Automatic Teleprinter Working

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This article reviews the automatic machines used on teleprinter circuits for point-to-point working, switched systems and the simpler tape relay networks. Some details of recent developments are included, and the trend of future development is referred to.

Introduction.

THE fundamental principles of automatic telegraph transmission, i.e. transmission from a perforated paper tape, have remained unchanged during the transfer of telegraph working from morse to teleprinter. The basic machines required are still the perforator, automatic transmitter, reperforator and printer; the difference being that they are designed for operation on the 5-unit start-stop code instead of the morse code. The method of operation is to prepare a paper tape by means of a keyboard perforator, the perforations on the tape corresponding to the code signals of the message to be transmitted, and to feed this tape into an automatic transmitter which "reads" the tape and translates the perforations into electrical signals for transmission over a telegraph circuit. At the receiving end these signals either operate the receiving mechanism of a printer to produce a printed message, or the perforating mechanism of a reperforator to give a perforated paper tape similar to that prepared on the original perforator.

The objects of automatic operation are,

(*a*) to enable circuits to be operated at the maximum speed of which they are capable, and

(*b*) to avoid manual re-transmission at relaying points, and thus economise both in time and operating staff.

At present the standard transmission speed adopted in the British Post Office, in conformity with international agreement, is 50 bauds, or 66·7 words per minute (the average word being considered to consist of five letters and one space). Although it is possible that machine speeds might be increased by careful re-design, and, in fact, machines capable of operating at 75 bauds (100 words per minute) are already in production in the United States and are being developed in this country, a further limitation is imposed by the band width of 120 c/s adopted for the multi-channel voice-frequency system which forms the trunk telegraph network of this country. Experience has shown that any attempt to operate over this network at signalling speeds much in excess of 50 bauds results in increased distortion and either necessitates more frequent maintenance attention or limits the number of channels which may be connected in tandem. It is therefore unlikely that any change will be made in the near future in the speed of operation over lines.

Another requirement, however, arises in the system of operation known as "tape relay." In this system the incoming messages at a tape relay centre are received on reperforators (or printing reperforators) and retransmitted over the next stage by means of automatic transmitters. In the simplest form of tape relay centre the tapes are taken from the incoming position to the outgoing position by hand or by means of some conveyor system such as pneumatic tubes, but other methods are envisaged in which the message is transmitted across the office from an automatic transmitter associated with the incoming reperforator to a reperforator associated with the outgoing automatic transmitter. For this cross-office traffic the limitations on speed imposed by the line conditions do not apply, and economies in switching equipment and machines can be effected by arranging for the cross-office transmission to take place at high speed.

The machines used for automatic teleprinter operation in the British Post Office are described in the following paragraphs, together with some indication of current developments.

Keyboard Perforators.

Keyboard perforators are used for the initial preparation of a paper tape perforated to correspond with the signals comprising a telegraph message.

The majority of keyboard perforators in use in the British Post Office are Perforators No. 44. These were developed from the Murray perforator used on the Murray Multiplex system. The principle of operation is shown in Fig. **1**.

The depression of a key positions five combination bars which have saw-tooth projections on their upper edges engaging with the lower edge of the keybar. The combination bars can move either to the right or to the left, and the saw teeth are cut so that the movement corre-

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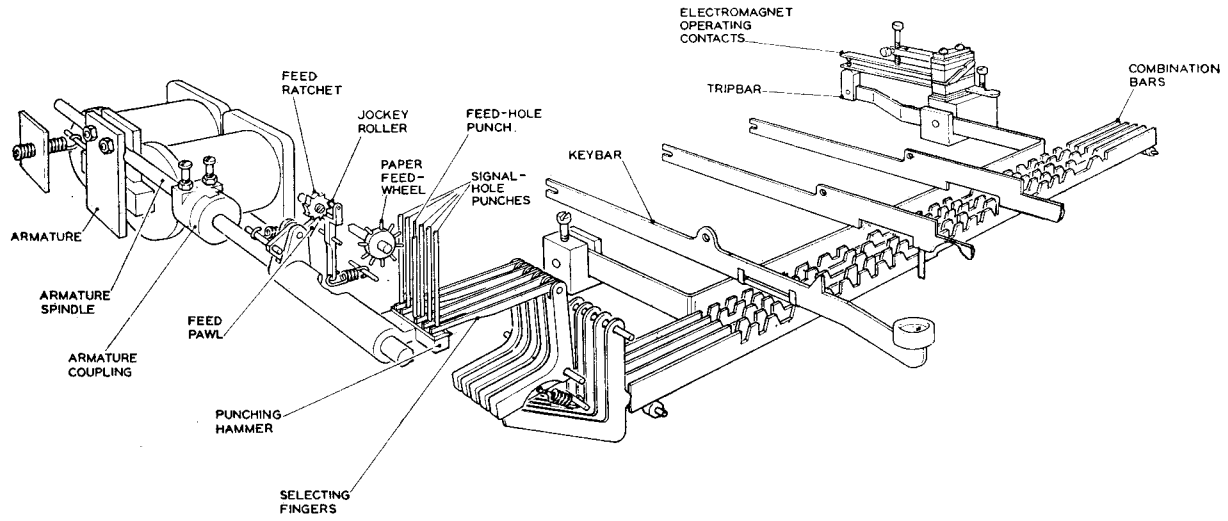


FIG. 1.—SELECTING AND PUNCHING MECHANISM OF PERFORATOR NO. 44.

sponds to the 5-unit code of the required character. The movement of the combination bars is transferred through a system of levers to the selecting fingers, and those corresponding to spacing elements of the code are withdrawn from under the punches. When the keybar approaches the lower limit of its travel it engages with a trip bar and operates a pair of contacts which close a circuit for the punching electromagnet. This raises the punching hammer, and those punches from under which the selecting fingers have not been withdrawn are forced through the paper tape to form perforations corresponding to the "marking" elements of the code. The feed-hole punch is slightly longer than the code-hole punches, and has no associated selecting lever, so that it is raised, and a feed-hole is perforated, on every operation of the electromagnet. When the key is released the electromagnet is de-energised, and during its restoration the paper tape is fed forward ready for the next punching operation.

This perforator has been found to be somewhat noisy in operation. This was probably not considered of great importance when the machine was originally developed, but the present tendency is to reduce noise in instrument rooms as far as possible, thereby lessening the nerve strain on the operating staff. In addition, the machine is slow in operation. The maximum speed is about 80 words per minute, a speed which can be exceeded for short periods by a good operator, and as the keyboard is not "locked" during each operation, a second key can be depressed before the operations initiated by the first key have been completed, with consequent incorrect perforating of the paper tape.

A new perforator, known as the Perforator No. 45 (Creed Model 7P/N3), has recently been introduced and is shown in Fig. **2**. This is a motor-driven machine which uses the

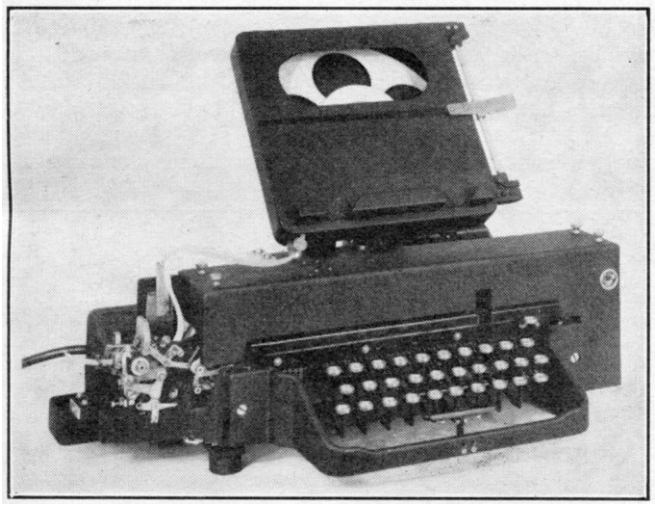


FIG. **2**.—PERFORATOR NO. 45.

energy stored in the rotating motor to operate the punching mechanism. The keyboard is similar to that used on the Teleprinter No. 11[1], and locking arrangements are provided although, as the maximum speed is about 130 words per minute, there is little risk of an operator "racing" the keyboard.

Fig. **3** shows the perforating mechanism of the Perforator No. 45. The combination bars have saw-tooth projections, and are operated from the keybars in the same way as in the Perforator No. 44; they cause the selector bars corresponding to "spacing" elements of the code to be withdrawn from beneath the corresponding punches. At the same time a trip bar is operated which releases the punching cam to perform half a revolution; this causes the punch block to rotate about its pivot and the punches corresponding to the

[1] "The Teleprinter No. 11." *P.O.E.E.J.*, Vol. 46, p. 53.

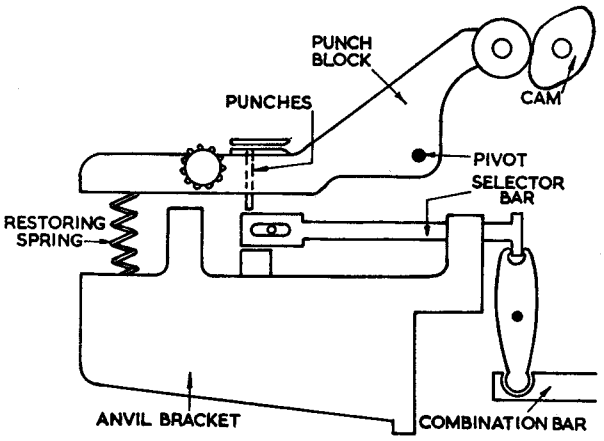


FIG. **3**.—PERFORATING MECHANISM OF PERFORATOR NO. 45.

marking elements of the code engage with their selector bars and are forced through the paper tape. A further cam (not shown) restores the punch block to its normal position when perforating has been completed; the feeding forward of the paper tape takes place during this restoration period.

Automatic Transmitters.

The standard automatic transmitter used by the Post Office is the Transmitter Automatic No. 2A (Creed Model 6S/4), shown in Fig. **4**. When in use the mechanism

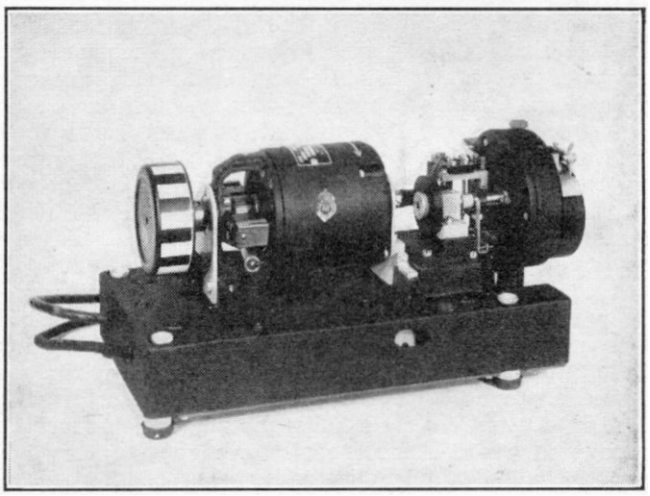


FIG. **4**.—TRANSMITTER, AUTOMATIC, NO. 2A.

is protected by a sheet steel cover. A number of earlier models may remain in use for some time, but it is not proposed to describe them separately as in principle they are the same as the 2A.

The machine is driven by an electric motor, the speed of which is controlled within close limits by a centrifugal governor. The governor cover is painted with 12 white and 12 black segments, to enable the speed to be checked stroboscopically. The motor drives the transmitting head through a ratchet and pawl clutch of the type commonly employed on teleprinters, and in the rest position the clutch is held out of engagement by means of a control lever which can be operated by hand or by the tightening of the paper tape being fed into the transmitting head.

The mechanism of the transmitting head is shown in Fig. **5**. The perforated paper tape passes between the pecker guide plate and the tape retaining plate, and when the clutch is released the tape is fed forward continuously by the tape feed wheel. At the same time the transmitting cam rotates and allows each pecker lever in turn to rise provided that this is permitted by a hole in the paper tape. If the

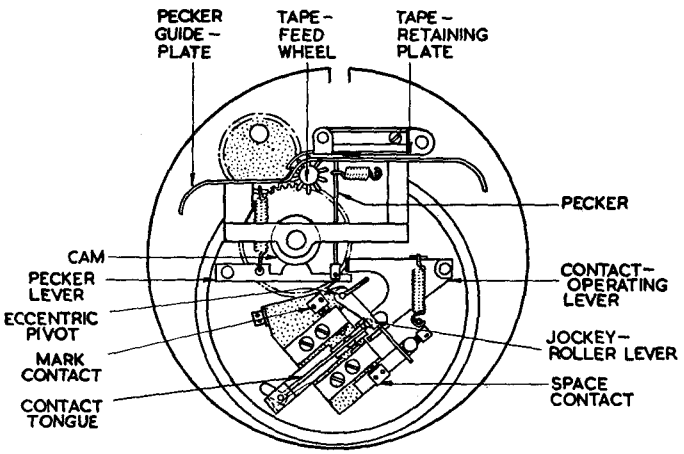


FIG. 5.—TRANSMITTING HEAD OF TRANSMITTER, AUTOMATIC, No. 2A.

pecker lever rises, the movement is transferred via the contact operating lever to the contact tongue and moves it to the marking contact. If, however, there is no hole in the paper tape the contact tongue remains on the spacing contact.

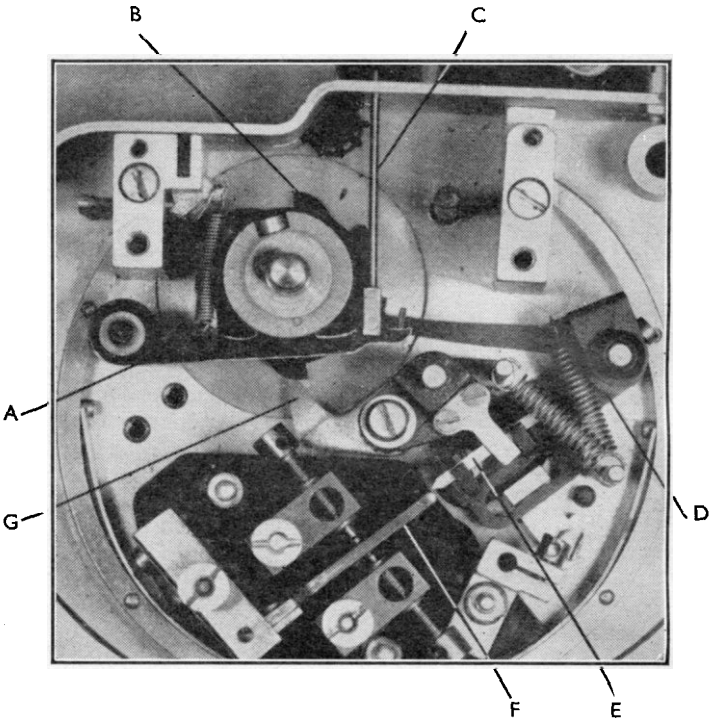
It will be appreciated that the operation of the contact tongue depends on the interaction of the pecker lever springs, the contact operating lever spring, and the jockey roller spring, and it has consequently always proved difficult to adjust the machine to give accurately timed signals. It had been realised for some time that an improved performance could be obtained if the striker principle employed on Teleprinters Nos. 7 and 11, whereby the moment of transit of the contact tongue is controlled from an accurately cut cam, could be applied to the automatic transmitter, and a model embodying this principle was developed at the Post Office Research Station in 1949. This, however, involved a complete redesign of the machine, and when, in 1951, a suggestion was received from the New Zealand Posts and Telegraphs Department, showing a method of applying the striker principle to the existing machine, this was considered a more promising line of development. Using the New Zealand model as a basis, some further work was carried out in the Telegraph Branch Development Laboratory and successful field trials were carried out on 12 models manufactured by Creed & Co., Ltd., in which were incorporated certain minor modifications to facilitate mass production. These models have given a very good performance, distortion generally being of the order of 2 per cent., and wear after several thousand hours being negligible. In future, this will be the standard head supplied on this type of automatic transmitter, and the model will be known as the Transmitter Automatic No. 2D (Creed No. 6S/5).

The striker head, with some parts removed for greater clarity, is shown in Fig. **6**. The pecker levers, controlled as before by the transmitting cam and the paper tape, position the contact operating lever which carries the striker dart. The moment of operation of the striker dart is controlled from the timing cam via the striker timing lever.

A further change which has been incorporated in the Automatic Transmitter No. 2D is step-by-step feed of the paper tape. The tape is fed forward during the transmission of the stop signal and is stationary during the transmission of the code elements, thus providing greater tolerance of any inaccuracies in the spacing of the perforations in the tape.

Ganged Transmitters.

When large numbers of automatic transmitters are installed at one station, it is desirable from the points of view of both operating and accommodation to mount them



A—Pecker Lever; B—Timing Cam; C—Pecker; D—Contact Operating Lever; E—Striker Dart; F—Transmitting Tongue; G—Striker Timing Lever.

FIG. 6.—STRIKER HEAD OF TRANSMITTER, AUTOMATIC, No. 2D, WITH SOME PARTS REMOVED FOR CLARITY.

as close together as possible. The Automatic Transmitter No. 2A does not readily lend itself to this requirement since, as the tape is fed from right to left across the front of the machine, a space must be left between machines for the tape to enter and leave. The Teletype Corporation had developed a triple-headed machine in the United States of America, and this machine is now manufactured under licence in Great Britain by Creed & Co. One version of the machine is shown in Fig. **7**. In this machine one motor is

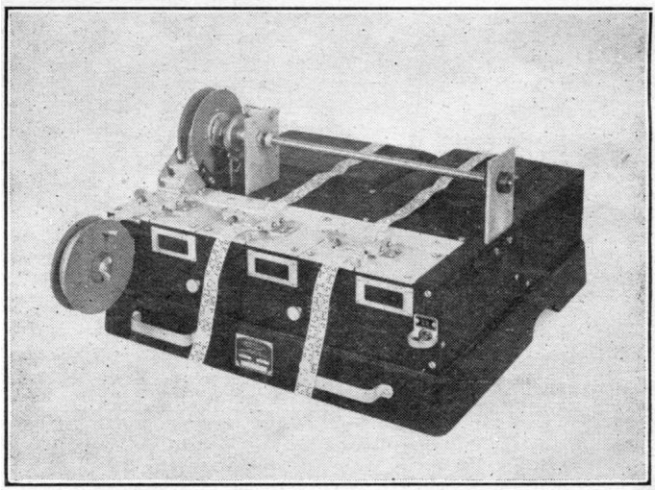


FIG. 7.—TRIPLE-HEADED GANGED TRANSMITTER.

used to drive three transmitting heads, which can be brought into operation independently, and the tapes are fed from front to back. The machine has additional facilities which will be described in more detail later.

Although this machine meets a definite need in tape relay centres, it has the disadvantage from the British Post Office point of view that, being an American machine, manufactured virtually unchanged, the transmitter is designed for 7·42 unit signals, instead of the British

standard of 7·5 unit; this introduces some difficulties when using British testing equipment for measuring transmitter distortion. This point would undoubtedly have been brought into line with British practice had time permitted, but there was an urgent demand for machines of this type, mainly from the air-operating companies, which could only be met by adopting the machine unchanged.

The transmitting portion of the machine differs from the normal British standard in that it is designed for single-current operation, and a relay must be interposed in the circuit to give a double-current output. The single-current signals are obtained from six contacts connected in parallel, one providing the start and stop signals, and the other five, released in turn by five cams, are controlled from the tape by means of peckers to provide the five code elements.

Automatic Message Numbering.

Where automatic transmitters are used to pass large quantities of traffic over point-to-point circuits, it is very desirable that the messages should be serially numbered, so as to guard against the possibility of loss, and assist in tracing back in case of a query. The simplest method of achieving this is to perforate a series of tapes with the required serial numbers and insert them into the automatic transmitter in turn before each message tape, but this involves continuous attendance if lost circuit time is to be avoided, and a certain amount of care to ensure that tapes are inserted in the right sequence.

A more convenient method is to provide a second automatic transmitter solely for the purpose of transmitting the serial numbers. This transmitter is loaded with a continuous tape perforated with the required sequence of serial numbers, and automatic means are provided for switching between transmitters as required.

A method of achieving this was developed in 1947 by the Post Office in conjunction with Creeds and British Telecommunications Research, Ltd. In this system, each message was required to be followed by ten "letter shift" signals and each serial number by five "letter shift" signals. Electronic equipment monitoring the output from the transmitters recognised these sequences, and initiated the switching between transmitters. The transmitters used were similar to the Automatic Transmitter No. 2A, but were fitted with electromagnetic clutches, so that they could be controlled from the electronic equipment, and, in addition, the numbering transmitter was fitted with tape reels, to carry the numbering tape, and associated driving mechanism. These were known as the Transmitters, Automatic, Nos. 2B and 2C respectively (Creed Models 6S/4M and 6S/4N). A numbering transmitter could be associated with either one or two message transmitters, the latter arrangement enabling transmission to proceed from one message transmitter while a tape was being loaded into the other, thus avoiding lost circuit time between messages.

The present method employed by the Post Office makes use of the ganged transmitters mentioned earlier. The end-of-message condition is recognised by the absence of tape at the sensing point, i.e. the message tape has completely passed through the transmitting head, and the end of number is the "letter shift" signal; this, of course, imposes the limitation that a letter shift cannot be employed in the body of the serial number.

In order to recognise these conditions, the message transmitter is fitted with a sixth pecker which rises and closes a pair of contacts ("tape out" contacts), when there is no tape at the sensing point, and the numbering transmitter has a seeker mechanism which operates and closes a pair of contacts when all code hole peckers rise at once, i.e. when the "letter shift" signal is sent. The numbering transmitter is also fitted with tape reels and driving mechanism.

A ganged transmitter can be fitted with any combination of message and numbering heads, and those so far employed in the Post Office are the Transmitters Automatic No. 3A (three message heads), No. 4A (three numbering heads) and No. 5A (two message heads and one numbering head). These are the Creed models Nos. 71, 72 and 74. The switching between transmitters is controlled by relay sets which can be attached to the transmitters or mounted separately.

Development work is proceeding on the provision of "tape out" contacts and "letter shift" recognition on the Automatic Transmitter No. 2D. Although a group of these machines for the provision of automatic message numbering will occupy somewhat more space than the ganged transmitters described above, they will have the advantages of the extremely low distortion of the striker transmitter and a double-current output.

Reperforators.

The reperforator used by the Post Office is the Reperforator No. 2, the latest model being the Mk. III (Creed Model 7TR/3), see Fig. **8**.

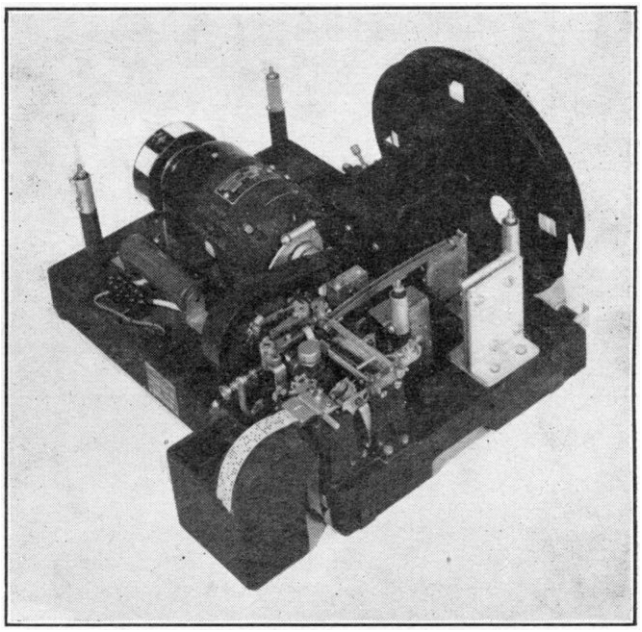


FIG. **8**.—REPERFORATOR NO. 2, MK. III.

The mechanism of the reperforator is similar in many respects to the receiving portion of a teleprinter. It comprises a receiving electromagnet which releases the receiving cam shaft on receipt of a "start" signal and subsequently controls the position of a setting blade in accordance with the code elements of the received signal. As in the teleprinter, the setting blade (see Fig. **9**) is moved forward for each code element; for marking elements it strikes the hammer-setting pin, but for spacing elements it passes beneath the pin. The setting pin is traversed behind five hammers, and the hammers corresponding to marking elements of the code are set downwards to engage with their appropriate punches. After the five code elements have been received, the hammer frame moves forward, the hammers engage with their punches and perforate the paper tape. Normal arrangements are made for feeding the tape forward prior to perforation.

The Reperforator No. 2 is a comparatively simple machine and has given, and continues to give, very satisfactory and trouble-free service.

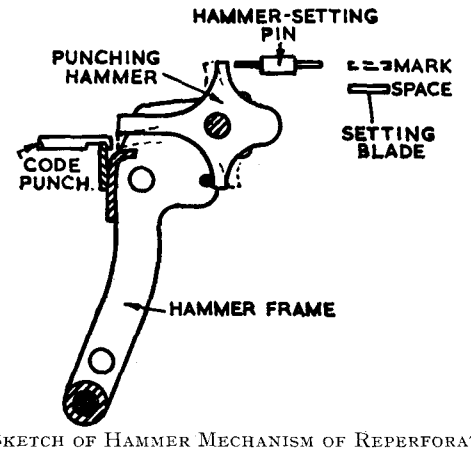


FIG. 9.—SKETCH OF HAMMER MECHANISM OF REPERFORATOR NO. 2.

Printing Reperforators.

The use of a reperforator at a tape relay centre to avoid manual retransmission presents some difficulty in that it is necessary for the operator to be able to read 5-unit code in order to read the address of the message, or else a monitoring teleprinter must be provided, which, of course, adds to the cost of the installation and doubles the amount of accommodation required. This difficulty has been overcome by the introduction of the printing reperforator, in which the message is printed and perforated simultaneously on the tape. In order that the printing may be legible, it is either necessary to use a wide tape with room for printing beside the perforations (Creed Model 86) or else to use the "chadless" method of perforation in which the code and feed holes are not punched completely out, but take the form of small lids attached by a narrow neck of paper to the main portion of the tape. The latter method has been adopted by the Post Office and the machines used are the Printing Reperforator No. 1 (Creed Model 85), shown in Fig. **10**, which includes a keyboard and transmitter, and the

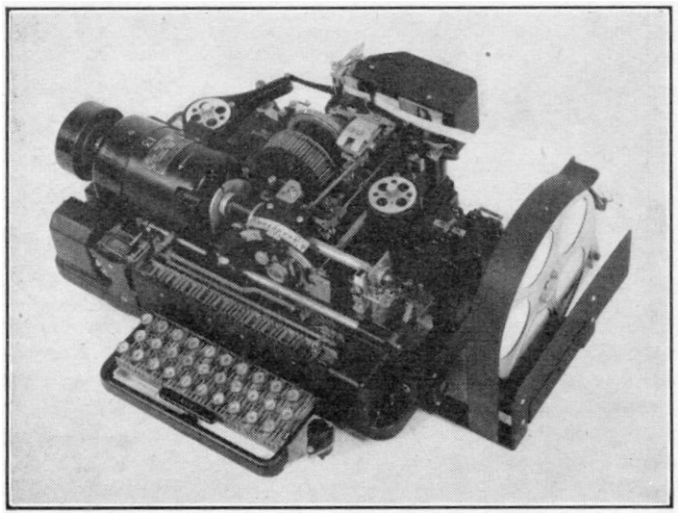


FIG. **10**.—PRINTING REPERFORATOR, NO. 1.

No. 2 (Creed Model 85R) which is a receiving machine only. A portion of chadless tape is shown in Fig. **11**; it will be observed that the printing is displaced relative to the corresponding perforations, it being, of course, impracticable to perforate and print simultaneously in the same position.

These machines are derived from the Teleprinter No. 7 by removing the page attachment and substituting a perforating unit, a tape reel being mounted at the side of the machine. The paper tape is led past the typehead, and

FIG. **11**.—SPECIMEN OF CHADLESS TAPE.

selection and printing take place as in the Teleprinter No. 7. At the same time the positions of the five receiving combs, which determine the character to be printed, are transferred via a system of levers to five punches, and the corresponding code holes are punched in the paper tape eight spaces ahead of the printed character. In order to obtain chadless perforation the die plate, into which the punches enter, is cut away on one side, as shown in Fig. **12**. Spring-loaded paper-layers are provided in the die plate which normally lie flush with the surface of the plate. When the punches are withdrawn after perforating the tape, the paper-layers push the paper lids back into the plane of the paper, so that they are not torn off by the die plate as the tape is fed forward.

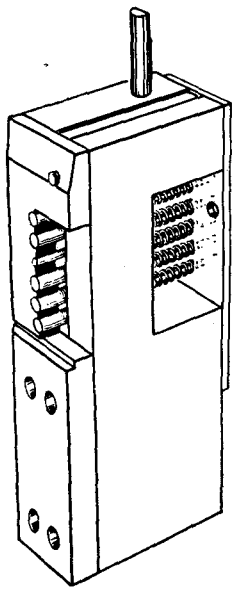


FIG. **12**.—DIE PLATE OF PRINTING REPERFORATOR, NO. 1.

Perforating and Reperforating Attachments.

A keyboard and perforating mechanism, almost identical with that of the Perforator No. 45 described earlier, can be provided in place of the normal keyboard on a Teleprinter No. 7. With this machine (Teleprinter No. 7BPK/N3) a message can be transmitted to line from the teleprinter, and at the same time a perforated tape can be prepared which can be used for subsequent transmission of the same message to other addressees by means of an automatic transmitter. In many cases the machine is used solely for the preparation of perforated tapes, and is not connected to line, the page copy of the local record being used as a check on the accuracy of the perforated tape.

A current development is the modification of the perforating attachment to dissociate it from the keyboard and control it from the receiving combs by means of Bowden cables, i.e., it will become a reperforating attachment. When connected for local record this will provide exactly the same facilities as the perforating attachment, but when the machine is connected to line a perforated record of the received signals can be made which can be used for subsequent retransmission.

Conclusion.

The series of machines which has been described appears to meet adequately the needs for point-to-point working, switched systems, and the simpler tape relay networks. The trend of development is now towards machines suitable for the more complicated semi-automatic or fully automatic tape relay systems. In these it is generally necessary for the machine to recognise certain characters, or sequences of characters, which provide routing instructions, and indicate the beginning and end of messages, separation between address and text, etc. Whether this recognition will be effected mechanically within the machine, or externally by electronic equipment is a question which has not yet been resolved.

The advantage of operating at higher speeds for cross-office transmission has already been mentioned and work is also proceeding on this problem.