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A CINEMA PROJECTOR FOR 70 mm AND 35 mm FILMS

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In the last few years various new systems of making and projecting films have been used. Philips is indirectly involved in one of these, viz. the Todd-A.O. [1]) system. The American Optical Company, the firm that undertook the development of the "Todd-A.O." system turned to Philips in Eindhoven for the development and manufacture of the necessary special projectors. We shall deal briefly with the "Todd-A.O. system" and its position in regard to two other well-known new systems, namely "Cinerama" and "CinemaScope", before turning to the projector itself.

The aim of these new systems is to strengthen the impression of "realness" created by the film. The method used in the above three systems is to photograph a wider field of view by using wide-angle taking lenses and to take up more of the field of vision of the audience with the projected picture by widening the screen. It is not sufficient to fill the bigger screen by projecting a normal film that has been enlarged still further; this would only produce the same effect as if the audience were to sit nearer to the screen.

It is most desirable to combine the use of a wide screen with stereophonic sound. The positions on the screen where the actions take place now vary so much that it would be distracting were the accompanying sound to come from just one fixed direction.

Increase in the picture angle at the filming stage has been taken furthest in the "Cinerama" system. In this system three cameras are used which take adjoining pictures, and this gives a total picture angle of 146° in filming. When these are projected, a wide curved screen is used on which the three films are projected next to each other (*fig. 1*) by three synchronized projectors. It is true, as can be seen from fig. 1, that the great majority of the audience will see the picture at an angle considerably less than 146°, but experience shows that this is not objectionable.

The success of "Cinerama", which in Europe has been seen in London, Paris, Milan and Rome, was so complete that audiences accepted the shortcomings of the system. From the audience's point of view the greatest objection is that the two dividing lines on the screen where the pictures join, have not yet been successfully eliminated. The brightness and colour of the three pictures are never absolutely alike. Moreover, every picture projected dances a little: the position of the frames on the film and the transport mechanisms of the projectors are never quite perfect and this means that consecutive frames never occupy exactly the same position in the film gate. The dancing effect is not the same for each of the three films so that they can be seen to quiver with respect to each other at the picture boundaries. Possibly even more distracting is the fact that at a picture boundary the faults in the picture, though slight, change in a discontinuous manner. This can cause, for example, a long object situated across the width of the screen to show a kink at a picture boundary. This is especially annoying when an object of this kind (e.g. a boat) moving right across the screen, passes a picture boundary.

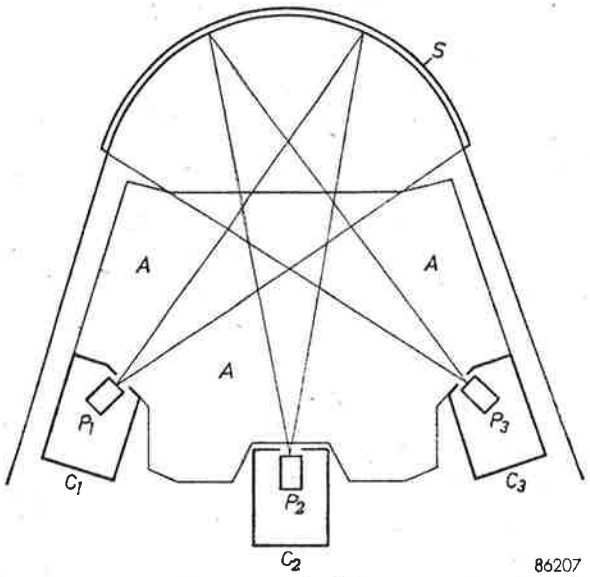

Fig. 1. Schematic diagram of the Cinerama system, showing the arrangement of the screen S, the three projectors P_1, P_2 and P_3 in their projection rooms C_1, C_2 and C_3, and the audience A.

From the point of view of the cinema management, "Cinerama" has the further disadvantage that the three projection rooms have to be placed in the auditorium itself, so that a considerable number of seats have to be given up to make room for them (fig. 1). Projection is not possible from rooms situated high up as the light beams would strike the screen obliquely and horizontal lines for instance would be reproduced as curved ones because of the curvature of the screen. Moreover, the whole arrangement is very complicated and several technicians are necessary to operate it. It is understandable that other systems have been tried with a view to achieving the desired effect while avoiding the difficulties mentioned.

An elegant approach to the problem was made possible by the development of a special wide angle

[1]) Todd is the name of the man who advocated the system; A.O. stands for "American Optical Company".

objective by Professor Brian O'Brien of the American Optical Company. This lens has a picture angle of 128° (but nevertheless has a comparatively large numerical aperture). A film taken with this lens consequently covers an area only slightly less than that of the three "Cinerama" cameras combined. Such a film can be projected on to a wide, curved screen and this produces, with a single projector, a similar effect to that of "Cinerama". Incidently, the "picture angle" of the projector does not need to be made specially large.

This special objective forms the nucleus of the "Todd-A.O." system, but the system has other characteristic features. One of these is that it has completely broken with tradition by using 70 mm film in place of 35 mm and at the same time the frame frequency has been increased from 24 to 30 frames per second. The higher frame frequency produces smoother motion and lessens flickering in the picture reproduced on the screen. This is very desirable, for the eye is most sensitive to flickering at the periphery of the field of vision and, as a result, flickering on a wide screen might become noticeable.

The problem of obtaining a sufficiently bright picture on the large screen is greatly simplified by the wide film, since the area of the frame on 70 mm film can be made 3.5× as large as that on normal 35 mm. For the same luminous intensity on the film, 3.5 times as much light strikes the screen. In addition, the higher frame frequency contributes to less heating of the film.

Another important advantage is that the big screen can be filled without abnormally large magnification. With the small frame of 35 mm film, the grain of the film emulsion would be visible and would tend to blur the image.

In *fig. 2* we have a strip of 70 mm film and in *fig. 3* strips of normal 35 film and of 35 mm film for "CinemaScope". In all the films the perforations have the same spacing. With the 70 mm film, however, the height of the frame is 5 times the perfora-

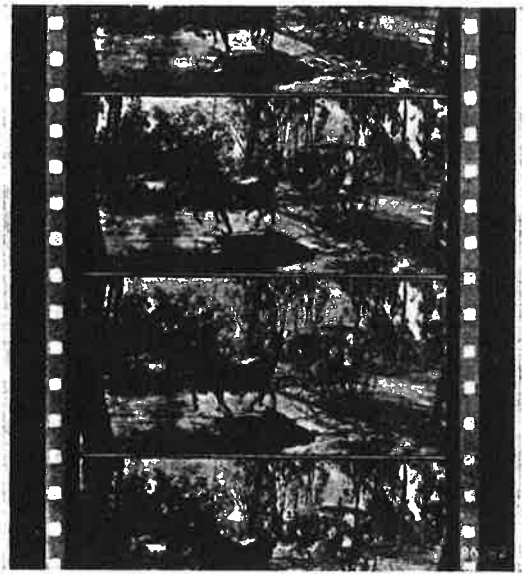

Fig. 2. Strip of 70 mm film. It has six magnetic sound-tracks, three on either side of the film. The wide black bands on the outside of the perforations carry two sound-tracks each; the narrower bands inside the perforations carry only one each. The height of the frame is equal to 5 perforations.

tion spacing whereas it is only 4 times with 35 mm film. This means that the frame on the wide film is not only wider but also higher than that on normal film. In contrast with "CinemaScope", the scene is photographed on the film in natural proportions. The shape of the projected picture therefore corresponds to that of the frame (the film mask is 48.5 by 22 mm) and a so-called anamorphic projection lens (as in "CinemaScope") is not used.

a *b* *c*

Fig. 3. Strips of 35 mm film (*a*) normal and (*b* and *c*) "CinemaScope". The normal 35 mm film has one optical sound-track; the 35 mm "CinemaScope" film has either four magnetic sound-tracks, two on either side of the film (*b*), or one optical sound-track (*c*). Only in the second case (*b*) is stereophonic reproduction possible.

n "CinemaScope", for which many cinemas have already been adapted, 35 mm film is used. By means of the anamorphic lens used in this system, the picture is compressed in a horizontal sense (fig. 3*b* and *c*) when being taken. When the film is being projected the picture is expanded horizontally by a similar lens, so that the natural relationships are restored. The relationship of width to height of the projected picture can be larger by these means than it actually is on the film. The picture angle during shooting is about 90° as compared to 146° for "Cinerama" and 128° with "Todd-A.O.".

On the wide film there is room for the six magnetic sound-tracks which give well-nigh perfect stereophonic reproduction. (A magnetic sound-track can give a higher quality of reproduction than an optical sound-track). Behind the screen there are five groups of loudspeakers, whilst in the auditorium there is a further number of loudspeakers used for special sound effects. Each group is supplied by its corresponding sound-track. It is now not necessary to have the six sound-tracks on eparate synchronously driven film as is the case with the "Cinerama" system. The greater frame-height and the higher frame-frequency combined, increase the film speed by a factor $^{5}/_{4} \times {}^{30}/_{24} =$ more than 1.5 times over that with normal film. This improves the quality of the sound: high frequencies can now be better recorded and reproduced.

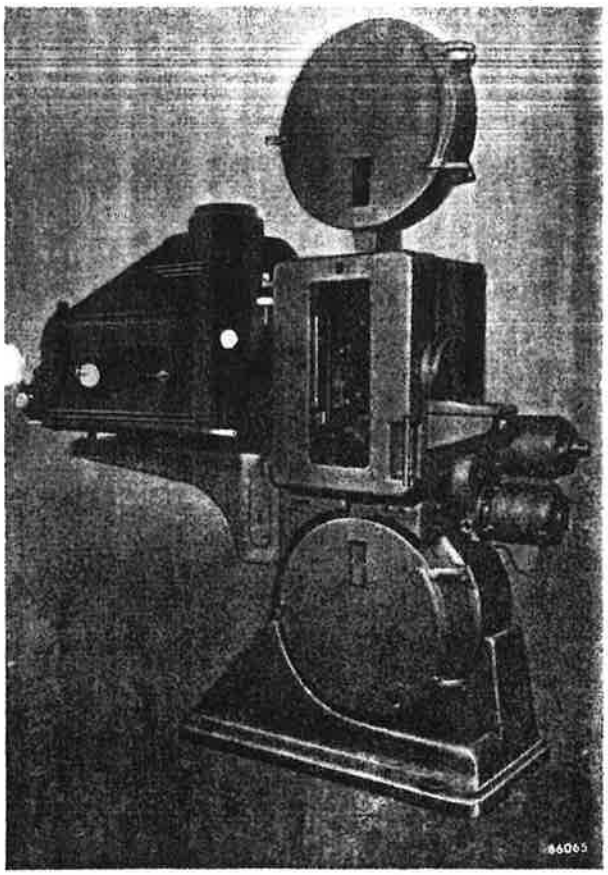

Fig. 4. The 70 mm film projector (type EL 4000) which at the same time is suitable for projecting normal 35 mm and "CinemaScope" films (with 4 magnetic sound-tracks or with e optical sound-track).

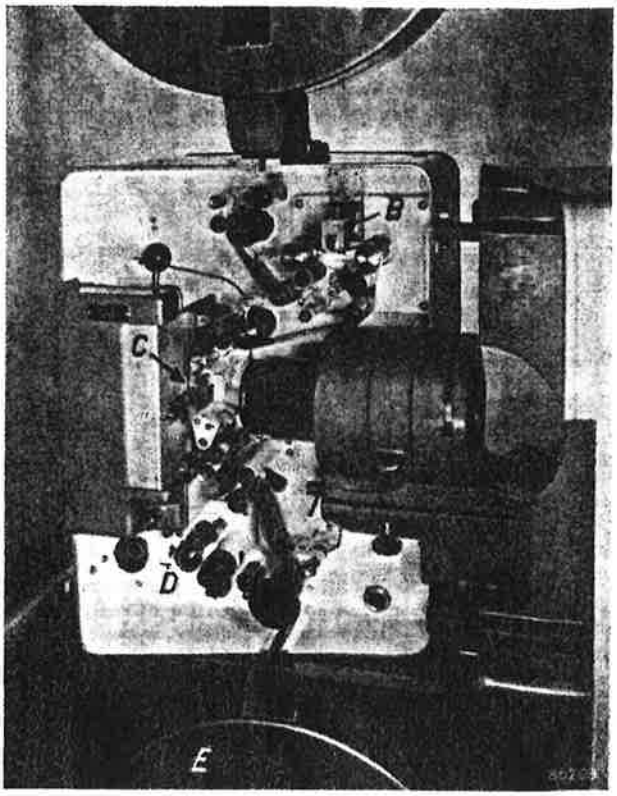

Fig. 5. Path of film when projecting either 70 mm or "CinemaScope" (35 mm) with magnetic sound-tracks. The projector in the figure is threaded with 70 mm film. After leaving the upper spool *A*, the film is fed past the magnetic sound head *B*. The film then passes to the take-up spool *E* via the curved film guide *C*, by-passing the optical sound head *D*. If normal 35 mm film or "CinemaScope" film with an optical sound-track is being projected, the film by-passes the magnetic sound head and is fed past the optical sound head.

The projector

As already mentioned, the special projector for the "Todd-A.O." system has been developed in Eindhoven and is now being manufactured there (Type EL 4000). The projector is so made that it is suitable not only for the new system but also for normal and for "CinemaScope" films. A cinema adapted for "Todd-A.O." is, with one type of projector, equipped for most other current projection systems at the same time (not, of course, for "Cinerama".) *Fig. 4* is a photograph of the projector.

The projector has an optical sound head (for the optical sound-tracks on 35 mm film) and a magnetic sound head for 35 mm "CinemaScope" film and for 70 mm film. These heads are so arranged that the film can by-pass the heads not in use (*fig. 5*). The magnetic sound head has a total of 10 pick-ups (*fig. 6*); 6 of these correspond to the sound-tracks of 70 mm film and the other 4 to the sound-tracks on "CinemaScope" film (35 mm).

The sprockets have 4 toothed rims; the inner two are used for transporting 35 mm film, the outer

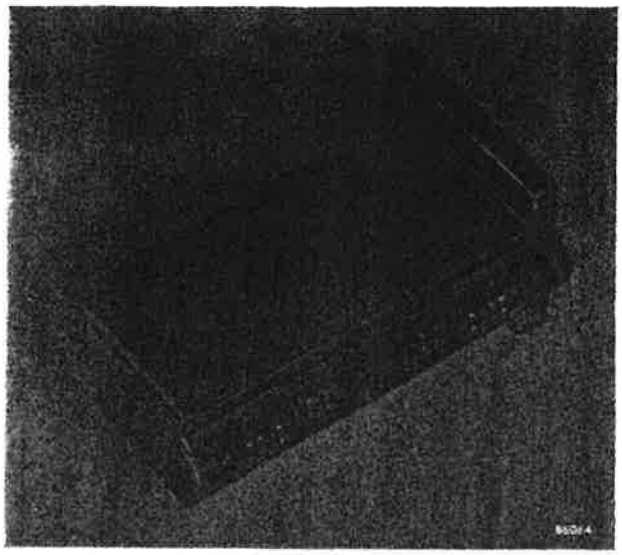

Fig. 6. The magnetic sound head of the EL 4000 cinema projector. 10 pick-ups can be seen as narrow ridges projecting from the mount. The four in the middle, which are those corresponding to the sound-tracks on "CinemaScope" film (35 mm), do not project quite as far as the others so that when 70 mm film is being projected they cannot cause any damage.

two for 70 mm film (*fig. 7*). The film is drawn forward by a 4-slot Maltese cross mechanism and the intermittent sprocket must therefore have a periphery equal to 4 times the size of the frame [2]). As already stated, the height of the frame in 70 mm film is $^5/_4$ times that of 35 mm film. The periphery, and consequently also the diameter of the intermittent sprocket must differ by this same factor for the two sizes of film. Hence the 70 mm film is clear of the sprocket teeth for 35 mm film.

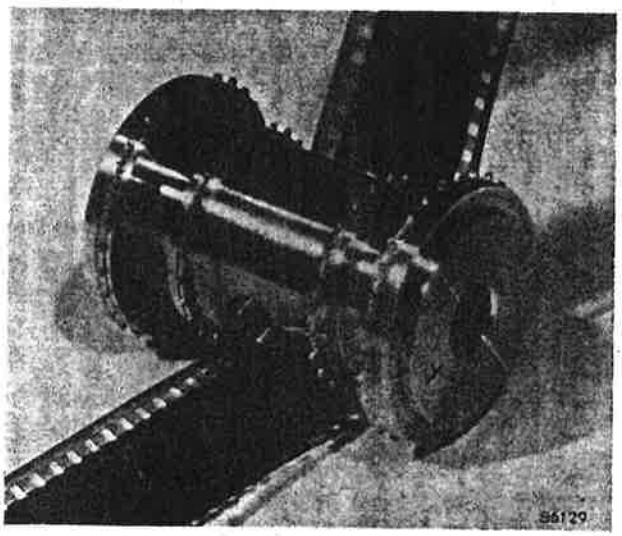

Fig. 7. Sprocket for 70 mm and 35 mm film. The toothed rims in the centre (for transporting 35 mm film) are set deeper so that they clear the 70 mm film.

[2]) See Philips tech. Rev. **16**, 158-171, 1954/55.

The sprocket shown in fig. 7 is the type used both for the take-off sprocket and for the take-up sprocket, which respectively draw the film at uniform speed from the feed spool and lead it on to the take-up spool. The diameters of the toothed rims for 70 mm and 35 mm film also differ by a factor of $^5/_4$ but the peripheries are six times the size of the frame.

When transferring from one film size to the other, some re-adjustments have to be made: e.g. the film guide (which guides the film at the gate, see fig. 5) and the pad rollers (which keep the film on the teeth of the sprockets) have to be changed. In addition the speed of the projector has to be changed and for this purpose the apparatus has 2 motors (visible in fig. 4) and a selector switch. The objective too must of course be the correct one for the projection system in operation.

70 mm film has a greater tendency than 35 film to buckle in the film gate under the influence of the heat generated by the arc lamp. This would cause the projection to become blurred and so to prevent this, the film guide has been slightly curved (fig. 5) which gives the film more rigidity at that point. The normal flat pressure springs need now to be replaced by thin steel strips, whose tension can be adjusted and which press the film tightly to the gate.

The projector is fitted with a single-blade rotating shutter and the two interruptions per frame that are necessary are achieved by allowing the shutter to make two revolutions in this period. The effective region of the shutter blade is at the outer edge and at a large distance (about 12 cm) from the point of rotation. This blade interrupts the light-beam only 12 mm from the film at a point where the diameter of the beam is small. With these measures shutter losses are reduced to 46% [3]).

The high number of revolutions of the shutter (3600 revs/min for 70 mm film) cause the projector to run with more noise than is usual. Also the flapping of the wide film is noisier than that of normal film. This is due to the increased width, the greater frame-shift and the higher frame-frequency. However, when the door of the projector is closed, the noise is not annoying for the operator.

The "Todd-A.O." system had its public debut on 13th October 1955 with the film "Oklahoma" shown in the Rivoli Theatre on Broadway, New York. The strip of 70 mm film reproduced in fig. 2 contains a scene from this film.

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[3]) The high speed of the effective part of the shutter blade produced by the doubled rotation speed and the large radius of the shutter, lessen the effect of the so-called "covering angle". A small beam diameter at the point of interception is also favourable in this connection. See article quoted in [2]).