A 16-mm Clear-Print Sound-Film Time-Code Transfer Machine and Associated Editing Table

By JEAN-JACQUES BESSIRE

This paper describes two 16-mm film equipments which have been developed to assist in the introduction of code techniques in the identification and synchronizing of 16-mm picture and sound film. The paper deals mainly with a new sound transfer machine designed not only to transfer the recorded sound-associated time code from 1/4-in tape to 16-mm SEPMAG film, but also to print the code information in clear numerals on the back of the magnetic film. The second machine briefly described is a picture and sound synchronizing table equipped not only to facilitate the rapid assembly of films with numerals in a manual mode, but also to function automatically with full recorded code control if required.

Introductory Note: The basic film time code system standardized by the EBU some years ago has only recently begun to be used by a limited number of companies. It is believed that the reason for the slow introduction is the high cost and complexity of adding decoding apparatus to all editing units in a production system. Perfectone Products S.A. has now developed, in association with TDF (Telediffusion de France, Paris), a 16-mm SEPMAG film transfer recorder, which in addition to re-recording the film code in the conventional way, also prints onto the base of the SEPMAG film between the perforations, the information in decoded form using sequential groups of 13 digits. The author's final paper on this subject, which has been prepared by Norman Chapman, describes the method used on their equipment.

Development of Film Codes in Europe

A brief summary of the development of film codes in Europe over the past years will assist in setting the background to the production of these two machines. Reference will be made in this paper to the organizations TDF, TF1, and IRT. For those not familiar with these abbreviations, TDF stands for Telediffusion de France, which, among other activities including the transmission of all radio and TV programs, ensures research for sound and television broadcasting. TF1 is one of the French TV networks, and IRT is, of course, the Institut für Rundfunktechnik in Munich, which is the central research group for German television.

Concrete proposals to develop new techniques in the identification and assembly of films for television were formulated in Europe around 1976 by IRT in Germany and TDF in France. Much credit is due to both these organizations for their work in this field. Both of these proposals (the IRT specification is shown in Fig. 1) made use of code techniques to record on both the picture and sound films including sync marks, and these proposals have been the subject of many papers and documentation and have received general acceptance as standards by the European Broadcasting Union (EBU, also known as UER). These standards need no further discussion here except perhaps to mention the basic differences between the two systems.

As shown in Fig. 2, the picture film carries time code information defined in the EBU document 3096 and provides time of shooting information plus the camera number and, of course, the start mark—all in binary decimal form. This information is the same for both systems with respect to the picture, but the recording of this identical information on the magnetic sound record has some differences.

The IRT proposal specifies the use of pulse polarity modulation as shown in the lower waveform in Fig. 3, whereas the French TDF proposal employes a differential phase shift keying of the modulation as shown. Furthermore, it should be pointed out that these two proposals recommend different ways of setting the codes in tape recorders and cameras.

Slow Acceptance of Time Codes in Film Production

However, it has to be said that, although both the IRT and TDF code systems are immaculate in conception and have been shown to be eminently practicable, neither is in wide use, and it is an undoubted fact that the adoption of film codes in Europe has been very slow, and in the U.K. film codes are not used at all so far.

Perhaps a factor here has been the existence of two standards inhibiting progress by the manufacturers and creating some confusion with respect to the equipment required and the likely demand. It is suggested, however, that a more likely cause is the considerable expense involved in installing the necessary decoding equipment on film editing machines already in service. Most TV networks have a very considerable number of film cutting rooms in use, and this considerable extra expense must be a major difficulty, particularly when it is borne in mind that the cost effectiveness of film codes is as yet not proven.

The Printed Clear Numeral Proposal

Without underrating the probable final superiority of a full code system, but more with the aim of assisting the introduction of codes initially in a cheaper and more simple form, proposals have been made in France and Switzerland, with considerable interest in the U.K., for a numeral system printed on both the picture and sound films in a form easily identifiable by the film editor without the necessity for any additional equipment. Participants in this proposal have been TF1 as user (with a watching interest by the BBC) and TDF as technical advisor; the camera manufacturers Aaton and Eclair, particularly Aaton, which has carried out much pioneer work in this field; and Perfectone in Switzerland, which has worked on the problem of printing the numerals on the magnetic film—which work is the main subject of this paper.

It should be emphasized at this point that the numerals used are based on the binary decimal code referred to earlier, and also that this code is recorded on both the picture and sound films in addition to the numerals so that full code control can be employed if required.

Figure 4 shows the final form of the numerals on the magnetic film—the information being similar to that provided in the IRT and TDF proposals giving the exact time of shooting, the camera reference, and the sync "star." With respect to the sound, the requirement is to print clear numerals on the back of either acetate or polyester magnetic film produced from information

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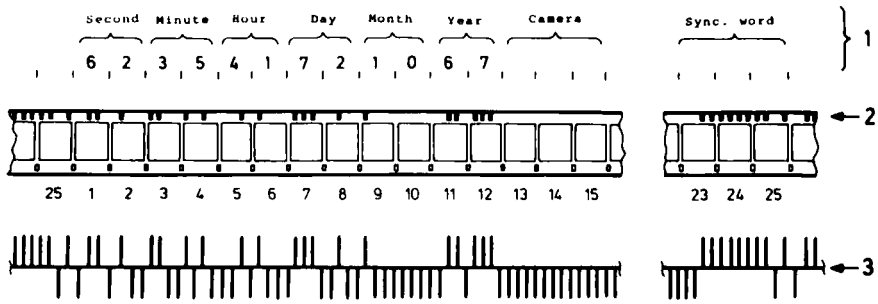

Fig. 1. The IRT film time code method. Binary group content (top); density modulation on edge of picture film (center); magnetic modulation on sound film (bottom).

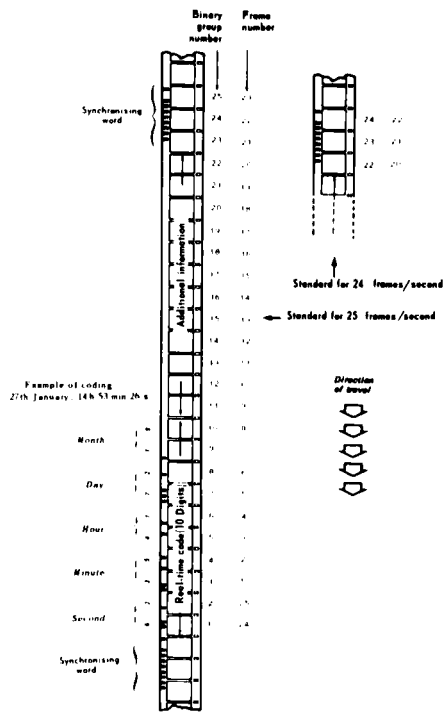

Fig. 2. Location of the binary code groups on 16-mm motion picture film.

derived from the code track and to print these numerals plus the sync star between the perforations—all the information to be identical to that on the picture film.

The Numeral Printing Problem

The most difficult printing aspect of the development has been to devise a system which will be equally effective on both acetate and polyester film stocks and which will provide numerals sufficiently permanent to withstand the continual handling necessary in the film process.

Latest Developments

It should be said at this point that the complete development has resulted from electronic research and development by the recording laboratory of the TDF in Paris including the provision of electronic units, together with mechanical research by Perfectone including the investigation of the ink and durability problem.

The Sound Transfer Machine

The complete Orcodim machine which is shown in Fig. 5 uses the basic O.R. type Perfectone recorder with the normal magnetic scanning mechanism displaced to the left to provide space for the numeral printing system. Obviously an add-on unit to existing machines of the O.R. type would have been desirable, but this was not found possible due to various technical requirements. However, if the overall system is proved to be very successful, then this may be considered as a later development. The only external equipment needed in the transfer process is a 1/4-in tape reproducer with code read-off.

The machine records to the standard EBU track dimensions as shown in Fig. 6, although of course it can be modified to operate on any standard.

The complete machine provides the following facilities:

1. synchronous transfer of modulation from 1/4-in tape to 16-mm film using either 50-Hz or 100-Hz pilot tone;
2. synchronous transfer of modulation employing the EBU/TDF code with regenerative transfer of that code and with or without printing of the code in numeral form;
3. numeral printing on the back of the 16-mm magnetic film derived from the code information previously recorded;
4. display of the code information recorded either on 1/4-in tape or on the 16-mm magnetic films, at any speed more or less than nominal.

It can be emphasized that the complete equipment can be relatively easily modified to operate with any code system or recording standard.

The type of track recorded on the 1/4-in magnetic tape is of course mainly a requirement on the 1/4-in tape reproducer, although the transfer machine must know the characteristics and frequency of the signal to be supplied. The machine described is arranged to receive a signal to the EBU/TDF specifications.

Figure 7 is a simplified schematic showing the basic mechanical components in the film path.

The film proceeds in the normal manner from the upper spool through the sound

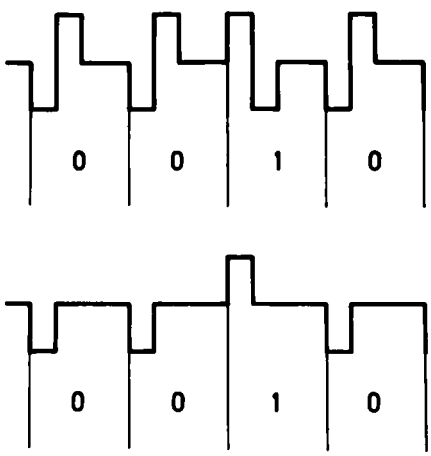

Fig. 3. Low energy modulation techniques as used by IRT and EBU/TDF. Pulse phase modulation (top); pulse polarity modulation (bottom). The rate is 4 bits/frame, 100 bits/s.

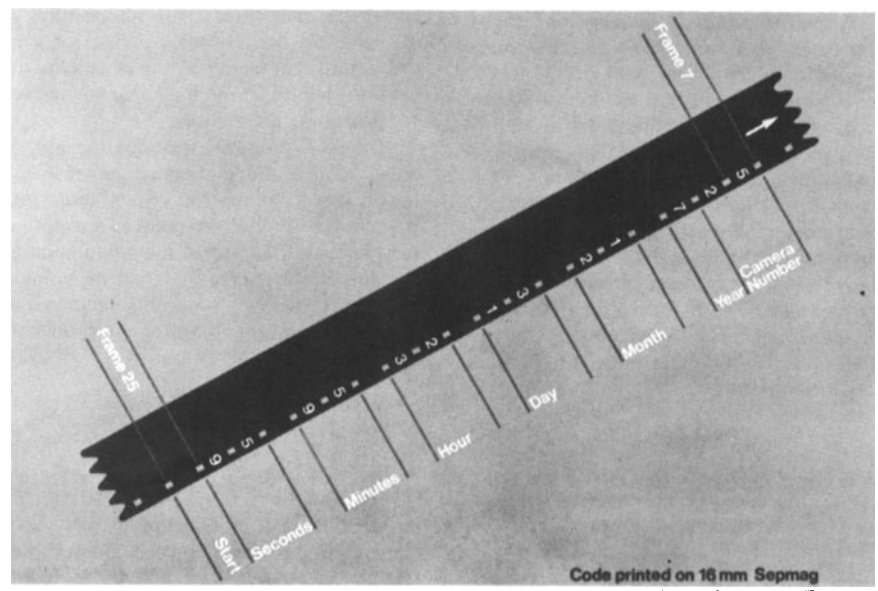

Fig. 4. Clear numerals on SEPMAG film.

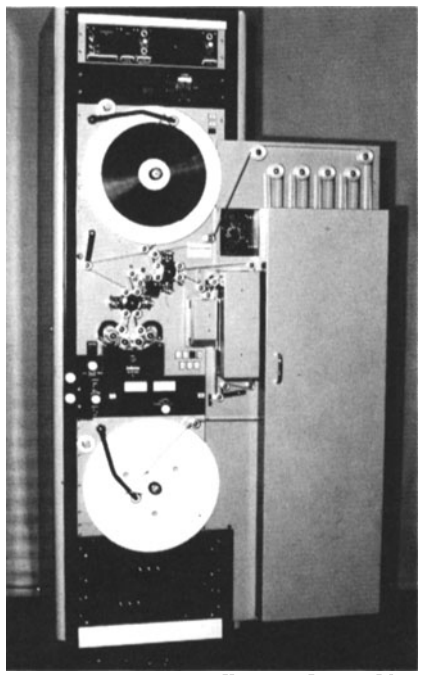

Fig. 5. Perfectone Orcodim transfer machine.

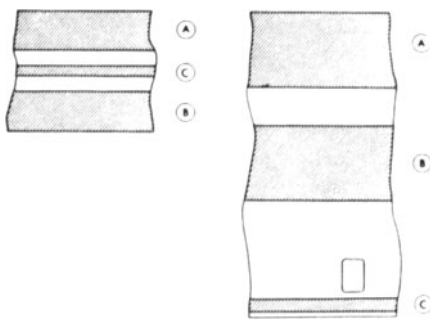

Fig. 6. SEPMAG tracks on 1/4-in tape (left) and 16-mm magnetic fullcoat film (right). Tracks (A) and (B) carry program content, and track (C) carries time code information.

sprocket and over the normal recording reproducing assembly, where the modulation and the code information are all recorded to the EBU/TDF standard. The film then traverses the second special reproducing head, which reads off the code, and then over a printing sprocket through the numeral printing head system. It then returns to the printing sprocket, passes through a drying cabinet, and then to the final take-up spool. The film is running continuously at 25 frames/s, and it is necessary to immobilize the film at the moment of printing each set of 13 numerals. This is achieved by a cam mechanism positioned after the printing sprocket and before the printing section. It is necessary to read off the code by a separate reproducing head positioned as shown, because an absolute distance must be maintained between the code position on the film and the point of printing the numerals. This absolute distance would not be ensured if the reproducing head in the tight loop scanning system was used. A delay built into the electronics ensures that both sets of information coincide on the film, i.e. the recorded code and the corresponding numerals.

Figure 8 shows the electronic control network. The film path is as depicted in Fig. 7. When the machine is operating in the interlock transfer control mode, the system extracts the code information recorded on the 1/4-in magnetic tape using a specially designed process, highly resistant to errors and ensuring a high degree of reliability, even in the case where the time code information from the 1/4-in tape is affected by dropouts or by high level crosstalk signals from adjacent audio tracks. The electronic chain also controls the traction speed of the 16-mm film. Code signals are recorded on the 16-mm film by the head gap in the EBU recording head. Erase and recording controls are linked for the audio and code channels.

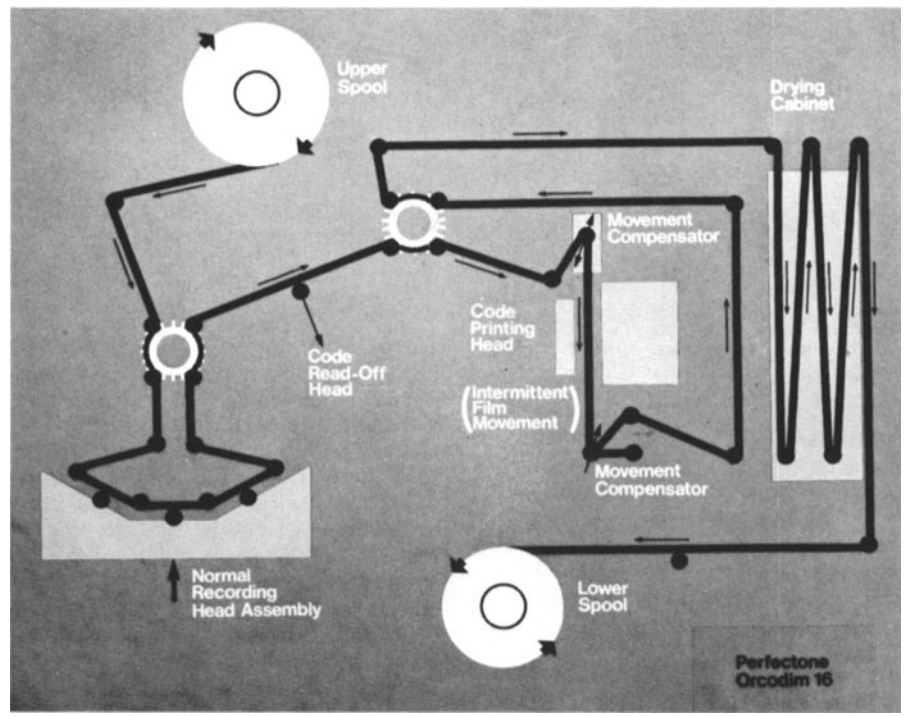

Fig. 7. Schematic of the film path in the transfer machine.

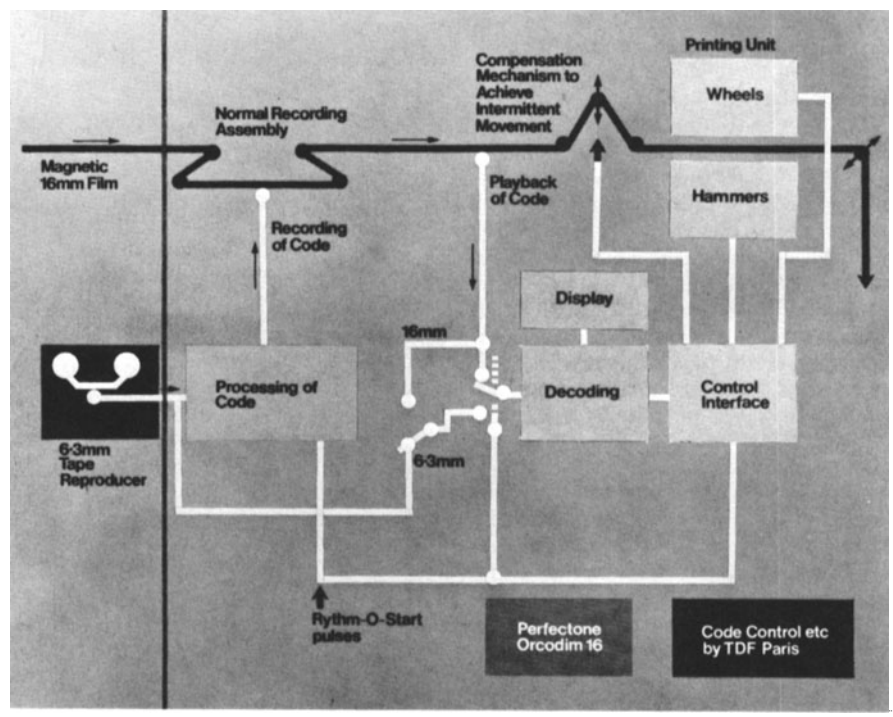

Fig. 8. Schematic of the electronic components and print-out elements of the transfer machine.

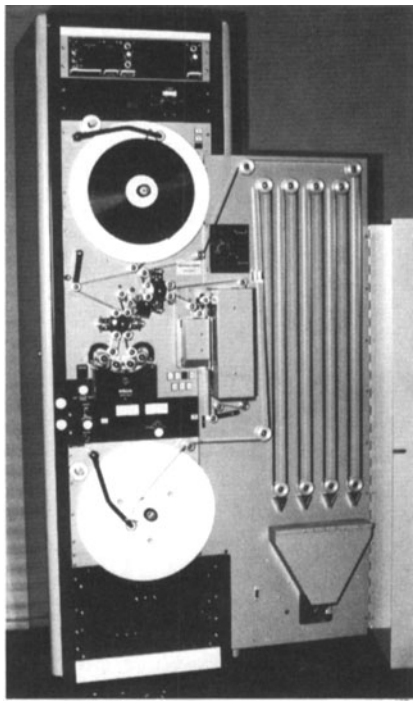

Fig. 9. Transfer machine with its drying cabinet open.

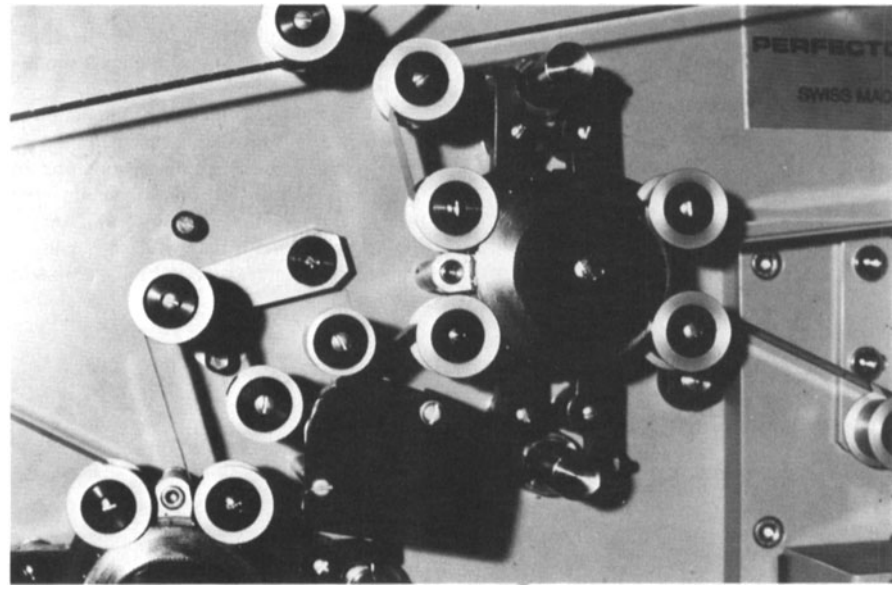

Fig. 10. Time code reading head.

The recorded code is read off by the special replay head as shown, processed in the manner depicted in the schematic, and the information fed to the printing unit. The machine prints the odd seconds. To ensure a high degree of protection against error, seconds which are not preceded by the corresponding even second are not printed.

The time code information, magnetically recorded on the 16-mm film, has no fixed relationship to the perforations. Therefore, the printer is arranged in such a way that it will always place the sync star in the best approximation between the two most appropriate perforations. Consequently, the 13 numerals are also printed between the perforations.

Figure 9 shows the complete machine with the drying cabinet open. The film path can be followed from the upper spool through the normal recording mechanism, through the printing sprocket, through the printing head, and via the drying cabinet to the take-up spool.

Figure 10 shows the code read-off head positioned between the two sprockets. As stated previously, this head re-reads the code and furnishes the command information which actuates the printing system.

Figure 11 provides a close-up of the printing head including the cam action to arrest the motion of the film which enables printing of the code section to take place. The picture also shows the regulating cam which ensures printing of the numerals and the sync star between the perforations. The 13 numeral dies and ratchets can be seen on the right, and the hammer unit which presses the film against the printing dies can be seen on the left. The hammer unit is split into three units, operated simultaneously to ensure close contact with the film. The printing ribbon runs between the printing heads and the film.

Figure 12 provides a close-up of the printing unit and hammer mechanism. Each of the 13 numeral printers is positioned independently by commands from the electronic elements. It should be emphasized that the design of the printer can accept a wide range of types of code information. It will obey whatever information is on the code track. The advance of the bobbin is effected automatically with each printing cycle and also with respect to the direction at the end of the bobbin.

The ribbon used at present is a special ribbon, manufactured for Perfectone in Switzerland, and the impression requires just over 15 s drying time before the film can be safely wound up. Printing is possible on both acetate and polyester stocks. While the present ink is satisfactory, the 3M Company in the U.S. has developed an ink which cures in 1 s after being exposed to a pulse of ultraviolet light. Samples of this ink have been tried in the Perfectone printer with good results, and have the advantage of improved visibility of the numerals because they are white rather than blue/violet. In addition, the drying process is eliminated. It is hoped that the 3M Company will decide to market this ink, making it available for use in this printer.

The rear view of the machine (Fig. 13) shows the normal recording elements on the right and the elements involved in the

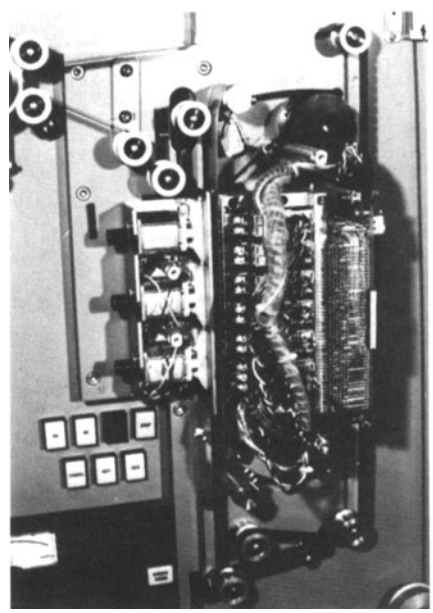

Fig. 11. Printing head with cam arrester.

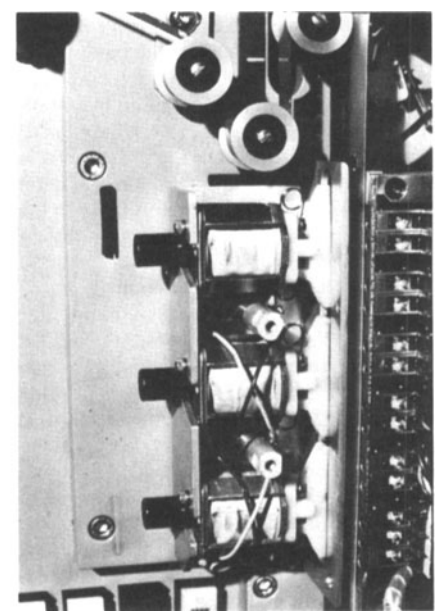

Fig. 12. Detail of printing head.

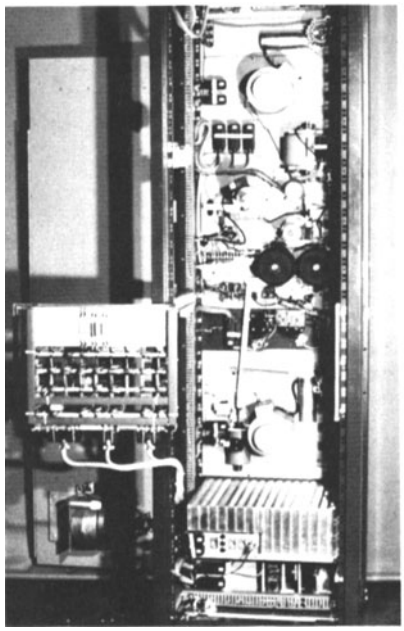

Fig. 13. Rear interior view.

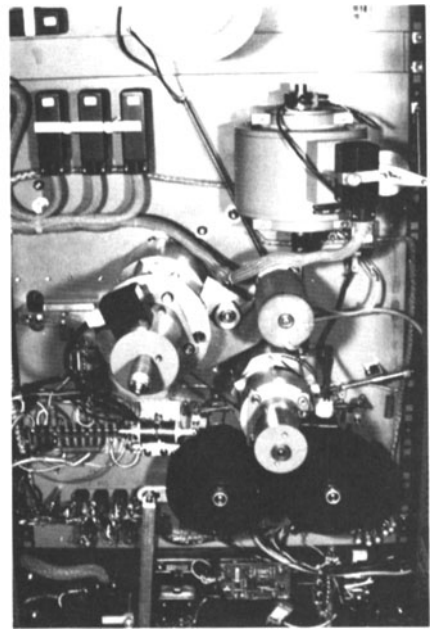

Fig. 14. Motor drive.

printing of the numerals on the left. A special drive motor, powered from the electronic control system and capable of being synchronized by the code originating from the 1/4-in tape, drives both sprockets. The motor driving system and the cam action mechanism to arrest the motion of the film, which enables the printing to take place, can be seen in Fig. 14. The main driving motor drives the sprocket system via a gear box. Connected with the printing sprocket is a lever controlled by the immobilizing cam which causes the momentary stopping of the film at the time of printing. The electronic elements, visible at the rear of the printing sprocket case, cause the engagement of the cam at the precise moment chosen by the electronic control system.

The control panel (Fig. 15) permits selection of the various modes of operation, including selection of the frequency of the pilot tone being used. A 1/4-in/16-mm switch is fitted to permit the decoding system to be connected either to the 1/4-in tape replay or to the 16-mm film replay when the machine is not in interlock transfer mode.

As can be seen from the picture of the complete machine, a display of the decoded signals plus a speed error indicator for the 1/4-in tape machine is included.

A complete picture and sound numeral coding system is shown in the March 1980 issue of *The BKSTS Journal*.

Summary and Outlook

The Orcodim machine thus provides a full transfer facility between 1/4-in tape and 16-mm film, plus the ability to print the code numerals so that, at least initially, the expense of code introduction is restricted to the single transfer process rather than involving each editing machine.

The machine has undergone much testing in the TDF laboratories and has been used extensively in experimental production sessions earlier this year. It is now in operational service with TF1, and it is hoped that later an account of the service experience and results will be published, especially from the point of view of productivity and production flexibility.

It can be said, of course, that the system of arresting the motion of the film and printing the 13 numeral sets sequentially is perhaps a mechanically complicated solution and that the recently developed continuous jet printing process may be a better way, as it eliminates the necessity for stopping the film. It must be remembered, however, that the method described was a development started two to three years ago when the system seemed to be the only way of providing a practical solution within a measurable time span, and the fact remains that the development has provided an equipment already in service and is providing valuable data with respect to the validity of clear numeral marking. A study of the jet printing method shows that it could have some problems in this field of use which might take some effort to solve, and in addition the printing unit itself seems to be very expensive without counting the adaptation work necessary to incorporate it in a machine.

Sound and Picture Assembly and Synchronizing Table

It was felt that in parallel with the printer development there was also a need for a specially designed film assembly table, not only to facilitate the editing of picture and sound film with clear numerals, but also to provide fully automatic sync-up using the full code system if and when it is desired to proceed to this method of operation. This development was primarily to explore possible increases of productivity in this stage of the film process.

Following transfer of the 1/4-in tape to 16-mm film using the previously described machine with code re-recording, with or without numeral printing, the next stage in production is the rapid assembly in sync of the picture and sound takes. The machine designated as Synchrocode (Fig. 16) has been designed specifically for this purpose in an attempt to give film all the benefits of modern technology to provide maximum productivity.

As can be seen, a sloping profile has been adopted to provide maximum ease of handling of the film, and the shelf in front with the control panel hinges down to allow easy passage through doors, etc.

Figure 17 provides a picture of the film paths with polygon scanning of the picture

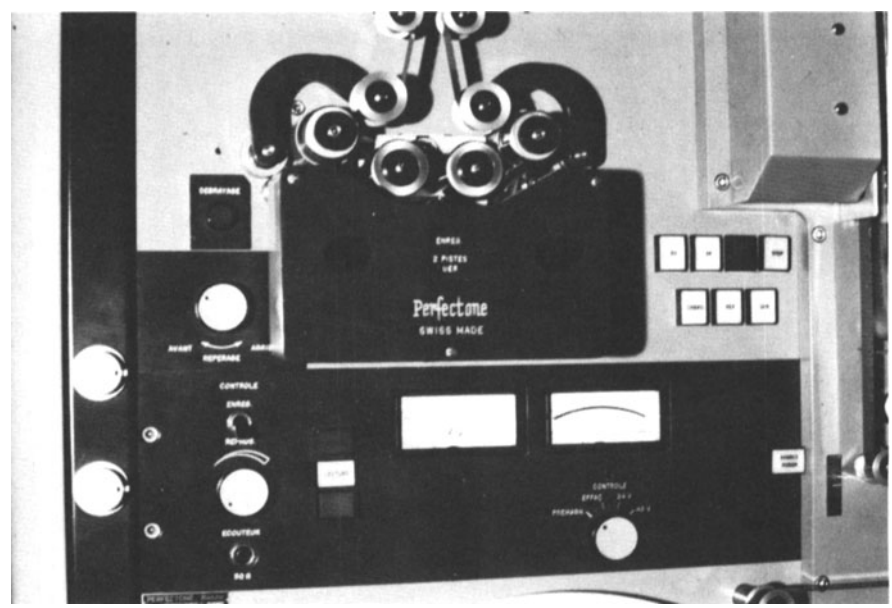

Fig. 15. Control panel.

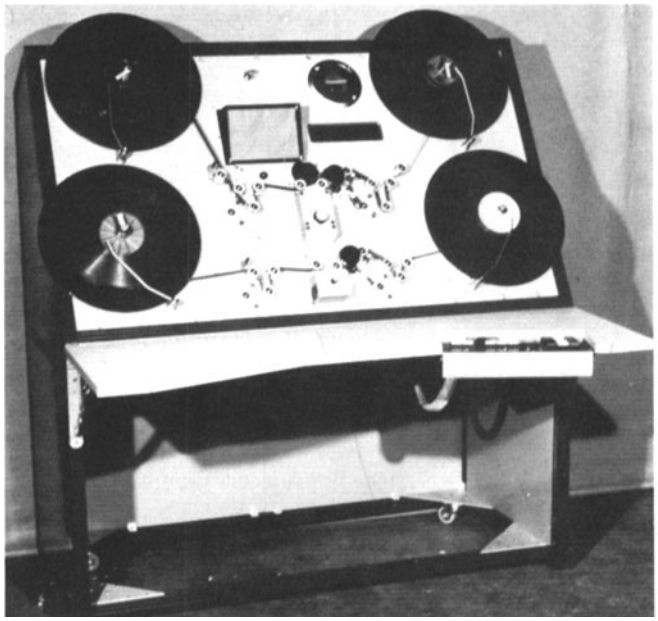

Fig. 16. The Synchrocode editing and synchronizing table.

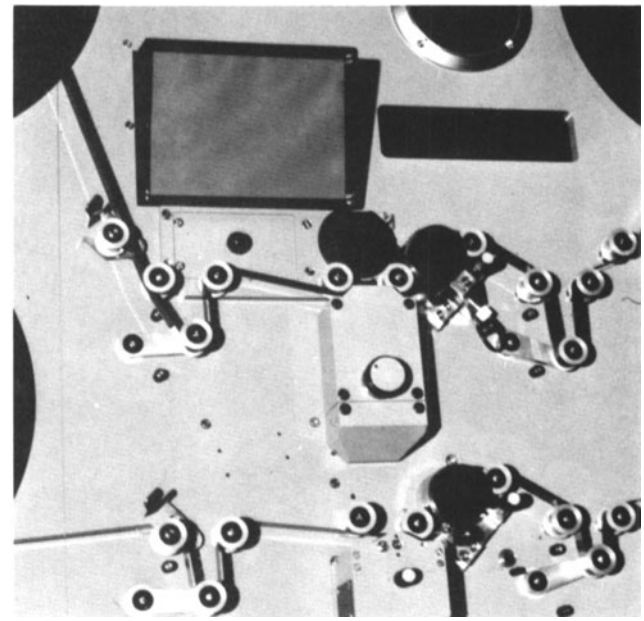

Fig. 17. Detail of film paths on the editing table.

in the upper path and sound scanning in the lower path. Very rapid and easy lacing is a feature of the design, and care has been taken to ensure a level cutting sync relationship between the picture and sound films in a vertical direction (editorial sync).

The machine is equipped for full automatic code control either with the picture film being the master to which the sound is synchronized or with the sound as the master. The machine is also arranged so that both the picture and sound numerals are visible if manual handling is being used. In addition, a visual digital display of either the picture or sound code in decoded form is provided.

A full range of controls is provided, with high and low speed running together with very slow speed inching.

The mechanical layout resulting from the sloping front design offers excellent accessibility to all mechanical and electronic components, and the construction specifications are up to the highest broadcast standards for continuous service. As with the transfer machine, this table is a TDF/Perfectone development with overall design and electronics by TDF and mechanics by Perfectone.

Acknowledgments

The cooperative nature of these two developments cannot be too highly stressed, with both TDF and TF1 leading the way with operational and technical specifications. Particular mention must be made of Research Group Director Mr. Grejoie, and of Mr. Wessor and Mr. Lemaire of TDF, who have played a major role in the development, and to whom Perfectone is greatly indebted for all their guidance, efforts, and technical expertise. Also, of course, with respect to the general principle of the use of clear numerals and their realization in the picture camera, mention is hardly necessary of Jean-Pierre Beauviala, who from the beginning has pioneered this proposal in various papers and in practical form in his Aaton cameras.

Acknowledgment is made with regard to extracts from the TDF report dated May 1979 on the transfer machine which have been used in this paper, and also the use of diagrams on codes extracted from the IRT report dated October 1976.

In conclusion, perhaps a comment can be made concerning the extreme value to the film manufacturing industry on the type of lead given in this instance by TDF and TF1 to enable progress to be made in exploring new methods to provide film with all possible benefits of modern technology without destroying the basic flexibility and operational individuality which is the essence of film. However willing, the manufacturer cannot do this alone without their operational guidance, expertise, and general backing.