Progress Report No. 1

GETTERING OF GASES WITH TITANIUM

Cathode Ray Tube Sub-Department

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Materials and Processes
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1. Objective

It is known that under certain conditions titanium is very reactive with most of the common gases. In this investigation it is desired to find methods, techniques and processes by which titanium may be effectively used in a cathode ray tube as a dynamic, self-regenerating type, long-lived getter material.

2. Results

Two 12LP4A tubes with a small titanium disc welded to the first grid were placed on life test for 2291 hours (running with no anode voltage) with encouraging results. These tubes started with very high gas ratios (5.3 and 1.6) and within 16 hours and 7.5 hours respectively the pressures were within design specifications. Throughout the rest of life the pressures decreased steadily.

Three 21EP4A tubes with the titanium disc and one 21EP4A tube with a small flag of titanium welded to the cathode shield and supported parallel to the cathode were placed on regular life test (with full anode voltage and raster) with the following results: During the first eight hours the pressures stayed within limits; then the pressures of all three went above limits and didn't return to within limits until sometime between the 14 hour and 40 hour check. These tubes have been on life for more than 1000 hours with the pressure decreasing steadily.

Along with the two groups of tubes using titanium as the only source of gettering, tubes using the standard barium getter in combination with the titanium were tested. In each case the pressure was initially low, as expected, and in one case continued to decrease until it reached an extremely low constant value, much lower than the standard barium gettered control tubes.

The processes believed to occur in this type of gettering are chemical combination at the surface followed by diffusion into the interior. It was felt that the hot HCl acid was not cleaning the surface of the titanium thoroughly; thus, during initial gettering the oxides, nitrides, etc., left on the surface after cleaning would lower the efficiency of gettering until they had sufficient time and temperature to dissolve into the titanium. In order to obtain a surface of pure titanium a closed loop of it was mounted in a vacuum furnace and R.F. heated to 1025°C for three minutes. The bright and smooth condition of this surface compared to the matte surface after cleaning in hot HCl acid proved that all of my previous tests were made with titanium with surfaces which were more or less oxidized initially.

3. Conclusions to Date

Titanium appears to offer an excellent method of gettering dynamically throughout the life of a tube. It appears to be very efficient with respect to surface area per volume to be gettered, can be heated to an efficient gettering temperature by radiation or conduction from the cathode, and can even getter at room temperature to a certain degree. Under the conditions applied to date there is no adverse effect on emission characteristics. In order to getter the different gases most efficiently it appears desirable to maintain a temperature gradient across the piece of titanium.[1,2] It is very desirable to have a clean surface on the titanium at the start of any gettering; therefore, until a means of descaling can be found which is more efficient than the hot HCl acid, vacuum firing should be done to accomplish this.

At the present time the most effective technique is the regular flashing of barium for immediate reduction of pressure and use of titanium heated by radiation from the cathode for maintenance of low pressure throughout life. It may be necessary to use the barium-titanium combination regardless of the efficiency which may be attained through the use of titanium alone due to the following reason: When the tube is turned off and allowed to remain idle the temperature of the titanium drops to room temperature and becomes relatively inefficient; during this same period elements in the tube continue to outgas and build up pressure. When the tube is turned on again the titanium will begin gettering but may not reduce the pressure before damage has been done to the screen or cathode.

4. Plans for succeeding work

a. In order to subject a large surface area of titanium to radiation from the cathode and to contact with the gases, tubes are being built with the first grid cap fabricated completely of titanium. Sufficient temperature gradients should exist for optimum gettering of the various gases. These will be vacuum fired before mounting. If this procedure proves satisfactory, attempts will be made to find a source which can electroplate titanium to our standard steel first grid cups. The powder metallurgy technique will also be investigated to see if first grid cups can be made of titanium powder within the specified tolerances. If this is possible, then this method of gettering could be given a trial run in the factory without requiring any changes in the factory mount room.

b. In order to obtain higher temperatures of the titanium for more efficient gettering, strips of titanium have been welded directly to the cathode. During activation, however, a temperature higher than the eutectic point temperature for Ti-Ni (955°C) was reached and the titanium, cathode and heater fused together. Tubes are now being made in which titanium strips are being welded to the cathode through interfaces of tantalum, molybdenum and tungsten.

c. A tube with a special gun is being built, with thermocouples welded at different spots on the first grid and with holes drilled through the first grid for sighting with an optical pyrometer, so that the various temperatures can be determined.

d. A tube with a wide titanium flag welded to the cathode is in process to determine any possible cooling effect the additional flag may have on the cathode.

e. One effect which slows down the process of activation and aging is the poisoning of the emissive mix which will occur if the pressure in the cathode ceramic-first grid volume is allowed to reach an excessive value. By making the first grid and cathode spacer ring of titanium, it may be possible to prevent some of the cases of poisoning which show up as low emission tubes. It may also be possible to activate and age tubes at a more rapid rate, the gases being sorbed immediately upon release.

This may be a very useful technique in combination with pulse aging, and will be investigated at a later date.

5. <u>Experimental Procedure</u>

The titanium used in these experiments was obtained from Dr. V.L. Stout, G.E. Research Laboratory; the thickness of the sheet is 0.010 inch; and is 99 + % pure titanium.

Dimensions of titanium:

<u>1st. grid disc</u>

diameter of disc = 0.375 in.
aperture = 0.031 in.
thickness = 0.010 in.
total surface area = 0.22 sq. in.
volume = 0.0011 cu. in.

<u>flag welded to cathode shield</u>

a polygon 0.44 inch in length and shaped to fit between cathode and first grid
total surface area = 0.22 sq. in.
thickness = 0.010

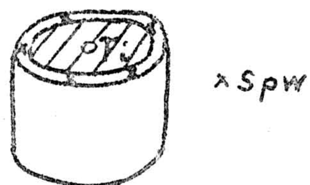
Method of cleaning titanium:

Immersion in hot HCl acid, acetone rinse, deionized water rinse.

Location of titanium:

<u>1st grid disc</u>

An aperture 0.275 inch in diameter is cut in the plane surface of the first grid cup and a titanium disc 0.375 inch in diameter is spot welded over this aperture; then a 0.031 inch aperture is punched through the titanium.



Flag

A flag 0.44 inch long with a total surface area of 0.22 sq. inch, shaped so that it will fit between the cathode and first grid, is crimped at the small end and spot welded to the cathode shield. It is positioned parallel to and at a distance of 1/16 inch from the cathode.

Treatment of titanium before tip-off:

During exhaust and activation the first grid is induction heated to a barely visible red (around 700°C) for 18 minutes. No severe outgassing of the titanium is attempted.

BIBLIOGRAPHY

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