-stem orientation, the new cathode assemblies described may also promote higher cathode temperatures.

The probability that cathode temperatures may be pushed upward brings up many questions concerning what effects or possible changes may occur in cathode characteristics later on in an evacuated tube. Answers to these questions would probably necessitate some lengthy experiments which sooner or later must be carried out. However, as a first approach some answers had to be gained as to what temperatures cathodes actually achieved in a standard factory gun during a gun seal operation, and to what extent these temperatures changed on new short gun-cathode assemblies.

MEASUREMENT OF TEMPERATURE

Cathode Temperatures

A number of standard factory guns and new guns were mounted on 110° stems. The guns and their respective cathode to stem press distance are shown in Figs. 1, 2, and 3. Chromel-alumel thermocouple wires 0.005 inch in diameter were attached to each cathode and led to the side of each cathode assembly and thence upward through aluminum oxide insulators on the side of each gun. Precautions were taken that no thermocouple junctions were made either with the stem leads or gun electrodes. Clean 110°, 21" bulbs were positioned over the stem mount on the gun sealer. Prior to this step the 0.005 inch diameter thermocouple wires were joined to 0.013 inch diameter thermocouple wires of the same material. These latter wires were extended up into the bulb and passed through an opening normally occupied by the anode button. From here the wires were brought to the top of the bulb face where connections were made to a recently calibrated Alnor, type 1500 Illinois Testing Co. meter of 0 - 900°C temp. range. Each tube was gun sealed on a 3 inch Cathode Ray Sealing Machine Type 5151, Model I (Property Tag CR688) in the Monochrome Development laboratory. Flame temperatures of the 4 positions and the index time for each had been previously adjusted to closely match those of the factory gun sealer.

During the operation of the gun sealer the Alnor meter was closely observed to obtain the maximum cathode temperature achieved at each position. For gun sealer positions 1, 2, and 3, the maximum cathode temperatures occurred at the end of each period; for position 4, the maximum cathode temperature occurred 20 seconds after start. Line nitrogen gas, at the rate of 3 cubic feet per minute, was introduced into the glass tubulation of the stems for all tubes except one.

Bulb Temperatures

For the determination of bulb temperatures during each gun seal position, a chromel-alumel thermocouple (.013 inch diameter wire) was introduced into the open anode button position of the bulb to a point in the center of the large bulb cavity.

RESULTS:

All data obtained for cathode and bulb temperature measurements and their respective position index time periods are presented in Table I. Also included in Table I are flame temperature data for each gun sealer position. Curves for most of the data collected are plotted in Fig. 4.

The data show that the temperature of the cathode in the mica assembly is about 60°C higher than cathodes on other assemblies. But it is seen also that the temperatures of the cathodes in these latter assemblies are high in themselves, reaching a peak of about 440°C. One tube carried through a gun seal operation without the introduction of nitrogen gas shows only about a plus 10°C difference in cathode temperature. The slightly lower cathode temperatures found for nitrogen flush tubes is probably due to the constant flow of fresh gas.

DISCUSSION:

It has been shown by the limited data collected above that cathode temperatures are quite high during gun seal for all guns investigated. Moreover, the open mica-cathode assembly with closer cathode to stem orientation is even more prone to heat absorption with a resultant cathode temperature peak.

High cathode temperatures in an oxidizing atmosphere can be anything but satisfactory. Mostly deleterious effects can occur due to premature oxidation of the reducing constituents in the base nickel and to the oxidation of the nickel itself. The latter state can create conditions which are especially severe if intimacy of contact exists between the nickel oxide and the alkaline earth coating material. One cause of adverse effects is the formation of alkaline earth nickelate compounds which may act as a "sink" for barium during an initial activation and aging sequence thus promoting shortened cathode life and lower emission level.

Occasionally benefit may be gained from some degree of oxidation of a portion of the cathode assembly. For example, the oxidation could remove some organic contaminants and some highly volatile inorganic contaminants that might be on the metal surfaces, present there because of some pick-up during fabrication of metal parts; also a more specific case in point would be the removal of the organic binder of the cathode coating by oxidation. Removal of this latter material would preclude the possibility of its carburization or incomplete combustion later on during a non -ideal activation schedule.

Very little information is available concerning specific adverse effects which might arise from high cathode temperatures prior to evacuation. Related data collected from some pertinent experiments such as cathode emission life as related to mass spectrometry would be quite helpful. Until such data is available we must rely on some basic facts as a criterion of cathode temperature limitation; namely, that it is the oxidation <u>rate</u> of cathode constituents which must be considered and that the rate is intimately related to both cathode environment and temperature.

Since some adverse changes in a cathode can be expected from a combination of a wrong environment and high temperature one or both should be avoided if at all possible. Cathode-stem orientation is one logical consideration, however, with an objective being short short structures in conventional center seal tube types this is not immediately feasible. On the other hand recourse to the use of a pure non-oxidizing gas environment and/or to the use of a low temperature frit seal is not out of the question. Such steps have beenconsidered by most of us.

It is recommended that the same experiment be carried out on the factory gun sealer to determine cathode temperatures.

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TABLE I

CATHODE TEMPERATURE AT GUN SEAL (* 3CFM Nitrogen Flush)

Assembly	Monochrome Eng. Mount No.	°C Temperature at Gun Seal Positions				Remarks
		Preheat 1 86 seconds	Drop down 29 seconds	Seal in 3 21 seconds	Anneal 4 120 seconds	
Std. Factory DL# 16061AC	1791 1792	*190° *200°	*290° *300°	*310° *290°	430° 440°	Each temperature was read at the end of each position with the exception of 4, wherein the temperature was read at peak or 20 seconds after start
Short gun Short G_1 cup Std. cathode	1795 1796 1797	*190° *190° 200°	*300° *290° 310°	*310° *320° 320°	440° 440° 450°	
Short gun, mica cathode structure (Philco type)	1799 1800	*280° *280°	*430° *430°	*430° *440°	500° 500°	
		°C Flame Temperature at Gun Seal Positions				
		550°	670°	710°	250°	
		°C Air Temperature in Bulb at Gun Seal Positions				
		70°	80°	90°	90°	

Chromel-alumel thermocouple - temperatures read in an Alnor, Type 1500 meter (Ill. Test. Co.) 0 - 900°C Range

Data collected by S. Sofia

Coppola

GLASS 4 GUNS

COMPLETE BEST 3 MOUNT

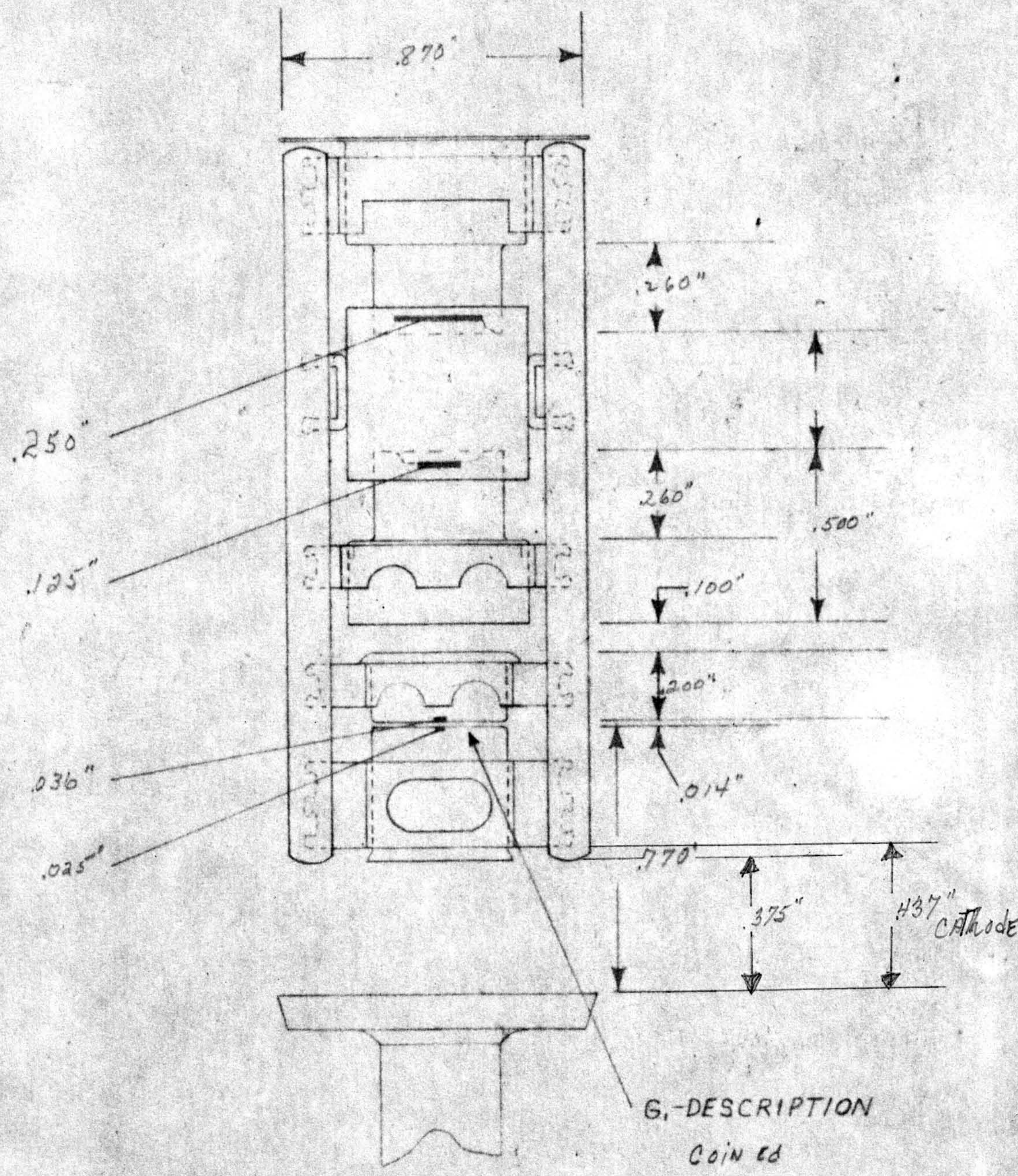
USE FACTORY CATHODES

CATHODE INFORMATION Notched by

Sonny T.C. on Cathodes

GUN #s 1791-94 E.T.I. - —

USE PIN - G



G.K .005"

GUN NUMBER

1791
1792
1793
1794

Fig. I

ENGINEER COPPOLA

GLASS 4 GUNS

COMPLETE BEST 3 MOUNTS

CATHODE INFORMATION

GET NOTCHED CATHODES FROM SONNY

GUN #'S 1795-1798 E. T. 1 —

ACCUMLATED

COMPLETED

GUNSEAL LENGTH —

SPRINGS VOLKERT

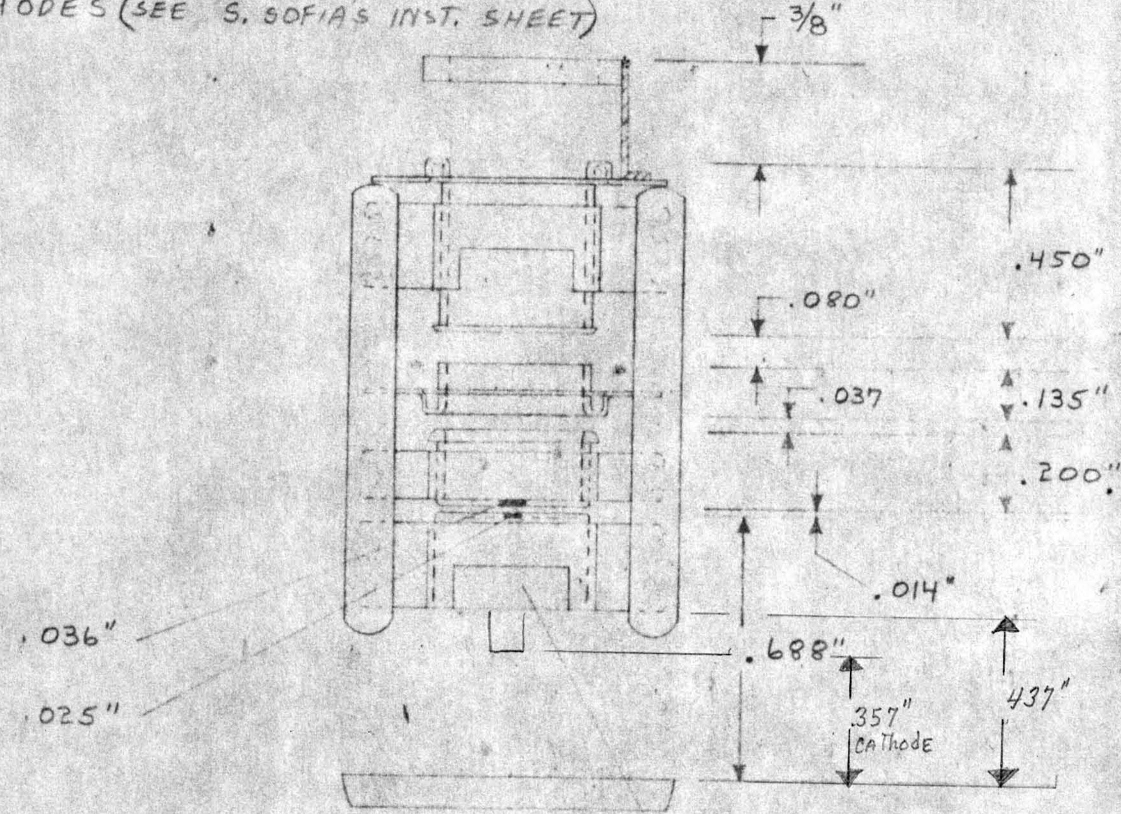
USE PIN G

— GUNSEAL LENGTH

— GUN OVERALL LENGTH

— PAINT LENGTH

T.C. ON CATHODES (SEE S. SOFIA'S INST. SHEET)



G,K .007"

GUN NUMBERS

1795

1796

1797

1798

G, DESCRIPTION

COINED AVG. TOP THICKNESS

3.000 RECEIVED 9/9/58

Fig. 2