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TELECINE-SIMPLEX OR MULTIPLEX?

INTRODUCTION

TELECINE—SIMPLEX OR MULTIPLEX? This is a choice which has to be made with most telecine installations and in this short article some of the factors governing this choice are examined. The discussion will be limited to vidicon camera telecines though many facets of the argument apply equally to flying spot systems. Some consideration will be given to the cost, to the utilization of the equipment, its versatility and technical performance, but before discussing each of these factors both systems will be described.

SIMPLEX

This (as its name implies) is the simplest of all telecine systems, one projector and one camera being used together with a very simple optical arrangement. Usually the camera tube is placed some 12–18 in. from the film gate and the film is imaged directly onto the camera tube target with a single, and often specially computed, lens.

Such a system is shown in Fig. 1, where on the left can be seen the lamphouse and projector mechanism and on the right the camera and mounting. Both camera and projector are fitted onto a common bedplate of substantial proportions to ensure absolute stability. Although the example illustrated is a 35-mm machine, similar equipment is produced for 16-mm film and for slides. Discussion will mainly be limited to the 35-mm machine.

Mechanical Layout

A description of the mechanical layout of a simplex telecine can best be divided into two parts, the machinery and the control position.

The control position houses the camera control unit and power supply unit, picture and waveform monitor and control panels for camera, and sound amplifiers. There are also the control units for the projector, and the three-phase inverter providing power for the projector motor so that the mechanism may be driven in synchronism with the television field. The latter, although not strictly necessary where the mains frequency and field drives do not differ by more than $\frac{1}{2}$ c/s, would usually be supplied with a simplex 35-mm film projector to provide the ultimate in performance, which, as will be seen later, is the characteristic mark of distinction of this type of equipment.

The machinery is supported on a substantial cast-iron bed which in turn is supported by robust pillars so that the optical height of the projector is 48 in. (122 cm) above floor level. Although 48 in. is quite arbitrary in this context its choice for the optical height positions the projector spool boxes at a height which is both convenient and customary for the projectionist. The camera is mounted in an adjustable cradle (which will also take a 3-Vidicon Colour Camera) in such a manner that it may be removed and replaced without the need for optical re-alignment. The cradle has screw adjustments to simplify the optical alignment, which can be set up in the factory and would only require minor adjustment on installation if the equipment is not stripped for shipping.

Optical System (Film Projectors)

In designing any optical system the following factors must be taken into consideration: (a) The light source and the control of the intensity of illumination over the film gate, (b) the quality or degradation of the image of the film produced at the vidicon target, and (c) the transfer of the maximum amount of the illumination at the film gate to the vidicon target with as little vignetting as possible.

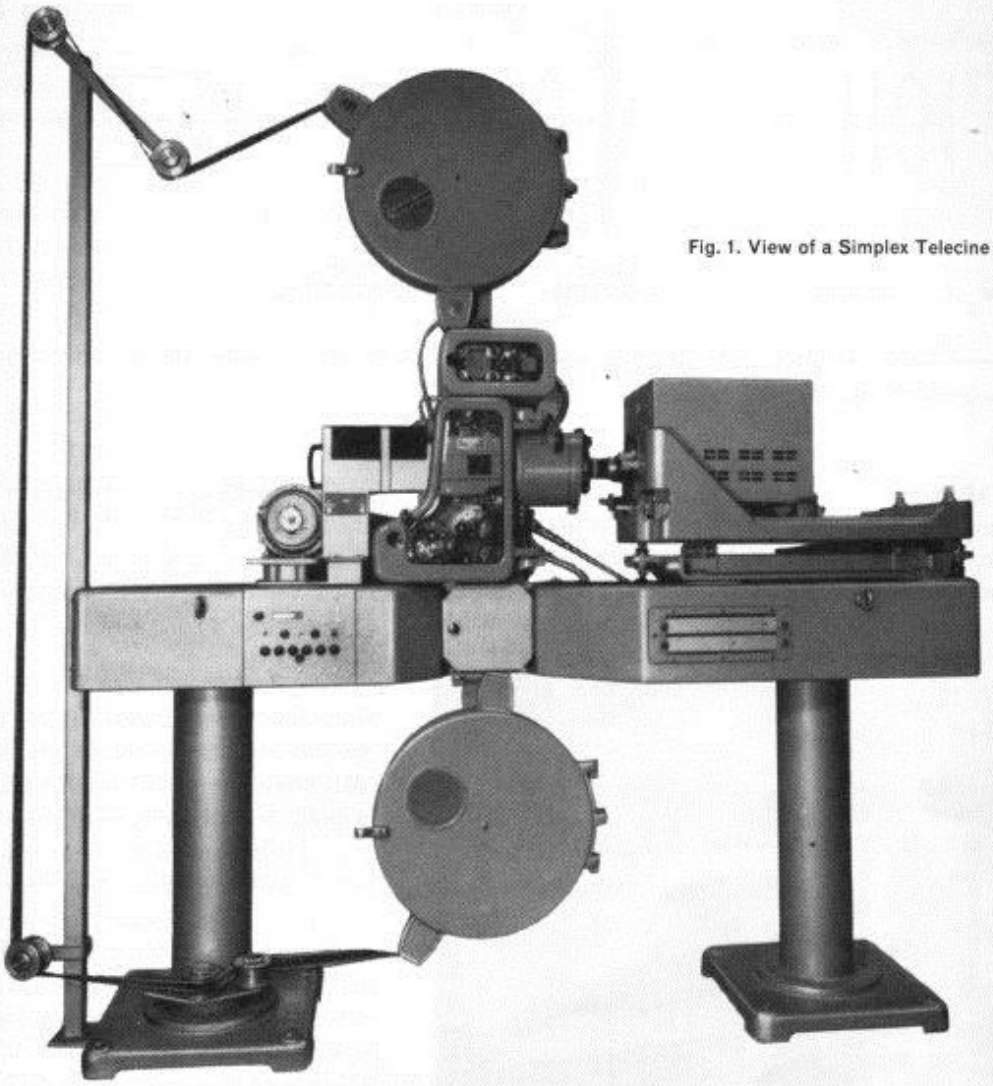

Fig. 1. View of a Simplex Telecine System.

The light source and its control is a problem which is common to both simplex and multiplex operation, but the optical system must be considered as a single unit to avoid uneven illumination, or, worse still, an image of the lamp filament appearing at the vidicon target. Similarly, the uniformity of illumination is a common problem, and where the optical system is particularly compact various artifices may be used to obtain maximum uniformity. The quality or degradation of the image produced at the vidicon target in a simplex telecine is a function of the lens, the vidicon face plate and of the steadiness of the film in the film gate (Fig. 2). As short optical conjugates are used with a reduction ratio of approximately 3:1, an enlarging lens or one specially computed for this service is used, and a resolution loss of as little as 1½–2 dB at 400 lines in the centre of the picture is typical. Loss of contrast and vignetting are similarly small.

Optical System (Slide Projectors)

Even simplex slide projector equipments usually employ dual slide projectors, and for this reason the optical system is more complex than that outlined in the previous section and employs relay optics—a subject discussed later in relation to multiplexed equipment.

Sound and Vision Equipment

Sound and vision equipments are common to both simplex and multiplex systems and are adequately described elsewhere.[1] However, there is just one point to be observed; each projector is usually provided with its own sound-amplifier and sound-equalizer circuits in both simplex and multiplex systems.

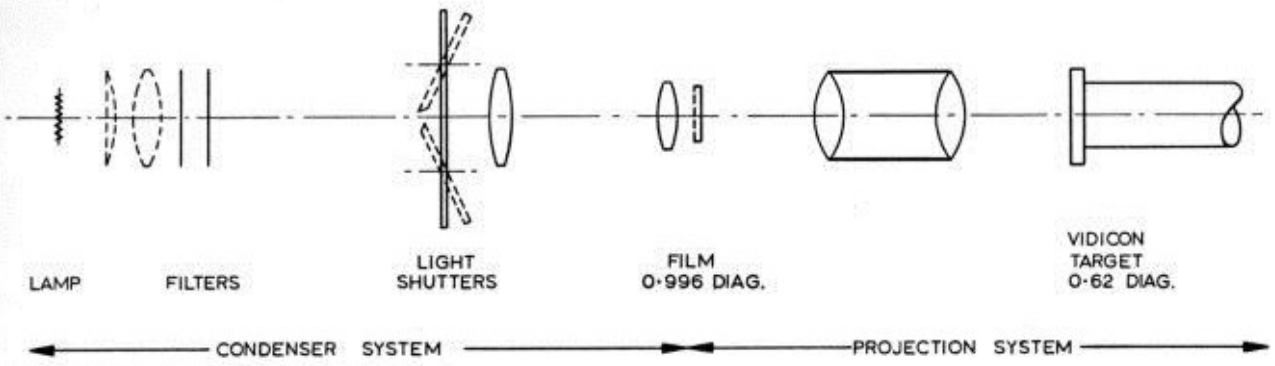

Fig. 2. Diagram of Simplex Optical arrangement.

MULTIPLEX

In a multiplex system, the optical arrangements are more complex because several projectors must either separately or simultaneously project images onto a single camera tube. In order to obtain a reasonable working distance between the projectors and the camera, relay optics must be used. The mechanical arrangements are more complex in that each projector must be accurately positioned relative to the remainder of the system and electrical interlocks must be provided on the operating controls for the projectors (Figs. 3 and 4).

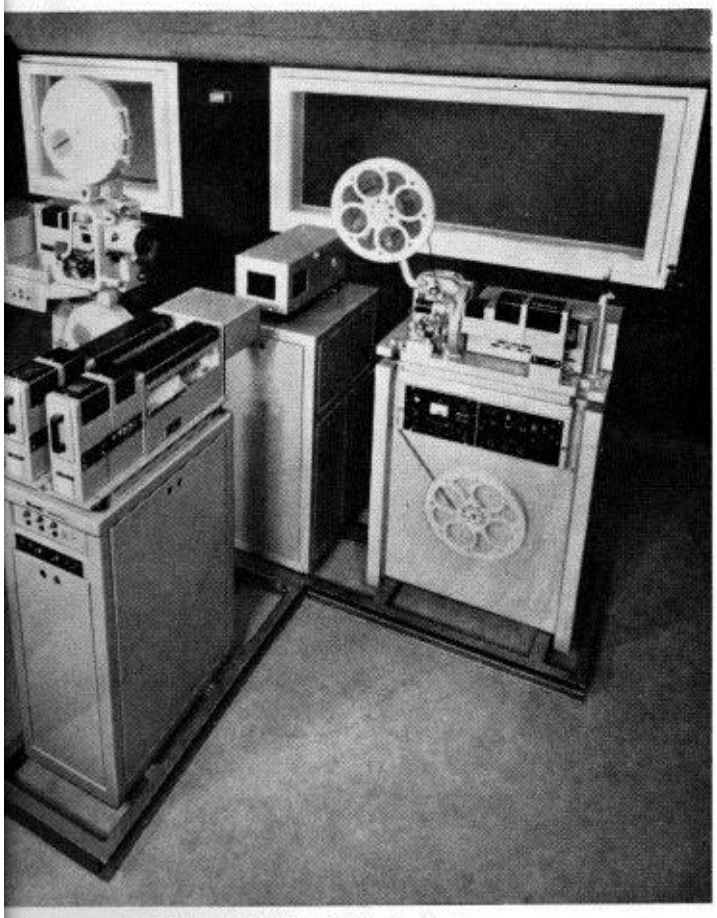

Fig. 3. View of Multiplexer Projector System.

Optical System

Since the optical arrangements of a multiplex telecine govern, to a large extent, the mechanical layout, the relay optics generally employed, and several varieties of optical multiplex, will be examined.

In a relay optics system each projector produces an aerial image in the same plane using normal projection lenses, and these images are focused onto the camera tube with the camera taking lens. To improve the light transfer a field lens is placed at the position of the aerial image, the power of the lens being such as to focus the exit pupils of the various projection lenses into the entry pupil of the camera taking lens. This ideal is rarely achieved for economic reasons, though good compromises are generally obtained. Reasonable mechanical stability is required, though the requirements are not so stringent as between projector and camera of a simplex arrangement.

Considering the diagram in Fig. 5 (for the 35-mm projector) the field lens has a focal length of 14·1 in. (36·8 cm) and the size of the aerial image at this point is 5·65 in (13·4 cm) diagonal. The camera lens is 2·0 in. (5·08 cm) focal length and the projection lens 6 in. (15·2 cm) focal length. As the field lens images the exit pupil of the 6 in. projection lens into the entry pupil of the camera lens these two pupils must be in the ratio of 39·5:20 for optimum working, i.e. there is no point in increasing the aperture of the projection lens to let through more light because it will fall outside the collecting area of the camera lens and, conversely, increasing the aperture of the camera lens will not significantly increase the amount of light

transmitted for there is hardly any more light to collect. The whole system is a delicate balance of apertures and focal lengths and the changing of any one element will have repercussions all along the line.

In order to obtain the best results from all projectors their projection lenses must be the same distance from the field lenses and of the same diametric aperture (not *f* number).

Some arrangement for combining the light paths of the several projectors must be made and there are three major alternatives for optical multiplexing, mixing prisms, moving mirrors and pellicle half mirrors. Of these, the mixing prism is usually only made in the smaller sizes because its cost rises very rapidly with size, an increase from $1\frac{3}{4}$ in. (4·5 cm) cube to $2\frac{3}{4}$ in. (7 cm) cube increases the price by about four times. Its advantage is that its efficiency is very high—44–48% transmission and similarly for reflection.

Moving mirrors are still in favour in some quarters, their high optical efficiency has to be offset by the mechanical complexity of the operating mechanisms and very high initial costs. In addition, moving-mirrors multiplexing cannot be used to mix optical signals.

The multiplexer shown in Fig. 6 has three inputs and uses two pellicles as mixing elements. These pellicles are quite cheap in large sizes, though their optical efficiency is only moderate—37% transmission and 30% reflection from the front surface and 13·5% from the back. Their large size enables a large aerial image and field lens to be employed so that the stability required of the pedestals is not impossibly high.

With a dual slide projector a dichroic mixing prism is used because it can be made quite small and its efficiency is high. The mixing prism is placed after the projection lenses, and these have a very small adjustment for their focal length in order that a pair may be matched for equal image size.

The optical loss in multiplex systems is its major technical deficiency. Between the film or slide and the vidicon face for the system shown in Fig. 3, the optical elements are detailed in Table 1.

The losses may be divided into loss of light level and loss of resolution and reduction of contrast. Briefly, only some 5% of the light available at the film gate will reach the vidicon target, and 400-line resolution bars in the centre of the picture will suffer a loss of between 5 and 6 dB under the best conditions.

TABLE 1

	Slide Projector		*Film Projector*	
	(a)	(b)	(I)	(II)
Projection Lens	x	x	x	x
Mirror 1	x	x		
Mirror 2		x		
Mixing Prism	x	x		
Window	x	x		
Window	x	x	x	x
Pellicle	x	x	x	
Pellicle	x	x	x	x
Mirror	x	x	x	x
Field Lens	x	x	x	x
Taking Lens	x	x	x	x
No. of Optical Elements	10	11	7	6

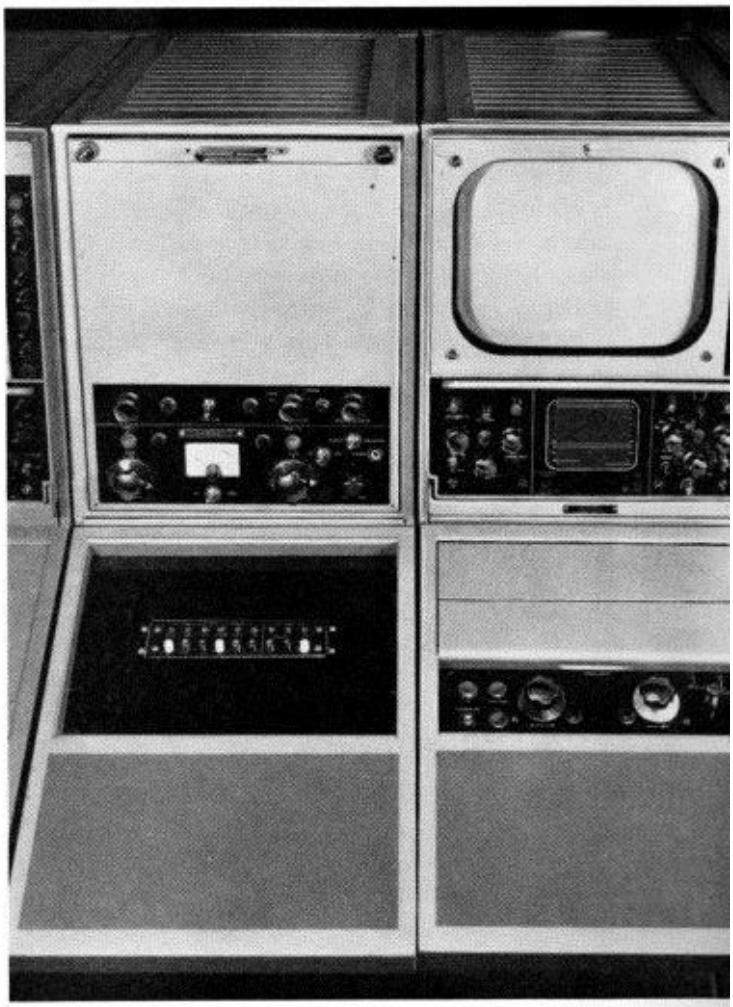

Fig. 4. View of Multiplexer Control Position.

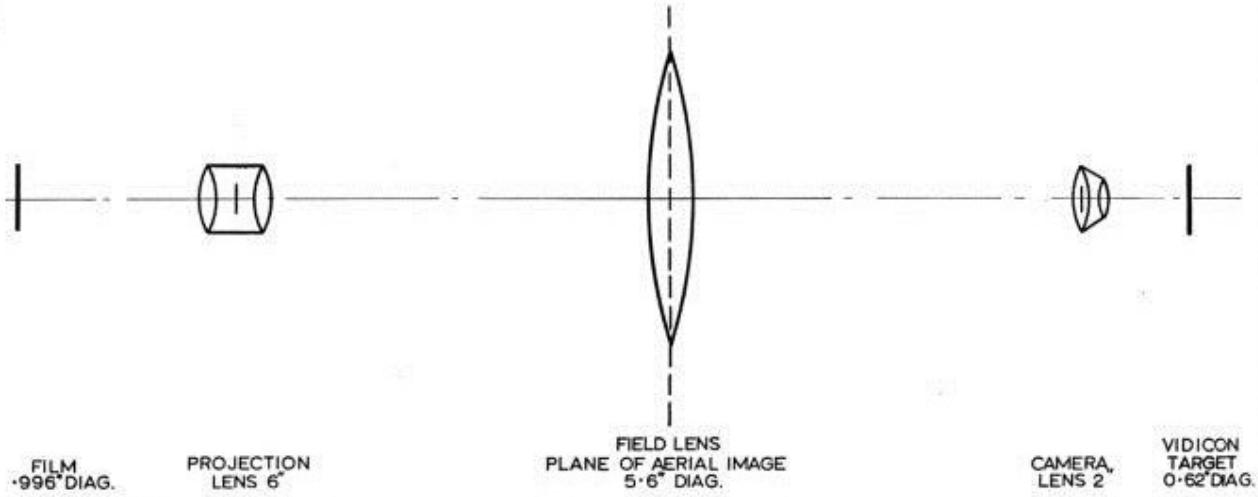

Fig. 5. Relay Optics.

Mechanical Layout

The mechanical layout is determined by the optical system, or rather that part of the optical system which brings the three images together at the field lens. The layout of a system employing a pellicle multiplexer is shown in Fig. 3. The positioning of each projector is critical in order that the images produced at the field lens shall all be the same size and all have the same axes. Because of the tolerance on the focal length of lenses (usually 4%) each projector must be positioned individually and lenses between similar projectors may not be interchangeable.

A COMPARISON— SIMPLEX OR MULTIPLEX?

For a much simplified discussion on the relative merits of the two systems, Table 2 gives a basic list of equipment required, assuming one 35-mm projector, one 16-mm projector and a dual slide projector in each.

Cost

The cost of two extra camera channels and monitors must be balanced against the cost of the multiplexer, though, if all outputs were not required simultaneously, the two extra monitors for the simplex systems

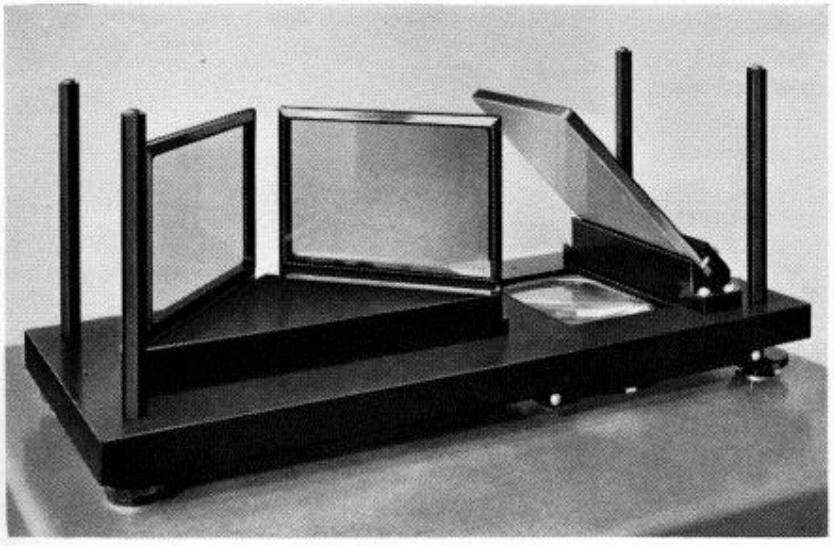

Fig. 6. Optical Multiplexer.

TABLE 2

Item	*Simplex*	*Multiplex*
Camera Channels	3	1
35-mm Projector	1	1
16-mm Projector	1	1
Dual Slide Projector	1	1
Multiplexer	None	1
Projector Control Panels	3	3
Monitors	3	1

might not be required. Where auxiliaries are added, e.g. a SEPMAG sound unit, the proportional difference in cost between simplex and multiplex system is further reduced. In a simplex system the bedplate is usually specially built, whereas for multiplex operation the film projectors may be used on their normal cinema pedestals, and this will widen the price gap.

Facilities

In a multiplex system one output only is available at any one time and mixing or fading from one source to another must be carried out optically, though this is not possible with all multiplex systems. In a simplex system all three outputs are available at any one time. Mixing between sources must be carried out electrically, and it is possible always to preview the various outputs.

Performance

Optically, the use of relay optics degrades the resolution by 3–4½ dB and distorts the grey scale, especially in the blacks, due to optical scattering on the many glass to air interfaces. Most of the loss can be made up by the judicious use of aperture correction though only at the expense of increased noise.

CONCLUSION

From the foregoing it can be seen that simplex operation results in substantially increased performance, particularly in respect of resolution and contrast range. It also gives greater flexibility in respect of projector usage and preview facilities. It is, of course, more expensive than multiplexed operation, and this is the most probable reason for its small use as a system in existing stations. However, with the worldwide trend towards improved technical performance, and hence picture quality, it is almost certain that simplex operation will become more and more popular.

REFERENCES

1 W. T. Underhill: Vidicon Cameras; *Sound & Vision broadcasting*, Vol. 3, No. 3, Winter 1962.