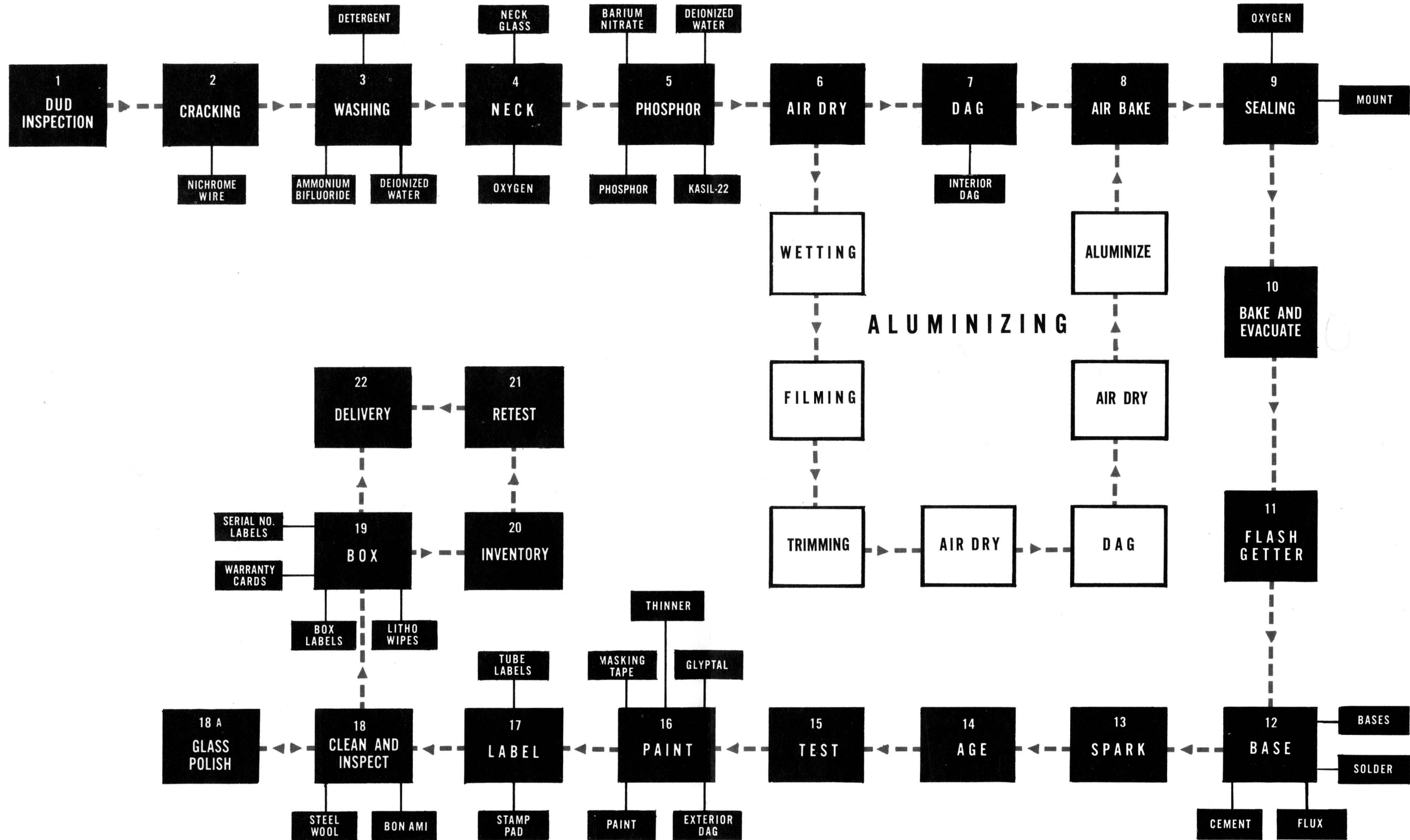CATHODE RAY TUBE
PROCESSING INFORMATION

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CLIFTON, NEW JERSEY

FLOW CONTROL CHART FOR THE MANUFACTURE OF CATHODE RAY TUBES

1 DUD INSPECTION → **2** CRACKING → **3** WASHING → **4** NECK → **5** PHOSPHOR → **6** AIR DRY → **7** DAG → **8** AIR BAKE → **9** SEALING → MOUNT

- 2 CRACKING: NICHROME WIRE
- 3 WASHING: DETERGENT; AMMONIUM BIFLUORIDE, DEIONIZED WATER
- 4 NECK: NECK GLASS; OXYGEN
- 5 PHOSPHOR: BARIUM NITRATE, DEIONIZED WATER; PHOSPHOR, KASIL-22
- 7 DAG: INTERIOR DAG
- 9 SEALING: OXYGEN

ALUMINIZING

WETTING → FILMING → TRIMMING → AIR DRY → DAG → AIR DRY → ALUMINIZE

9 SEALING → **10** BAKE AND EVACUATE → **11** FLASH GETTER → **12** BASE

- 12 BASE: BASES, SOLDER; CEMENT, FLUX

22 DELIVERY ← **21** RETEST

19 BOX → **20** INVENTORY

- 19 BOX: SERIAL NO. LABELS, WARRANTY CARDS; BOX LABELS, LITHO WIPES

18 A GLASS POLISH ← **18** CLEAN AND INSPECT ← **17** LABEL ← **16** PAINT ← **15** TEST ← **14** AGE ← **13** SPARK ← **12** BASE

- 16 PAINT: THINNER; MASKING TAPE, GLYPTAL; PAINT, EXTERIOR DAG
- 17 LABEL: TUBE LABELS; STAMP PAD
- 18 CLEAN AND INSPECT: STEEL WOOL, BON AMI

SUPERIOR ELECTRONICS CORPORATION

Manufacturers of Electron Guns

208-212 PIAGET AVENUE   CLIFTON, NEW JERSEY

TELEPHONE: GREGORY 2-2500

CRT NOTES

COMMON SETTLING PROBLEMS
AND POSSIBLE CURES

Courtesy of: Radelin Division
United States Radium Corporation
535 Pearl Street, New York 7, N. Y.

COMMON SETTLING PROBLEMS AND POSSIBLE CURES

I. PIN HOLES

A. GLASS CLEANING

The importance of absolutely clean glass tubes for the production of high quality screens cannot be overstressed. Much of the trouble encountered (pin holes, slippage, etc.) can be traced to improper cleaning.

A 5- to 10% ammonium bifluoride (NH_4HF_2) solution should be applied with a good strong jet properly distributed. It may be well to use a piece of rubber tubing at the end of the piping so that the jet is distributed over the entire surface. Evidence has established that a strong jet more thoroughly cleans the glass surface than mere washing. The acid wash should be followed by thorough rinsing.

In many border-line cases, some tube manufacturers have found it advantageous to add 1 oz. of sulfuric acid (H_2SO_4) per gallon of bifluoride solution and follow with a 4- to 5% trisodium phosphate (TSP) rinse.

A good test for the cleanliness of the tube is to place 500 cc of clean water into the tube and rinse. Then transfer the water into a clean flask. By using a sharp focus light a Tyndall effect should not exist. Any sign of a Tyndall effect indicates a dirty tube.

B. GOOD PHOSPHOR WETTING

This helps in achieving good distribution and in preventing formation of agglomerates. On decanting, agglomerates may fall away and cause holes or runs. Many manufacturers find sufficient wetting may be achieved by good (but not violent) agitation in water or potassium silicate. If in the specific case, agitation does not seem to remedy agglomeration, it may be necessary to resort to a moderate milling procedure. A good milling slurry would consist of 200 gm. phosphor, 1800 cc of water or potassium silicate, and a few porcelain balls (1/2 to 1-1/2 inch diameter) in a one-gallon mill. Milling is recommended only when agitation does not do the job completely.

C. GOOD FEED NOZZLE

Poor phosphor-silicate distribution to the cushion water may cause an incomplete reaction with the barium and poor adhesion in spots to the glass.

D. MATERIALS AND FORMULAS

It is understood that good screening results depend upon good phosphor properly prepared, good silicate solution, and good electrolyte. 4.5 to 5.0 gm. of potassium silicate (as solids) to 1 gm. U. S. Radium (Radelin) phosphor is recommended. In addition to this, 1 liter of 0.001 molar barium acetate should be used for every 3.5 gm. of potassium silicate. We recommend 4.5 to 5.0 gm. phosphor for 17 inch tubes and 8.0 to 9.0 gm. for 21 inch tubes. Particular conditions may require some modifications.

E. IMPROPER CLEANING OF EQUIPMENT

The funnel, 325 screen mesh, containers, etc., should be maintained clear and free of solidified potassium silicate and any other contamination. Any foreign material, either from the equipment or air borne, may leave a pin hole after the liquors are poured off.

F. CLEANLINESS OF WATER SUPPLY

All the water used for the screen settling must be free of all foreign material. The presence of particles (fine resin from deionizer, for instance), bacteria, and slime are all causes of pinhole formation. Extreme care must be maintained to insure uncontaminated water.

II. DISTRIBUTION

A. TEMPERATURE CONTROL

Heavy centers, light edges, and uneven screen texture are often encountered on placing a phosphor screen on the glass face. To insure proper distribution of the suspended particles, most tube manufacturers resort to the use of convection currents within the cushion water to disperse and provide a uniform phosphor screen. Most people pre-cool the cushion water so that it is approximately 10° C cooler than the ambient room temperature, thereby setting up convection currents within the tube.

B. PROPER NOZZLE

Very often a well designed nozzle at the end of the phosphor feed funnel can be the difference between good and poor distribution. A fine, evenly distributed spray into the cushion water, taking care that the phosphor does not strike the glass walls, will aid in good distribution.

C. PROPER POTASSIUM SILICATE QUANTITY

The suggested formula as described in 1-D may aid in good dispersion. It is essential that proper reaction take place to give uniform screen.

D. PROPER WETTING

Phosphor which is not uniformly wet will not settle upon the glass surface with good distribution.

E. PROPER CUSHION WATER LEVEL

The cushion level must be at such a height that sufficient settling time is obtained, allowing convection currents to provide proper distribution. A low cushion level will tend to decrease the actual settling time and give an uneven coating. Care must be taken not to place too much cushion water in the tube so that no air space is available during pour-off period. Air bubbling into the tube will disturb the entire screen.

F. PROPER MIXING OF CUSHION SOLUTION

Cushion water which is not properly mixed with the barium salt will not give a uniform chemical reaction and may yield a poorly distributed screen. Practice has established that the addition of 0.001 molar barium acetate solution provides better results than the addition of a concentrate of barium salts or solid barium salt before or after the cushion water.

III. ADHESION

A. PROPER GLASS CLEANING

See Pin Holes 1-A

B. PROPER POTASSIUM SILICATE AND BARIUM SALT

See Pin Holes 1-D

C. TEMPERATURE CONTROL

Both the glass and solution temperatures must not be extreme. Either too warm or too cold conditions can tend to give poor adhesion characteristics to the glass or phosphor.

IV. POTASSIUM SILICATE

A. EXTREME TEMPERATURES

In order to avoid any screening difficulties, care must be taken not to subject the potassium silicate to any extreme temperatures. Practice has established that extreme temperatures and age tend to allow the potassium silicate to polymerize and it can only be detected by use. The silicate will not provide good screens if polymerization has occurred.

B. FILTRATION

All potassium silicate should be prefiltered before use. Fine particles of dried silicate falling from the container can cause severe problems.

C. SILICATE SUPPLY

Each portion of silicate used should be representative of the contents of the container. Drawing the supply off the top at all times may tend to make the bottom more concentrated and screening may not be the same day to day. It may be advantageous to shake the container before drawing off the top.

SYLVANIA ELECTRIC PRODUCTS INC.
Tungsten and Chemical Division
Towanda, Pennsylvania

BLACK AND WHITE SCREENING INFORMATION

1. Electrolyte or Gelling Agent

Barium acetate is the most widely used gelling agent. It can be used at various concentrations and mixed for use in the dilute or concentrated form. If mixed in the dilute form it can be funneled directly into the bulb, with good mixing being important. For example, take a 21" bulb, and say you would use 25 liters of .300 gms/liter concentration, this would be 7.5 gms of $BaAc_2$; therefore, the same results can be obtained by using 24 1/4 liters of water and 750 ml of a 10 gms/liter solution of $BaAc_2$.

2. Potassium Silicate - Sylvania PS-5

Potassium silicate is always used in the dilute form with a specific gravity reading being a good control check. The degree of dilution varies throughout the industry from 1 part 28% potassium silicate to 1 part deionized water, to 1 part 28% potassium silicate to 4 parts water. The degree of dilution depends mainly upon the manufacturer's equipment. For obtaining good wet and dry screen adherence approximately 40 ml. of 28% potassium silicate should be used for each gram of $BaAc_2$ used. For example, take the 21" bulb mentioned above containing 7.5 gms. of $BaAc_2$; to this bulb you would have to add 300 ml. of 28% potassium silicate. Now, if the potassium silicate was diluted 1 part potassium silicate to 2 parts water, it would require 900 ml. of the diluted potassium silicate.

3. Phosphor

Phosphor is sometimes used in the dry form, but normally it is slurried with deionized water, using 25 gms. of phosphor per liter of water. The phosphor is normally coated at 4 mg/sq. cm. for aluminized tubes and 5 mg/sq. cm. for non-aluminized tubes.

PHOSPHOR VOLUMES

Bulb Type	Sylvania-CR402 Uncoated P4 for Aluminized Tubes		Sylvania-CR421 or CR422 Protective Coated P4 for Non-aluminized Tubes	
	Dry P4	P4 slurried 25 gms/liter	Dry P4	P4 slurried 25 gms/liter
17"	4.5 gms	180 ml	5.5 gms	220
21"	7.0 gms	280 ml	9.0 gms	360

4. Screening Procedure

First, the electrolyte cushion is inducted into the clear bulb, keeping the turbulence and swirling motion at a very minimum. The phosphor, (either dry or slurried) and potassium silicate are then dispensed into the bulb simultaneously with a small amount (1/2 - 1 liter) of deionized water added to prevent the silicate from gelling in the dispensing equipment. The phosphor and silicate

solution should be well mixed while entering the bulb, and the funnel through which this phosphor-silicate solution is dispensed should be equipped with some type of spray tip so as to <u>disperse</u> the phosphor out to the edge of the bulb as well as the middle.

5. Settling Time

The settling time varies throughout the industry from 15 - 55 minutes, but 25 - 30 minutes settling time seems to give good results.

6. Lacquering

Any one of several lacquering processes can be used, all with equal success. The two most common being flotation and spray. The flotation process consists of floating the lacquer on a water cushion, and the spray process consists of spraying the lacquer on a rewetted screen.

7. Aluminizing

The suggested weights of aluminizing slugs for 21" bulbs is 200 - 250 mgs and for 17" bulbs is 150 - 175 mgs. The slugs should be cleaned in very dilute solutions of sodium hydroxide and acetic acid before using. After aluminizing, the bulbs are baked in a lehr, maintaining the bulb temperature at 410°C - 430°C for 30 minutes.

8. Screening Formulations

The screening formulation used is determined by the particular lacquering process to be used. The spray lacquer process requires higher dry screen adherence; therefore, more concentrated settling solutions are required. Based on the total settling volume, typical concentration ranges are as follows:

Lacquer Process	Ba(Ac), Conc.	Potassium Silicate Solids
Flotation	.025% - .035%	.35% - .45%
Spray	.035% - .045%	.50% - .75%

A typical screening formulation for a 21 inch bulb when lacquering is done by the flotation process would be the example mentioned in paragraphs 1 and 2 under electrolyte and potassium silicate. This particular formulation will give 0.03% $Ba(Ac)_2$ and 0.42% potassium silicate solids.

A typical screening formulation for a 21 inch bulb when lacquering is done by the spray process would be as follows: total settling volume - 25 liters, 10 gms of $Ba(Ac)_2$ mixed in a dilute or concentrated form, and 500 ml of 28% potassium silicate. This formulation gives 0.04% $Ba(Ac)_2$ and 0.70% potassium silicate solids.

The total settling volume used for 17 inch bulbs is from 8 - 13 liters, and for 21" bulbs from 20 - 26 liters. Screen distribution is the main criteria for determining the settling volume to use because screen distribution improves as the total settling volume is increased.

9. <u>Screen Defects</u>

The following is a list of common screen defects and the possible aids to cure the specific defect.

Defect	Possible Cure
1. Screen pull-offs	1. Increase silicate or decrease $Ba(Ac)_2$.
2. Grainy texture screens	2. " " " " "
3. Gel holes in screen	3. a. " " " " " b. Clean dispensing equipment.
4. Sliding screens	4. Decrease silicate or increase $Ba(Ac)_2$.
5. Pin holes in screens	5. " " " " "
6. Dirt holes in screen	6. a. Clean dispensing equipment. b. Filter solutions better. c. Better cleaning of raw bulbs.
7. Yellow centers	7. a. Increase solution volume. b. Maintain bulb temperature above solution temperature. c. More rapid induction of phosphor and silicate slurry. d. Modify spray tip to disperse more phosphor out to edge of bulb.
8. Yellow edges	8. a. Increase solution volume. b. Lower bulb temperature and raise solution temperature.
9. Spot contamination after bulb baking.	9. Purge all solution manifolds and tanks.
10. Mottled screens after lacquering.	10. Better and faster drying of lacquer.

10. <u>Wet and Dry Adherence</u>

Wet strength is determined by measuring the diameter of holes eroded in the screen by a submerged jet of water operated for a standard time at a standard height, and having a constant pressure. Thus, smaller diameter holes indicate higher wet strength and vice versa. The jet size is usually 1 - 2mm in diameter, and located 1 centimeter from the screen surface with a 100 centimeter water head to maintain the constant pressure.

Dry strength is determined by noting the pressure in pounds per square inch required to blow a hole in a screen. A standard jet is used at a standard distance and the air pressure is increased until a hole is blown in a screen. The standard jet for testing dry strength is usually .050 - .060 of an inch, and the standard distance 1/2 inch.

Wet and dry screen strength are very important for successful screening. Wet strength is increased by decreasing the silicate concentration per bulb and dry strength is increased by increasing the silicate concentration per bulb. Some of the common screening defects caused by poor wet strength are slipping screens, pinholes and sliding screens. Some of the common screening defects caused by poor dry strength are screen pull-offs at lacquering or aluminizing, grainy screen texture, and excessive screen holes. Dispensing equipment must be cleaned frequently to keep gel and dirt holes at a minimum.

11. General

This information is based on data acquired using Sylvania PS-5 potassium silicate, and Sylvania CR402 phosphor and is intended to be used only as a guide because it is known that the optimum screening conditions differ from one plant to another.

R. L. DOEPKER
February 4, 1958

RLD:EJO

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A. T. BAXTER COMPANY
MANUFACTURERS REPRESENTATIVES
14574 BENEFIT STREET
SHERMAN OAKS, CALIF.
STate 4-2665

GLASS AND ITS ROLE IN THE MANUFACTURE OF CATHODE-RAY TUBES

1. General Discussion of glass.
2. Properties of glass.
3. The manufacture of blanks, defects encountered, etc.
4. Factors affecting glass in fabrication of cathode-ray tubes.

1. What is glass?

It is really an undercooled liquid since there is no definite temperature at which glass changes its state in cooling down from a molten condition. This, as you know, is not so in the case of metals.

There are certain properties which are characteristic of glass:

    a. absence of structure.
    b. brittleness.
    c. conchoidal fracture.
    d. gradual softening with rise in temp. - no definite m.p.
    e. simple optical properties.
    f. general transparency-exception, opal glasses, etc.
    g. poor conductivity for heat and electricity.

Glasses are of varying compositions depending upon the applications for which they are made. Certain ingredients are used to give certain properties to the glass. One oxide that is found in nearly every glass is silica. Soda is added for ease of melting. Silica by itself has a melting point in the range of 1700 degrees C. Adding 25% soda brings this down to just below 800 degrees. Lime is used for ease of working; it also gives chemical durability to a glass. Alumina imparts better electrical properties. Boron oxide gives stability, lowers expansion, and acts as a flux.

Typical compositions

    Lime glass - Silica 72-74%, soda 15-17%, lime 3-5%, magnesia 4-5%.

Pyrex (774) - Silica 81%, boron oxide 12%, alumina 2%, soda 4%, others 1%.

G-12 contains silica, potash, soda, lead and other minor constituents.

2. Properties of glass.

a) Physical - From our standpoint the most important property is tensile strength as glass, when it fails, almost always does so under tension. The average tensile strength of a piece of well-annealed, well polished glass is from 7,000 to 10,000 lbs. sq. in. When we speak of the strength of glass we are usually talking about the surface strength, since, as mentioned before, glass practically always fails under tension. Microscopic flaws in a glass surface such as checks, chips, scratches, etc. lower its breaking strength tremendously. Fractures almost always originate at the surface of glass. Exceptions - imbedded material, such as stones.

b) Thermal properties -

Strain point - That temp. at which 90% of the strain in a piece of glass, 1/4" thick can be removed in four hours.

Annealing point - That temp. at which 90% of the strain can be removed in 15 minutes (glass 1/4" thick).

The temp. range from strain point to annealing point is referred to as the annealing range. For soft glasses, the annealing range runs from about 31 to 36 degrees C.

The softening temp. is that temp. at which a glass fiber, .5mm in diameter, 22.9 cm. long, elongates under its own weight at a rate of 1 mm/minute when the upper 10 cm. of its length is heated in a prescribed furnace.

The working range is that temp. range at which a glass is ready for working.

Viscosity is the reciprocal of fluidity and is measured in units called poises.

Coefficient of expansion - Glasses like other materials, expand when heated and contract when cooled. This es expressed numerically as the coefficient of expansion. In making glass-to-metal seals, this property becomes of extreme importance. The expansion of the glass must match that of the metal fairly closely or excessive stresses will be set up that will rupture the seal. Exception is the housekeeper type of seal where copper of extreme thinness is sealed to almost any type glass. The metal is thin enough to yield to any inherent stresses. Properties of typical glasses:

	Strain pt.	Annealing pt.	Soft pt.	Working-pt.	Coeff. of exp. cm/cm/deg.C x 10-7
		Degrees Centigrade			
G-12	400	433	630	975	89
772 (Nonex)	484	518	755	1110	36
774 (Pyrex)	510	553	820	1221	32.5

Designations, hard and soft glasses -- One definition is that those glasses with working ranges from 800 to 1000 deg. C are considered soft, while those glasses with working ranges from 1000 to 1300 deg. C are considered hard.

c) Optical properties - Glasses vary as to the transmission of different wave lengths of light. Glasses have different indices or refraction. The index of refraction is a measure of the speed

with which light is transmitted through glass.

d) Electrical properties - An outstanding property is resistivity. Normally glass is considered a good insulator. However with increase in temp., there is an increase in conductivity. Likewise with an increase in humidity, there is an increase in surface conductivity.

Chemical properties - Glasses vary in their resistance to attack by acids and alkalies. Generally speaking, those glasses containing a high percentage of alkali in their composition are much more susceptible to weathering or attack by moisture than are alkali-free glasses. Pyrex glass, with only a small percentag of alkali is excellent in chemical durability as compared with a window glass such as Fourco with about 15% alkali.

Strain in glass -

If we heat a slab of glass, we establish a temperature gradient. The outside surfaces are hotter than the middle. These outer surfaces try to expand but are restrained by the middle portion. The result is a crowding or compression in the outer layers balanced by a stretching or tension in the middle. These strains persist as long as the temperature gradient persists. If we hold the glass at, let us say, at a temp. of 350 deg. C until the middle portion has reached the same temp. as the outer layers, then there can be no more strains. If we now cool the glass, the opposite condition is set up. The surface now tends to contract more than the middle portion. There will be tension at the surface and compression within. When the glass reaches room

temperature, and the gradient flattens out, there will be no more strain. These are called temporary strains and, as we know, can be of sufficient magnitude to cause cracked blanks.

Now suppose the same slab be brought to a uniform temp. near its softening point. It is at a temp. where viscous flow is possible within the glass although there need be no change of shape. At this point there can be no strain because of this flow. Now we cool the glass, the temp. gradient producing tension at the surface and compression within as mentioned before. Since there is some flow, part of the strain will be relieved, although the gradient remains. This condition persists as the glass cools to rigidity. As the glass cools further we have less strain than we should have in view of the temp. gradient. Now the slab is cooled to room temp. where we have a full reversal of strain. This is called permanent strain and can only be relieved by proper annealing. Annealing is accomplished by cooling slowly enough so that there is little temperature gradient.

This fact is made use of in the tempering of our face-plates in the metal tube. The glass is allowed to cool down rapidly in air with resultant permanent compressive strain set up on the surfaces of the plates.

The polariscope is an instrument used to determine whether a piece of glass is strained. We do not have the time here to give a detailed explanation of the optical theories involved. It suffices to say that the instrument consists of a polarizer, a sensitive tint plate, an analyzer and a light source. The polarizer and analyzer in our polariscopes are merely polaroid

screens. Strained glass has the property of retarding certain rays of the polarized light which shows up as color effects. Unstrained glass viewed in the polariscope against the reddish-purple background shows no color effect. Depending on the amount of strain present the color effects will differ. The colors will also vary depending upon whether compression or tension is present. For example, if we hold a piece of glass tubing in our polariscope in an east-west direction, a band of axial tension will show up as blue, blue-green or green, depending upon the amount of strain. A band of axial compression will show up as red, red-orange, orange or yellow, depending upon the amount of strain.

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Sealing

In sealing cathode-ray tube mounts into glass bulbs it is import-
ant that both the mount stem and the neck of the tube be well pre-
heated. They may be heated separately or by placing the mount inside
the neck of the bulb, both may be heated simultaneously.

The number of fire positions on the sealing machine will determine
the right temperature setting for each fire for a strain free seal. The
glass should be heated at low temperature at the first position, grad-
ually increasing the temperature until "neck drop" and "glass cut"
positions. A typical fire set-up for an eight position machine is as
follows:

Position 1. Load mount over mount pin and place the bulb over the
mount.

Position 2. Preheat main seal area by the use of one 790D burner.
A soft, bushy flame is directed just above the main
seal area.

Position 3. Preheat main seal area with three 790D burners directed
at this area. Soft fires are to be used.

Position 4. Third main seal preheat fire using four 1142A burners.
Medium fires are directed at the area.

Position 5. Four 1142A burners with very sharp fires are used to
tack on bulb to flare and drop cullet.

Position 6. Cut off cullet and roll edge with five 1142A burners
using sharp fires. The bulb is also cut-in in this
position. Fishtail burner with a soft fire is used to
keep the cullet warm and thus avoiding its shattering.

Position 7. Final roll fire using eight 1142A burners directed
around the main seal edge.

Position 8. Unload. The unloading must be performed very carefully
so as not to bend main seal area which is still hot.

The sealing fires should be adjusted to give a seal of a particular shape as indicated by the following sketch:

1. Outside shape: The preferred outside shape of the seal is pictured below. It should be noted that there are two distinct curvatures to the glass as shown by the dotted lines. This shape minimized the effect of many of the slight variables at the sealing such as differences in mount pin height or crooked seals. (Fig. 1)
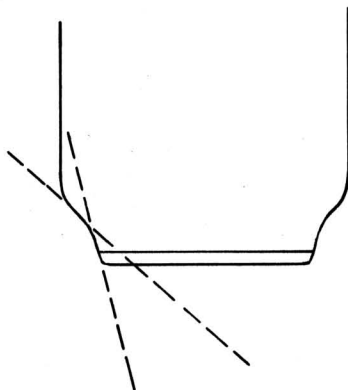
2. Inside shape of seal: The dummy should be examined for hot or cold seals. A hot seal is indicated when the neck tubing seals into the base of the fillet. (Fig. 2)
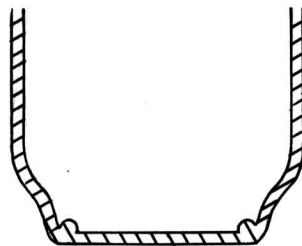
3. A cold seal is indicated when the neck tubing does not reach into the flare. (Fig. 3)
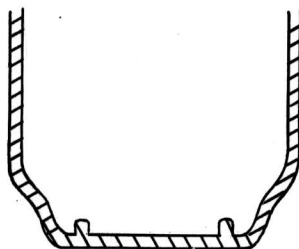
4. A check can be made on the depth of sealing on the machine by looking down inside the neck as the tube is in the cutoff and sealing fires. A seal that is midway between the edge of

the flare and the base of the fillets is desirable. (Fig. 4)
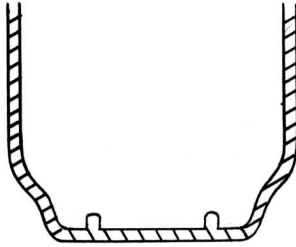
5. The depth of sealing is determined by the two shaping fires
   in the sealing fire and the cutoff fire. The height above or
   below the stem, and the intensity of these fires, are the
   determining factors.

Improper cooling of the seal is perhaps the greatest cause of
sealing shrinkage. On machines that have annealing positions it is
usually possible to remove the tube from the sealing machine and place
it right on a rack if care is taken to avoid the presence of any
drafts. If the machine does not contain annealing positions or an
insufficient number of them, it will be necessary to place the tube
in a "hot box" for a short period or to place a cover over the seal
to allow the seal to cool down gradually.

POLARISCOPE

The polariscope, an instrument for revealing strain in glassware, is used to determine whether or not the degree of annealing, i.e., the temper of the ware, is commercially satisfactory. It consists, chiefly, of a light source, a polarizer, a sensitive tint plate, and an analyzer. In the latest type polariscope, both the analyzer and the polarizer are made up of Polaroid screens which consist of a fixed suspension of certain crystals in the form of a polarizing film sandwiched between protecting plates either of glass or plastic. This film, which may be had in large sheets, replaces the earlier types of polarizers, and affords a large, uniform field. It is not appreciably affected by age, light or moderate temperatures.

A througly annealed strip of glass, when examined edgewise in the polariscope field (without sensitive tint plate), remains dark and colorless against the dark background.

When the glass is put in strain, however, as by bending with the fingers, light begins to appear through it. First a dim illumination appears, which then becomes brighter and brighter as the bending increases.

Finally colors begin to appear, first an orange shade, then red and purple followed quickly by blue. If the bending keeps on increasing, the blue turns to green, then yellow, then orange and red again as before. Furthermore, the thicker the glass is in the direction of view, i.e., the more glass the light passes through, the more color will be seen for a given amount of bending. This is important in relation to thick and thin walled ware, because due to its thickness a heavy weight sample may show more color while actually having less strain than a thin, light one.

The colors keep repeating in this way, getting a little paler at each repetition, as the bending increases. Each repetition is called an "order" because the brilliance and purity of the colors in any one group seems to be about the same. The first order, however, begins with darkness and ends in reddish purple. The second order begins with blue and goes through green, yellow, orange, and ends with red which merges into the blue beginning the third order, and so on.

It is not very often that second order colors are encountered in glassware except when the sensitive tint plate is used. This plate is simply a means of causing the progression of colors to start with the reddish purple lying between the red of the first order and the blue of the second order, instead of starting with the neutral grays occurring at the beginning of the first order. When the sensitive tint is used, very small changes in strain will accomplish the change either to red or to blue, producing strongly contrasting colors. By this means any moderately strained piece of glass, although incapable by itself of causing more than a small change in the shades of gray found at the lower end of the first order, will show a contrasting color effect that is much easier to see. This optical effect may readily be seen by flexing a strip of glass in the field of view.

The colors in the second order are the same as in the first order but are slightly faded by mixture with white light. The same series of colors is repeated in the third order except that they appear still more washed out. In the fourth order the colors are even less distinct, and above the fifth there is a transition to tinted whites. When the sample being inspected with the tint

plate shows one or more of the orders higher than the second, it is an indication of very high strain.

When a piece of strained glass is examined in the polariscope the colors form definite patterns indicating the kind and amount of strain present. From these patterns it is possible to distinguish between areas of tension and compression, and so to discern the stress distribution throughout the sample. For example, if a broken ring section is held in the field so that the light passes through it parallel to the sample wall, the effects of tension and compression may be readily demonstrated. If the section is bent in the direction to straighten it, tension occurs on the inner surface and compression on the outer. The contrasting colors so produced are clearly seen.

The correct position in which to hold the sample varies with the type of polariscope. With the older type instruments, the samples were usually held in one of the two "corner-to-corner" positions if the side walls were to be examined. In the case of the newer polariscopes, the samples must be held horizontally or vertically, but not in the 45° position. If there is any doubt as to the correct position, a moderately strained sample should be placed in the inspection field and the positions of maximum color intensity determined. There are two such positions of maximum color intensity and they are always 90° apart. Samples may be examined in either of these positions, but it must be recognized that the colors in one position will be the exact reverse of those in the other position. To avoid confusion, all samples should be held in the same position.

In using the polariscope it is necessary to distinguish between: (1) strains set up by cords, and (2) those remaining after lehring. Glass that is free from strain will appear the same as the background. However, when the glass is strained, bands or areas of color show up, varying in intensity with the amount and kind of strain present.

In glass that is free from obvious cords, annealing strains, i.e., strains remaining after lehring, appear in the glass as wide bands or areas of color. With the sensitive tint plate moderate strains appear as reddish yellow or as bluish green; high strains more nearly approach a light yellow or light green. Intense strains show up as colors of a higher order.

When the glass is "cordy," however, narrow streaks of color may appear. The intensity of the streaks of color will depend on the size and nature of the cords.

Manufacturers should determine for each kind of ware just what limits for "Temper" and cords are required to insure satisfactory service. These limits will frequently differ from one type of sample to another. They will, generally speaking, be higher for thicker walled ware. In such ware, because of the thickness of the glass, the color is higher for an acceptable amount of strain than in thin ware. The limits will also naturally depend upon the structure of the glass and upon the manufacturer's previous experience with the performance of similar ware in service.

Excerpts from the January 1942 issue of "The Glass Industry" from article entitled, "The Polariscope As A Glass Factory Instrument" by V. C. Swicker.

EXHAUST AND AGING

During the exhaust process the carbonates of the alkaline earth metals (cathode coating) were converted to oxides by thermal decomposition. The electron emission of emitters of the oxide-coated type appears to arise from a layer of alkaline earth metal, i..e. metallic barium and strontium which forms on the surface of the oxide coating. Emission is at a maximum when this layer covers the entire surface of the oxide to a depth of approximately one molecule. During operation of the emitter at its normal working temperature, the surface metal that is evaporated is replenishing by diffusion of additional molecules from the interior of the oxide coating.

During the aging process, we first activate the cathode completely and then stabilize the emission. This is done by gradual heating of the cathode up to about 1250°_{C} and by drawing current off the cathode. During this period, the electron emission increases and when it has reached a rather large value, the electrostatic field around the grid is returned to zero and the emitter temperature is then lowered and maintained for an additional period. The life of oxide-coated cathodes is limited by the supply of active electron-emitting material of the cathode.

CATHODE ACTIVATION SCHEDULES
FOR EXHAUST AND AGING

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	First Grid Voltage	Second Grid Voltage	Anode Voltage	Time
6.3	0	0	0	1 min.
12.5	0	0	0	1½ min.
9.0	+5	+150	−100	10 min.
9.0	0	0	0	10 min.
6.3	0	0	0	5 min.

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Manufacturers of Electron Guns
208-212 PIAGET AVENUE **CLIFTON, NEW JERSEY**
TELEPHONE: GREGORY 2-2500

EMISSION VS. CUT-OFF
PERCENT OF CATHODE

SE

SUPERIOR ELECTRONICS CORP

Manufacturers of Electron Guns

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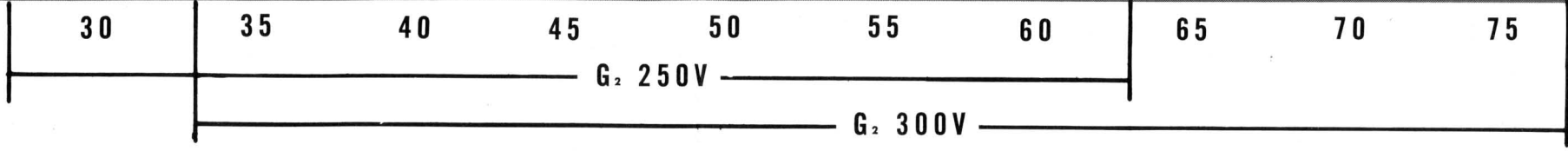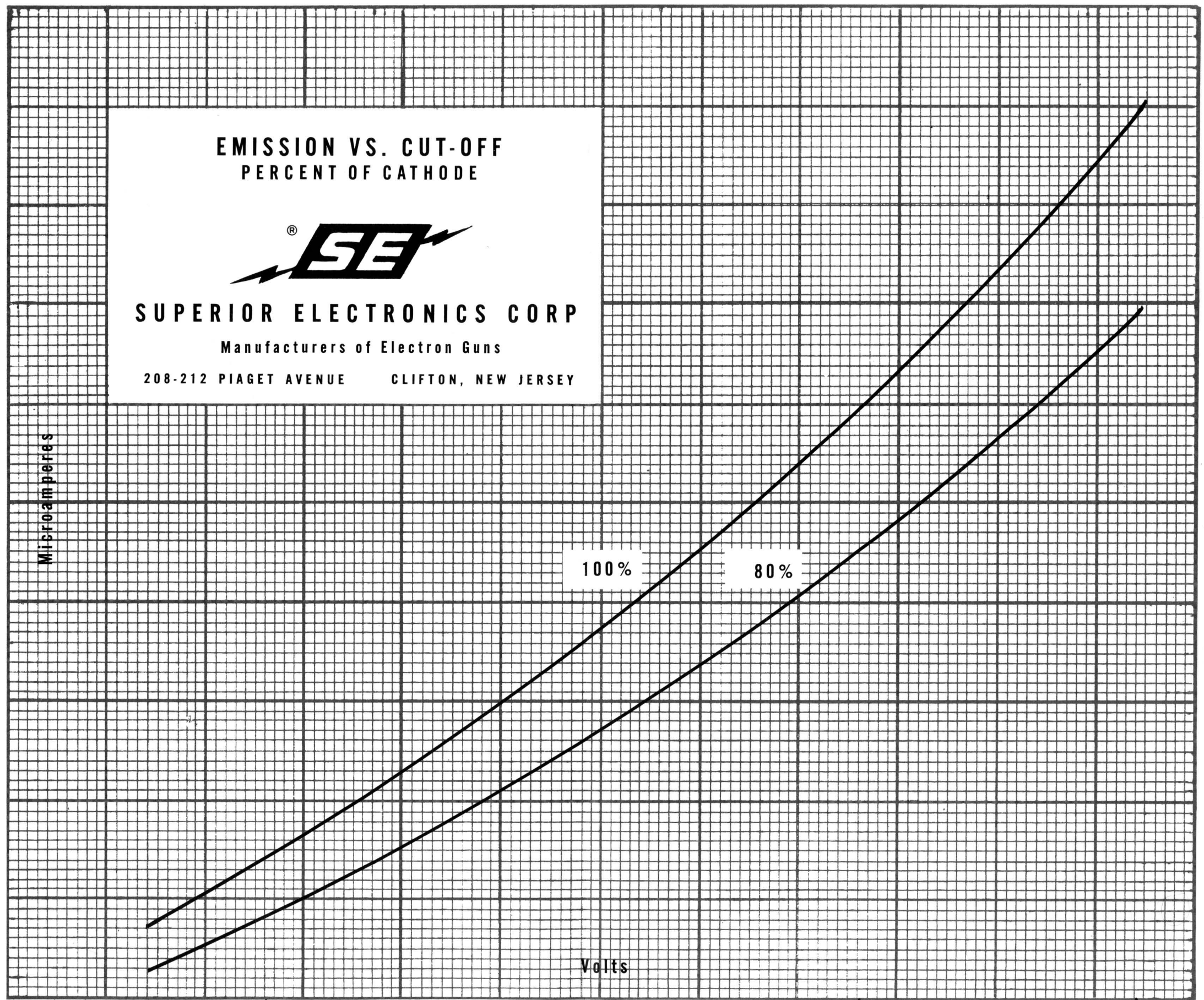
REAGING

The quality of a reprocessed tube must be as good as any other

tube. No steps should be taken which will endanger the life of

the tube in the field.

LOW BEAM CURRENT - The reasons for low beam current are:

1. Improper breakdown on exhaust.
2. Filament lit up in air or cathode broken down in poor vacuum.
3. Gun bombarded in air.
4. Gun not bombarded at all.
5. Oil vapor in tube at time when filament is lit.
6. Peeled cathode coating.
7. Cathode coating broken down in air due to too high heat at
     sealing.
8. Foreign material on or under coating.
9. Improper aging.
10. Cathode bombarded by ions due to too much gas.
11. Poor contact of snubber.
12. Poor connections to electrodes due to poor welds, or solder.
13. Insufficient amount of cathode coating.

If the cathode sleeve did not oxidize or if the coating was not damaged,

it is possible to recover such a tube which failed the beam current test.

This is done by the following schedule:

Ef	6.3 V	5 min.
Ef	12 V	1 min.
Ef	6.3 V	30 min.

The intention is to bring the cathode up to temperature much higher than

normal to get activation.