suitable masters or interpositives using a beamsplitting prism printer to minimize the amount of printing required to obtain the four images.

Possible advantages of the quadruple-rank system could be the use of existing equipment so that the release prints can be printed and developed on the same printer and developer as are used for printing double-rank 16mm prints. No additional printing or developing equipment would be required in the release channel, and inspection could be carried out on all four prints at a time on the 16mm double-rank projector. In printing and developing, we use only the two outside set of holes. The remaining three sets of holes come into use only when the film is slit and are then used for projection purposes.

There are also substantial economies in the application of the magnetic soundtrack, since all four prints can be striped in the 35mm-width form with a single pass through the striping machine. Similarly, all four prints can be electrically printed with the magnetic sound with a single pass through the magnetic printing machine.

We have experienced unexpected trouble with grain when working with some of the combinations which can be outlined from various source materials and have spent a considerable amount of time in studying means of avoiding these difficulties.

We are also studying the application of the Technicolor imbibition process to the problem of making 8mm release prints from both 35mm and 16mm source material with very gratifying results. This application appears most interesting on the basis of the tests so far completed, and we believe the benefits of printing down directly from a relatively larger area negative to be particularly beneficial in producing 8mm prints of good grain and definition characteristics.

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# Developments in Magnetic Striping 8mm Sound Film

By EDWARD SCHMIDT

**Although the idea of coating a stripe of magnetic material on the edge of motion-picture film was the subject of American patents as early as 1919, it was not commercially feasible for 8mm film until recently. Successful 8mm sound projectors became possible after the development of high-precision, long-wearing magnetic heads and low-cost compact electronic components. Two machines for coating magnetic stripes on film have been produced by Soundcraft, the first for coating 16mm raw stock, and the second for coating 8mm processed film.**

THE YEAR 1960 saw the commercial introduction of magnetic sound 8mm projectors. This promoted the design and construction of two new striping units: one for single 8mm film and the other a high-speed laboratory production machine for prestriping raw stock prior to exposure and development. These units represent a continuation of the development of the wet striping process which was first demonstrated by Reeves Soundcraft at the October, 1950, Lake Placid SMPTE Convention. Why did it take ten years for magnetic sound on 8mm film to become a commercial reality? For that matter, perhaps an even more interesting question is, why did it take fourteen years from the time of the original Marvin Camras demonstration of November 14, 1946, at a meeting of the Acoustical Society of America in Chicago? A brief history of the development of 8mm sound on film is extremely interesting and will serve as a proper background and understanding for the 1960 and 1961 work which we will describe.

Many years ago the practicability of obtaining sound for motion-picture film through the medium of a magnetic stripe and magnetic heads had been explored. When Soundcraft applied for Magna-Stripe patents in 1950, the patent office cited a number of references to American and foreign patents. The earliest of these was 1884, but this had no significant bearing on the process or method. However, in 1919 there were two patents issued which separately thoroughly covered the basic article of a stripe of magnetizable material on perforated film for the production of moving pictures with sound. One of these patents was especially significant. Here the inventor had placed, alongside the perforations, a pod of collodion containing magnetizable particles of iron. His patent drawings illustrated the use of a ring-type head, but he drew the film down through the gap between the pole pieces.

Continued attention was paid to the perfection of striping systems from the days of those early patents and culminated in Marvin Camras' aforementioned demonstration. He repeated this demonstration on April 5, 1947, at an SMPE Convention in Chicago.*

For an illustration of additional activity in the field, Lloyd Thompson presented, at the same convention in Chicago, a paper entitled "Movie Sound 8mm Projector." He summarized his paper, "The first commercial 8mm sound projector has been introduced with the sound on a disc running at $33\frac{1}{3}$ revolutions per minute. Automatic synchronization is used and the turn table and projector are not connected. 8mm sound films for use with the projector are available."†

Camras' demonstration and subsequent application work by many experimenters clearly indicated the technical advantages of magnetic recording for the motion-picture industry and demonstrated that a striping system should have considerable application in the market place. Characteristics such as frequency response, signal-to-noise ratio and freedom from deterioration with use, plus the inherent simplicity of the magnetic recording and reproducing process itself, ensured that the process should someday find acceptance. Striped film represents the only practical method of obtaining sound on 8mm film.

### Amplitude Modulation Problems

However, there was a serious stumbling block — that of amplitude modulation. The magnetic recording process depends upon intimate contact between the head and the surface of the magnetic oxide. This problem is not too severe in the case of 35mm film, with its high lineal speeds and relatively wide track areas, but when we reduce the speed to the neighborhood of 3.6 in./sec and have only 25 mils of track width available for the stripe, we find that it is necessary to employ high unit pressures between the surface of the stripe and the head

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* See Robert A. Colburn, "8mm color positive release prints with magnetic sound: a progress report," in this issue of the *Journal*.

† See William D. Hedden and Kenneth B. Curtis, "Early 8mm sound developments," in this issue of the *Journal*.

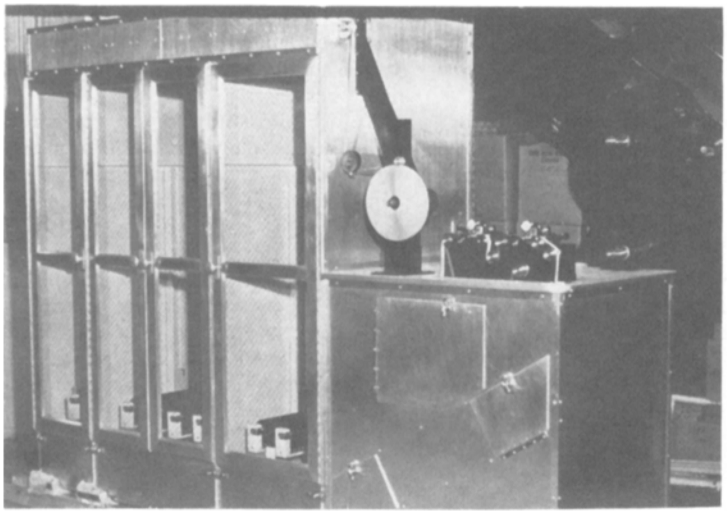

**Fig. 1. General view of high-speed 16mm striping machine.**

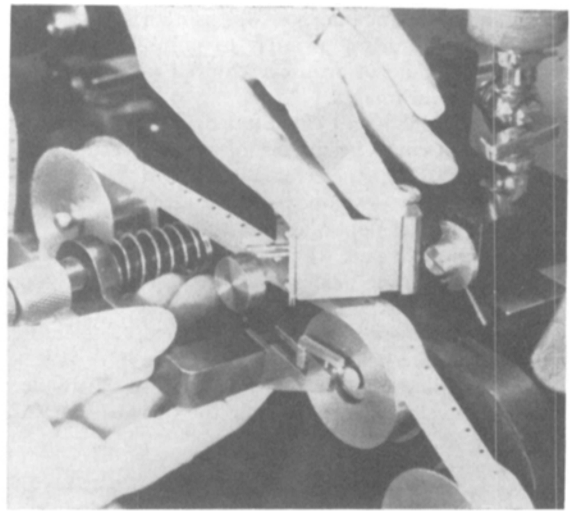

**Fig. 2. Close-up of striping head, 16mm striping machine**

itself to maintain good intimate contact. The amplitude modulation on 8mm film is extremely severe with head-to-stripe contact pressures of the order which are satisfactory for 35mm applications at their high lineal speeds and wide widths. Furthermore, the fact that the stripe is so close to the perforations results in severe sprocket hole modulation unless high unit pressures are employed to maintain intimate contact between the film stripe and the head.

Mu-metal heads 25-mil wide have extremely limited life under conditions which permit satisfactory performance in the 8mm field. Therefore the application of striped film for the 8mm industry had to wait for the development of hard, long-wearing heads. This problem has been solved through the use of Alphenol pole tips. Similarly, refinements in producing heads at low costs with very small gap widths, approximately ¼-mil wide, were required in order to obtain the necessary frequency response on a reliable basis.

One should also comment that the use of solid-state electronic components and printed circuitry, which of course are relatively new techniques, was also required to reduce the cost and volume requirements of the electronics by a significant degree. It is this combination of long-wearing heads and miniaturized electronics which has resulted in the introduction of successful 8mm sound projectors.

#### Development of Stable Striping Mixture

In August, 1953, Soundcraft built the first successful multistripe unit for producing CinemaScope prints for the Twentieth Century-Fox film *The Robe*. Since that time more than a billion feet of film have been striped using the process. Its success was due to the development of a very stable striping mixture which had a high degree of thixotropy. This is the property of a mixture to assume a gel-like consistency when stagnant but to have relatively free flowing properties in motion. This characteristic permits long shelf life and also ensures that the freshly applied wet stripe will not sag and deform during the drying process after it leaves the applicator. In this fashion a flat uniform cross section of the stripe is achieved.

The physical properties of the dried stripe are equally critical in applications for projection purposes. The stripes must have low frictional characteristics, must be extremely well bonded to the surface of the base, must be very flexible and must have unusually high thermal softening properties for plastic materials. It must be remembered that the optical systems of projectors often subject the film to extremely high local temperatures during the time the film is in the gate of the projectors. Minor refinements have been made in the process since 1953, but the fundamental characteristics are unchanged.

#### Prestriping Large Quantity of 8mm Film

We saw three areas of activity in the field of 8mm striping during 1960. The first of these was the striping of over three million feet of unexposed reversible color film for use in the Fairchild Cinephonic 8mm camera. Here the stripe is applied in total darkness on laboratory equipment in the Soundcraft plant. This film is run through the camera and after exposure is subject to normal processing. No contamination of the film emulsion by the magnetic oxide or of the processing solution occurs nor has any deterioration of the recorded sound due to the development process been noted. Very few technical problems were apparent during the manufacture of this significant quantity of prestriped 8mm film.

#### Design and Operation of 16mm High-Speed Striping Machine

During the course of this work it became apparent that for reasons of economy of transporation and service, it is desirable to perform the raw-stock striping operation in the facilities of the producers of raw stock and on a local geographical basis. Therefore a production 16mm-width machine was designed and built (Figs. 1 and 2). It has an operational speed of 200 ft/min. Every feature that is necessary to guarantee freedom from handling problems associated with the extremely sensitive unexposed photographic emulsion is included. It must be installed in an air-conditioned laboratory environment and supplied with humidity-controlled warm air with a maximum of approximately 90 F for the drying operation. It is designed for one-man operation, the loading section, striping head and take-up reel and all controls being located on one table at the head end of the machine. All rotating idlers on the precision striping head are mounted on class 3 ball bearings.

The emulsion surface of the film, within the picture area, does not contact anything throughout the entire film path, except in the striping head area itself. Here it is insulated from scratches and handling problems through the use of thin, conductive-surfaced 16mm loops. These loops are made of Mylar and are coated with a pigmented conductive resin. This system has established its ability to produce large quantities of prestriped raw stock without introducing scratches, pressure marks, rubs, dirt, etc., on the most sensitive emulsions.

After the film leaves the feed spindle, it passes into the first section of the drybox, which is actually a feed and take-up elevator section. This is to permit splicing of one roll onto the other for continuous operation. The

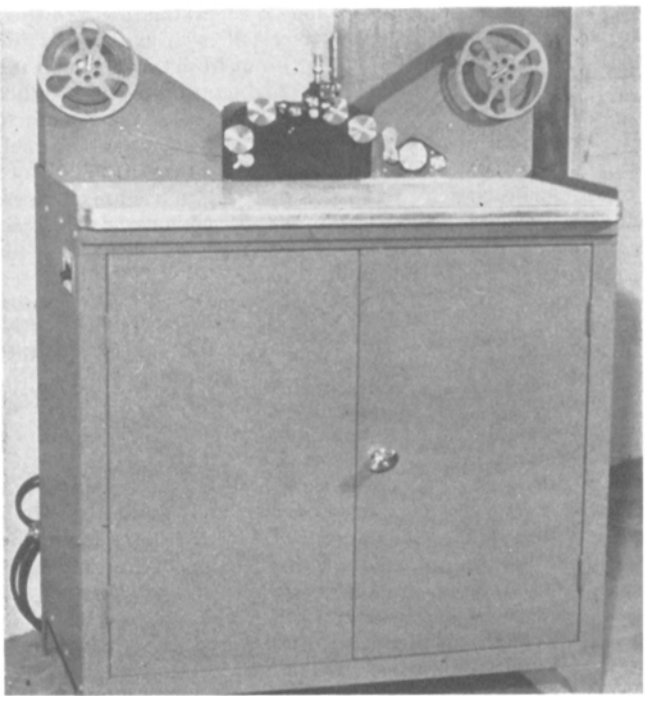

**Fig. 3. General view of Model S-8 striping machine.**

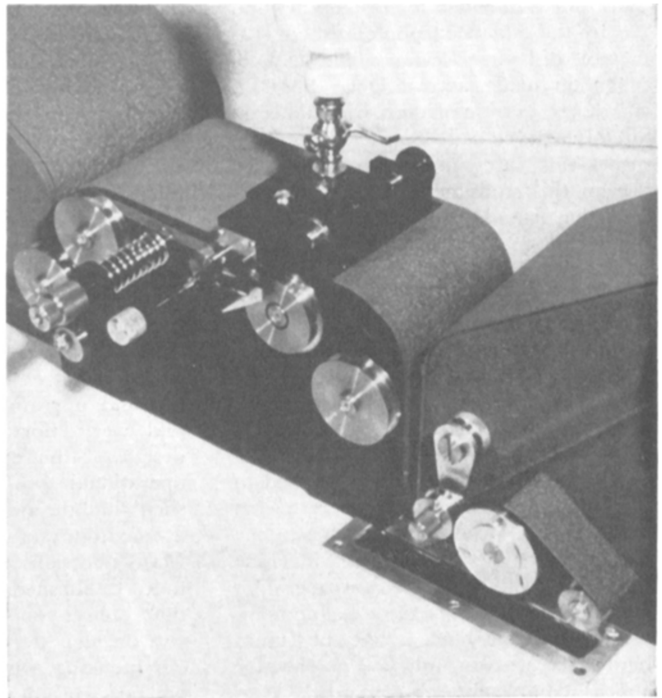

**Fig. 4. Close-up of striping head, Model S-8 striping machine.**

first section of the drybox is served with humidity-controlled room-conditioned air. This is necessary to minimize curl, which is occasionally noted on unexposed raw stock. The film passes from this elevator over the striping head. The striping is achieved through the use of two sapphire applicators and the film is held in intimate contact at the orifice of these applicators by means of sapphire pressure shoes. The oxide is fed to the film through the applicators from a closed circulatory system at a predetermined rate which is controlled by an adjustable header. The control of the thickness of the dried stripe is a combination of the dimensions of the orifices on the applicators and the viscosity of the mixture.

Since this equipment uses a significant quantity of dispersion during the 24-hr operating day, a circulatory system is provided. The slow-running gear pump takes the dispersion from a stainless-steel pot, located in the striping table, through an Ertel filter. This filter is capable of removing foreign particles above 10 microns. In addition to the circulatory system, a stainless-steel mixing pot is provided on the coating table. It is also equipped with a filter and a pumping system, and has a capacity of 16 gal. For this application the dispersion is shipped in a high-viscosity condition, approximately 1550 centipoise. Prior to use it is cut to operational viscosity of approximately 550 centipoise by the addition of a suitable amount of methylisobutyl ketone. Viscosity is best measured with a Brookfield Viscosometer in which the speed of the rotating cup can be varied through different ranges, although the use of the Ford-type cup is adequate for production control purposes.

Wide widths of freshly applied stripe must be protected from sudden drafts and thermal shock. The film path is therefore arranged so that the film runs through a channel of relatively low air volume characteristics into the back of the drybox. The first section of the drybox is not equipped with any air supply but is connected to the exhaust system. In this fashion some concentration of solvent fumes is achieved, permitting slow evaporation of the solvent, which is necessary during the early part of the drying schedule. By the time the film leaves the first drying section and enters the 90 F area, over 75% of the total volatile solvents have left the stripe. (This figure depends to some degree on the width of the stripes being applied, and slow drying is especially necessary on relatively wide stripes — 100 mils and up. It is not so critical for 25-mil wide stripes.)

The film is exposed to the 90 F air for approximately six minutes during the normal drying schedule and then it returns to the first section once again to re-establish room temperature and humidity conditions on a take-up elevator. It is fed out of this take-up elevator by means of a one-direction sprocket onto the take-up spindle, which is equipped with a level-wind system and tension control to ensure the delivery of carefully wound reels which are in a shippable condition. A three-position switch controls the function of the take-up elevator and take-up spindle. In one position the take-up elevator operates at line speed. In a neutral position the drive is disconnected from the elevator shaft and take-up spindle simultaneously. This causes the roll to stop to permit loading an empty spool onto the precision-wind take-up spindle. In the third position the take-up elevator and spindle run at 25% above the line speed so that the elevator can be emptied in preparation for the next roll change.

There is an end-of-roll alarm which operates on a signal obtained from a hole punched in the head end of the roll during feed-in splicing. The activating system is an air stream so that no mechanical components are required to touch either side of the films.

A tachometer, line-speed control and other instrumentation are also provided on the striping table.

A microscope with a reticule eypiece is mounted on the end of the striping head for measurement of track width and position, etc., during white-light operations. Observation of stripe width is also practical during the striping of some of the lower speed color and pan films during dark conditions by providing grazing columnated green safelights.

The equipment is constructed entirely of metal. Aluminum is used for door frames, etc., and interior surfaces are painted with baked enamel paint. A choice of drybox rollers is available, either all stainless steel or bakelite. The use of stainless-steel rollers is recommended for operations involving the striping of some of the high-speed photographic emulsions which tend to have static sensitivity.

**8mm Striping Machine for Photofinishers**

Also during 1960 a model S-8 striping machine was designed (Figs. 3 and 4).

This unit is intended for installation and use by the advanced photofinisher. It is capable of laying down a single stripe of magnetic oxide according to SMPTE standards, outside of the perforations on already developed 8mm film. Two dispersions are made available for use on this equipment. One of these is for the standard-position film, the bulk of the material in the market place, where the stripe is placed on the base side. The other is for the occasional non-standard-position prints which require striping on the emulsion side of the film. The dispersion used for base-side striping is the same material that is used for unexposed photographic raw stock, whereas the dispersion used for striping on the emulsion side cannot be used in the striping of raw stock and is restricted to developed prints. In both cases the dispersion for the 8mm striping machine has been adjusted to normal operating viscosity requirements, prior to shipment.

This little machine, unlike the 16mm high-speed striping unit, has no elevator and is completely self-contained. It is designed for local installation in ordinary facilities. It requires space which is relatively clean and dirt-free, provided with 110-v a-c power and a convenient window or exhaust duct to install the exhaust hose. The oxide is fed to the striping head from a half-pint polyethylene bottle. No circulatory system is provided. The mouth of the bottle contains a re-usable 200-mesh stainless-steel screen. A steel striping applicator is ordinarily supplied for this application. The striping head itself is an 8mm version of the 16mm striping head and is built to the same conditions of precision, except that in this case sleeve bearings are employed, rather than ball bearings. It does not require the use of precision transfer ways or microscope. The drybox is exhausted with a small self-contained blower directly to the outdoors by means of a flexible hose, attached to the back of the machine. No provisions are made for raising the temperature of the drybox air since drying of the narrow 25-mil stripes is not especially critical. Threading and operation are straightforward, and every effort has been made in the design of the equipment to minimize operational problems. The design is such that the entire film path is under a maximum of six ounces of tension. Many hours of operation of the prototype unit established the interesting fact that splices on old dried prints will run through the striping machine without breaking, whereas these same prints will not run through a standard 8mm projector.

Every effort was made to minimize the equipment cost to ensure its adaptability for a wide variety of striping. It has been built around a standard metal cabinet which was modified by the insertion of air baffles and separators. Standard link chain is used for all transmission. All shafts in the drybox are removable by the loosening of two screws. This is necessary to facilitate cleanup and washing procedures. Guide separators are provided on all drybox rollers to ensure that the film cannot jump from one spool to the other. All machine components, other than the stainless-steel striping surface, are either anodized or baked enamel. The feed spindle and take-up spindle are equipped with standard friction clutches. Precision 2400-ft capacity 8mm reels are made available as accessories for this equipment.

Operational speed is 30 ft/min. Observation of the cabinet is possible at all times through a window on the side of the machine. All rollers in the drybox are of Nylon and are undercut to eliminate danger of scratching prints, etc.

At no time is more than a half pint of striping solution and a pint of wash solvent required for the operation of the 8mm machine; therefore fire danger is minimized. Obviously, enforcement of ordinary safety rules such as rigid "No Smoking" is required. The blower and drive switch are interconnected so that the drive will not operate unless the blower is operating. The exhaust ports are at the base of the cabinet so that solvent vapors are exhausted even if the doors are opened, thus eliminating the possible concentration of solvent odor in the room.

While every attempt has been made to make the machine simple to operate and reliable in operation, some operator training is required. This can be accomplished either in Soundcraft's Danbury plant or on a local basis.

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