Color Television Picture Tube Manufacturing

RCA

1CE-446

C.A. Meyer

RCA

CTV Picture Tube

Color Television Picture Tube Manufacturing Process

This manufacturing process flow chart further illustrates the construction of a color television picture tube as described in words and color photographs in Section III of this Volume

CTV Picture Tube

Color Television Picture Tube Manufacturing Process

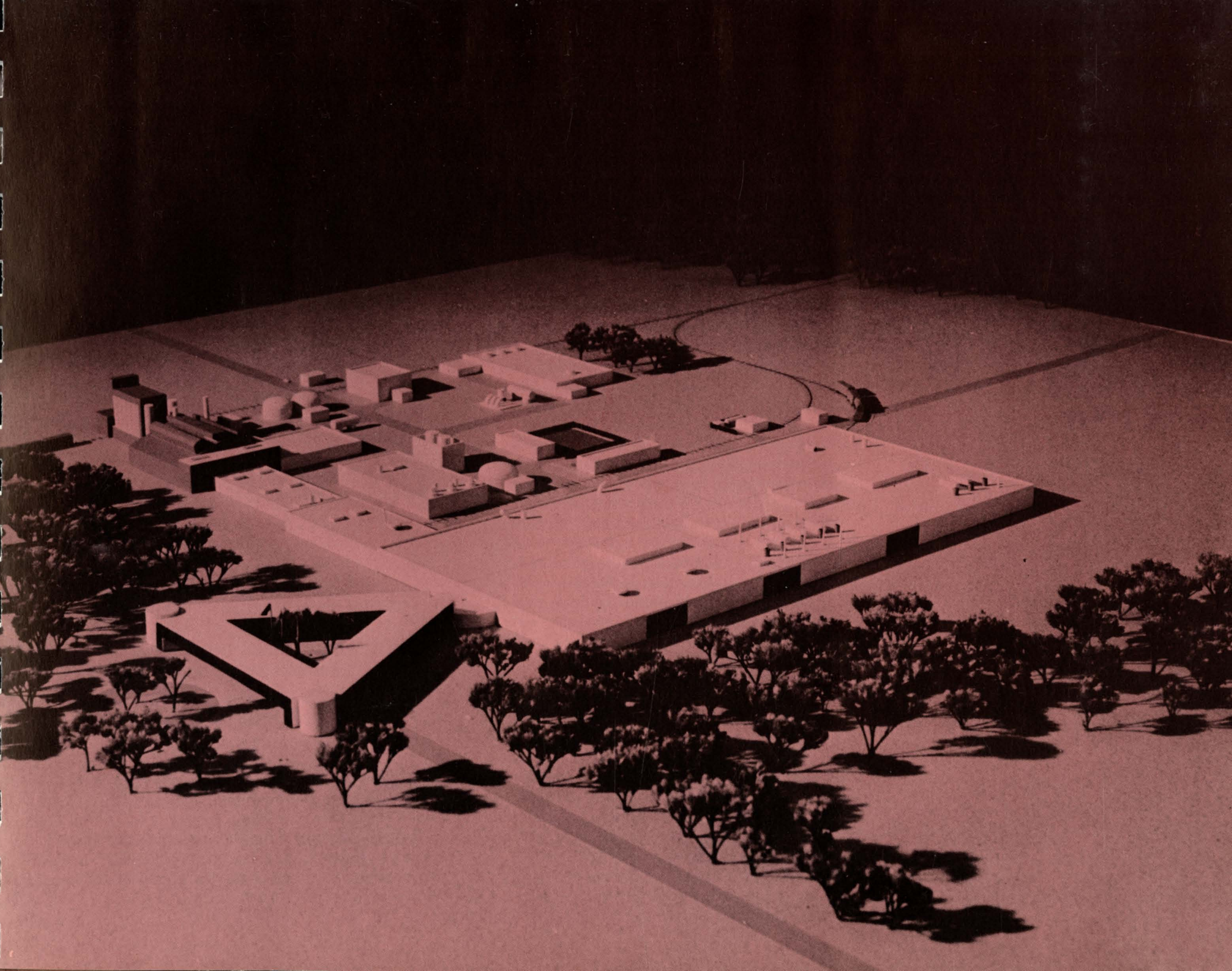
Contents

Section I

Introduction

The color picture tube is **the master key** to practical color television as we know it today. It is an electro-optic decoding device that translates electrical information back to color luminescent information. This device is considered by many as the most complex and exacting consumer product ever developed for home usage. RCA has been the world leader in the design and production of the color picture tube and because of the intensive effort it has applied to the manufacturing technology, color picture tubes are now characterized by consistently high color purity achieved with simple adjustments.

In this Volume, a brief summary of RCA's part in the development of triple-gun shadow-mask color picture tubes is given along with a description of RCA's capabilities in the development and support of a color picture tube manufacturing organization. Also, a pictorial description of the color picture tube manufacturing process is given demonstrating the high complexity of the operation yet, at the same time, showing how RCA has systematized and simplified this intricate process so that the manufacturing details can be transferred with a minimum of effort and a maximum of assurance that the transfer is complete, thoroughly understood, and reliably followed.



Section II

Picture Tube Design and Development

RCA's electronic direct-viewing color picture tube was first demonstrated publicly on 29 March 1950, in Washington D.C. On 24 December 1953, RCA introduced the first mass-produced commercial color picture tube, EIA registered Type 15GP22. By the following 17 March, 15-inch tubes were being used in the first commercial color television sets made at RCA's Bloomington, Indiana plant.

During a Color Television Symposium at Princeton, New Jersey in September 1954 RCA showed its first 21-inch color picture tube. This tube, RCA's EIA registered Type 21AXP22, was the first 21-inch, 70-degree deflection, triple-gun, shadow-mask color tube ever developed. It employed a round glass faceplate and a metal funnel for the envelope. This tube was followed by Type 21CYP22 which featured an all-glass envelope. RCA then demonstrated Type 21FBP22 with a 50% brighter "all-sulfide" phosphor screen. RCA also introduced a safety plate glass, bonded to the front of the faceplate. The safety glass was treated by an etching process to reduce specular reflections resulting from the ambient lighting conditions.

During the pioneering period of the 1950's, RCA shared its knowledge of the design, development, processing, and manufacturing technology of color picture tubes with its competitors. RCA recognized that the introduction of color television to the public should be an industry-wide program, rather than one sponsored by a single manufacturer. Throughout the development of the color picture tube, RCA disclosed to the television industry, detailed technical information on its color tubes, including blueprints and manufacturing instructions.

In this pioneering stage, RCA, virtually alone, also invested heavily to obtain public acceptance, and built a market for shadow-mask color picture tubes. Other manufacturers explored alternate color systems, including the beam index, grill switching, focus grill, and focus mask types of color tubes. The competitive commercial industrial market began in the early 1960's when twelve domestic television set manufacturers began marketing color receivers. Significantly, all these manufacturers used the RCA-developed and RCA-manufactured 21-inch color picture tube.

The first United States company to follow RCA into volume production of color picture tubes was Zenith. It was on 17 April 1962 that Zenith announced it would start manufacturing color picture tubes early in 1963. On 5 May 1962, Sylvania Electric Products, Incorporated announced its plans for color television picture tube production.

RCA has continued over the years to make many major contributions to color picture tube technology. RCA designed, developed, introduced, promoted, and produced a complete line of 90-degree deflection, rectangular color picture tubes.

RCA has also made highly significant contributions in the development of cathodoluminescent phosphor screens for color picture tubes. As a result, the relative improvements over the years in color picture tube brightness, when compared to the 1957 sulfide-silicate-phosphate screen, have been as follows:

CTV-PT Brightness Improvement.

Year	Phosphor Screen	Relative Brightness
1957	Sulfide-Silicate-Phosphate	1.0
1961	All-Sulfide	1.9
1965	Vanadate Rare-Earth Red; Blue and Green Sulfide	2.1
1967	Oxysulfide Rare-Earth Red; Blue and Green Sulfide	2.5
1968	Oxysulfide Rare-Earth Red; Blue and Green Sulfide	3.0
1969	RCA HI-LITE MATRIX	6.1

Together with glass vendors, RCA established the design parameters in March 1969 for a new series of 90-degree deflection, ultra-rectangular color picture tubes.

On 26 June 1970, RCA introduced its first commercial wide-angle color picture tube having a deflection angle of 110 degrees. RCA's new tube featured an overall tube length 4 inches shorter than its predecessors, thereby permitting more pleasing cabinet styling designs, especially in medium screen size, portable color television receivers.

RCA's bipotential and einzel focus lens electron gun assembly designs, in the standard "delta" arrangement, set a new standard for precision-crafted components. These gun designs are employed today by most color picture tube manufacturers because of the proven performance record of RCA's multi-element triple-gun assembly in practically all shadow-mask color television picture tubes made to date. In May 1969 RCA introduced a new, high-resolution, precision-aligned electron-gun assembly for large-size color tubes. Improved electron optics of the new bipotential gun provided a significant increase in focusing action, resulting in improved resolution over the entire brightness range, a 25% increase in resolution in low-light areas of the pictures, and a 10% increase in resolution in typical highlights. With the introduction of the 110-degree picture tube, RCA introduced a triple-beam electron gun assembly in the "delta" configuration but with a smaller spacing between guns.

Because this gun can be enclosed within a smaller neck diameter (29 mm vs. 36 mm), it minimizes the increase in power required for wider-angle deflection and reduces the beam landing and convergence correction required.

One of the more recent RCA color picture tube developments is the precision in-line tube. This tube, a new concept in color television display systems, utilizes a precision close-spaced in-line electron gun and a line-focus deflection yoke to make practical the first coherent self-converging color system. Instead of dots, this tube uses a screen consisting of continuous vertical phosphor lines of alternating red, green, and blue emitting phosphors.

The mask apertures are vertical slits with small cross ties to provide strength. This line-screen arrangement has the advantage of reducing beam-to-phosphor misregister, enhancing color purity, and improving white uniformity.

The electron gun of this tube uses a horizontal in-line structure rather than the 120-degree spacing of the phosphor-dot tube and is designed for use with a precision static toroid line-focus-type deflecting yoke. With this structure, the three beams and the deflecting field are in precise alignment. As a result, this precision in-line tube assembly is inherently self-converging and does not require dynamic convergence correction or its associated circuitry. Consequently, the deflecting yoke and neck components can be preadjusted and permanently attached to the picture tube by the tube manufacturer.

RCA's significant basic color patent contributions are well documented. Some of RCA basic patents which relate to the color picture tube itself and to the performance characteristics of the shadow-mask tube include a patent for the photographic method of depositing phosphor dots on the inside surface of the tube faceplate, patents on the simultaneous multi-color TV and synchronizing system, and a patent on the color TV interlacing system.

Section III

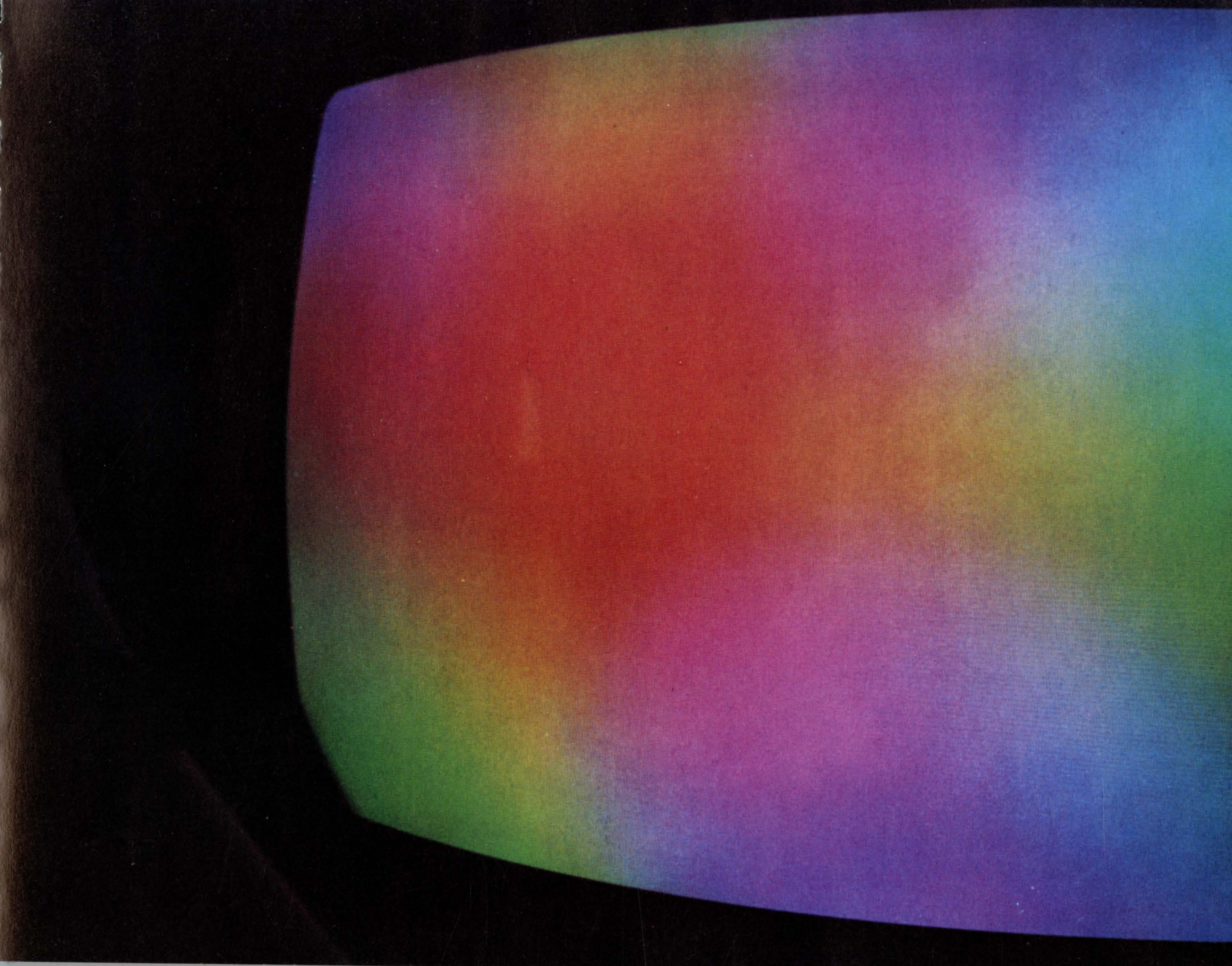
Color Television Picture Tube Manufacturing Process

A. Phosphor Preparation
B. Shadow-Mask Fabrication
C. Electron Gun Mount Assembly
D. Glass Manufacture
E. Final Tube Assembly

The manufacture of color television picture tubes embraces not only a variety of scientific disciplines and technologies, but a large assortment of skills, crafts, and arts.

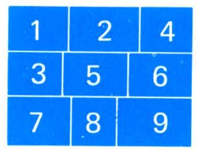
Chemistry, physics, photometry, metallurgy, glass technology, and electronics are some of the specialized fields contributing to the development and manufacture of color television picture tubes. In addition, the skills of talented craftsmen in tool making, equipment design, fabrication, and installation, and plant maintenance are also vital ingredients. Industrial Engineers are required to assure an economical manufacturing procedure, and quality assurance experts are needed to establish the inspection techniques and schedules necessary for a reliable product.

In this section, the color picture tube manufacturing process is described in some detail. The separate manufacturing steps are shown along with photographic illustrations of the processes taken at the various RCA color picture tube plants. This description covers the following manufacturing and fabrication steps.

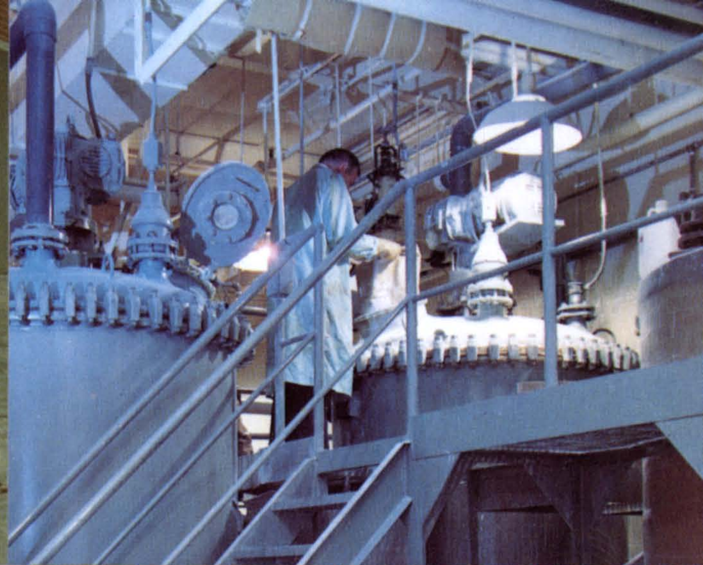


A. Phosphor Preparation

The phosphors now used in color television picture tubes are the result of a long continuing energetic effort to improve the quality and brilliance of the color television picture presentation. The current color television picture tubes are many times brighter than the original designs of the 1950's. The contributions made by RCA are a very significant part of this improvement. The phosphor preparation process begins with the receipt of raw materials. These materials include acid in bottles 1 and tanks 2, dry chemicals in bags and packages 3. Using the blue phosphor as an example, the next step is the mixing of sulphuric acid and zinc oxide in glass lined tanks 4 to obtain a zinc sulfate solution. This solution is then filtered 5 and a precise batch size is transferred to special tanks 6. Precision laboratory measurement equipment is used at inspection stations 7 to assure that the solution contains the precise quantities of each ingredient. The addition in the precipitator 8 of hydrogen sulfide gas to the zinc sulfate solution then forms a suspension of zinc sulfide in sulfuric acid. This manufacturing area is carefully monitored with a ''sniffer'' 9 to assure that excessive hydrogen sulfide gas is not present.







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ZINC OXIDE
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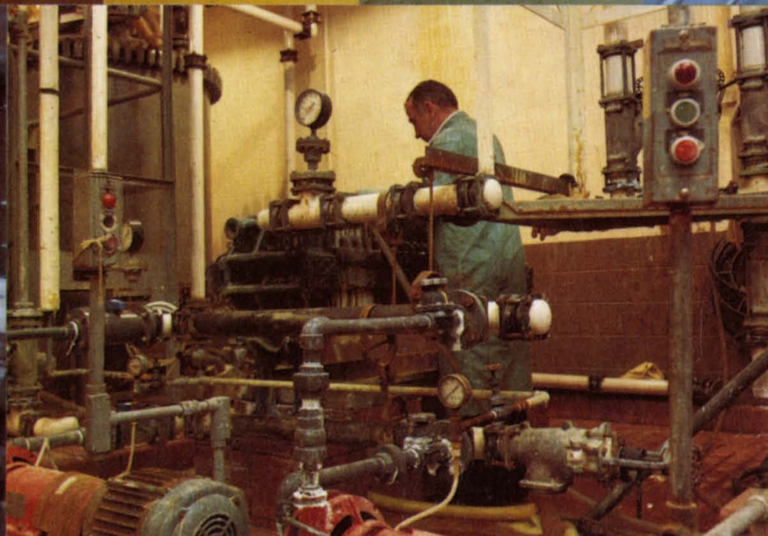
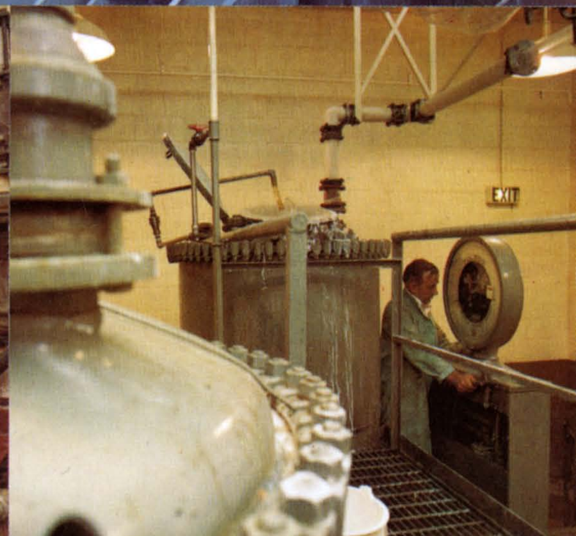
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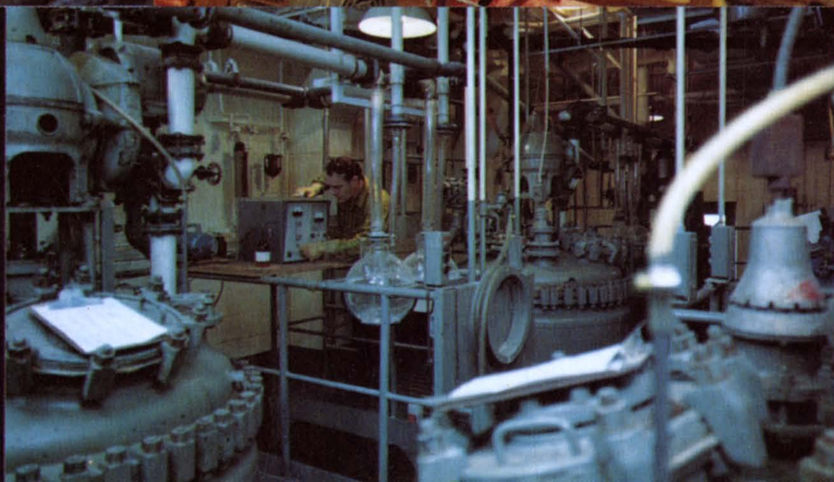
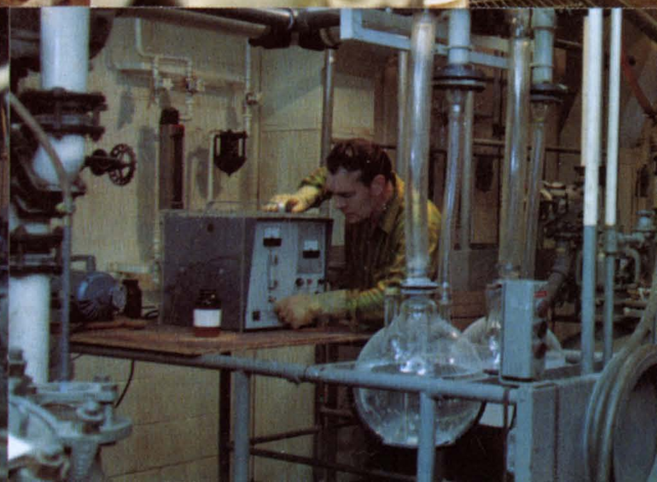
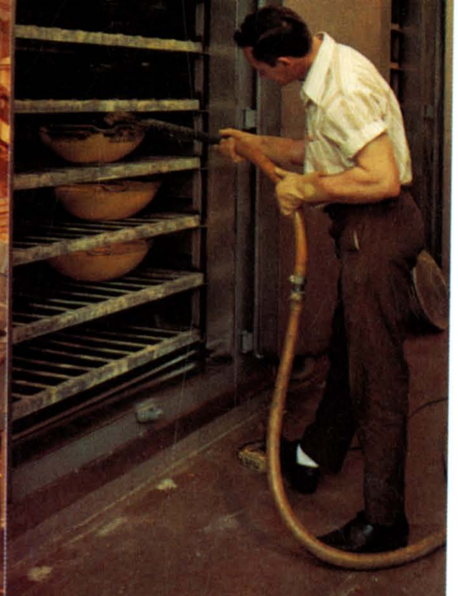
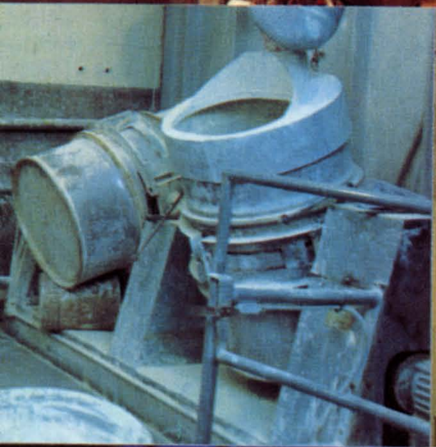







The suspension is next transferred to a decanter 10 where a small quantity of silver nitrate is added. It is then washed to reduce the acid concentration and special ingredients, which help to improve the subsequent firing, are added. After decanting the resulting mixture is oven dried with forced air at 175° C 11 and then barrel tumbled 12 to homogenize it. The powder is then carefully transferred manually to boat-shaped containers so that losses are minimized. The powder is then fired 13 at 990° C to obtain extremely pure ZnS:Ag. To assure purity, the material in the boats is inspected under ultraviolet light 14 and hand cleaned to remove impurities. Special chemicals are added with water 15 to improve adherence to the tube faceplate.

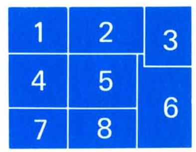
10 11
12 13
14 15

The water is then removed by a centrifuge 16 and the material undergoes additional baking. 17 The material, now in powder form, is sieved through a 200-mesh screen 18 and barrel tumbled in batch quantities 19 to obtain consistency of product. The output of the barrel tumbler is packaged in fifty-pound drums 20 for delivery to the panel-slurry rooms.

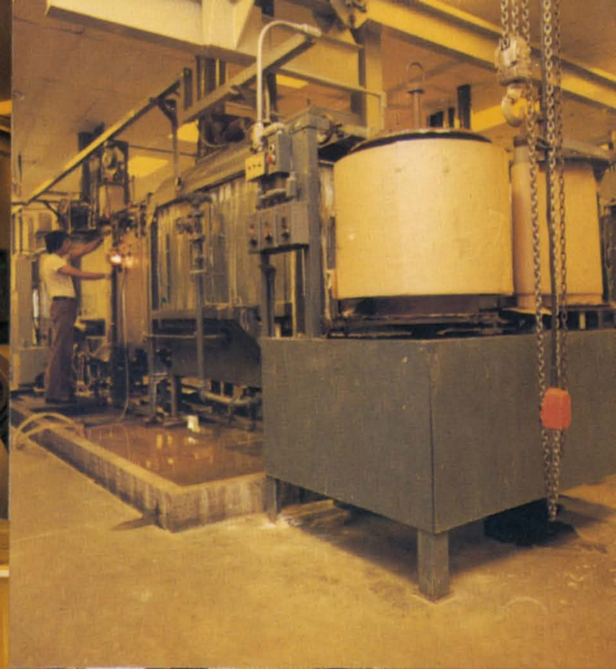
16	17
	19
18	20

B. Shadow Mask Fabrication

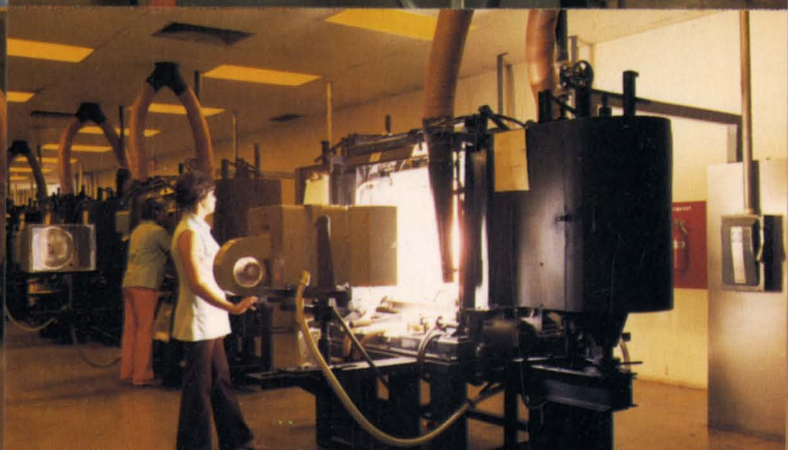
The shadow mask is used in color television picture tubes to guide the electrons to their respective color phosphor. To assure accuracy in this action, the mask is very precisely made and then used as a precision template for the accurate application of the phosphor materials on the glass panel. The basic materials 1 for the shadow mask are the rolls of steel and the photosensitive chemicals needed for the printing, developing, and etching of the aperture pattern across the metal mask. The first step in the process is the mixing of the photosensitive fluid. 2 Next, the specially formulated steel in roll form is thoroughly cleaned with a caustic wash 3 and after rinsing with deionized water is coated with the photosensitive fluid. 4 After the roll is rewound with an interleaving of paper, 5 it is placed in the chase or exposure machine 6. After it is accurately aligned, 7 the roll is exposed 8 through a special master.

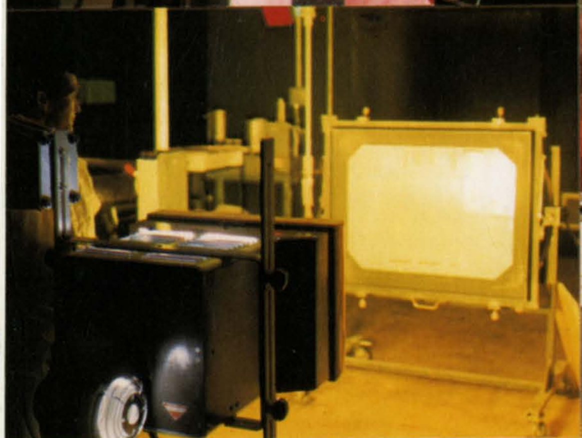




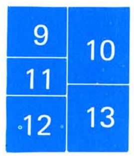




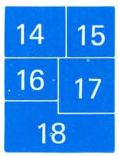



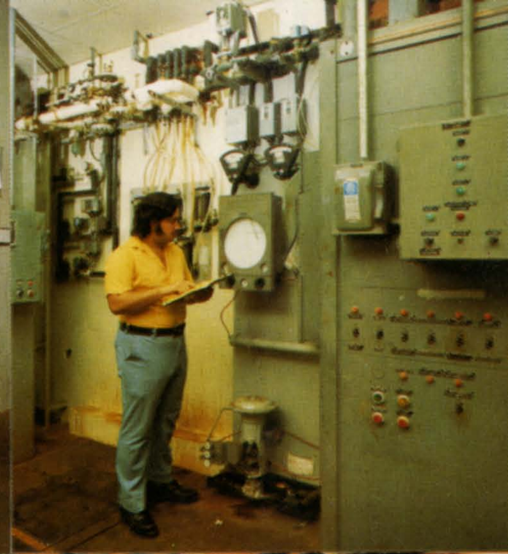


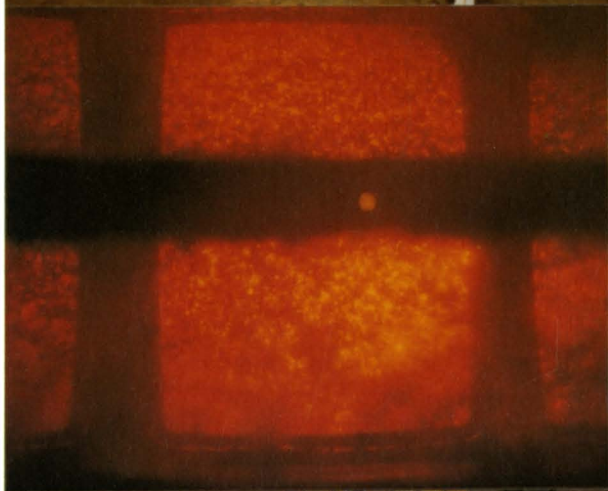
The special master 9 is maintained and duplicated in the dark room facilities 10 11. After the photographic exposure, the roll of steel is developed in a special process 12 which cleans the aperture pattern and coats the balance of the steel with an etch-resist so that only the aperture pattern is affected. Close inspection 13 assures that the processing is adequate.



The exposed and developed steel roll is then run through an etch bath 14 which is precisely controlled with automatic equipment 15. This etch bath removes the steel in the aperture pattern only 16. The etch solution is replenished 17 for further use with special chemicals 18.





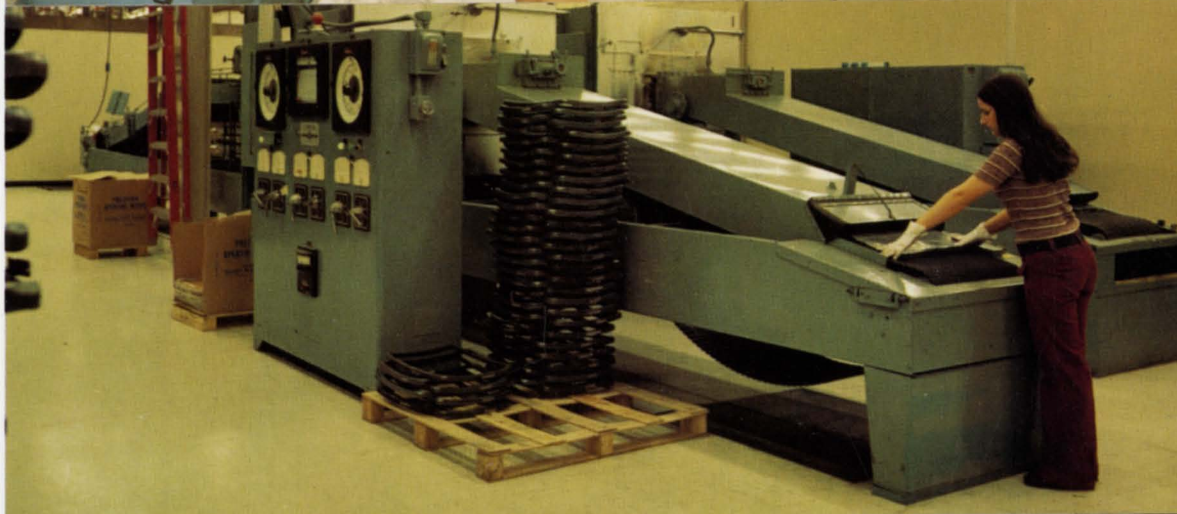


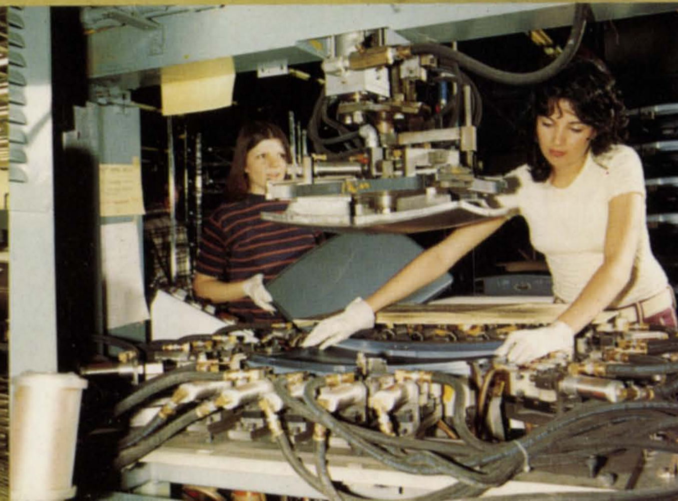
One mask is then stripped from the roll 19 and inspected for aperture size at several locations 20 across the mask. The finished masks are individually stripped from the roll 21 and each one is inspected 22 23 for aperture position, size, and shape.

19 20
21
22 23

Each mask is then passed through a rolling mill 24. Four passes in different axes are used in the mill and the mask is then formed in a precision press 25. After the mask is shaped, its internal stresses are relieved by baking it in an annealing oven 26. It is then blackened 27 and framed 28. Hook-type holders are welded prior to its insertion into the glass panel.

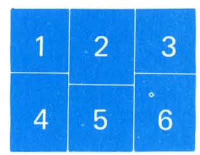
24	25
26	
27	28





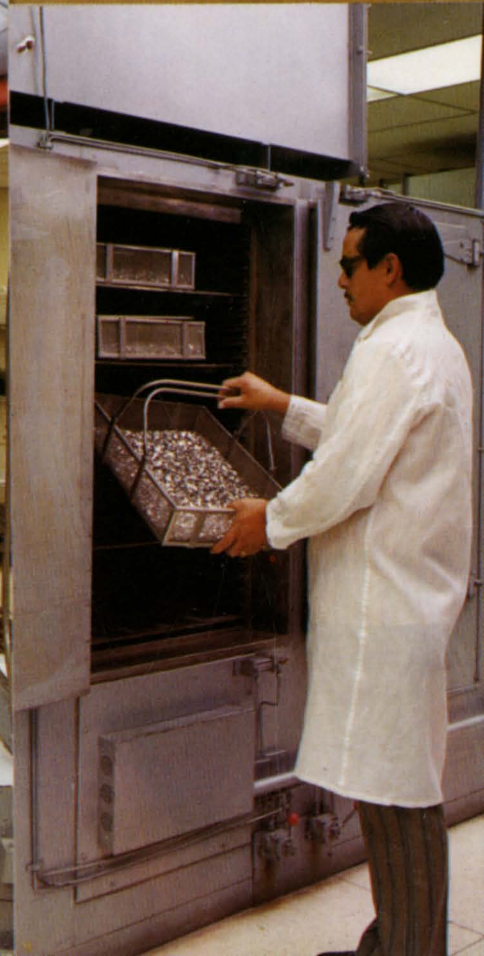
C. Electron Gun Mount Assembly

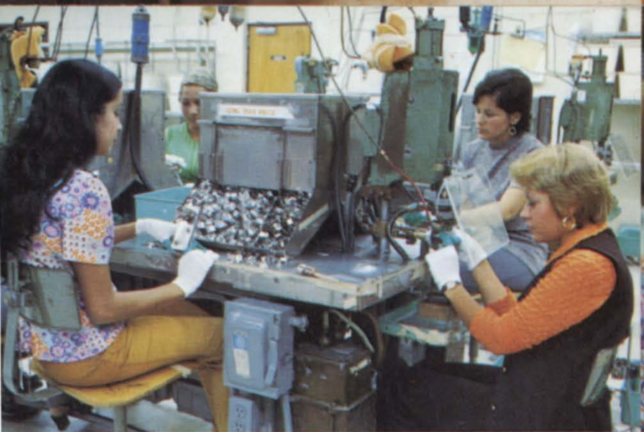
The assembly of the electron gun mount and the activation of the cathode are very special processes 1 in which cleanliness is paramount in every step. After the parts are inspected, 2 some with one of numerous gages 3 and others visually with a comparator 4, they are thoroughly cleaned with a solvent 5 and oven dried 6.

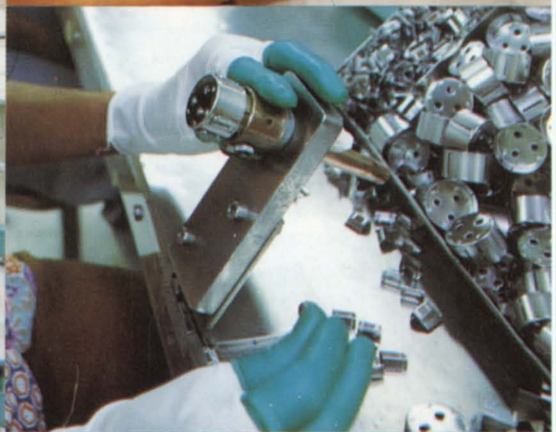










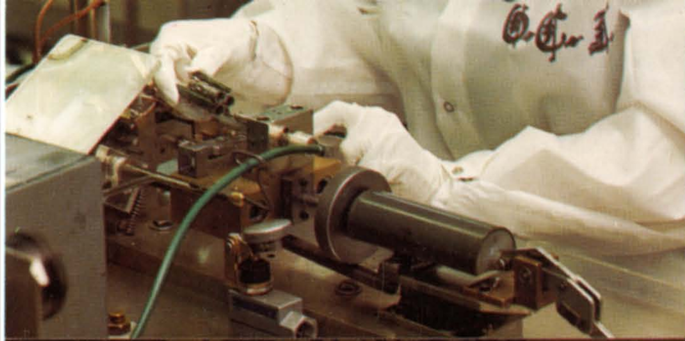
They are further decontaminated by firing in a hydrogen atmosphere 7. After this step great care is taken to assure against recontamination. Special gloves and finger tip coverings are used throughout the subsequent processing 8. The assembly process includes several sequential welding steps 9 10 11 12.

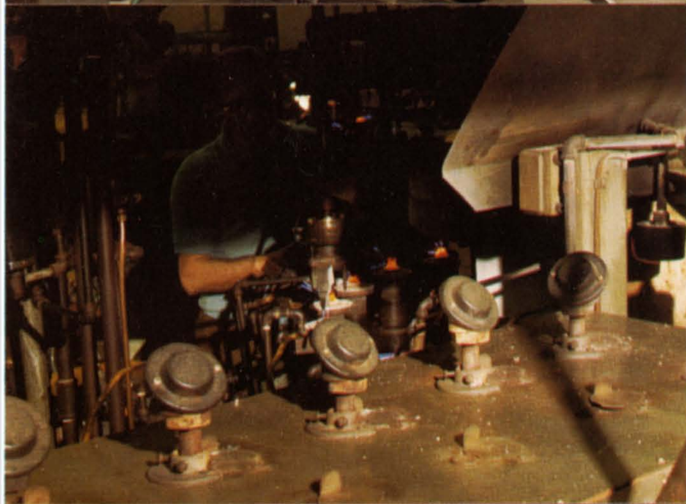
7	10
9	8
11	12

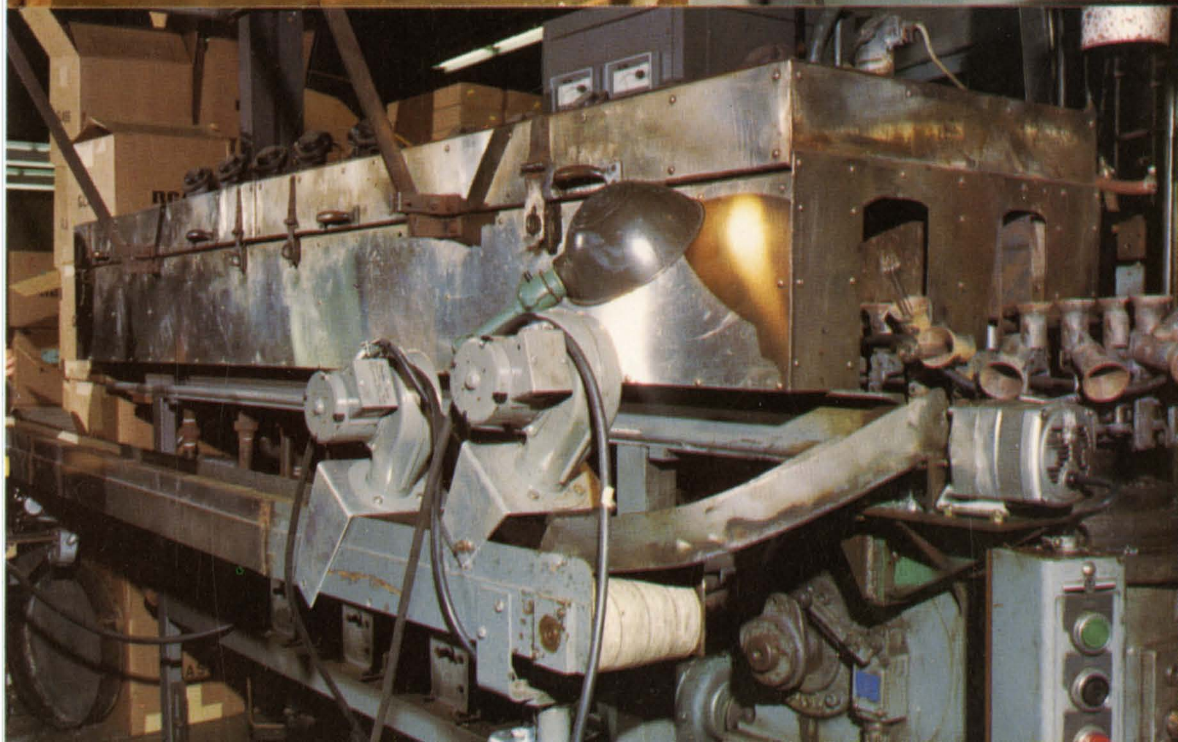
Other parts are prepared in a special room having a carefully controlled environment 13. In this room the cathode substrate is coated and then activated 14. Stem making is a special operation 15 which requires bonding of the leads to the glass base and thermal stabilization 16.

13 15 14

16







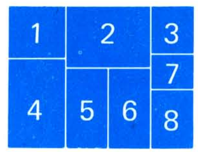
These various parts are assembled with a special fixture around a revolving work table 17, and when completed 18 each assembly is bonded by beading with flame 19.

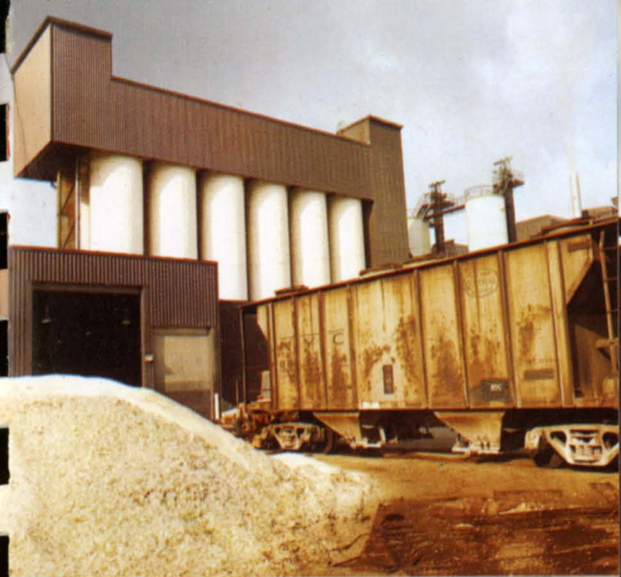
After a thorough wash 20 and dry 21, the units are inspected 22, tested 23, and stored in a plastic bag 24 to keep them clean until they are inserted into a color picture tube.

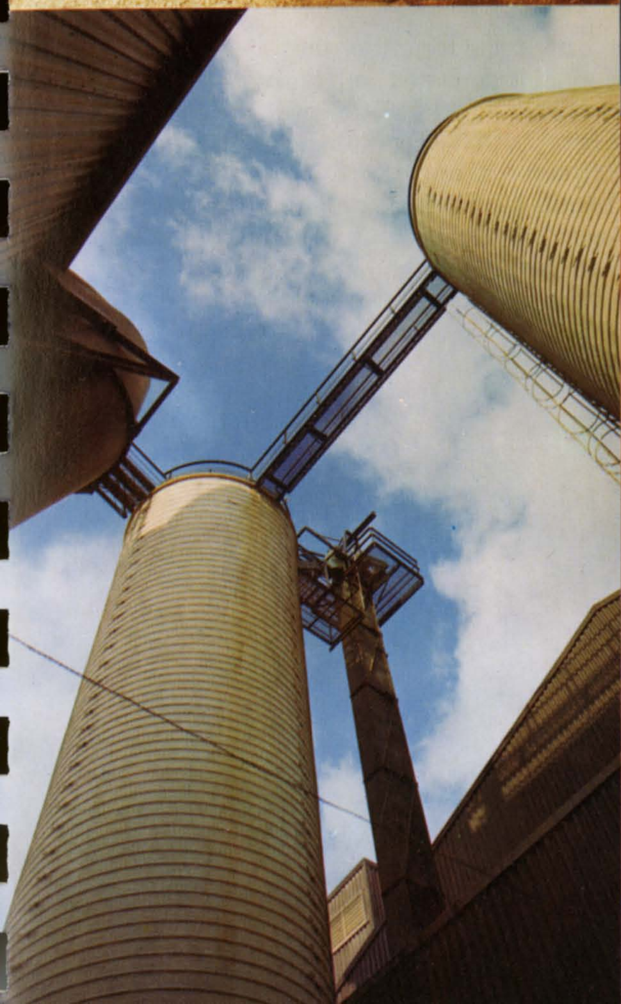
20 21
22 23
24

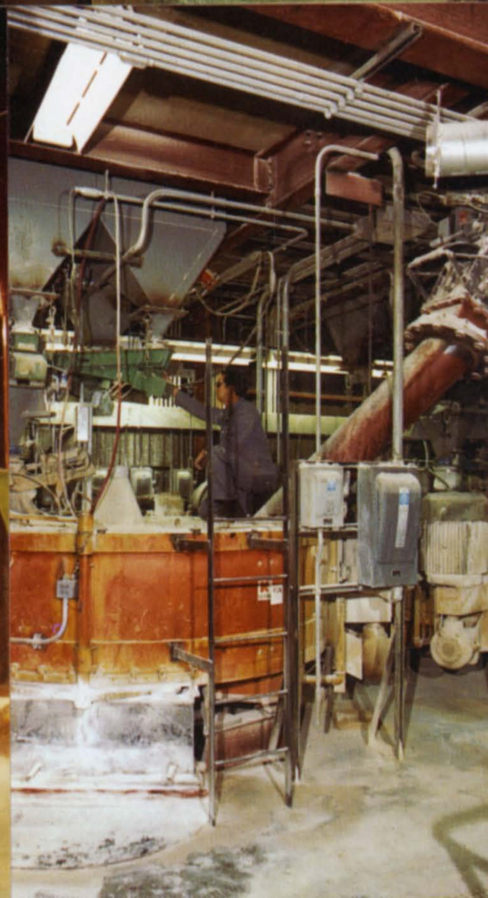
D. Glass Manufacturing

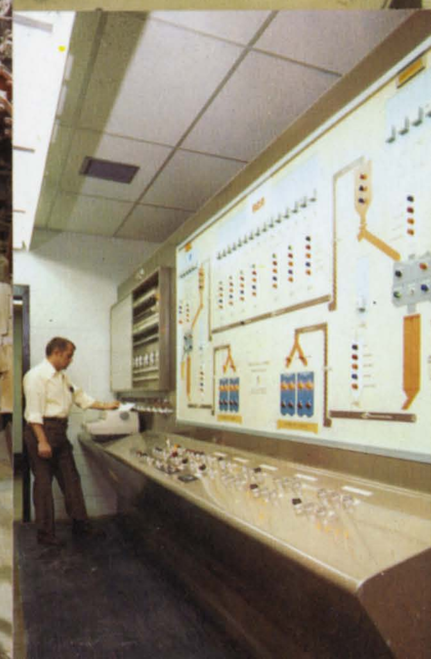
Glass manufacture is a very complex process requiring careful adaptation to special conditions and output requirements. In picture tube making, although the raw materials are the same, different mixtures are used for the panels and funnels and separate furnaces are used to fire each mixture. The process continues on parallel paths to the final inspection and transfer of the panels and funnels to the tube assembly line. The raw materials come in bulk quantities by rail 1 and are then transferred by conveyor to the top of storage silos 2. The raw materials are combined with glass cullet 3 which is stored in separate silos. 4 These materials are precisely weighed 5 and delivered to the mixing station 6 where the small amounts of special ingredients are added 7. These processes are centrally controlled from a single instrument panel 8 so that control is at one point.

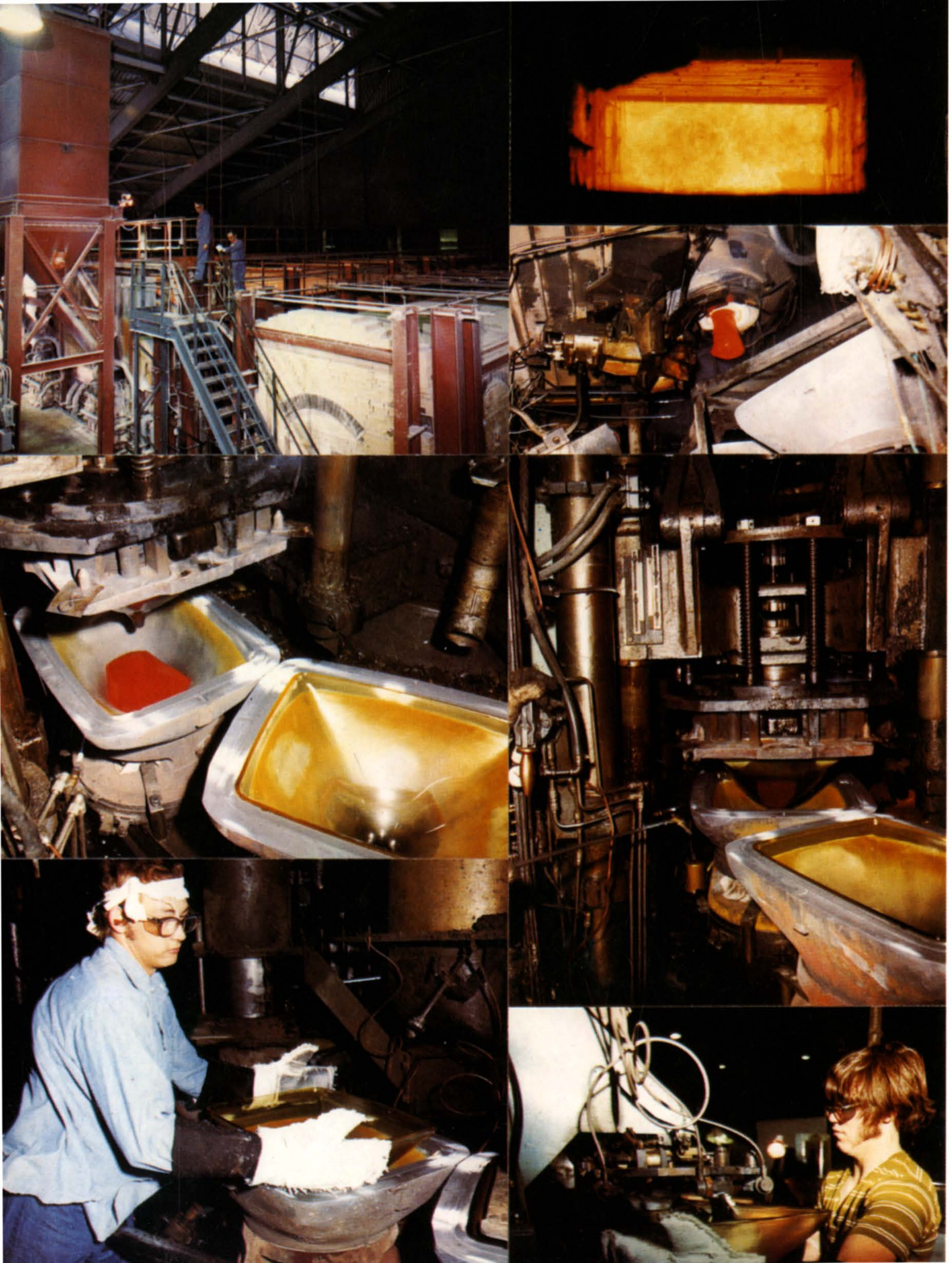




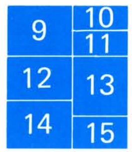







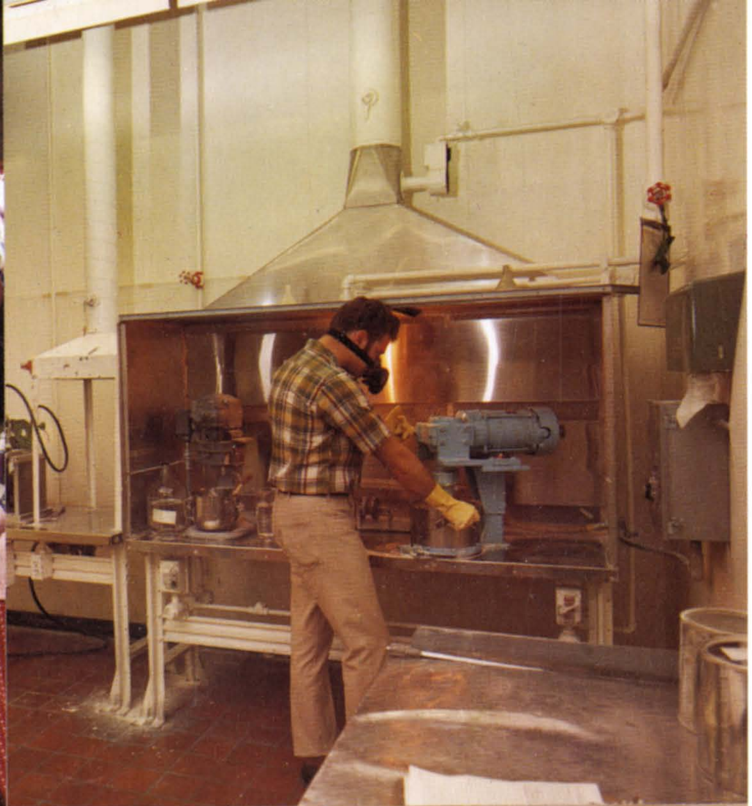


The mixture formulated for either the panel or the funnel is delivered to its furnace 9 where the mixtures are melted 10. For the funnel-making process, a portion of molten glass 11 is drawn from the furnace, cut off, and dropped into the funnel mold 12. A shaping plunger enters the mold and is then withdrawn 13. After blasts of cool air are applied, the hot funnel is removed from the mold 14 and the neck is formed 15.



At this stage, provision is made in the hot-glass for the high-voltage connection 16. Then, after the funnel is passed through a Lehr for thermal stabilization 17, the rim of the funnel is ground and beveled 18. Various reference surfaces are also ground 19. After an acid-fortifying treatment and washing 20, the funnels are inspected 21.

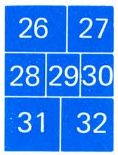
16	17
18	19
20	21



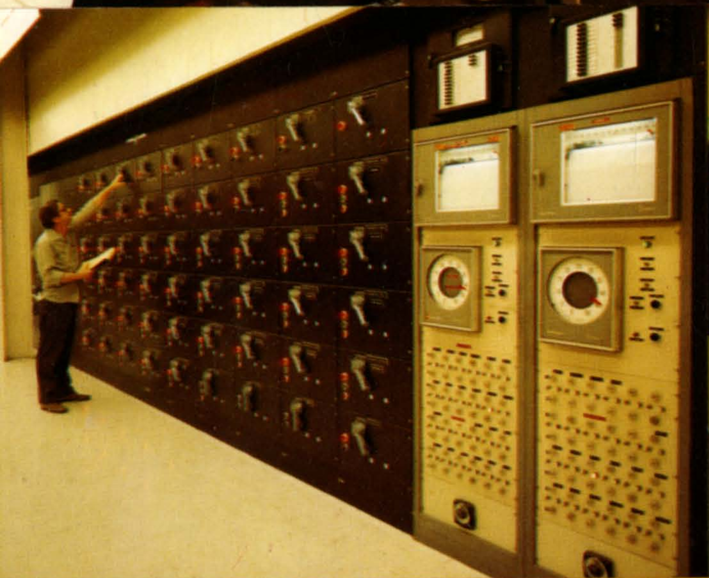
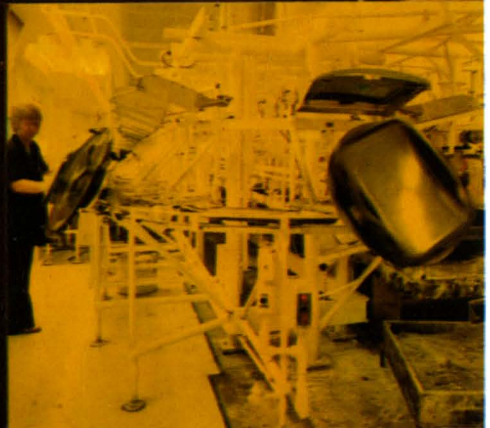
After inspection, a coating is applied to the inside of the neck 22. The frit material, which is mixed 23 in small batches, is applied to the lip of the funnel 24. Then, after another washing 25 the funnel is ready for attachment of the panel.

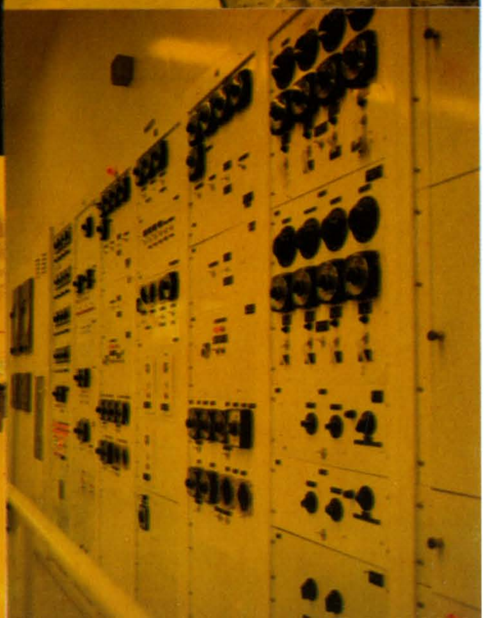
22	23
24	25

The panel goes through some of the same steps as the funnel. The specially formulated mixture is fed to the panel furnace. A similar but larger portion of molten glass is drawn from the furnace 26 and dropped into the panel mold. After the plunger is lowered and raised and cooling air applied to the panel, it is removed from the mold and the special studs for holding the mask are inserted 27. After a trip through the Lehr for thermal stabilization, the panels are ground 28 and polished 29 in several steps using successively finer abrasives. The grinding plates 30 are specially fabricated so that the concentric abrasive buttons are maintained individually on a flexible disc. After the panel is polished, it is tested for flatness and contour in a special computer-controlled machine 31 32 which is an important key to the maintenance of the quality of the glass.

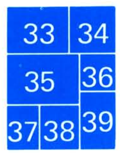




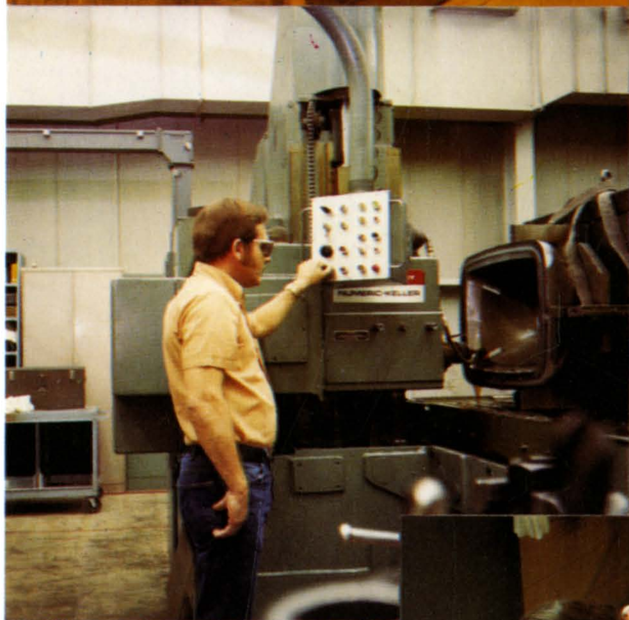



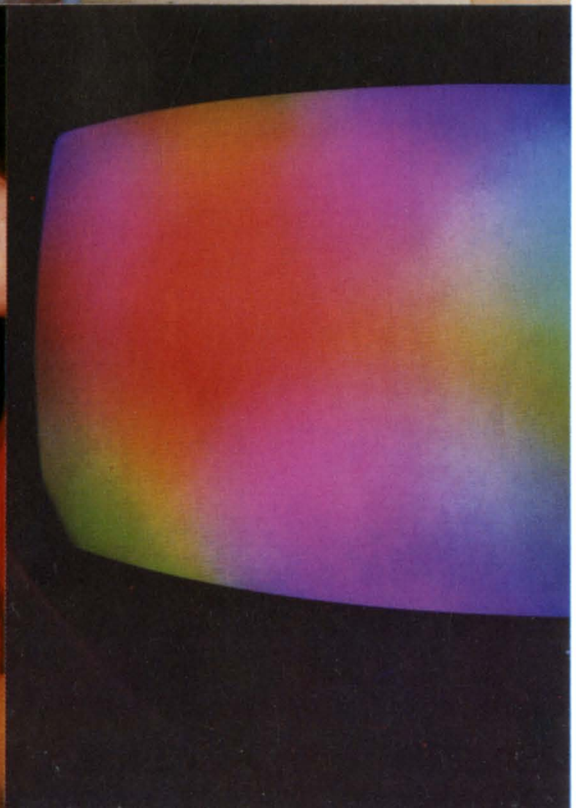
The panel is then transferred to the assembly line where the mask is accurately positioned on the panel studs 33. Then, after another trip through the stabilizing Lehr 34, controlled from a single board 35, the panel goes to the slurry room 36 where the three phosphors are applied 37 and the locations set by an exposure on the light-house stands 38. In the slurry room, the electrical controls are centrally located so that the entire operation can be monitored and checked from one position 39.



A clear thin film is then applied which coats the entire inner surface of the panel 40, and the panel is transferred to the aluminizing area 41 where a thin film of aluminum is applied by vapor deposition. A baking operation removes the clear film from between the phosphors and the aluminizing, and the panel is ready for attachment to the funnel. The molds used for making both the funnels and the panels are specially designed. They are precisely formed on tape-controlled milling machines 42 and very carefully checked with a special measuring instrument 43. The molds are then plated 44 polished 45, and given a careful visual inspection 46.

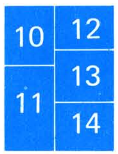
40 41
42 43
44 45 46

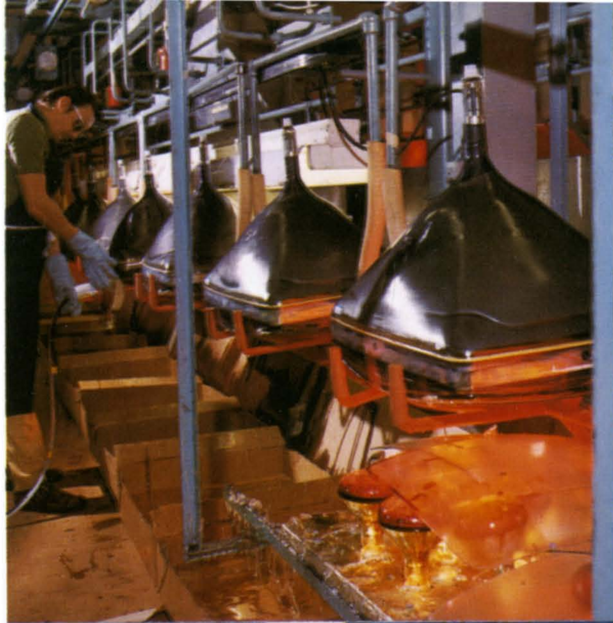


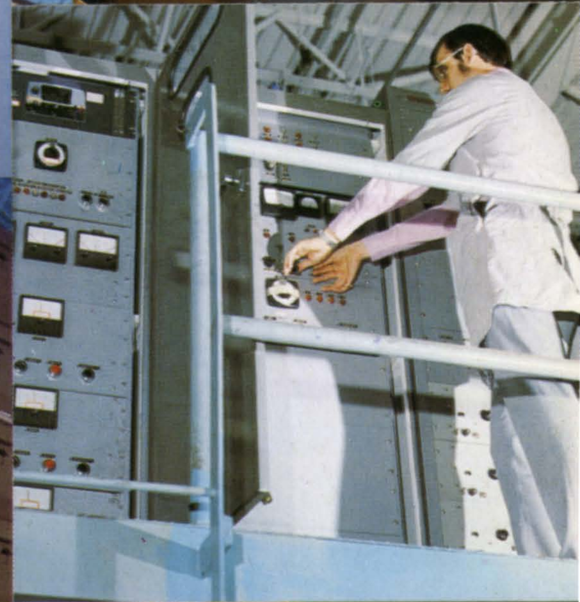


The final steps in the tube processing are varied to optimize production efficiency and to suit the needs of particular tube configurations. Here is shown the application of a conductive coating to the tube envelope 7, assembly and adjustment of the precision in-line yoke 8, and a preliminary characteristic test 9.

Implosion protection is incorporated 10 and the tube is held for several days 11 to insure stabilization of characteristics before final test 12 13. The tube is then packed for shipment 14.







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