U. C. Campbell

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OPERATING CATHODE TEMPERATURES IN 17" 110° CATHODE RAY TUBES

(N-16063 GUN MOUNT)

P. P. Coppola

INTRODUCTION

Since there appeared to be a relatively large spread in the operating temperatures of our cathodes, as shown in some limited data presented in the report entitled, "A Comparison of RCA and G-E Cathode Temperatures", December 23, 1958, a cooperative program was set up with Factory Engineering to collect more temperature data from random lots of factory tubes over a period of several months.

CONCLUSION

As shown by the data collected, there are some undesirably large differences in cathode temperatures from tube to tube and from lot to lot. Some examples of the many individual and/or combined conditions which can cause variations in cathode temperatures are listed for convenience.

EXPERIMENTAL

The 17" tubes containing N-16063 guns (with .040" diameter grid 1 side holes for sighting on to the cathode) were fabricated, activated, and aged by the factory. Cathode temperatures at 6.3 filament voltage were measured with a micro-optical pyrometer in the laboratory. All optical temperatures were corrected to true temperatures using the laboratory spectral emissivity data for nickel enclosed in a grid 1 cup.

Five lots of tubes or a total of 62 tubes were read. The results are shown in Table 1.

Many individual and/or combined conditions may reasonably account for the variations in temperatures shown in Table 1. These are listed in Table 2 for convenience. Many of these conditions as probably affecting cathode temperatures are obvious, but pinpointing one or more of these is not so obvious. Contributions from some of the individual conditions mentioned may be negligible, but combined, the results may be cumulative. Cancelling effects are also probable.

Loss of heat from the cathode shank nickel through thermal conduction can occur principally at the point of maximum mass contact, most likely at the area of attachment to the ceramic button. There are other minor areas listed in Table 2 through which heat can be lost by conduction. Other major losses of heat by radiation can occur principally through the back end of the cathode assembly. Radiation losses which can normally occur from an open upper portion of a cathode assembly may be reduced by the presence of a surrounding grid 1 cup, acting as a radiation shield.

Any slight disarrangement of the cathode assembly, through accidental change in geometry or mass such that it falls within the influence of major conductivity and radiation areas mentioned above, may lead to large changes in cathode temperatures. However, the many other conditions mentioned in Table 2 cannot be entirely ignored.

It would be extremely difficult to determine all of the parameters involved as affecting a change in temperature between say two cathode assemblies which are apparently identical and which are provided with the same heater power input. Calculations of heat transfer effects can be made and, as a matter of fact, have been made by Bennie Findeisen. But these calculations require a considerable amount of experimental temperature data at many positions within the cathode assembly locale collected simultaneously; a difficult procedure to say the least.

Some filament voltage-temperature data relative to the cathode, the grid 1 cup, the ceramic button, the cathode tab, and the internal stem area have been collected by the laboratory and are shown on Table 3. The temperatures of the ceramic and tab collected at their midpoints are significantly high and show their importance as heat sinks.

To further the investigation and to provide some additional clues, it would be desirable to run several more experiments in cooperation with the factory whereby tubes would be processed through Factory Engineering; and cathode temperatures would be read in the laboratory.

For example:

1. Series of tests with one piece RCA cathode assemblies.
2. Series of tests with Sylvania cloverleaf ceramic cathode assemblies.

Some limited data in respect to test (1) above have been given in the reference report mentioned previously.

A third test, namely, the investigation by X-ray of heater orientation vs. cathode temperature in the cathode nickel shank at 0 hours and during life is being run by the laboratory. To date 0, 500 and 1000 hour data have been collected on 4 tubes.

TABLE I

Date	Lot #	Tube #	True T°C	Low-High AT°C	Average T°C	Standard Deviation σ
3/6/59	1	C06L6A136	868°	33°	843°	8.9
		168	845			
		257	835			
		067	844			
		255	838			
		167	843			
		246	835			
		193	838			
		200	836			
		055	840			
		019	852			
		160	844			

Date	Lot #	Tube #	True T°C	Low-High AT°C	Average T°C	Standard Deviation σ
3/25/59	2	C25L6A054	858°	75°	863°	17.8
		160	870			
		040	905			
		248	846			
		047	872			
		076	843			
		007	865			
		196	830			
		140	861			
		129	877			
7/13/59	3	G13L6A061	837	50	857	14.0
		205	887			
		227	868			
		169	855			
		015	862			
		166	874			
		248	839			
		253	849			
		972	856			
		120	849			
		169	850			
8/13/59	4	H13L6A265	874	69	857	20.2
		193	855			
		207	854			
		072	854			
		095	887			
		221	864			
		199	854			
		268	892			
		176	852			
		149	817			
		100	867			
		245	878			
		132	842			
		239	847			
		009	823			
10/4/59	5	J04L6A063	835	48	844	14.2
		030	854			
		168	841			
		259	851			
		203	841			
		237	840			
		266	864			
		135	832			
		057	830			
		205	836			
		130	840			
		040	851			
		106	829			
		264	877			

TABLE 2

Factors Which May Influence Temperature Spread in Planar Disc Indirectly Heated Cathodes

1. Orientation of the shank nickel in the ceramic button due to loose cathodes or to firmly mounted off center cathodes.
2. Shank and cap nickel variations in dimensions and in mass.
3. Degree of attachment of the nickel cap to shank.
4. Cathode tab variations in dimensions, mass, and orientation.
5. Cathode shank and cathode cap nickel spectral emissivity variations.
6. Orientation of the heater in the shank nickel (e.g. depth of penetration of the heater coils).
7. Heater geometry (e.g. non-uniformity and spacing of heater coils).
8. Heater power input variations.
9. Non-uniformity in heater wire and heater coating.
10. Crystal structure of heater wire.
11. Spectral emissivity of heater coating.
12. Heater sag during cathode activation and aging.
13. Change in heater orientation during cathode activation and aging.
14. Length of heater legs and attachment to stem leads.
15. Ceramic button density and over-all dimensions as affecting thermal conductivity; and surface conditions or spectral emissivity as affecting heat radiation.
16. Orientation and contact of the ceramic button to the grid 1 cup as affecting thermal conductivity losses.
17. Spectral emissivity of the grid 1 cup interior as affecting radiation shielding characteristics.
18. Oxide coating adherence.
19. Spectral emissivity of an interface layer between nickel base and oxide coating.
20. Oxide coating thickness variations.
21. Oxide coating spectral emissivity variations.

TABLE 3

Temperature Orientation in N-16063 Gun Mounts

Number	E_f	True Cathode T°C	Grid 1 Temp T.C.	Midpoint Ceramic Temp T.C.	Midpoint Cathode Tab Temp T.C.	Vac. Stem Temp T.C.
E27J1B	6.3v	815°C		478°C		
	7.5	885		564		
	8.5	946		636		
	9.3	988		698		
	11.0	1086		808		
E27J2B	6.3	818		492		
	7.5	887		578		
	8.5	943		646		
	9.3	975		700		
	11.0	1063		806		
E27J3B	6.3	790		454		
	7.5	857		538		
	8.5	910		618		
	9.3	946		670		
	11.0	1025		786		
E27J4B	6.3	894				78°C
	7.5	985				100
	8.5	1035				114
	9.3	1087				126
	11.0	1198				154
E27J6B	6.3	825				78
	7.5	905				94
	8.5	962				110
	9.3	1000				122
	11.0	1088				148
E27J7B	6.3	840			458°C	
	7.5	903			504	
	8.5	958			538	
	9.3	990			564	
	11.0	1095			626	
E27J8B	6.3	855			436	
	7.5	933			480	
	8.5	989			512	
	9.3	1025			536	
	11.0	1118			586	
I17I3D	6.3		305°C			
	7.5		360			
	8.5		403			
	9.3		433			
	11.0		488			

PPC:am

cc: V. C. Campbell
G. L. Case
B. A. Findeisen
H. H. Gros
W. F. Hopkins
L. W. Jenne
W. L. Jones
E. M. Krackhardt
C. A. Perkins
D. Protzman
A. N. Reagan
S. S. Sadowsky
E. F. Schilling
J. H. Shepp
P. E. Sullivan