# Film Printing

**David Pope**

*David Pope, Chairman, Laboratory Committee, provides a history of and an essential tutorial to the film printing business.*

## Printing – how it's done

There are two main ways of printing cine film. One is by employing an optical printing machine, and the other is by using a contact printer. Both types can be used to print all film gauges, but there are some fundamental differences between them.

## The optical printer

A basic optical printer is designed so that the negative and positive film paths are separate, and each goes through its own gate or movement. These movements have a step mechanism whereby metal pins (one of which is fully fitting to the dimensions of a perforation) engage the perforations of the films and pull them through the movements one frame at a time. This action is synchronous for both movements, and a segmented rotating metal shutter ensures that no exposure can take place until the films are at rest. The actual amount of film travel is determined by the film gauge, e.g. it is small for 16mm, at one perforation to the frame, and large for standard 65mm at five perforations to the frame.

This type of operation leads to the more accurate description of "step optical printer". It should be noted at this point that it is possible to thread both negative and positive films through the same movement, thereby making a contact print on an optical printer. The essential difference between this and a conventional contact print, which will be described later, is that it is a step contact print. It should also be noticed that it is quite possible to have a third film path, which could be threaded in contact with either negative or positive paths so that in this case both optical and contact printing takes place simultaneously.

## Printing for SFX

Finally, it is also the case that much more complex designs employ multiple film paths with their own movements. This type of printer would be used in the area of special effects.

It is normally the case that this type of printer is fitted with a light tight magazine for the rawstock, which permits the printer to be operated in a normally lit room. The speed of operation is much less than for contact printing, with a top speed rarely exceeding 40 f.p.m., and some work at only 5 f.p.m.

## Main elements of an optical printer

The main elements of an optical printer are:

- light source
- light modulation system
- negative movement
- copy lens
- positive movement.

Most optical printers also have wet printing capability. With separate negative and positive film paths it is possible to have a relatively simple system, since only the negative needs to be coated. Indeed, wet printing started on this type of printer and the modern system of total immersion wet-gate printing, necessary for contact printers, is much more complex, and was developed later.

Although the speed of printing is slow, step optical printers have some features which make them indispensable. Because the negative and positive films are separate with a copy lens between, it is possible to perform a number of operations which are quite beyond the capability of a contact printer.

## A versatile device

It is quite possible to fit a 16mm negative movement and path and a 35mm positive movement and path. With the correct copy lens type and position, this permits enlargement printing from 16mm to 35mm. With a negative 35mm movement and a 16mm positive movement fitted it is, of course, possible to make reduction prints. When the possible permutations between the gauges 8mm, 16mm, 35mm and 65mm are considered, some of the versatility of such machines can be imagined.

In addition, a good step optical printer set up has also to cater for the frame size differences between standard and super 16mm, eight perforation lateral Vistavision type 35mm camera material, and the different types of 65mm photography, ranging from conventional five perforation frames right up to fifteen perforation lateral IMAX type material.

It does not stop there. It is quite common to need to introduce a Cinemascope type anamorphic squeeze (or to remove one) in the optical printing stage. Without even considering the complexities of the use of this type of printing for special effects work, other common requirements include:

- the need to reposition the negative relative to the positive to remove intrusive sound booms, for example,
- to print subtitles from a transparent titling facility onto a duplicate negative,
- black matting,
- scene to scene flashing, etc.

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## Ideal for archivists

The step optical printer is also ideally suited to deal with very old or damaged materials, this being a common problem for archives. Many adaptations have been made, including the fitting of special movements to cope with the short perforation pitch which commonly occurs as films shrink with age.

Most of these operations just cannot be done using a contact printer, so, whilst the volume of work done on step optical printers is tiny compared to that done by contact printers, it is of great importance.

## Contact printing

There have been many types and makes of contact printing machinery over the years. As this is not intended to be an exhaustive study I am only going to outline some of the developments that have taken place with respect to the more modern and more common printers like the Peterson or Bell & Howell model C type.

This type of rotary contact printer had a running speed far in excess of a step optical printer, at some 240 f.p.m. It operated by having the negative and positive stocks in contact at the exposure point. Here the stocks were located onto a one foot circumference toothed sprocket by the perforations on one edge only. The stocks were kept in contact by means of a large rubber contact roller. Light modulation was effected by means of a dichroic mirror system and a mechanical light valve controlled by a punched paper tape. Because the films moved continuously it was possible to fit a second path and light source to permit the printing of a sound track as well as a picture image on a cascade principle. Because the films were fed from open plates, the printer had to be housed in a darkroom which was lit by low level process lighting. Film direction was from top to bottom and a complete rethread was necessary between each printing.

Cut reels of feature negative rarely exceeded 1000 ft. in length, and rawstock positive 2000 ft.

## Elevators introduced

Speed was increased to 480 f.p.m., but the first real change was when film elevators were fitted to both the picture and the sound negative paths, which had a capacity to accommodate the modest lengths of things like trailers and commercials. This allowed the negatives to be rethreaded through the printer as continuous loops, which meant that the only restriction was now the length of the rawstock.

Another development took advantage of the fact that 16mm has only two-fifths of the linear footage of 35mm for the same screen time. Larger elevators were constructed for 16mm printers, which held feature cut reel lengths for threading as continuous loops.

## Panel printers

A big design change now made an appearance to increase the productivity of 35mm printing. This was in the form of a panel printer. Speed again increased – to 720 f.p.m., but the light exposure systems were turned through 90 degrees, so that film travel could now be horizontal instead of vertical.

A bi-directional drive system meant that, with electronic stop devices to prevent the negative from completely unwinding, a simple lever setting permitted head to tail printing to be immediately followed by tail to head. Although it was still necessary to rethread the positive rawstock between each printing operation, the fact that the negatives were relatively untouched meant that they did not have to undergo time consuming cleaning operations at anything like the same frequency as before.

## Joining up

At this time two negative cut reels were joined to make a standard cut reel up to 2000 ft. in length, with a similar change to sound track negatives, and the stock length was increased to 4000 ft. Two thousand ft. lengths were still available and are still used. Total immersion wet gate kits then began to appear.

Modular panel printers with running speeds up to 960 f.p.m. were the next development, and by this time the light modulation system had progressed to electronic light valves with grading information being stored directly by the printer instead of via punched paper tape.

## Coping with digital sound

Other industry developments taking place had to be catered for, including digital sound tracks. A number of digital sound systems made their appearance, but those that have survived are DTS, SRD, and SDDS.

As these are additional to, and not in place of analogue sound, it follows that they have to occupy different areas of the film. This has been done by positioning them variously inside, between, or outside the perforations. [See *Image Technology* May 1997, page 30 – Ed.]

It is becoming common practice to print all sound systems simultaneously.

### *Changes for sound*

To achieve this, a number of changes have had to be made to the sound exposure head on the printer. This has been done by making heads with multiple exposure slots and feeding light to them via fibre optic cables. In this way it is possible to modulate the light to the correct intensity and colour for each system, even though it is from a common source.

Quality control of these printers has become increasingly complex, and just a few of the typical requirements are to monitor and correct:

- evenness of illumination
- position of picture
- all sound systems
- exposure of key numbers
- elimination of any D lines
- elimination of flutter
- performance of wet printing.

Some early printers were also fitted with vertical moving shutters whose purpose was to enable fades and dissolves to be made. These were mechanical devices, and later developments produced an improved type with electronic control.

Supplied rawstock length was again increased, this time to 6000 ft., although it was impracticable for all printers to accommodate this longer length.

### Productivity & quality improvements

Other changes to productivity and quality that have been developed include joining all the cut reels of an average feature together so that a complete feature could be produced with one printing operation.

Another application is to provide large film elevators for the rawstock as well as the negatives. This idea allows high speed continuous printing, as no re-threading is necessary at all. Providing that "on the run" arrangements are made to keep the negatives clean and that the rawstock rolls can be spliced together as they are fed in, it is possible to make very large numbers of copies before changing to another reel of negative.

*"A bi-directional drive system meant that, with electronic stop devices to prevent the negative from completely unwinding, a simple lever setting permitted head to tail printing to be immediately followed by tail to head."*

### What of the future?

With the increasing use of polyester base stock for release positive, as well as its common use for sound and duplicate negatives, one of the restrictions to very high speed operations, i.e. the fragile nature of cinefilm, will be removed. Some tests have been made by printing at a speed of 3000 f.p.m. This is equivalent to printing a full length feature film every three to four minutes!

Logically, this suggests the need for even longer rawstock lengths. Stock manufacturers have indicated that there are no insurmountable problems, and discussions have taken place about the timing of producing raw stock in 10,000 or 12,000 ft. lengths.

With release prints being produced in such lengths and at this rate, it suggests that even more changes are going to be needed for film processing machines – but that is another story!

### THE AUTHOR

Following his military service in the R.A.F. and a brief foray into the insurance world, Dave joined Technicolor Ltd. (now Technicolor Film Services) in 1955. He remained there for the next 41 years until his retirement in August 1996. This long involvement has provided a unique insight into the workings of a film laboratory including, until its demise in 1978, the much acclaimed dye transfer system. A 20-year involvement with the B.K.S.T.S. has enriched this experience by providing opportunities to meet and exchange views with his peers in the other film laboratories.