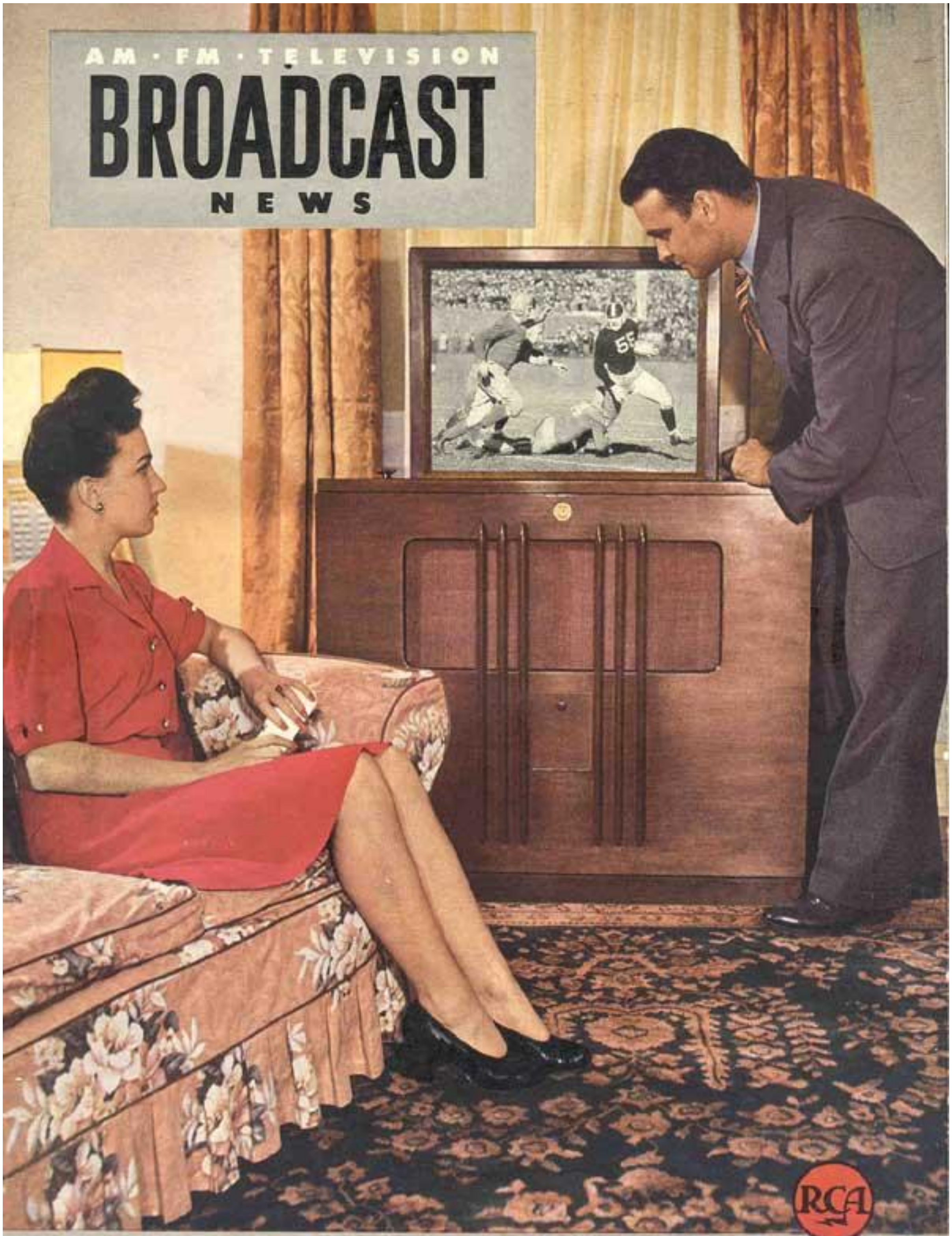
AM · FM · TELEVISION

BROADCAST NEWS



Large-Screen Television Receiver . . . Feature Story on Pg. 2

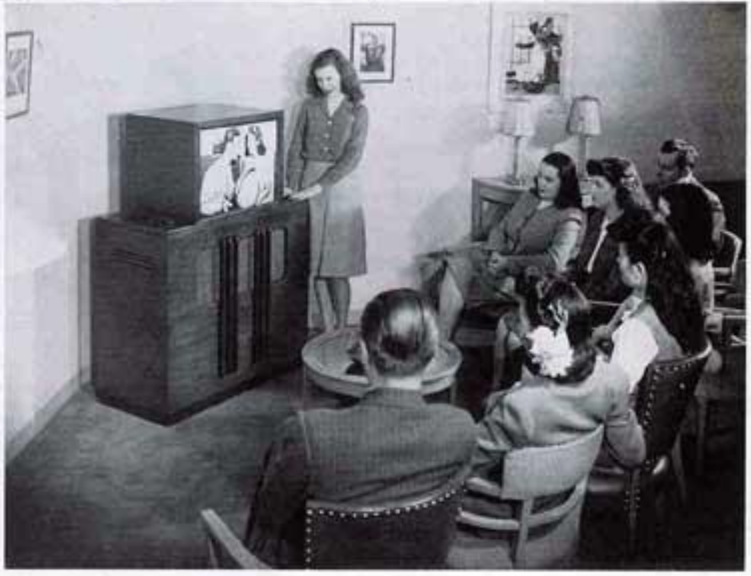
RCA ENGINEERS DEVELOP PROJECTION-TYPE TELEVISION RECEIVER

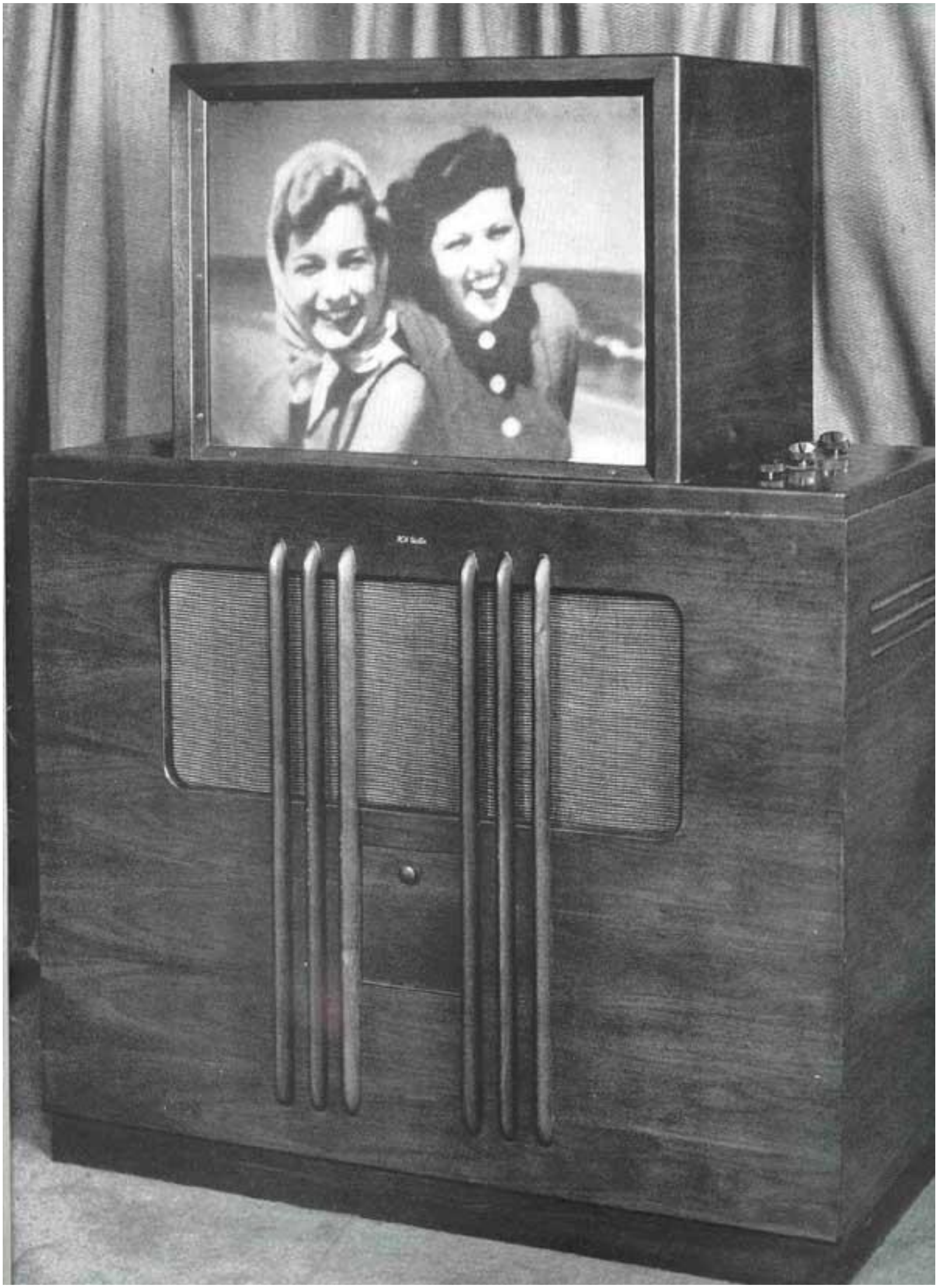
A preview of postwar television—the real thing, not the "dreamstuff"—is afforded by the RCA projection-type home television receiver shown on the opposite page. This receiver, which has recently been demonstrated for various groups in the industry, is a relatively compact console model in which a picture 16 inches x 21½ inches in size is projected on a built-in, translucent screen. Through the use of a new highly-efficient optical system a picture is produced which has about the same brightness and contrast as that of pre-war, direct viewing tubes—while the size is such as to overcome the one important objection to pre-war television receivers; namely, that "the picture is too small." A comparison of this new receiver with the best of pre-war types is provided by the illustrations on this page. A technical description of the new receiver will be found on the following pages.

A developmental model of the RCA Large-Screen Television Receiver for home use. This is an unretouched picture taken during an experimental transmission of slide films. It should be remembered that the 120-line screen used in making half-tone cuts such as this tends to reduce the resolution.

Above: With the 7½" x 10" picture on a pre-war direct-viewing receiver the optimum viewing distance was about 2½ feet. This is satisfactory for small groups, but results in crowding when there are more than three or four lookers-in.

Right: With the 16" x 21½" picture on the RCA Large-Screen Receiver the optimum viewing distance is about 8 feet. Much larger groups can look-in without crowding. In fact, tests indicate that a picture of this size may be satisfactorily viewed from any point in a fair-sized living room.





Projection Receiver (con.)

The projection set shown on these pages is an "experimental" model and obviously has not been "styled" or otherwise dressed up. However, the general arrangement of the components in this set approximates that which may be expected in post-war production models and, therefore, will serve as a satisfactory example of the principles involved.

There are four features of this set which represent outstanding engineering accomplishments. These are:

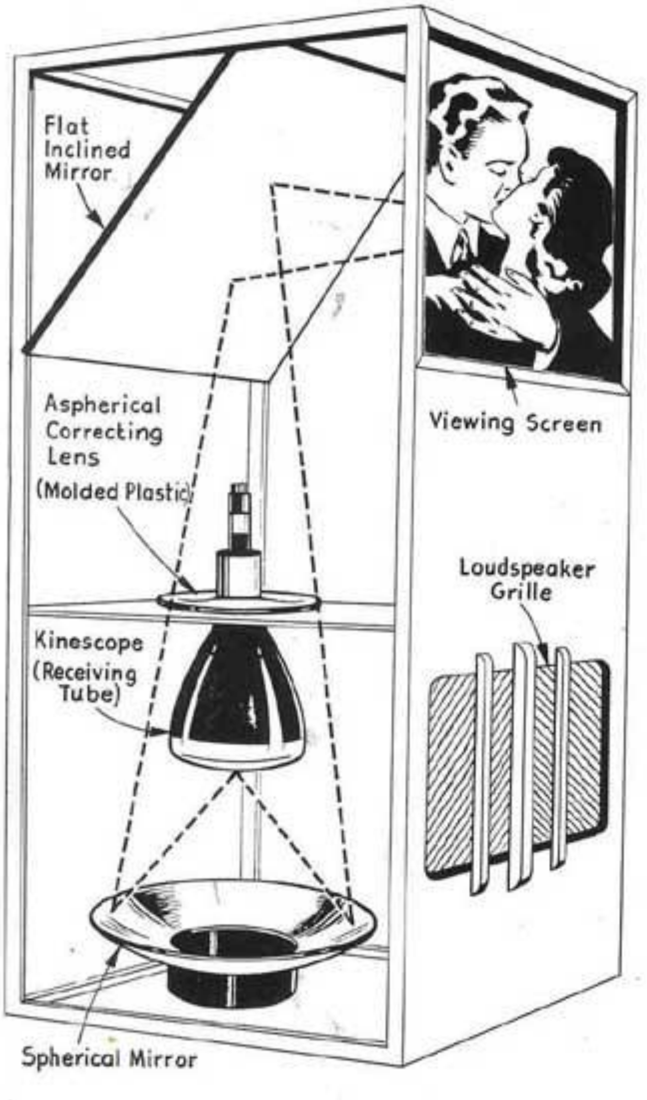
(1) A simple, but ingenious arrangement which allows a projection system having a "throw" of nearly three feet to be mounted, together with high voltage power supply and other components, in a cabinet only a little larger than many pre-war consoles or phonograph combinations.

(2) A new projection-type 5-inch kinescope in which a very bright image is produced by operating with 27,000 volts on the anode and a high beam current.

(3) A new type highly efficient optical system in which an aspherical correcting lens is used in conjunction with a large spherical mirror.

(4) A method of manufacturing (at low cost) the aspherical correcting lens by molding it of clear thermoplastic material.

I. Arrangement of the Projection System



The projection receiver illustrated on the preceding pages is a self-contained unit containing all elements of the system from antenna lead-in to viewing screen. In this respect it differs radically from most of the proposed projection receivers in which the picture is usually intended to be projected onto a wall or screen some distance away.

The built-in system has many advantages. It is a much less awkward addition in the average living room; it is more convenient to use—doesn't need to be re-setup each time the furniture is moved; it can have a fixed focus—eliminating one control and simplifying the optical system; and, for viewing under semi-light conditions, the translucent screen represents a more efficient use of the available image illumination than would a reflective screen.

Getting all the components of this receiver into a single unit, without making that unit unreasonably large, represents more of an achievement than an outward look at the cabinet would indicate. The major problem, of course, was the optical projection system proper. The magnification which can be obtained with a given lens arrangement depends, of course, on the "throw" (i.e., distance from lens to screen). For a picture of the size desired the required distance was about three feet. Obviously, the cabinet couldn't be that deep. The answer was to mount the projection system vertically. To keep this from making the receiver too high, a reflective arrangement was used. This is illustrated in the diagram at the left.

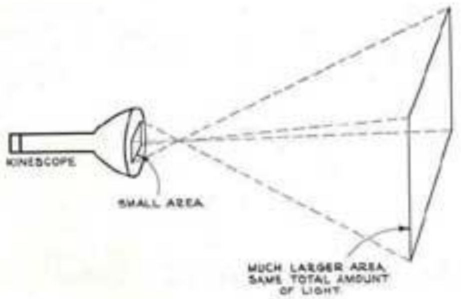
In addition to the optical system it was also necessary to provide space for the receiver chassis, the video diflection circuit chassis, the audio chassis, the high voltage power supply, and the loudspeaker. The first three of these are simply modifications of the standard chassis used in the pre-war TRK-12 Receiver. The development of a stabilized 27,000 volt power supply (in itself something of an engineering achievement) that could be mounted complete on a small chassis made it possible to group the four chassis around the outside cabinet; thus leaving the center free for the projection system. The loudspeaker is mounted in the usual position toward the base of the cabinet.

II. The High-Voltage Projection Kinescope

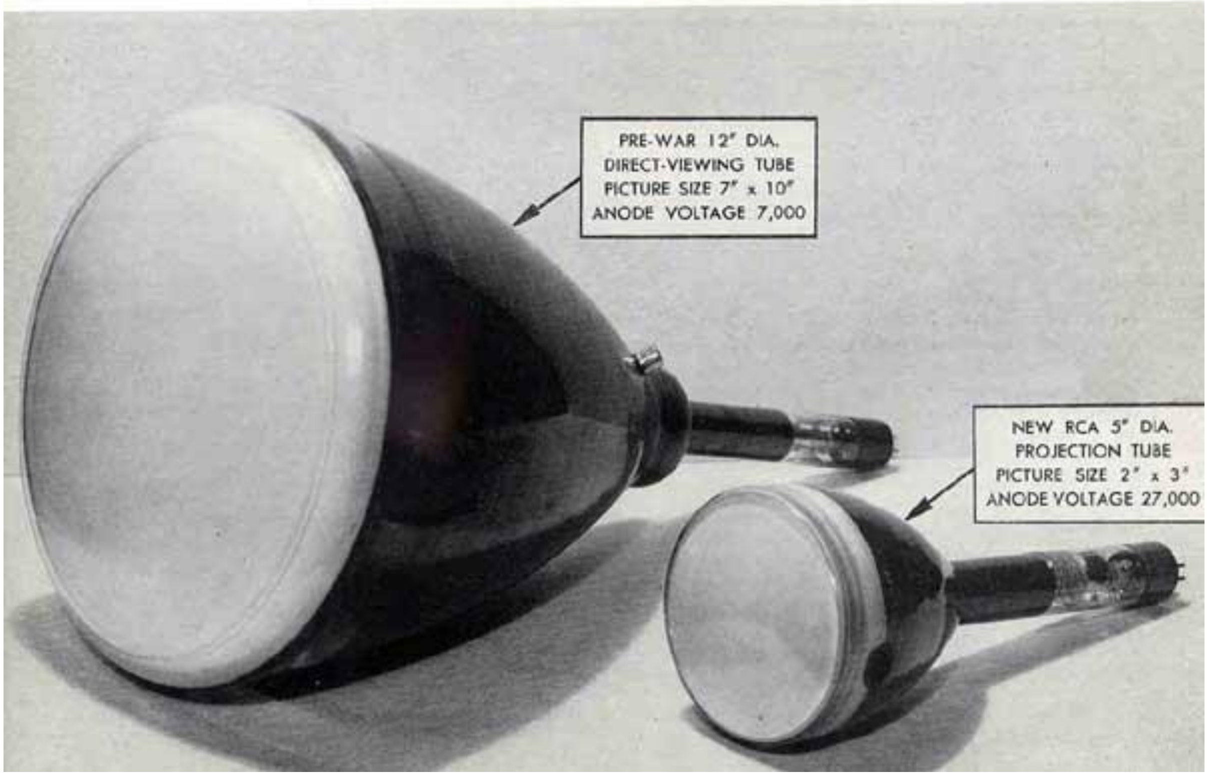
The earliest projection television systems consisted of a standard direct-viewing kinescope plus a lens suitable for projecting an enlarged image on a screen some feet away. The picture projected in this way had very low illumination. There were two reasons: first, the optical systems suitable for use with such a projection system had low "light-gathering" power and hence made available only part of the light in the original image and, second, the light thus made available was spread over a much wider area and hence the average illumination was greatly reduced.

It will be apparent that a successful projection tube must have much higher illumination than a direct-viewing picture tube. For instance, the 16 inch x 21⅓ inch picture on the receiver shown on the preceding pages has an overall area a little more than four times that of the 7½ inch x 10 inch picture on a standard 12-inch viewing tube. If the projection optical system were 100 percent efficient (which, of course, it is not) the total illumination required would be four times as great. Moreover, since the projection tube should preferably be smaller than direct viewing tubes (in order to use small-size lenses) the average illumination or brightness on its face must be even greater. For example, the 5-inch projection tube, shown at the right in the picture below, produces an image about 3 inches x 4 inches in size. Thus, in an area approximately one-sixth that of the picture on the 12-inch viewing tube, there must be produced a total illumination four times as great. This means an average illumination (or brightness) some 24 times that of the image on the direct viewing tube. When the loss in the optical system is taken into consideration these ratios must be even greater.

Increased brightness of the beam spot in a kinescope (and hence of the average illumination) can be obtained by increasing the second anode voltage and thereby causing the electrons in the beam to travel faster, or by increasing the number of electrons in the beam (i.e., the beam current). Both entail difficulties. Increasing the voltage requires greater spacing and better insulation within the tube. Increasing the current requires higher emission cathodes.



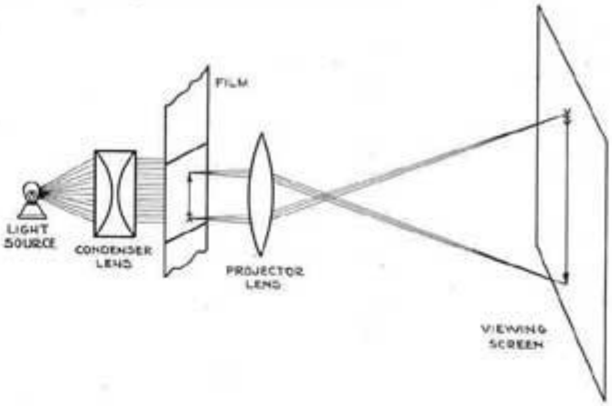
RCA engineers have been working on this problem for more than ten years. The projection tube shown below is the result of this long-extended research. This tube operates satisfactorily with 27,000 volts on the anode (approximately four times that of the standard 12-inch viewing tube). It produces an image having an overall illumination about 12 times that of 12-inch, pre-war, direct-viewing tubes. Used with the improved optical system described in the following pages this tube is capable of producing 16 inch x 21⅓ inch pictures having an average illumination comparable to that of home movies.



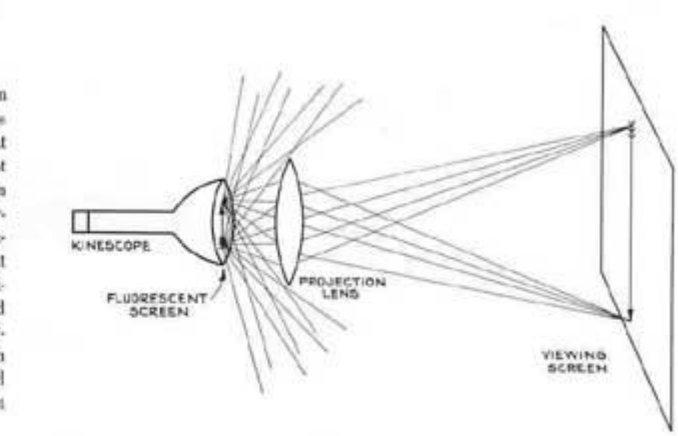
III. How the Optical System Works

It would seem on first thought that the projection of television pictures could easily and satisfactorily be accomplished with a simple projection lens system such as that used in motion picture projectors. The first projection receivers were, in fact, so constructed. However commercially available lenses of the type required have relatively low light-gathering power (which means, in effect, that they gather light in from a relatively small angle). As a result, when these lenses are used for television projection, the overall efficiency of the optical system is very poor. The reason for this can best be understood by comparing the arrangement used for television projection with that used in motion picture work, as shown below.

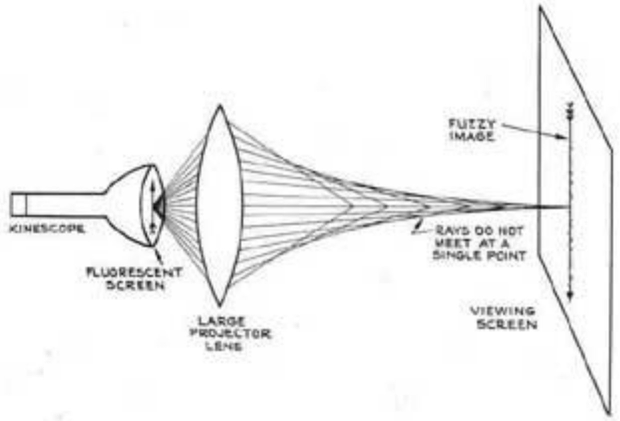
1. In a typical motion picture system, such as shown in the diagram at the right, light from a lamp or arc is converged by a condensing lens so that as it strikes the film it consists of a bundle of nearly parallel rays. Nearly all the light which strikes the film passes through (except, of course, that part which is stopped by the dark part of the film). Moreover, as the light rays emerge from the far side of the film, they diverge only slightly. Thus, all the light originally falling on the film eventually reaches the screen, except that part stopped by the picture on the film. For comparative purposes (and disregarding losses) such an optical system can be said to have a very high efficiency. This fact, together with the relatively intense illumination of the film, makes for a very satisfactory projection system.



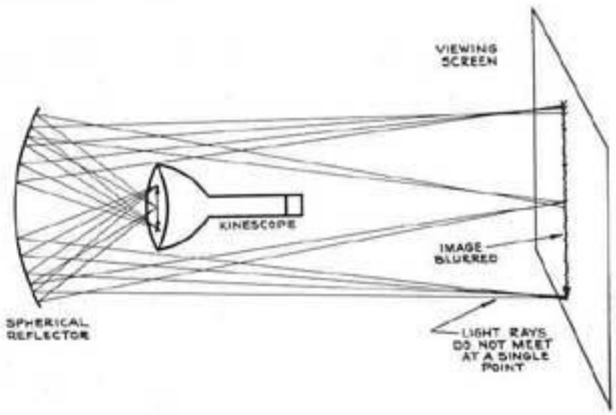
2. Now, what happens when the same optical system is used to project a television picture as shown by this sketch. The only source of light in this case is that in the picture itself. Moreover, this light does not emerge from the fluorescent screen in parallel, or even nearly parallel rays. Rather, since the screen is a perfectly diffusing surface, these rays emerge in all directions and only a small part are gathered in and brought to a focus by the lens system. Thus, the overall efficiency of the optical system is very low. Maloff and Epstein have calculated that good, commercially available (f/2) lenses, when used at the magnification typical of home television receivers, will collect and deliver to the screen less than five percent of the light generated.



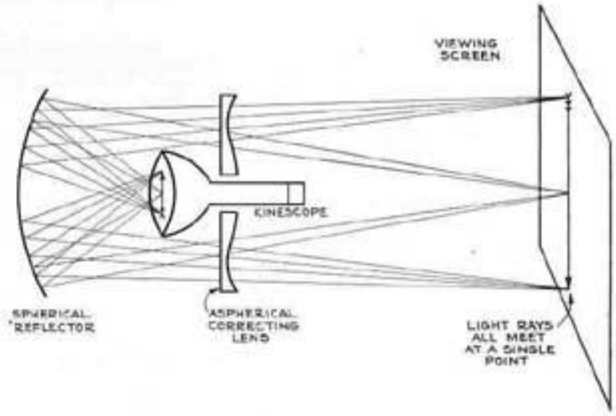
3. From the foregoing, it would seem that the obvious answer would be to increase the size of the lens and thereby increase the amount of light it will collect. This, however, brings up another problem; when the rays from a single point source are refracted on different parts of a large spherical lens, they do not all meet accurately at a single focus. Instead, the rays refracted by the outer portions of the lens come to focus nearer to the lens than those that pass through the central portion. This dissimilarity of focus—known technically as "spherical aberration"—can be avoided by masking all but the central part of the lens ("stopping it down," as the photographers say). Doing this, however, cuts down the "light-gathering" power again so that the net amount gained by going to a larger lens size is relatively small.



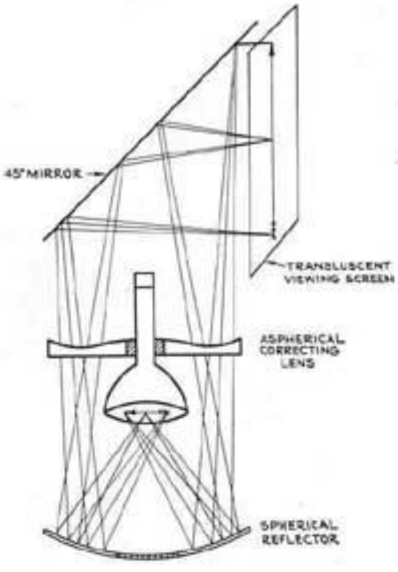
4. In the actual arrangement of the optical system for a home receiver, a reflective system is used as shown in the diagram at the right. The main "lens" in this arrangement consists of a bowl-shaped spherical reflector some 12 inches in diameter. When the fluorescent screen of the projection kinescope is placed at a point between the principal focus and the center of curvature, an enlarged image is projected on the screen. The tube itself blocks off a small part of the reflected rays, but does not affect the image (just as reducing the aperture on a camera reduces the light, but does not affect the size of the picture). Unfortunately, a reflector such as shown here—if of large size, introduces "spherical aberation" with the result that the image is not sharply focused.



5. In order to correct this "spherical aberration," an aspherical correcting lens is arranged as shown in this sketch. A hole is cut out of its center so that it can fit over the neck of the tube. This lens is shaped in such a way that it bends slightly the rays reflected from the outer part of the reflector and thus brings these to a focus at the same point as the rays reflected from the center part. By locating this lens at the center of curvature of the reflector, a minimum of shaping is required. The reflector itself is polished glass with an aluminized surface. The center part of this mirror is masked (actually, it is cut away) since most of the light reflected by this part is blocked by the tube; masking prevents reduction in contrast which would be caused by the light it would otherwise reflect on the face of the tube. So efficient is this arrangement that the overall system has an efficiency of approximately 30 percent (equivalent to an aperture of f/.9). This is six to eight times better than direct projection optical systems.



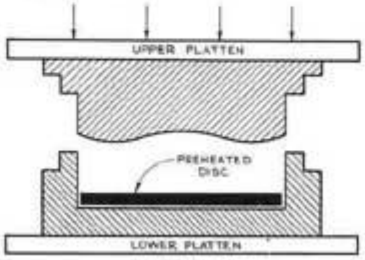
6. The final step in the development of the projection optical system is shown here. In order to get the whole system into a cabinet of relatively shallow depth, the main axis of the system is arranged vertically. The projection kinescope tube points downward. The image, projected downward from the tube, is reflected straight up by the spherical reflector, passes through the correcting lens, strikes a 45° mirror near the top of the cabinet and is projected forward onto the translucent screen in the front of the receiver. Some added advantage is gained here since a translucent screen can be made to have a higher efficiency than a diffusive, reflective screen. The picture on this screen actually has a brightness in the highlights of approximately 8 foot-lamberts, which is about the same as that of home movies.

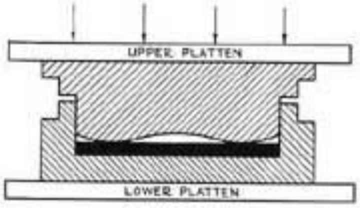


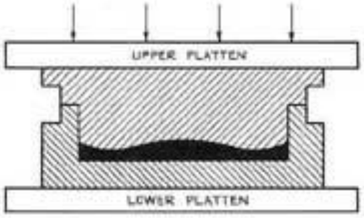
IV. How the Lenses are Made

In order to make the reflective optical system, described in the previous pages, a practical solution for home receiver use it was necessary to find some way of producing the required lenses at a relatively low cost. The spherical mirror, while of larger size, presented no problem because such a surface is naturally generated. Most optical lenses are of spherical shape (largely for this very reason) and equipment suitable for grinding such lenses in quantities is available.

The correcting lens, however, since it is of non-spherical shape, presents a much more difficult problem. No machines are available for mass production of aspherical glass surfaces of the type required. To make them by laboratory methods would make such lenses far too expensive for use in home receivers. The problem, therefore, was one of finding a new method of making the aspherical lens. How RCA engineers did this is shown in the illustrations below.



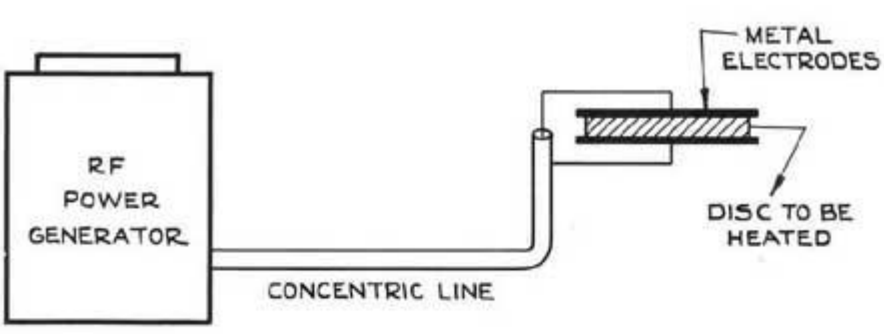




1. RCA engineers solved this problem of making aspherical lenses at low cost by developing a method of molding these lenses from a clear thermoplastic material called methyl methacrylate (sold under the trade names of Lucite and Plexiglass). Essentially, this process consists of placing a flat disk of the thermoplastic material in a molding press (as shown here) and applying high heat and pressure to make this disk assume the shape desired. It is then cooled under pressure so that when removed it retains its shape permanently.

2. This seemingly easy solution was not arrived at without plenty of headaches. In order that the lens will have just the right bending action on the light rays, the contour of dies (shown here partly closed) must be exactly true. Moreover, the faces of these dies must be free from any trace of scratch or blemish. To achieve this, stainless steel plates are carefully ground and polished to exact shape, hardened so that they will resist abrasion, and polished to a mirror finish.

3. In order to speed the molding process, the methyl methacrylate disks are preheated before being placed in the mold. The mold itself is heated by passing steam through pipes inside it. Since the methacrylate is a thermoplastic and does not harden with heat (as thermosetting plastics do) it must also be cooled in the mold. This is done by running cold water into the pipes that previously passed steam. When the shaped lens is down to room temperature it can be removed and it will hold its shape indefinitely.



4. RCA engineers have added a final touch to this molding procedure by using radio frequency power as the means of preheating the thermoplastic disks. R-F current from an 8 Mc oscillator is caused to flow through the disk to be heated as shown in the diagram above. The resistance of the material to the passage of the current causes heat to be generated in the material. It is then placed in the mold and pressure applied as described above. The process is illustrated in the pictures on the following pages.

5. A methyl-methacrylate disk, 8 inches in diameter and ¼ inch thick, is placed between metal electrodes connected to a radio-frequency power generator. Application of power (1 KW) for 3½ minutes heats the disk to a temperature of 150° throughout. The electrodes are located in an interlocked, screened enclosure

6. The heated disk (usually referred to as a "preform") is soft and flexible as it comes from the radio-frequency preheating cabinet. The molds, heated by steam pipes, keep it soft during pressing. When the heating cycle is completed, steam is shut off and cold water turned on.

7. When the mold has cooled to near room temperature, the press is opened and the fully shaped lens removed. Except for boring the hole in the center for accommodating the neck of the projection tube, the lens is ready for use as it comes from the mold. No polishing or finishing of any kind is required.

8. Lenses molded in this way have excellent optical properties. They have slightly better light transmission than glass and slightly less light scattering—both of which are, of course, advantageous. They do not have the surface hardness of glass, but in tests have stood up well without any special care.

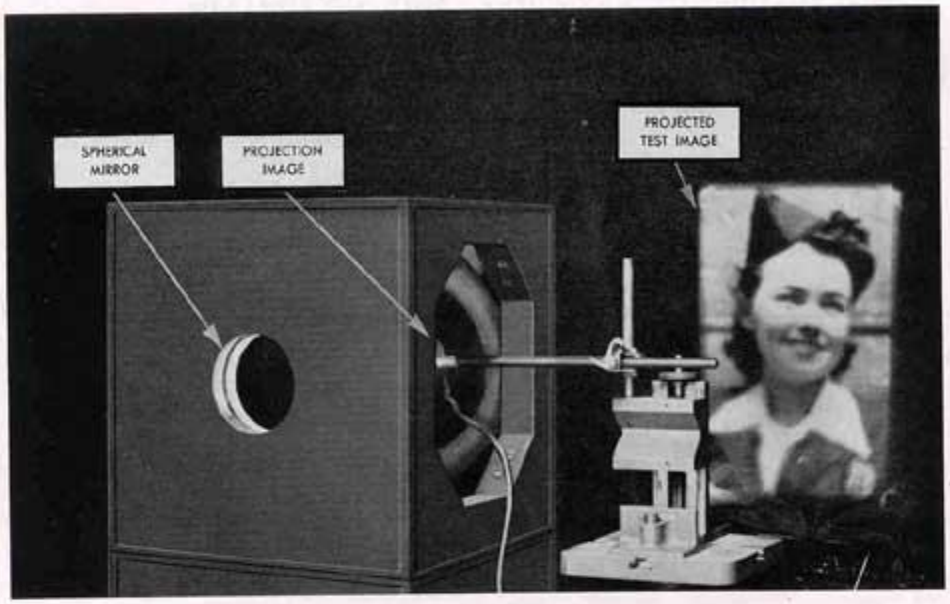
9. The spherical mirror which forms the main "lens" in the reflective optical system is shown here before aluminizing. It is a salad-bowl shaped piece of glass 14 inches in diameter with a 4-inch hole in the center. The inner surface is ground to a true spherical shape on a standard optical grinding machine.

10. The aluminizing procedure consists of placing the glass bowl—inner side down—in a bell jar which is then evacuated. In the jar are two aluminum filaments from which aluminum is evaporated by heating to incandescence. The aluminum vapor which is driven off condenses on the under side of the glass.

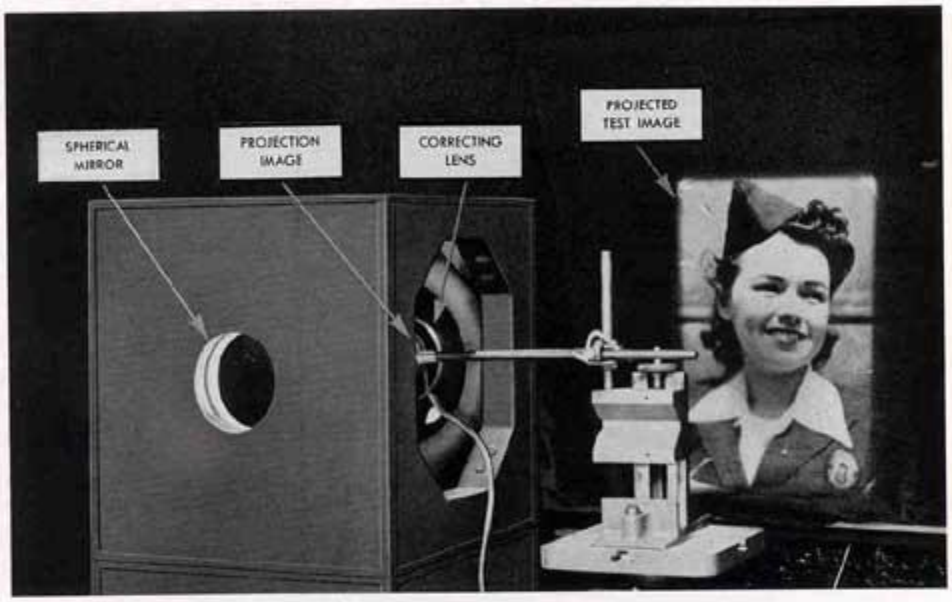
11. The spherical mirror, removed from the bell jar after aluminizing has been completed, is shown in this illustration. The polished, aluminized inner surface has a true "mirror-finish" of high reflective properties. As a "lens" it has very high light gathering power.

12. The two lenses, completed and ready for mounting in the projection-type home receiver. In the background is the standard RCA Type 15-B Radio Frequency Generator used in preheating the plastic disks before molding. At the right rear is the screened enclosure containing the heating electrodes.

V. Testing the Lenses



1. This is a temporary test setup used to check the molded correcting lenses before they are mounted in a receiver. The box in the foreground contains a standard spherical mirror mounted on the inner surface of the near side. At the proper focal point is an illuminated image simulating the face of the projection tube. In this view, no correcting lens is in place, hence the projected picture is very fuzzy.



2. In this view, one of the molded correcting lenses has been placed in the correct relative position on the front of the box (the far side). The picture, as will be seen, is now very much sharper and brighter. (In these two views certain details of the test box have been retouched, but in neither case has the projected picture been retouched at all.)