 No. 150.

THE INSTITUTION OF
POST OFFICE ELECTRICAL ENGINEERS

TELEPRINTERS.

BY

E. S. RITTER, M.I.E.E.

A PAPER

Read before the Northern Centre of the Institution on 15th March, 1933, and the Cambridge Centre on 28th March, 1933.

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INTRODUCTION.

A considerable amount of information has already been published in articles in the *P.O.E.E. Journal* and in Technical Instructions on specific Teleprinters; as a consequence, it is proposed in this paper to deal with first principles and their application. The author feels that no apology is necessary for treating the subject in an elementary manner, in fact he feels that in some cases first principles have been lost sight of owing to the complexity of the instruments and the circuits which are used.

The paper covers the main features of different machines and does not purport to describe the detailed design and construction of any particular machine. It has been written to answer the following questions:—

(*a*) What is a "Teleprinter?"—Part 1.
(*b*) How does it work?—Part 2.
(*c*) What can it do?—Part 3.

PART I.—WHAT IS A TELEPRINTER?

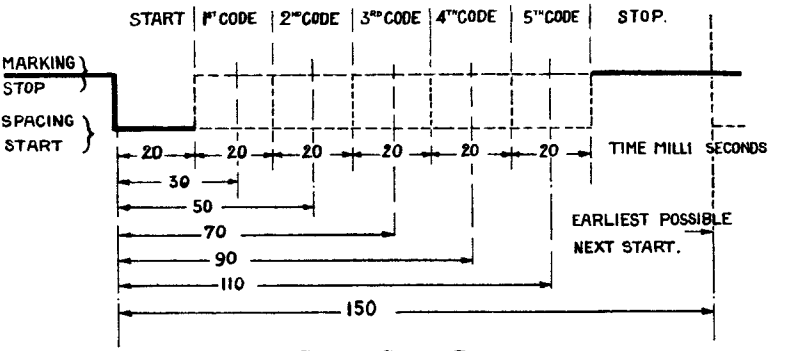
"Teleprinter" is the title adopted by the Post Office for a number of self-contained telegraph instruments, working on the "start-stop" principle. A typewriter keyboard is used for sending, and the received characters are printed either on a tape or a roll of paper.

The "start-stop" principle (see Fig. 1) makes use of a fixed or constant number of equal time or length two polarity code elements, generally five, to represent each letter or character transmitted, preceded by a "start" element and followed by a "stop" element. The "stop" element is the polarity of the normal rest position, and the opposite to that of a "start" element. The receiving mechanism comes to a stop at the end of each letter or character and is started again by the "start" element of the next letter.

Brief details of the teleprinters used in the Post Office are given below:—

Teleprinter 1A, now obsolescent, in which the printing and receiving system resembles the Baudot printing unit which prints on tape. The operating speed of this teleprinter is about 40 words per minute.

TELEPRINTER SIGNAL.



START STOP CODE.

FIG. 1.

Teleprinter 2A is manufactured by the Morkrum Teletype Corporation of America, who also made the 1A. The printing is done on tape by means of type bars as in a standard typewriter. The same machine is manufactured in Germany by the Lorenz Company in Berlin, under licence.

Teleprinter 2B is a teleprinter 2A with the keyboard and code characters modified to take Code International No. 2.

Teleprinter 3A is the standard machine used in the British Inland Telegraph service, and about 2,000 are in use. The printing is on a paper tape by means of a typehead. The machine is manufactured by Creed and Company, Croydon.

Teleprinter 5A, now obsolescent, is a keyboard transmitter fitted with a counter and working to a Teleprinter 4A as a printer. The Teleprinter 4A is a column machine printing from a typehead. The two machines together comprise one installation.

Teleprinter 7A is the latest teleprinter manufactured by Creed and Company for use on Public " Telex " and Private Wire service. It is a column printer using a typehead. The carriage carrying a roll of paper can be substituted by a tape unit when printing on a tape is preferred. The machine minus keyboard, *i.e.*, for reception only, can be had if required. The instrument has been designed for simplex or half duplex working, the printing unit producing a copy of

the message typed at the transmitting end as well as at the receiving end or ends.

Teleprinter 7B is a teleprinter 7A modified in respect to the receiving portion so as to accept a character or letter of about $6\frac{1}{2}$ units or a 7 element signal with adequate margin, whereas the 7A machine was designed on the basis of a signal of $7\frac{1}{2}$ elements. Teleprinter 7B will work to and receive from a 7A machine but in addition will receive from a machine transmitting a letter or character as 7 elements or having a minimum " stop " signal one element in length instead of one and a half. Teleprinter 7B has been introduced since the paper was read.

The tape attachment has been designed so that it may be used when working to or receiving from a column machine.

The tape unit is fitted with a counting mechanism to indicate the approach to the end of a line when sending to a column machine. The counting mechanism closes two contacts which are used to light a lamp at the point in a line corresponding to the ringing of the alarm bell in the case of the carriage unit. The contacts could, of course, be used to ring a bell in addition to, or in lieu of, lighting the lamp. The length of line up to the point where the lamp lights is adjustable. The counter is released by the carriage return signal, no space appearing on the tape; on receipt of a line feed or column signal a space is arranged to appear on the tape. Normally in sending from a column machine the space bar would not be operated at the end of a line or on commencing a new line.

The column machine is not arranged for duplex working or sending and receiving simultaneously over the same circuit. If duplex operation is required it would be necessary to use a separate receiving unit, or to do away with the local record; in the latter case some form of counter would be necessary on the keyboard to indicate the end of a line as well as some change in the automatic motor starting and stopping arrangements. Two tape machines may operate together blind duplex. In this case the counting mechanism can be put out of action on the tape unit as it is not now required. In addition the automatic motor starting and stopping mechanism requires alteration as, if no message is coming in, the transmitting machine stops, as there is no local record to keep the motor stopping mechanism from stopping about a minute after the machine has started.

The number of unit elements in a second of time is the " speed " in " Bauds." In Morse-Wheatstone transmission the interval between two centre holes on the transmitting tape comprises two elements, a dot and a space, a dash comprising three elements, and together with a space making up four elements, or twice the distance between two consecutive centre holes. The speed of transmission of Wheatstone signals expressed in " Bauds " is therefore twice the number of centre holes passing the transmitter per second.

The length of the stop signal in start-stop systems is indeterminate and depends on the skill of the typist operating the keyboard. The greater the skill the shorter is the length of the stop signal up to the maximum speed of the particular machine used. The minimum length of stop signal is one element, but in the 3A and 7A Teleprinters it is one and a half elements.

The Baud speed of the Teleprinter 7A is 50, or at the rate of 50 unit element signals per second; this makes the time of a unit element 20 milli-seconds and the minimum time of transmission of a letter or character of $7\frac{1}{2}$ units 150 milli-seconds, or 400 letters per minute.

If a minimum 7 unit letter signal were used at 50 Bauds the letter speed would have been 3000/7 or 428 letters per minute.

In the case of the 3A Teleprinter the speed in Bauds is set at 49. The unit signal is 20.4 milli-seconds with a speed of 392 letters per minute, each letter taking a minimum of 153 milli-seconds.

Certain advantages in testing would accrue if the transmission speed of 3A machines were raised from 49 to 50 Bauds. This alteration could easily be made by a slight adjustment of the motor governor, but it would mean an alteration of all the stroboscopes by means of which the machine speeds are set.

Teleprinters are driven by small electric motors which are fitted with governors so that the speed can be kept within plus or minus one per cent. of the rated speed. It will be seen, therefore, that the use of teleprinters presupposes the availability of an electric power supply, either from the mains or a self-contained power plant.

The speed adjustment, whilst of importance, is not so critical as with multiplex synchronic systems. Each start

element operates as a correcting signal and each character or letter transmitted is preceded by this signal. Multiplex systems, whilst being more complicated, are able to carry more traffic for a given Baud speed and possibly stand more distortion in the signals before failure occurs. If correction is made from the signal elements only 5 elements are required per letter or character transmitted but, where a separate correction signal is sent, from 5.25 with a quadruple to 6 elements with a double duplex are required per letter.

The corresponding figures for a Teleprinter 3A or 7A are $7\frac{1}{2}$ unit elements (7 in the case of the Teleprinter 2A).

Siemens and Halske, in Berlin, also manufacture a teleprinter. A number of these are used by the German Post Office. This machine has several features of interest.

PART II.—HOW DOES A TELEPRINTER WORK?

It will be found convenient to divide the description as follows:—

(1) The alphabet and code.
(2) The keyboard.
(3) The transmitting unit.
(4) The receiving unit, signal distortion and margin.
(5) The translating and printing unit.
(6) Method of inking.
(7) Special features of the Teleprinter 7A.
(8) Notes on power supplies.
(9) The power unit, comprising motor and governor.

(1) *The alphabet and code.*

Before describing the keyboard it will be well to consider the alphabet and code used. Each letter or character signal consists of one unit-length start signal, lasting for 20 milliseconds, when the speed of transmission is 50 Bauds or 50 unit element signals per second, followed by five unit-length code signals and terminated by a stop signal.

The " start " signal unit is of opposite polarity to the " stop " or " rest " signal; in double current working the rest condition corresponds to " marking " with a negative voltage applied to the line, the start signal unit corresponds to " spacing " with a positive current sent to line; the five code elements consist of combinations of the two conditions, thus 2^5 or 32 combinations are possible. The combination of

five spacing elements is not used, so the code characters are limited to 31. In the closed loop method of working the " stop " condition is current flowing, and the " start " condition is an interruption of the circuit and absence of current.

As more than thirty-one characters are required the instruments are so arranged that after the passage of a letter-shift signal the machine will print letters or primary characters and continue to do so until a figure-shift signal is received; after which the instrument prints, and continues to print, figures or secondary characters. The figure and letter signals use up two combinations of the 31, this leaves 2 (31-2) or 58 possible character combinations.

In the code used by the Teleprinter 3A and 2A the letter-shift signal and also the figure-shift are associated with the space bar which is divided and a " space " or " blank " is printed on operation of either the letter-space or the figure-space keys. In Teleprinters 7A and 2B, the latter being a 2A modified to use the same code as the 7A and using Code International No. 2 the letter and figure shifts are separated from the space signal. No " space " is printed when the " letter " or " figure " shift keys are operated. A separate code combination has, however, to be provided for " space." It is thus possible to print on the 7A Teleprinter,

" BY27XZ45WA "

on the Teleprinter 3A this could only be rendered as

" BY 27 XZ 45 WA,"

a space being necessary between each inversion of letters to figures and vice versa.

If a three-row keyboard is used, and this is standard in the British Post Office service, it is necessary to associate each key with a primary or letter character and also a figure or secondary character. The secondary character should have the code combination of the primary character associated with the same key. If this is not done the transmitting mechanism becomes complicated. A case where the primary and secondary characters have different code combinations occurs in the " Booth-Willmot " keyboard perforator, used for automatic Baudot transmission, where the primary and secondary characters on the same key have a different code combination.

It is also desirable that the key positions should, as far

as possible, correspond to standard typewriter practice, always bearing in mind that up to now telegraphy has only recognised capital letters. Lastly, the instrument should be capable of international use.

In German typewriters the type key of letter " Z " is associated with the figure " 6 " and placed in the position occupied in British typewriters by the letter " Y," which also has the figure " 6 " as its secondary character, whilst in Germany the type key of the letter " Y " occupies the position of the letter " Z " on British typewriters. In order to overcome this difficulty the German teleprinters have been made with a four-row keyboard, the top row being figures only and dissociated from the letters on row three. A number of British typewriters use the four-row keyboard with figures in the fourth row, but in this case the figure one is missing and is made by using the small " *l* " and the nought by the capital " O." French typewriters have five letters in different key positions from the British. Certain other countries, such as Denmark, Sweden, Norway, etc., have special letters to accommodate.

Code No. 1 is the international multiplex code. At C.C.I.T. (Comité Consultatif Internationale Télégraphique) conferences at Berlin in 1929 and Berne 1931, there was considerable discussion over the relative merits of the multiplex and Murray codes as a basis for teleprinter working. Ultimately unanimous agreement was reached and the present Code No. 2 was produced, being based on the Murray code and adopted for international working. The Teleprinter 7A conforms to this code as well as do the 7B ant 2B teleprinters.

The essential difference between the Baudot and the Murray code is the linking in the latter of the figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 0 with the letters Q, W, E, R, T, Y, U, I, O, P, whereas in the Baudot code these figures are linked respectively to the letters A, E, Y, U, J, B, C, D. The Baudot code is unsuitable therefore for a three-row keyboard layout if the primary and secondary characters of a key are to have the same code combination.

Four secondary characters, those of the letters " D," " F," " G " and H," have been set apart for national use. Countries using these secondary characters as letters did not desire a space before and after the national letters, and it is principally for this reason that the letter and figure shifts have been divorced from the space bar.

One of the Danish delegates to the Conferences has proposed that a six-unit code be used to avoid the use of the shift signals; while there is much in favour of this proposal there are equally good reasons against it. What is really required is:—

(i.) An international standard typewriter keyboard. (When this is in being then the international teleprinter keyboard may follow).

(ii.) The international teleprinter keyboard and characters should be identical with an international standard typewriter.

(iii.) The alphabet code should be such that it meets the keyboard requirements.

In view of the requirements stated above, a long time is likely to elapse before the desired end is attained. Meantime code International No. 2 may be used with Teleprinter 7A.

The C.C.I.T. further specified at the Berlin Conference that the speed of transmission should be 50 Bauds and the machine capable of receiving and printing when each character is sent out as seven equal units, that is to say, the minimum stop signal should be one unit in time. The Teleprinter 7A will receive signals where the stop element is one unit or slightly less, but in such a case the " margin " or the capability of the instrument for receiving distorted signals correctly is reduced. Teleprinter 7A has been modified so that the machine is capable of receiving when the stop signal element has been shortened to a minimum of about half a unit. Such a machine is known as Teleprinter 7B. Teleprinters 3A, 7A and 7B all transmit a minimum stop signal of one and a half units. Fig. 2 illustrates various alphabet codes.

The number of letters in a line in column printers still requires standardisation. Should an international switched service be introduced over the telegraph circuits it will also be necessary to specify " calling," " clearing " and " engaged " signal conditions. In the case of an international " Telex " service worked over trunk telephone lines the carrier frequency, the maximum power sent, and the minimum power received will also require to be specified and agreed with the C.C.I. Telephones.

START	1 2 3 4 5 TELEPRINTER	STOP	MORKUM TAPE TELEPRINTER Nos 1A & 2A	CREED TAPE TELEPRINTER No 3A	CREED COLUMN & TAPE TELEPRINTER 7A	AT & T Co TELETYPE-WRITER SERVICE	BAUDOT INLAND	BAUDOT CONTINENTAL
			P S	P S	P S	P S	P S	P S
O	● ● ● ● ●	●	/ /	✻ ✻	LETTERS	LETTERS	P +	P %
O	● ● ● ● O	●	K ⅗	K ⅗	K (	K ½	D O	D O
O	● ● ● O ●	●	Q 1	Q 1	Q 1	Q 1	V '	V '
O	● ● ● O O	●	U 7	U 7	U 7	U 7	O 5	O 5
O	● ● O ● ●	●	FIGURES SPACE	FIGURES SPACE	FIGURES	FIGURES	L -	L -
O	● ● O ● O	●	J 7	J 7	J BELL	J ,	H '	H #
O	● ● O O ●	●	W 2	W 2	W 2	W 2	Z :	Z :
O	● ● O O O	●	A .	A .	A -	A -	/ ½	E ' &
O	● O ● ● ●	●	X £	X £	X /	X /	Q /	Q /
O	● O ● ● O	●	F ½	F ½	F %	F ¼	C 9	C 9
O	● O ● O ●	●	Y 6	Y 6	Y 6	Y 6	T 2	T !
O	● O ● O O	●	S 1	S 1	S '	S BELL	U 4	U 4
O	● O O ● ●	●	B ?	B ?	B ?	B ⅝	K (	K (
O	● O O ● O	●	D 2	D 2	D WHO ARE YOU	D $	J 6	J 6
O	● O O O ●	●	Z .	Z .	Z +	Z "	- .	¼ .
O	● O O O O	●	E 3	E 3	E 3	E 3	A 1	A 1
O	O ● ● ● ●	●	V)	V)	V =	V ⅜	N £	N N°
O	O ● ● ● O	●	C (	C (	C .	C ⅛	F ⅝	F £
O	O ● ● O ●	●	P 0	P 0	P 0	P 0	W ?	W ?
O	O ● ● O O	●	I 8	I 8	I 8	I 8	I 3	I ¢
O	O ● O ● ●	●	G ¾	G ¾	G @	G &	M)	M)
O	O ● O ● O	●	R 4	R 4	R 4	R 4	G 7	G 7
O	O ● O O ●	●	L	L +	L)	L ¼	X ⅘	X ,
O	O ● O O O	●	+	/ /	LINE FEED	LINE FEED	E 2	E 2
O	O O ● ● ●	●	M '	M ,	M .	M .	R -	R -
O	O O ● ● O	●	N -	N -	N ,	N ⅞	8 8	8 8
O	O O ● O ●	●	H ⅘	H 5	H £	H STOP	S ⅞	S ;
O	O O ● O O	●	LETTERS SPACE	LETTERS SPACE	SPACE	SPACE	Y 3	Y 3
O	O O O ● ●	●	0 9	0 9	0 9	0 9	✻ ✻	✻ ✻
O	O O O ● O	●	-	- =	CARRIAGE RETURN	CARRIAGE RETURN	FIGURES SPACE. LETTERS SPACE REST POSITION	FIGURES SPACE LETTERS SPACE REST POSITION
O	O O O O ●	●	T 5	T 5	T 5	T 5		
O	O O O O O	●	BLANK	NOT USED ✻	NOT USED ✻	BLANK		

BAUDOT

● MARKING UNIT O SPACING UNIT

✻ ALL SPACING SIGNALS ON 3A TELEPRINTER WILL CAUSE PAPER TO FEED.
" " " " 7A " PAPER WILL NOT FEED.

VARIOUS 5 UNIT ALPHABETS.

FIG. 2.

(2) *The Keyboard.*

The Teleprinter 3A and 7A keyboards are illustrated in Figs. 3 and 4.

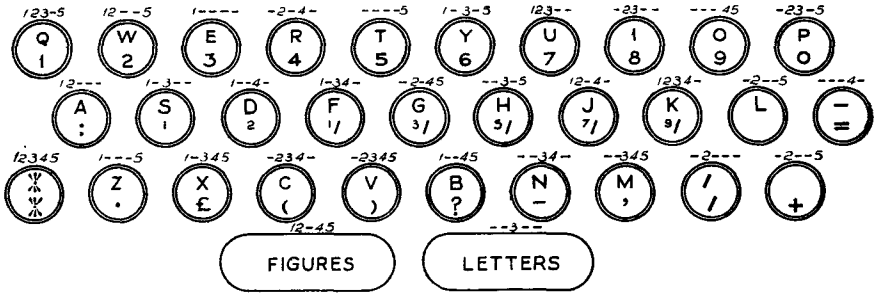


FIG. 3. TELEPRINTER 3A.

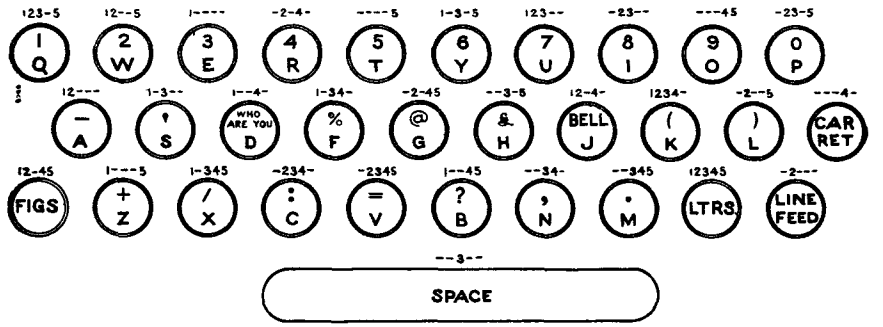


FIG. 4. TELEPRINTER 7A.

Most teleprinters use a three-row keyboard in which each key has a secondary character associated with it. Exceptionally in Germany a four-row keyboard is in use for the reason stated previously. It is unfortunate that the secondary characters in use on the 3A machine differ from those in use on the 7A, but this is the price paid for international agreement, together with the need for using column printing.

The 7A machine has only one space bar, whilst the figure and letter shifts are made with keys; in addition, two keys are used, one for carriage return and the other for line feed, or column. In the 3A machine two space bars are used, one for letter-space and the other for figure-space.

(i.) Depression of a key has to set up a code combination and start the transmission of this code as electrical impulses on the line.

(ii.) The key has to be locked or alternatively prevented from interfering with the transmission once this has commenced.

(iii.) The remaining keys have to be locked to prevent interference with the code being transmitted.

(iv.) The depressed key has to be released at the earliest possible moment in order to allow the next key to be depressed, and so avoid waste time between letters. The key release generally occurs on completion of the transmission of the fifth unit, and on the commencement of the transmission of the stop signal. In the case of Teleprinters 3A and 7A depression of a key lifts a pawl which in turn causes the engagement of a clutch which rotates the transmitting cam sleeve (see Fig. 5).

The cam makes one revolution in 1/392 minute in the case of the 3A machine, and 1/400 of a minute in the case of the 7A.

The transmitting cam has to:—

(i.) Send out the start signal.

(ii.) According to the code combination of the key depressed allow the code bars representing the " marking " units to drop back, the bars representing the " spacing " units being held by the depressed key. This sets up the code to be transmitted.

(iii.) Lock up all the keys.

(iv.) At the end of the signal unlock the keys and release the depressed key after the transmission of the fifth code unit.

(v.) Restore the code bars to their normal position.

The depression of a key locks out the keys not depressed, but two or more keys can be depressed simultaneously, in which case the " spacing " or " start " elements will cancel the " marking " or " stop " elements where the two clash.

In the case of the Morkrum instrument (Teleprinter 2A), the type key is pressed into " V " slots in the code bars,

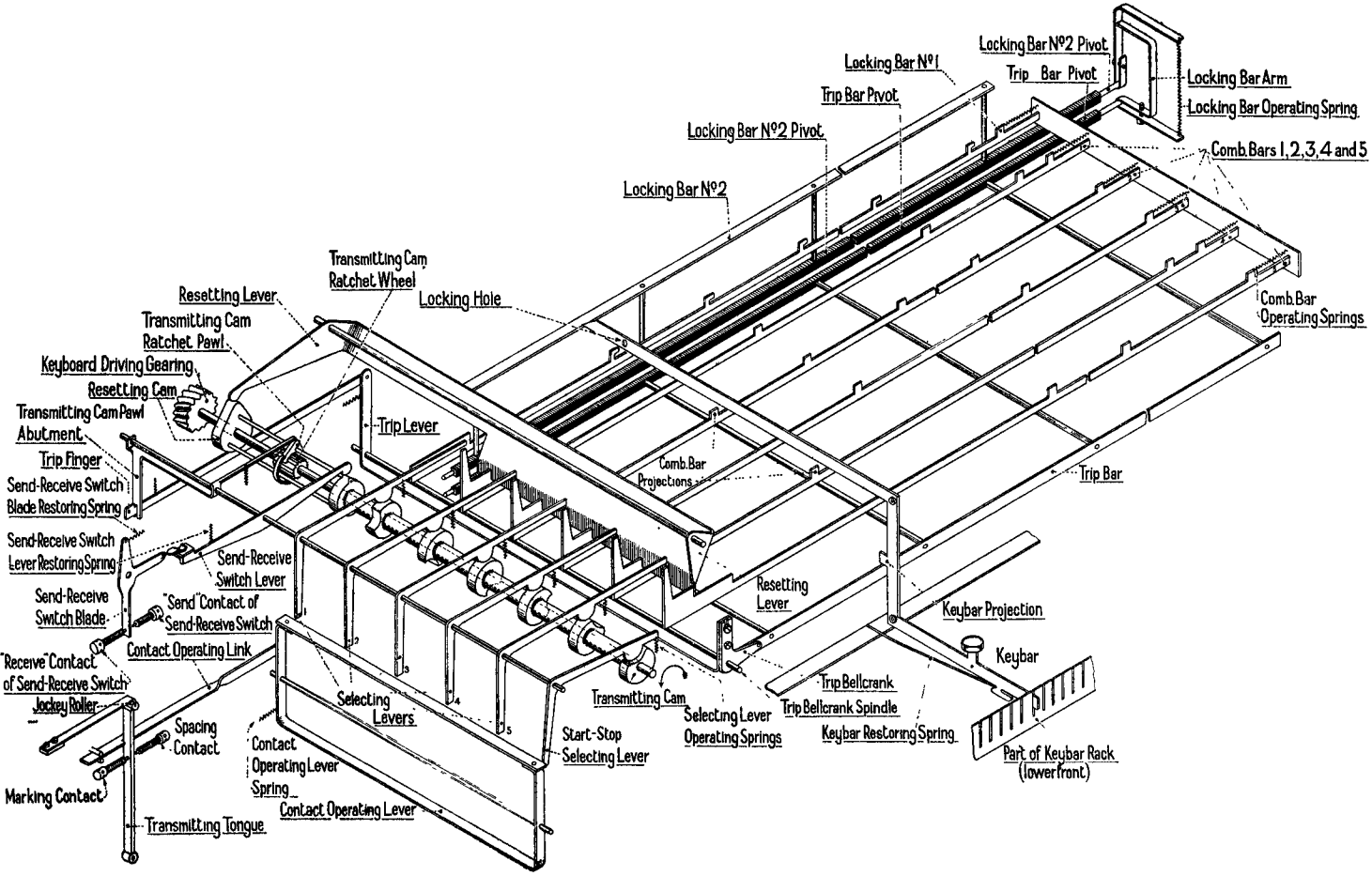

Locking Bar N°2 Pivot
Locking Bar N°1
Trip Bar Pivot
Trip Bar Pivot
Locking Bar Arm
Locking Bar Operating Spring
Locking Bar N°2 Pivot
Comb. Bars 1, 2, 3, 4 and 5
Locking Bar N°2
Transmitting Cam Ratchet Wheel
Resetting Lever
Locking Hole
Comb. Bar Operating Springs
Transmitting Cam Ratchet Pawl
Keyboard Driving Gearing
Resetting Cam
Transmitting Cam Pawl Abutment
Trip Lever
Trip Finger
Send-Receive Switch Blade Restoring Spring
Comb. Bar Projections
Trip Bar
Send-Receive Switch Lever Restoring Spring
Send-Receive Switch Lever
Send-Receive Switch Blade
Send Contact of Send-Receive Switch
Resetting Lever
Keybar Projection
Keybar
Receive Contact of Send-Receive Switch
Contact Operating Link
Jockey Roller
Selecting Levers
Transmitting Cam
Trip Bellcrank
Trip Bellcrank Spindle
Selecting Lever Operating Springs
Keybar Restoring Spring
Spacing Contact
Contact Operating Lever Spring
Start-Stop Selecting Lever
Part of Keybar Rack (lower front)
Marking Contact
Contact Operating Lever
Transmitting Tongue

FIG. 5.

moving them directly into the position for transmitting the code. Two keys cannot be depressed simultaneously as the " V " slots would not register.

(3) *The transmitting unit.*

Creed teleprinters are normally worked with double current both for transmitting and receiving, the reception being on a polarised electro-magnet. These machines can also be used, if required, transmitting single current on the closed or open system. The receiving mechanism can also be arranged to work in a similar manner by adding a biassing spring to the electro-magnet.

The transmitter in the case of the Creed instruments consists of a tongue or armature connected to the line and normally resting against a contact connected to a negative battery which will send out a " stop " or " marking " condition. The tongue is pushed over to a second contact stop connected to a positive battery, by the transmitting mechanism, so as to send out the " start " signal or the " spacing " code elements. The timing of the tongue operations is governed by the transmitting cam sleeve and the speed of the driving mechanism of the teleprinter. A jockey roller holds the tongue in positive contact with either contact stop. The contact positions are adjustable as also is the position of the jockey roller.

The possibility exists of the transmitter being maladjusted, so that the signals sent out are imperfect in respect to bias, or even breaks in the signals can occur, or other irregularities in its operation. In order to overcome these defects a suggestion has been put forward by one of the Post Office Engineering Department Research Section Staff. The five code bars are used to set up the code combination electrically on five change-over spring contacts, the signals being sent from a rotating brush or wiper connected to the line and sweeping over segments of a ring to pick up the " start," five code elements, and the " stop " signal. The negative pole of the battery is connected to the stop segment and the positive pole to the start segment, the battery connected to the five code elements being governed by the five change-over springs. An experimental model of this arrangement has been made and attached to a 7A Teleprinter and is now under trial. As the segments of the ring are fixed in length no lengthening or shortening of the elementary signals should be possible, and

so long as the wiper brush and the segments are clean, perfect signals should be sent out.

The Morkrum and the Siemens instruments use closed loop working, the circuit being made through the transmitting contacts and current normally flowing. The contacts break to produce the " start," signal, and " spacing " code elements. The receiving electro-magnet, which is non-polarised, is usually connected in series with the transmitting contacts, the operated position being the " stop " condition and the released condition being the " start " or spacing element position. In this manner a local record is conveniently produced.

Where double current working is required in the line transmitting and receiving relays are necessary in order to make the conversion from double to single current and vice versa, but these relays need not necessarily be near the teleprinter.

In some cases where double current simplex working is used with Creed teleprinters an automatic " send-receive " switch is connected in the teleprinter to cut off the transmitting battery when the machine is not sending in order to place the machine in a position to receive signals. In most of the circuits used by the Post Office this switch is not required, although it has been incorporated in the instrument.

The Creed teleprinter transmitter can be converted for single current open or closed working by the omission of the wire to one or other of the battery contacts.

(4) *The Receiving Unit. Signal Distortion and Margin.*

The receiving unit has to:—

(i.) Start the receiving mechanism on receipt of the " start " signal code element.

(ii.) Select and store the five-unit code signal received. This can either be done mechanically or electrically; so far most machines have done it mechanically.

(iii.) Stop the mechanism after the five-element code signal has been received until the next " start " signal comes in.

(iv.) Pass on the stored code signal to the printing unit for translation and printing.

On the whole, the operations are very similar in all teleprinters, though the means of carrying out the operations may be very different in different makes of machine.

The " start " signal operates the electro-magnet and trips some form of pawl, which in turn operates a clutch either of the friction or ratchet type, which in turn drives the selecting mechanism.

The selection of the code elements is governed by the position of the electro-magnet armature at the moment selection is made. In order to allow as much margin as possible should the signal be distorted, the selection is made as far as possible in the centre of what would be a perfect incoming signal. When working at a speed of 50 Bauds or unit signals of 20 milli-seconds the selection should be made at 30, 50, 70, 90 and 110 milli-seconds after the commencement of the " start " signal. It will be seen that the absolute limit of distortion is reached when the " start " signal is displaced 25% or 5 milli-seconds in one direction and any of the code elements 25% or 5 milli-seconds in the reverse direction. The statement above assumes that the distortion is fortuitous and can come on all units indiscriminately.

This is equivalent to saying that with perfect code signals the " start " signal could be lengthened or shortened 50%, *i.e.*, by 10 milli-seconds, or, if a number of signals coming in over the line are observed any one of which may be the " start " signal, the sum of the difference of the times of the earliest signal and its correct time and the latest signal and its correct time must be less than the unit signal of 20 milli-seconds. In practice the allowable distortion is considerably less than this. Allowance has to be made, firstly, for the fact that the selection is not instantaneous; secondly, mechanical differences (in particular adjustment settings) exist between machine and machine; thirdly, in the case of the Creed instruments, which use a ratchet clutch, an allowance must be made for the operation of the pawl just missing a tooth. There are 30 teeth and two pawls, or the equivalent of 60 teeth in the receiving shaft, which makes one revolution in 140 milli-seconds; so that a variation of 140/60 or 2.34 milli-seconds is possible; this is 11.6% of the unit signal element. 11.6 distortion is equivalent to the " start " signal being 5.8% early or late. In addition, if all machines are kept within 1% of their correct speed there is a possibility of a speed difference between the

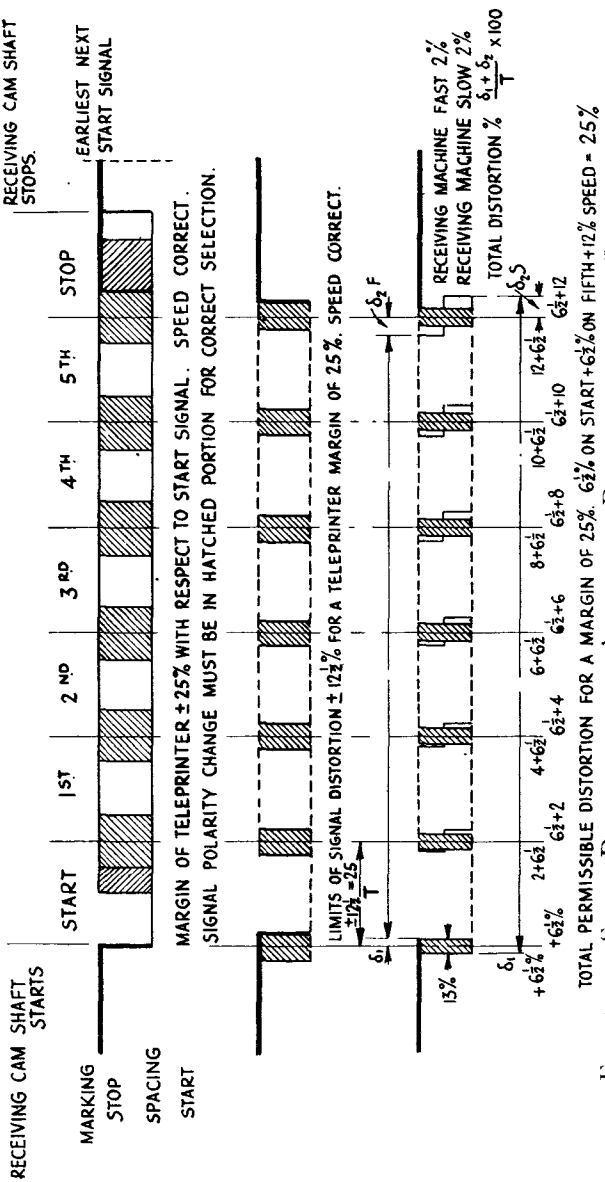
sending and receiving machines of 2%. This means a difference on the middle of the fifth unit of 2.2 milli-seconds at 110 milli-seconds after the start, which may be early or late, depending on which machine is fast. 2.2 milli-seconds is 11% of the unit signal. If the speed differences are less, then the 11% may be reduced in proportion. It will be seen that with a perfect mechanical adjustment and a 2% speed difference the allowable theoretical distortion has been reduced from plus and minus 50% on the " start " signal to 50, less 11 for speed and less 5.8, say 6, for the clutch, to 33% approximately.

In practice, with perfect signals and correct speed, an average teleprinter can be adjusted to take a " start " signal lengthened or shortened by 30%. This presupposes a suitable local circuit and voltage operating on the electro-magnets. Should the voltage be low and the resistance in the circuit high, a lower figure will be obtained. The optimum voltage appears to be about 80 plus and minus in series with a shunted condenser with a steady current of about 20 milli-amperes, the voltage and current values are not critical and may be varied between fairly wide limits.

In the case of the Morkrum teleprinter the clutch is of the friction type and there is a non-polarised electro-magnet with a spring with adjustable tension. It is also possible to alter the selection points in the signals with respect to the start. This provides so many variables that it is difficult to quote an exact figure for margin.

The maximum margin in a 3A or 7A Teleprinter can be taken as plus or minus 35%, or an average working figure of plus and minus 25%. This would allow a total distortion on the incoming signals of 25%, *i.e.*, the start signal can be $12\frac{1}{2}$% early or late and the code units $12\frac{1}{2}$% early and late. Fig. 6 illustrates this. If, however, a speed difference exists between two machines of 2%, that is, all machines being kept within 1% of a standard speed, then about 11% has to be deducted from the available margin of 25%. 25% less 11% leaves 14% margin, which can be regarded as distortion divided between the " start " signal and the code elements; thus any element including the start may be 7% early or late, or a total distortion of only 14% is permissible. It follows that a speed difference between the two machines of 2% has reduced the allowable signal distortion in the circuit from 25% to 14%.

It can be deduced from the above that the greater the distortion in a circuit the closer must the speeds of machines be



EFFECT OF SPEED DIFFERENCES ON ALLOWABLE DISTORTION OF THE SIGNALS FOR A MARGIN OF ± 25% ON TELEPRINTER.

FIG. 6.

adjusted. Two machines working together over a circuit may be more closely adjusted for speed difference than any two of a number of machines which may be connected together

indiscriminately by some form of switching service such as "Telex." In the case of switched connections the distortion must be less or the speeds more accurately adjusted to a standard than two machines working together over a fixed circuit.

A point to notice in connection with reception is that even when the transmitting teleprinter is running fast and the receiving teleprinter slow, the receiving shaft must be at a standstill when the following "start" signal comes in. If this is not so there will be a loss of margin on the signals. It follows, therefore, that the receiving shaft must complete its revolution in a shorter time than the transmitting shaft. In the Creed 7A and 3A Teleprinters the transmitting shaft makes one revolution for 7.5 signal elements and the receiving shaft one revolution for 7 signal elements. In the case of the Morkrum and Siemens machines the transmitting shaft makes one revolution for 7 unit signals. The Morkrum instrument makes one revolution in the time of about 6.5 signal units, and the Siemens in about the time of 6 units but with a delayed start of about half a unit, so that in both cases the effective time of one revolution is 6.5 units. Where the receiving mechanism is brought to rest in 6.5 units there is a possibility of the instrument failing to stop if the fifth code element is late and also "spacing" polarity, but in this case the margin would be so small that probably the fourth and fifth code elements would fail to select correctly.

The receiving shaft running faster than the transmitting shaft is one of the essential features of a teleprinter.

Fig. 7 shows the selecting mechanism of a Teleprinter 7A.

(5) *The Translating and Printing Units.*

The function of the translating unit is to take the five-unit code selection set up by the receiving mechanism and translate it into one of the 32 possible code combinations suitable for selecting the letter or character to be printed.

The printing unit has to print the desired character either on a tape or alternatively on a roll of paper.

In certain characters are included such operations as

"Bell."
"Space."
"Letters."
"Figures."

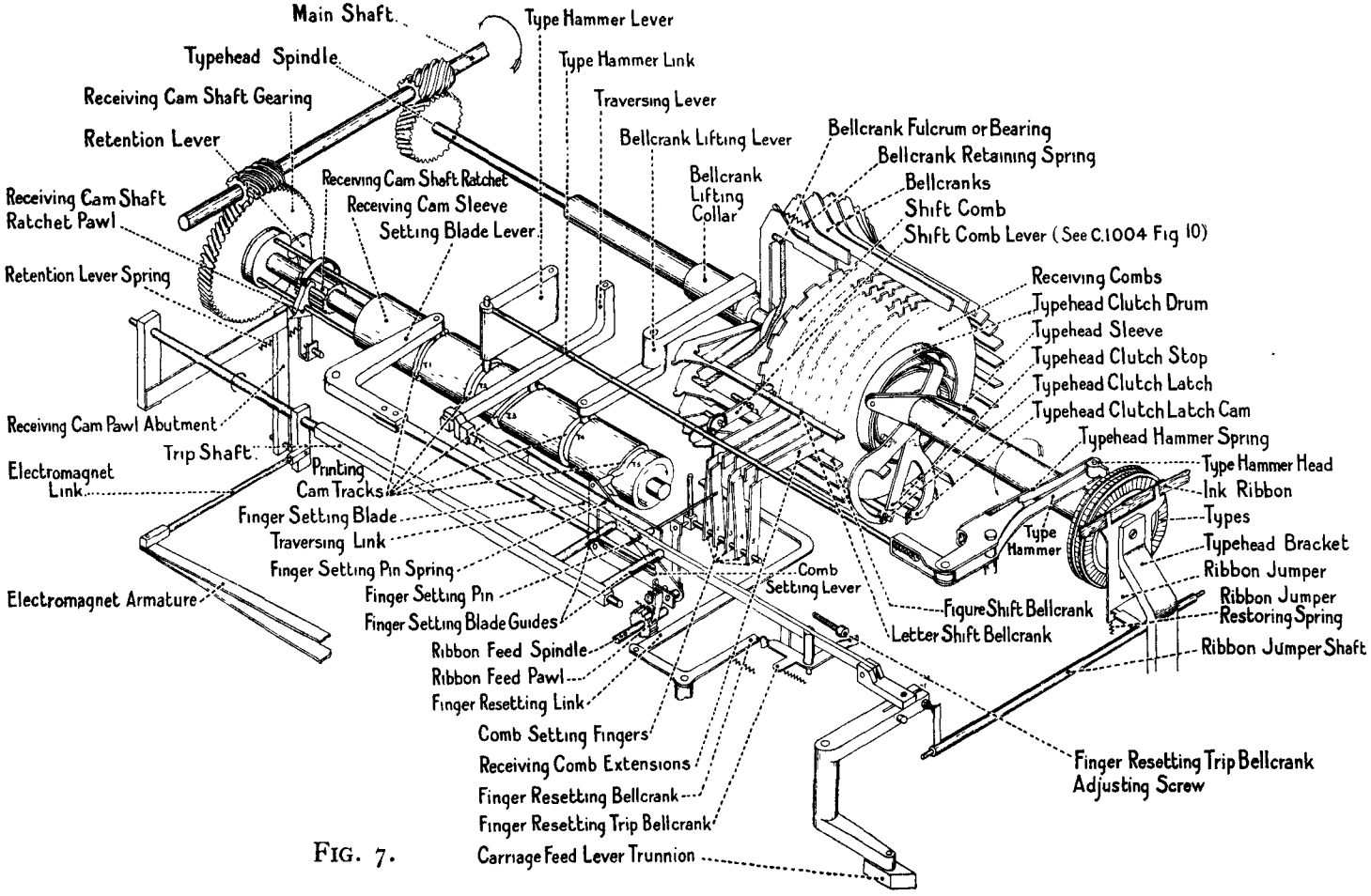

Main Shaft
Type Hammer Lever
Typehead Spindle
Type Hammer Link
Receiving Cam Shaft Gearing
Traversing Lever
Retention Lever
Bellcrank Lifting Lever
Bellcrank Fulcrum or Bearing
Bellcrank Retaining Spring
Receiving Cam Shaft Ratchet
Bellcrank Lifting Collar
Bellcranks
Receiving Cam Shaft Ratchet Pawl
Receiving Cam Sleeve
Shift Comb
Setting Blade Lever
Shift Comb Lever (See C.1004 Fig 10)
Retention Lever Spring
Receiving Combs
Typehead Clutch Drum
Typehead Sleeve
Typehead Clutch Stop
Typehead Clutch Latch
Typehead Clutch Latch Cam
Receiving Cam Pawl Abutment
Typehead Hammer Spring
Trip Shaft
Type Hammer Head
Printing Cam Tracks
Ink Ribbon
Electromagnet Link
Types
Finger Setting Blade
Typehead Bracket
Traversing Link
Type Hammer
Ribbon Jumper
Finger Setting Pin Spring
Comb Setting Lever
Ribbon Jumper Restoring Spring
Finger Setting Pin
Figure Shift Bellcrank
Electromagnet Armature
Finger Setting Blade Guides
Letter Shift Bellcrank
Ribbon Jumper Shaft
Ribbon Feed Spindle
Ribbon Feed Pawl
Finger Resetting Link
Comb Setting Fingers
Finger Resetting Trip Bellcrank Adjusting Screw
Receiving Comb Extensions
Finger Resetting Bellcrank
Finger Resetting Trip Bellcrank
Carriage Feed Lever Trunnion

FIG. 7.

" Carriage return."
" Line feed " or " Column."

The latter two operations are special to column printers. The above six operations do not require printing to take place and, except for the second, do not require the paper or tape to be stepped forward as when printing takes place. The translating and printing mechanism arrange for the above operations taking place.

There are two ranges on the teleprinter keys, primary characters or letters, and secondary characters which include figures. " Letters " once selected must remain so until a " figures " signal comes in and changes the printing to the secondary characters and vice versa.

Translation may be accomplished in several ways both mechanical and electrical; the principles underlying two mechanical and the two corresponding electrical methods will now be described. It may be pointed out that up to now mechanical methods have been favoured by makers of teleprinters.

The principle of mechanical translation will be best understood by regarding the mechanism as a kind of locking frame as used in railway signalling. Fig. 8 shows five long bars with notches cut in each bar lying parallel to one another, each bar corresponding to a unit of the five unit code. A sixth bar lies alongside corresponding to letters and figures. Across these six bars are laid 64 bars or latches, each bar or latch corresponding to a letter or character to be printed or an operation to be performed.

The unit code signal coming in is arranged to shift the corresponding code bar one notch to the right if of " marking " polarity, but to let the bar remain in position if of " spacing " polarity. Code bar one is cut so that latches 1-32 may fall into the slots if the bar is displaced and 33-64 if it remains in position. The other bars are arranged as in the figure. The " figures-letters " bar if displaced allows the " odd " latches to drop and if not displaced the " even." One latch and one latch only will drop, no matter what the selections set up on the code bars are. In practice the arrangement is slightly modified. For the operations " line feed," " carriage return," " space," " letters," " figures," which are required irrespective of the position of the sixth " letters-figures " code bar (for the purpose of Fig. 8 it is assumed that the first ten latches are referred to) blanks may be cut in the sixth bar to allow all ten latches to drop irrespective of the setting of this

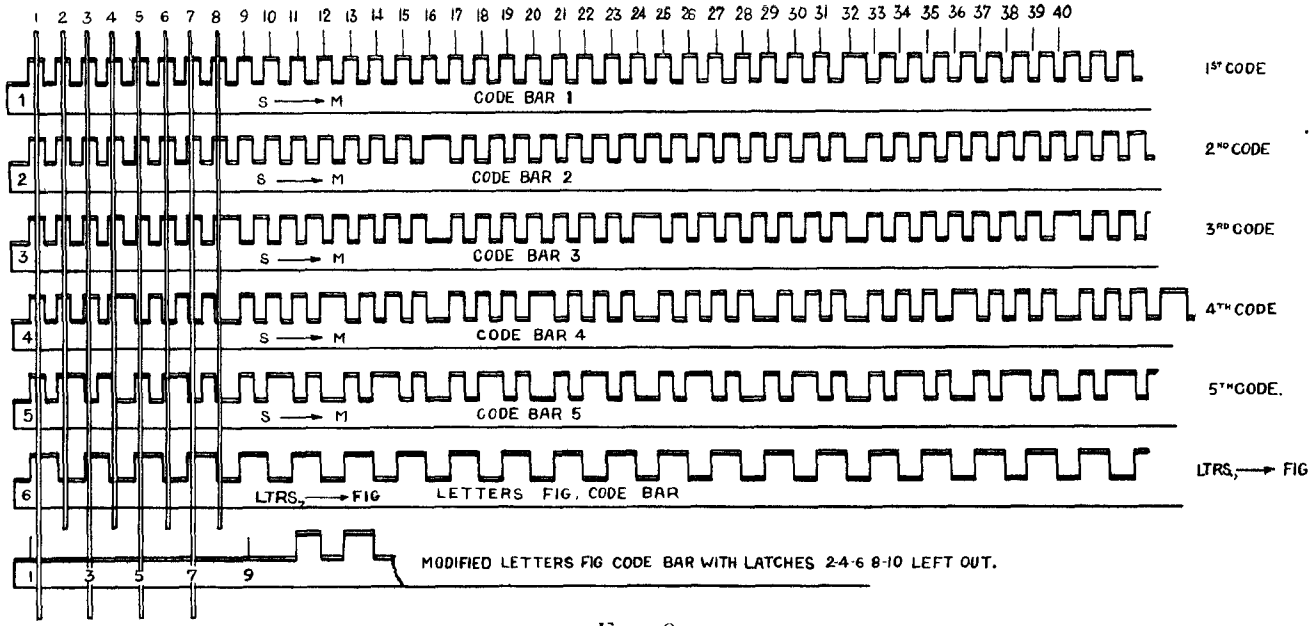

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
1
S → M
CODE BAR 1
1ST CODE
2
S → M
CODE BAR 2
2ND CODE
3
S → M
CODE BAR 3
3RD CODE
4
S → M
CODE BAR 4
4TH CODE
5
S → M
CODE BAR 5
5TH CODE.
6
LTRS.,→ FIG
LETTERS FIG. CODE BAR
LTRS.,→ FIG
1 3 5 7 9
MODIFIED LETTERS FIG CODE BAR WITH LATCHES 2-4-6 8-10 LEFT OUT.

FIG. 8.

bar, and the even (or alternatively the odd) latches may be left out. When the figures latch is dropped the sixth bar must be displaced from normal and remain so until the next time the letters latch is dropped, when the bar must be restored to its normal position and remain until the next time the figures latch is dropped. In order to allow the code bars to be shifted some arrangement such as a seventh bar must be provided to lift all the latches clear of the code bars in order to allow of their being reset, after which the seventh bar can be moved so as to allow the selected latch to drop in.

The above principle is used on Teleprinters 3A and 7A, but instead of long code bars discs are used with notches cut on their circumference, the bell cranks corresponding to the latches (see Fig. 9).

Another possible method which could be used would be to have the latches on the circumference of a circle and have a rotating member driven possibly by a friction clutch, the rotating member carrying the typehead being stopped by a dropped latch.

For the first code unit latch 1 would be down for " marking," but for " spacing " latch 33 would be lowered before 1 was lifted. The rotating member would travel to 33 and be stopped there. The second code unit would operate latches 17 and 49 and release 1 and 33 if " spacing," but perform no operation if " marking," the rotating member would therefore stop on 17 if the first unit was " marking " and on 49 if " spacing," the second unit being " spacing." If the second unit had been " marking " the rotating member would then have been either at 1 or 33. The third code unit if " marking " would perform no operation, but if " spacing " would drop latches at 9, 25, 41 and 57, as well as lift any previously dropped latches. The fourth and fith code units would operate in a similar manner. By this means the rotating member could be brought to a definite stop position. The above method is similar to that employed in the latest automatic telephone systems using uniselectors, where the switch rotates to one of ten positions, stops and goes on to find a spare junction to the next switch. The method is not, however, a good one when applied in the manner described above, as the rotating member would have been brought to rest several times in selecting a letter, probably causing excessive wear and tear. There are two electrical methods corresponding to the two mechanical methods outlined above. In the

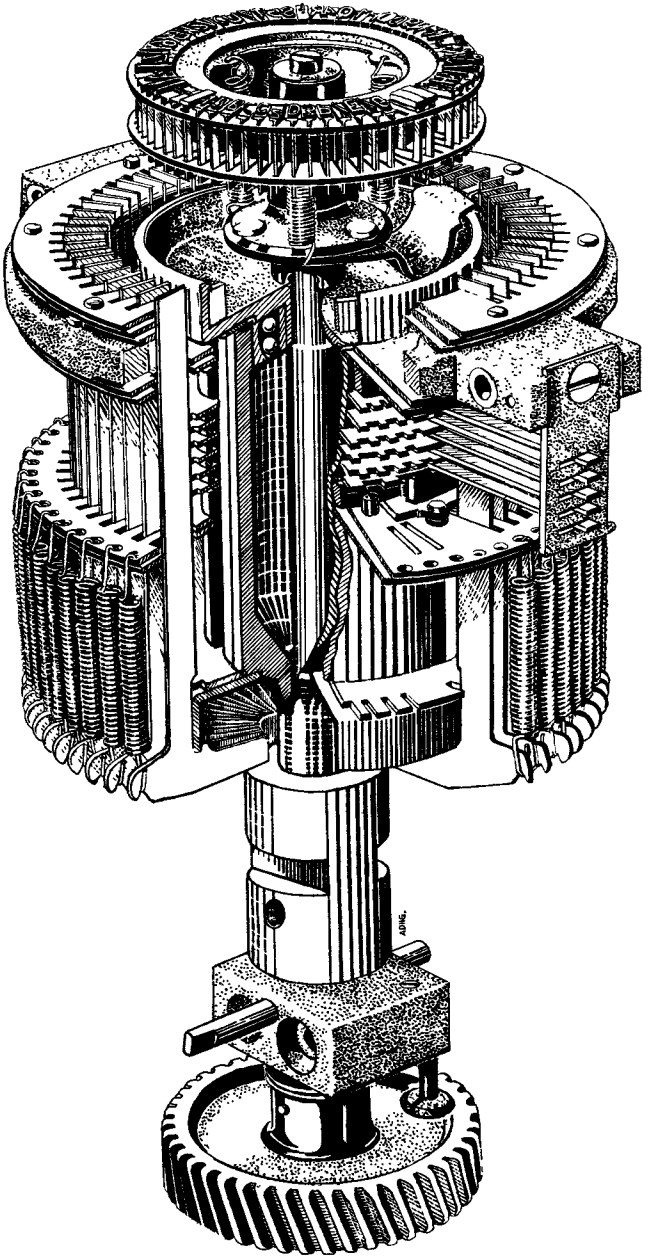
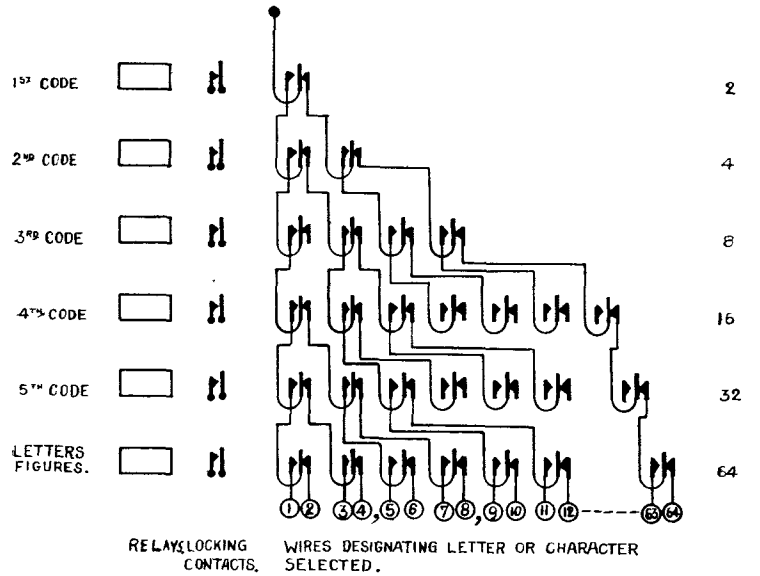


FIG. 9.

first (Fig. 10) the five code combinations can be designated by the normal or operated condition of five relays of the telephone type fitted with a multiplicity of springs so that a circuit can be completed to one of 32 contacts designating the

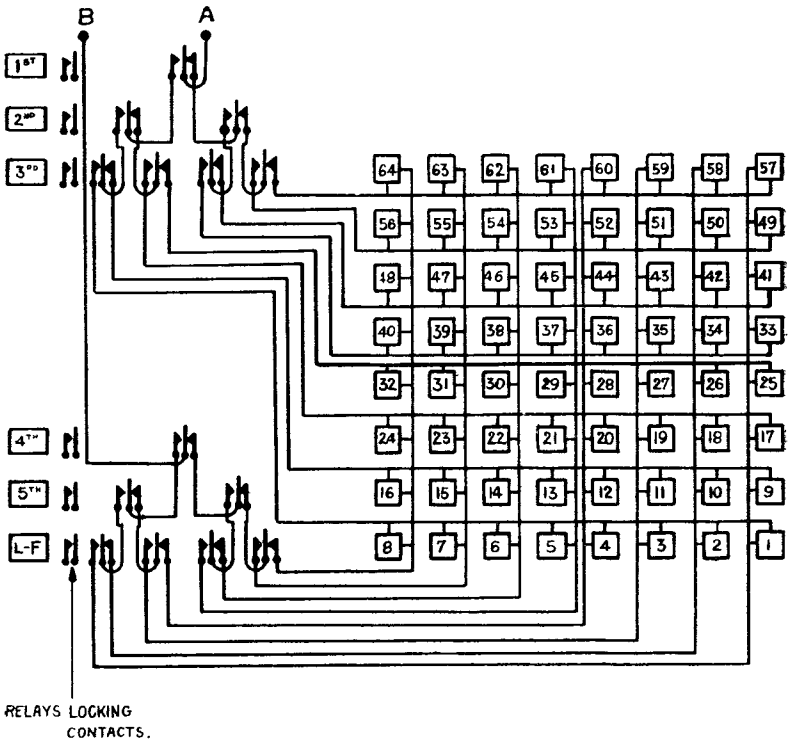


TRANSLATION BY SIX CODE RELAYS.

FIG. 10.

required character. Letters or figures are selected by a sixth relay completing the circuit to 64 contacts or electro-magnets, or the equivalent. The electro-magnets would choose or designate the letter or character to be printed. It might be thought that 32 moving springs would be required on the figures-letters relay, but by a suitable rearrangement of the circuit (see Fig. 11) it will be seen that no relay need have more than five moving springs, the fifth being required for a locking circuit.

The second method of electrical translation (Fig. 12) corresponding to the second mechanical method would be to have a single motion switch or uniselector such as is used in automatic telephony, but fitted with 64 bank contacts or some equivalent arrangement. The contacts on the banks would



ILLUSTRATING METHOD OF CHOOSING ONE OF 64 RELAY COILS BY MEANS OF THE SETTING AND LOCKING OF SIX RELAYS, NO RELAY HAVING MORE THAN 5 MOVING SPRINGS.

FIG. 11.

be "marked" by the operation of five code relays and a sixth letters-figures relay. The rotating brushes passing over the contacts complete an electrical circuit when the selected contact is reached. This circuit can be used to stop the rotation of the brushes and designate the character to be printed. A similar method to this is used in the printer of the Siemens high-speed telegraph instrument.

The two types of selection have been mentioned to bring out the point that the first of each type takes a constant or fixed time to function, that is, the time taken is the same for all letters or characters selected. In the second of each

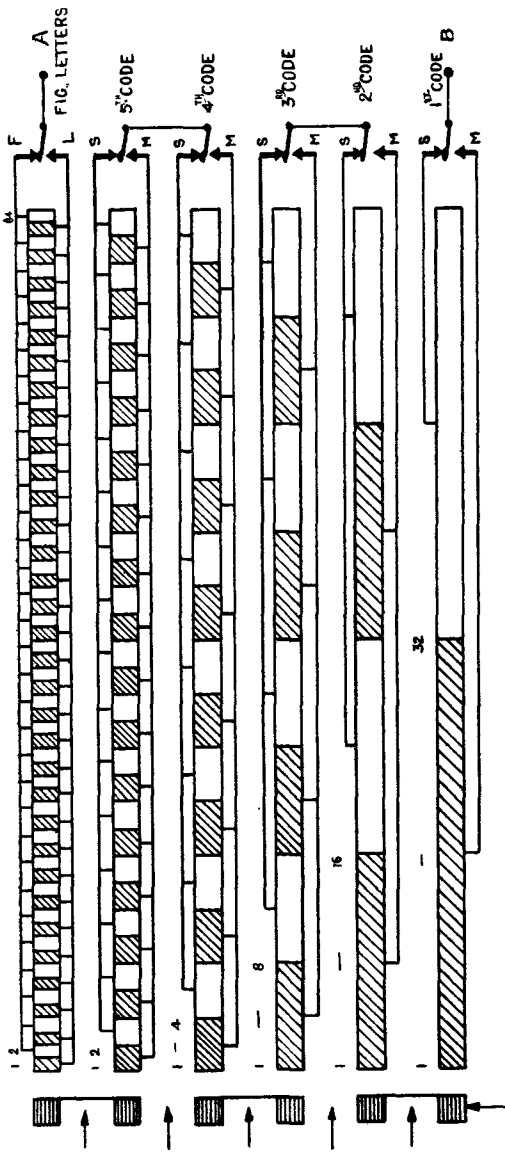


FIG. 12.

type the time of operation depends on the particular letter or character selected, the selection operation thus requiring a time period which is variable.

In the case of the Creed teleprinters the translation is a constant time function, but the setting of the typehead in position is a variable time function. Referring to Fig. 7, the striker blade or finger-setting blade sets up the combination on the five comb setting fingers. The combination is then transferred to the five receiving combs by the receiving comb extensions, a bell crank is dropped in accordance with the code set up and the typehead clutch rotates until stopped by the extremity of the bell crank. The time of the setting or stopping of the type head is thus dependent on the amount it has to rotate.

Printing.—Printing may be performed by means of a type wheel, type head or type bars. The type head may be looked upon as a set of revolving type bars. Much controversy has raged over the relative merits of type wheel or type head versus type bar operation; each method has advantages as well as disadvantages. The type wheel or type head has to be turned an amount varying with the character to be printed, and the last character printed, and to this extent the operation takes a variable time to perform. Type bar operation is similar to the operation of a normal typewriter, the striking of any key should take the same time as the striking of any other key, and should therefore be better; on the other hand, type bars take up more space. It is interesting to note that the Morkrum Company in America are using a type wheel with a selecting and translating system similar to that used by Creed for a high-speed stock ticker printing on tape.

The Creed Teleprinters use a type head rotated by a friction clutch and brought to a standstill at the correct position by the bell crank which has been dropped by the translating mechanism. In the Siemens and Morkrum machines the type is selected directly by the code bars. In the Creed machine therefore the time to get the type in position varies with the last letter and the letter to be printed. Whilst in the Siemens and Morkrum machines the operation takes a constant time. In the Creed machine the printing is operated from the same cam as the selection, the first letter being printed as the second is being selected, thus one letter or character is always stored in the machine. In the case of the other two machines the printing is done from a second cam set in motion and following on from the selection, no letter being stored.

In some machines the tape is brought into contact with

the type for printing, in others the type strikes the tape. In the case of column printers the carriage may move with or without holding the roll of paper, or, as an alternative, the type printing mechanism may move, the paper carriage being fixed in position and the paper alone being unrolled.

(6) *Methods of Inking.*

Inking the type may be performed by means of a felt roller impregnated with ink rolling in contact with the type wheel or type head. As a preferable alternative it may be done by means of a ribbon, as in the majority of modern typewriters. The type of a type head or type bar machine strikes the paper or tape through the ribbon. Mechanism is provided for feeding the ribbon forward at each printing operation and also reversing the direction of winding when one ribbon spool is empty and the other full.

(7) *Special Features of the Teleprinter 7A.*

Automatic Motor Starting and Stopping Switch.—On receipt of the first signal the operation of the electro-magnet causes a switch to close, completing the motor circuit and starting up the teleprinter. If no signal is received for about one and a half minutes a mechanism will in this time have been wound up and the motor circuit opened at the starting switch.

Answer Back Device.—In any switching system it is always desirable to know if the connection is established to the desired station and also, in the case of teleprinters, whether the distant machine is in operation, especially if it is unattended; this applies not only to switched connections but also to permanent connections such as may be set up over a private wire circuit. The answer back device is set in operation by sending the " figure " shift signal and then holding down the " D " key; this signal reaching the teleprinter at the distant end of the circuit sets in operation the " answer back " device on the distant teleprinter, which proceeds to send back the first three letters of its exchange code and four-figure telephone number. It will be appreciated that if the motor of the distant machine is not running, or if the circuit is disconnected, this operation will not take place. This facility cannot be made available if there is more than one teleprinter receiving the message, as in that case all the instruments would try to answer at once.

Fig. 13 shows the arrangement of the words on the "answer back" device drum. It will be noticed that the transmission commences with two letter shift signals. The reason for this is as follows:—

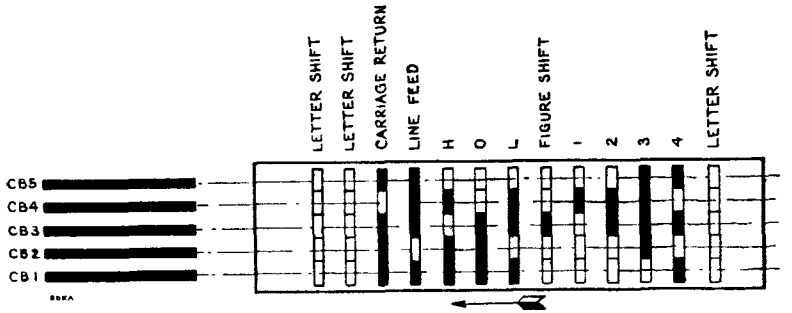


FIG. 13.

Originally only one letter shift signal was provided and a space between the exchange code and the figures. Where "Telex" calls have to be made over long distance trunk lines fitted with echo suppressors it was found necessary to allow more time before the signal was sent back from the distant end. The "who are you" signal operates the echo suppressor and renders the return speech path inoperative for a short interval in order to prevent an echo circulating round and round a high efficiency four-wire circuit. Time has to be allowed for the suppressor to restore. The time is given by the first letter shift signal; it will be noticed that the letter shift signal contains only one spacing element, the start, if this gets through a letter shift signal is recorded, if it does not get through there are no other spacing elements to give a false start. 300 cycle a second tone is only sent for spacing elements. The 150 milli-seconds of the first letter shift signal provides the necessary delay to allow the second signal to get through.

Where there are more than four figures in the exchange number, as in Newcastle and Leeds, then the exchange code is cut down to two letters. As an alternative, firms are permitted to use their name up to a maximum of eight letters.

(8) *Notes on Power Supplies.*

The teleprinter being driven by an electric motor presupposes that a supply of electricity is available where the

teleprinter is to be installed. Several cases have occurred where teleprinters were required in telegraph offices but no public electricity supply has been available in the town in question. It has been necessary to install a private plant similar to that used for country house lighting, with petrol engine and secondary cells. Where a public supply is available it is either direct or alternating; in the first case the supply is generally some voltage between 200 and 250 and in some cases between 100 and 120. Where the supply is alternating the voltage is generally in the range of 200 to 250 volts, and exceptionally in the range 100 to 120 volts; although the frequency usually met with is 50 cycles per second, frequencies of 25, 40, 85 and 100 also exist. No doubt in time the Central Electricity Board's standardisation proposals will gradually eliminate non-standard voltages and frequencies other than 50, at the moment the position has to be accepted as it is. In the case of direct current, voltages of 50, 80 and 150 have been met with exceptionally. From the point of standardising one type of teleprinter motor the position is most unsatisfactory. At present teleprinters are supplied with direct current motors with the following ranges: 100 to 120 volts, 200 to 220 volts, 230 to 250 volts.

In the case of alternating current supply a rectifier is used with a motor in the 110 volt to 120 volt D.C. range.

(9) *The Power Unit comprising the Motor and Governor.*

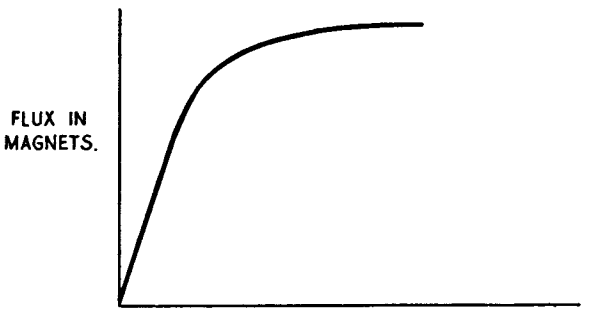
The power unit in a teleprinter consists of a motor, together with a governor to keep the speed constant. In addition, an automatic switch is sometimes provided to start the teleprinter automatically on receipt of the first signal and also to stop the machine if no signals have been coming in for a specified time, generally a minute and a half. This has already been mentioned under special features.

Direct current motors are of two general types, the first, in which the magnet winding is connected in parallel with the armature and known as a shunt wound motor, and the type where the magnet winding is connected in series with the armature and known as a series wound motor. Other types exist, such as the compound wound machine where the magnet has two windings, one in series and one in parallel with the armature.

Constant and correct speed is the primary consideration in teleprinters; freedom from vibration, noise, sparking, heat-

ing, and ability to run for a long time with a minimum of attention are also desirable qualities.

It will be desirable to consider the characteristics of the two types of motor mentioned above. The torque or twisting moment produced between the armature and magnets is due to the interaction of the flux from the magnets and the flux produced by the current in the armature. These fluxes in a two-pole machine are approximately at right angles in space, the commutator keeping the armature flux fixed in position whilst the armature rotates. The flux produced by the magnets is a function of the current flowing in the magnet coils (Fig. 14). With no current there is usually a small residual flux; for small currents the flux is proportional to the current, and as the current increases the flux tends to a saturation value.



MAGNETIC FLUX RELATED TO MAGNETISING CURRENT.

FIG. 14.

The armature flux is approximately proportional to the armature current. Shifting the brush position so that the armature and magnet fluxes are not at right angles in position will in one case cause part of the armature flux to add to the magnet flux, a shift of the brushes in the opposite direction will cause the magnet flux to be diminished by the armature flux.

A motor will tend to run at such a speed that it generates a back electromotive force which will allow only the current required to produce the load torque to flow through the armature. Increase of load causes the armature to slow down, less

back E.M.F. is generated, and more current flows, producing the necessary increase in torque. Diminishing the strength of the magnet flux tends to increase the speed and increasing the magnet flux tends to reduce the speed. A shunt wound motor supplied from mains of constant voltage tends to run at an approximately constant speed, the speed increasing as the magnets warm up and increase in resistance. Increase in load generally results in a slightly reduced speed, this result can be modified by shifting the brushes.

With a series motor the speed falls as the load torque is increased, as both the armature current and magnet flux increase with the load.

An increase in the supply voltage will have little or no effect on a shunt motor with an unsaturated field. As, however, the field is in most cases partially saturated, an increase in speed may be looked for. In no case will the percentage increase in speed exceed the percentage increase in voltage. In the case of a series motor increase in the mains voltage will usually result in an increase in speed.

It might be thought that the shunt motor with its constant speed characteristics is vastly superior to the series motor; this superiority is lost in practice as the series motor has better starting characteristics and, secondly, the governor tends to help the series motor. When a teleprinter motor is switched on the full mains voltage is applied; in the case of the series motor the first rush of current flows through the armature and field circuits in series, producing a heavy torque and starting up the motor promptly. In the case of the shunt motor the field is shunted by the relatively low resistance armature, as a consequence the field is relatively weak, and the starting torque is produced by an excessive armature current. When shunt motors are run from rectifiers the large starting current is limited by the internal resistance of the rectifier, so the starting conditions are not so good as with a series motor, especially if the torque required at starting is great.

The governor fitted to teleprinter motors usually consists of some form of electrical contacts which are either opened or closed centrifugally by an increase of the motor speed. Governor contacts opening with increase of speed may be used to insert a resistance in series with the motor when the contacts are open. This tends to reduce the current and voltage supplied to the motor and therefore slow it down. Fig. 15

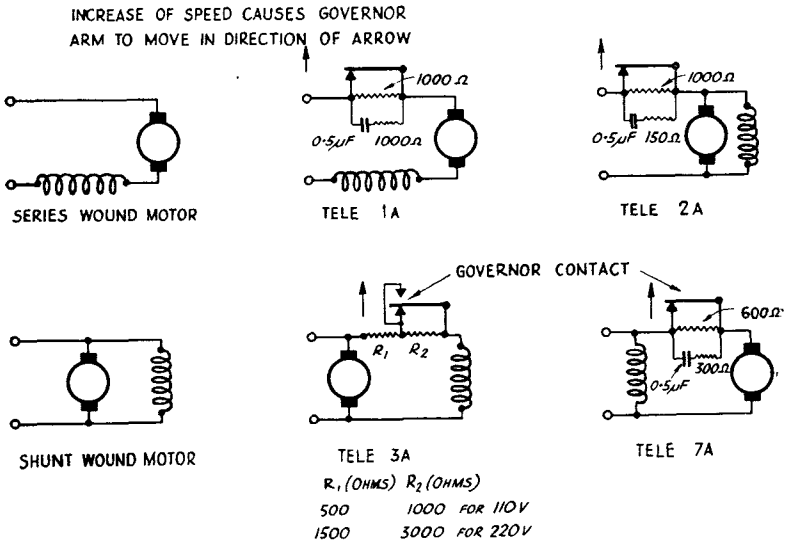


FIG. 15.

shows schematically the Teleprinter 1A fitted with a series motor rated at 1/40th B.H.P. as well as a Teleprinter 2A fitted with a shunt motor rated at 1/20th B.H.P.; the governor in both cases inserts a resistance of 1000 ohms in series with the motor and a condenser in series with a resistance is placed across the governor contacts to act as a spark quench. Teleprinter 3A is fitted with a shunt motor rated at 1/12th B.H.P. In this case the governor contacts close with increase of speed and short circuit a resistance in series with the shunt field, thus increasing the field current and tending to slow the machine. As the motor would have very bad starting characteristics with the weakened field, due to the added resistance, an auxiliary starting contact on the governor short circuits the field resistance until the motor has reached a minimum speed. In the case of the earlier series of motors fitted to 3A Teleprinters and generally marked with a speed of 1650 R.P.M., a fixed resistance of 1500 ohms for the 220 volt machines and 500 ohms for the 110 volt machines was inserted in series with the governing resistance of 3000 ohms (220 volts) or 1000 ohms (110 volts). In the later supplies of motors marked with the running speed of 2520 R.P.M. the motors are designed to run without this fixed resistance.

Teleprinters 7A are fitted wih shunt motors rated at 1/20th B.H.P., the running speed being 3000 R.P.M., the governor opens its contacts on increase of speed and adds a resistance of 600 ohms in series with the armature. In most cases some form of spark quench circuit is placed across the governor contacts.

Owing to the unsatisfactory running of a number of alternating current motors fitted to teleprinters, though it must be admitted that quite a number do run satisfactorily, rectifiers have been inserted between the supply and a 110 volt D.C. motor fitted to the teleprinter. Rectifiers have brought their own troubles, owing to their internal resistance the greater the load current the lower is the output voltage. Tappings are provided on the mains side of the transformer feeding the rectifier, so that the output may be adjusted to 110 volts; with the motor running a change of teleprinter may cause the output voltage to be either too low or too high. Variations in teleprinters and also in motor characteristics may make the motor load current as low as 0.4 amps., or as high as 0.8 amps.; if the rectifier has been adjusted for a low current output placing another machine in circuit drawing a large current will unduly lower the output voltage, and vice versa. This trouble may be overcome by changing the tapping on the rectifier when changing the teleprinter.

Although supply voltages are supposed to be kept within plus or minus 4% of the declared pressure, cases have been known where these limits have been greatly exceeded.* The only cure is to take the matter up with the Supply Authority, who are subject to a penalty if the above limits are exceeded. When extension of the National Electricity grid scheme links up all the supplies in the country, it may be possible to get a supply which is really 50 cycles. At the Post Office Engineering Department Research Station at Dollis Hill the frequency is within plus or minus 0.1 of a cycle of 50 or a range of 0.4%. A neat solution of the difficulties would be a self-starting synchronous motor to drive the teleprinter. No governor would be required. No brushes or commutator to maintain, constant speed, etc. Unfortunately, manufacturers so far have been unable to produce a motor with the required characteristics small enough in size to fit the Teleprinter 7A.†

† Since writing the paper a small synchronous motor has been developed. It appears satisfactory and is now on trial on a Teleprinter 7B.

* From 1st January, 1935, ± 6%. See Section 34, Electricity Regulations, 1934. H.M. Stationery Office.

PART III.—WHAT CAN A TELEPRINTER DO?

Teleprinters 3A used in the Inland Telegraph service are almost invariably worked blind duplex, that is, no record is made of the sent message at the transmitting end. Transmission is from the keyboard of each instrument to the printing mechanism of the instrument at the other end of the circuit. A typical circuit end is given in Fig. 16.

DIFFERENTIAL DUPLEX.

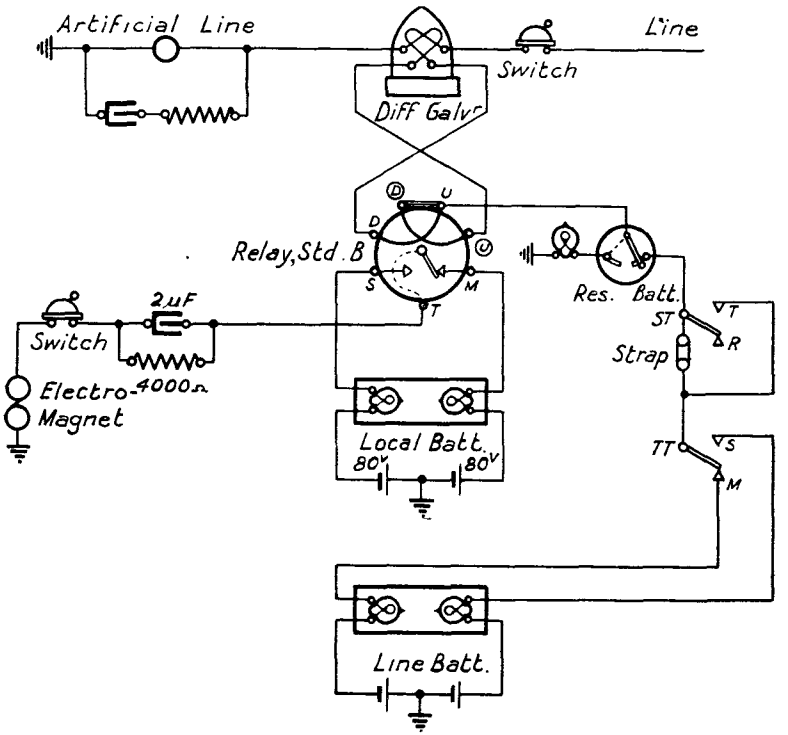
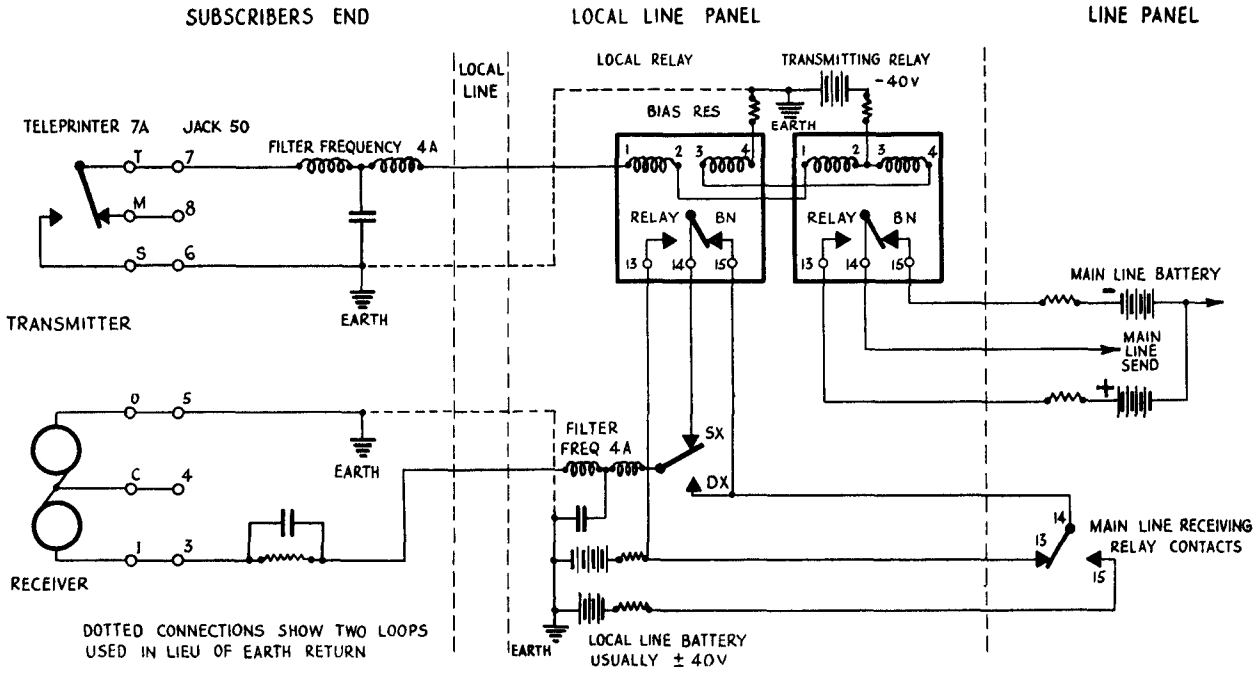


FIG. 16.

Teleprinters 7A used on private wire circuits are connected so that a local record is made at the transmitting end. Fig. 17 shows the principle of the " Tariff A " end where the battery supply for the renter's teleprinter comes from the main line terminal situated at a Post Office. Incoming signals from the distant end operate the main line receiving relay and send double current out over the " B " wire of a pair of wires



TERMINAL SCHEMATIC DIAGRAM.
FIG. 17.

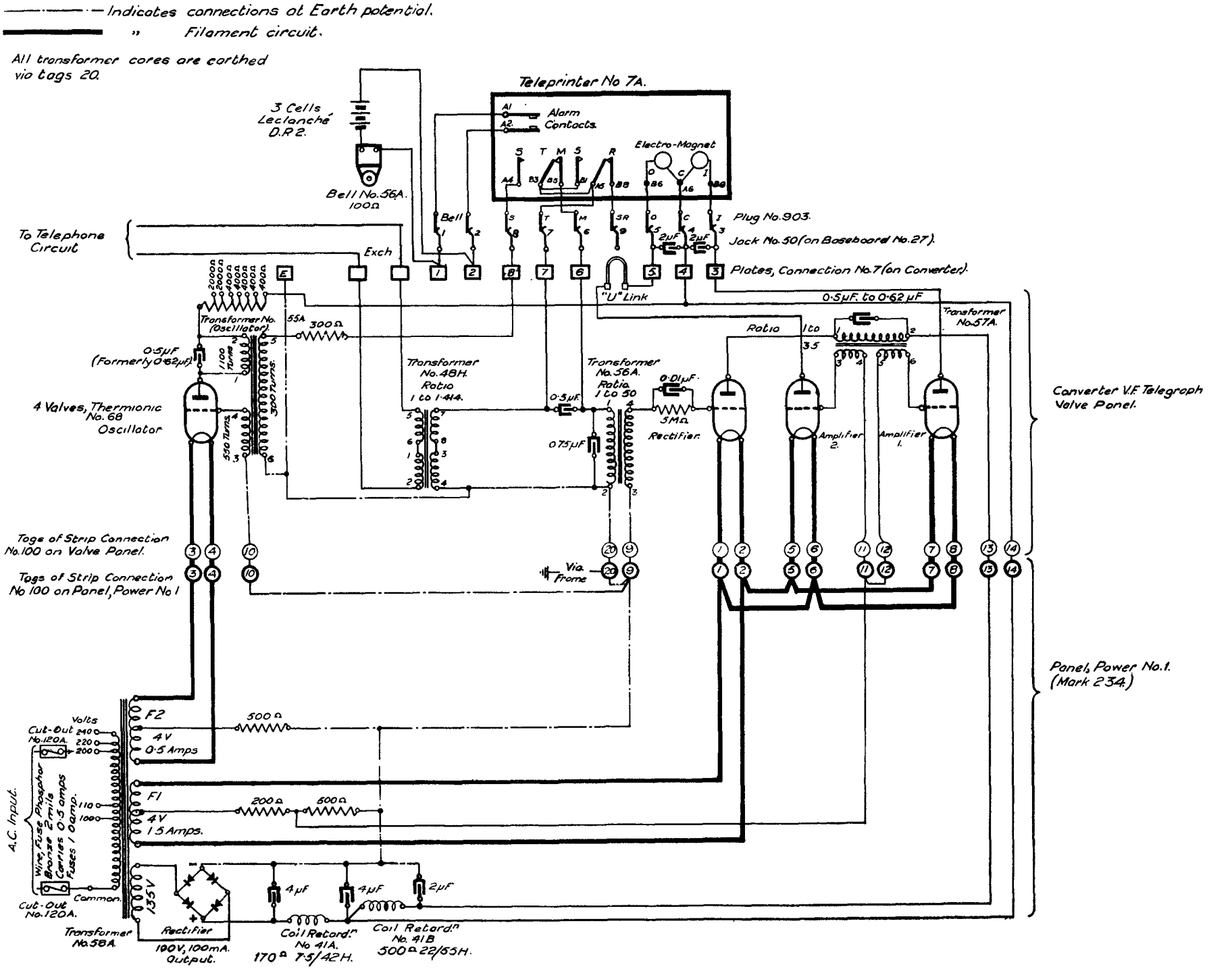

Indicates connections at Earth potential.
" Filament circuit.
All transformer cores are earthed via tags 20.
Teleprinter No 7A.
Alarm Contacts.
Electro-Magnet
3 Cells Leclanché O.R.2.
Bell No.56A. 100Ω
To Telephone Circuit
Exch
Plug No.903.
Jack No.50 (on Baseboard No.27).
Plates, Connection No.7 (on Converter).
"U" Link
0·5µF. to 0·62µF
Transformer No. (Oscillator)
55A
300Ω
0·5µF (Formerly 0·62µF)
Transformer No.48H. Ratio 1 to 1·414.
Transformer No.56A. Ratio 1 to 50
0·01µF.
5MΩ
Rectifier
Ratio 1 to 3·5
Transformer No.57A.
4 Valves, Thermionic No.68 Oscillator
0·5µF
0·75µF
Amplifier 2.
Amplifier 1.
Converter V.F. Telegraph Valve Panel.
Tags of Strip Connection No.100 on Valve Panel.
Tags of Strip Connection No 100 on Panel, Power No 1
Via Frame
Panel, Power No.1. (Mark 234.)
A.C. Input.
Volts
Cut-Out No.120A.
240
220
200
F2
4V
0·5 Amps
500Ω
F1
110
100
4V
1·5 Amps.
200Ω
500Ω
Wire, Fuse Phosphor Bronze 2 mils Carries 0·5 amps Fuses 1 amp.
Common.
Cut-Out No.120A.
135V
4µF
4µF
2µF
Transformer No.58A.
Rectifier
190V, 100mA. Output.
Coil Retard.n No.41A. 170Ω 7·5/42H.
Coil Retard.n No.41B 500Ω 22/65H.

FIG. 18.

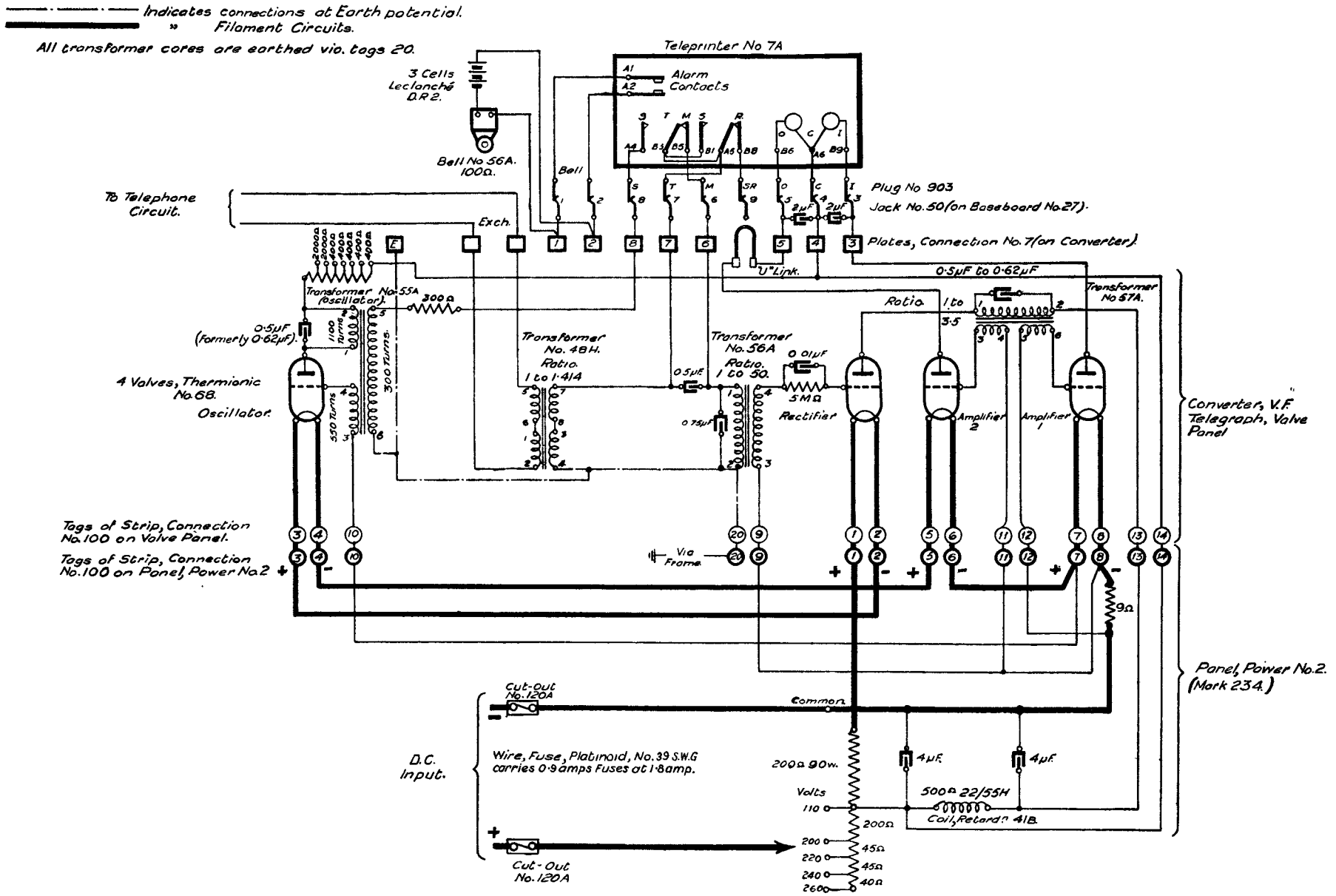

Indicates connections at Earth potential.
» Filament Circuits.
All transformer cores are earthed via. tags 20.
Teleprinter No 7A
Alarm Contacts
3 Cells Leclanché D.R2.
Bell No 56A. 100Ω.
Bell
To Telephone Circuit.
Exch.
Plug No 903
Jack No. 50 (on Baseboard No 27).
Plates, Connection No. 7 (on Converter).
U" Link.
0·5μF to 0·62μF
Transformer No. 55A (oscillator).
300Ω
0·5μF (formerly 0·62μF).
1100 Turns
300 Turns
330 Turns
4 Valves, Thermionic No. 68.
Oscillator.
Transformer No. 48H.
Ratio. 1 to 1·414
Transformer No. 56A
Ratio. 1 to 50.
0·5μF
0·01μF
5MΩ
0·75μF
Rectifier
Ratio. 1 to 3·5
Transformer No 57A.
Amplifier 2
Amplifier 1
Converter, V.F. Telegraph, Valve Panel
Tags of Strip, Connection No. 100 on Valve Panel.
Tags of Strip, Connection No. 100 on Panel, Power No. 2
Via Frame
9Ω
Panel, Power No. 2. (Mark 234.)
Cut-Out No. 120A
Common
D.C. Input.
Wire, Fuse, Platinoid, No. 39 S.W.G carries 0·9 amps Fuses at 1·8 amp.
200Ω 90w.
4μF
4μF
Volts
110
200
220
240
260
200Ω
45Ω
45Ω
40Ω
500Ω 22/55H
Coil, Retard.n 418.
Cut-Out No. 120A

FIG. 19.

going to the renter's office *via* the " marking " contact and tongue of the local relay, suitable filters being inserted to prevent interference with telephone circuits which may be in the same cable. In transmitting, the " A " wire of the pair is earthed at the teleprinter for " spacing " units and disconnected for " marking " units. The current flowing during the " spacing " units operates the " local " relay which transmits back over the " B " wire, producing the local record; the current also operates the " transmitting " relay, which sends forward into the main line circuit. The " local " and " transmitting " relays are held to " marking " when there is no current in the local line, by the biassing current flowing through the relay windings and biassing resistance. If an earth return for the currents from the renter's office is undesirable for any reason two loops may be used and the connections made as shown dotted.

The main line circuit must be of the duplex type so that transmission of signals may be in either direction without switching, but the duplex balances need not be so perfect as in a circuit worked in both directions simultaneously. Operation of the keyboard at the receiving end during the receipt of signals will not only mutilate the received copy but also the local record at the transmitting end. It is thus possible for the receiving end to call the attention of the transmitting end.

Where the renter is situated some considerable distance from the main line terminal it is possible to extend the range of working by disconnecting the biassing battery and providing the renter with a battery which can be used to transmit double current. On the receiving side the renter would have a relay which would relay the incoming signals into his teleprinter, using the transmitting battery as a local battery for feeding the teleprinter.

" Telex " working. In this case each renter is provided with a mains operated " Telex " unit in addition to the teleprinter, each connection being set up over the telephone network as a telephone call. Both renters then speak and switch over to teleprinter, the telephone circuit is held by the current flowing round the telephone loop and input transformer of the " Telex " unit. Figs. 18 and 19 show " Telex " units schematically for A.C. mains and D.C. mains respectively. Transmission is accomplished by transmitting an alternating current of 300 cycles per second over the circuit for the spacing

code units, the 300 cycle current being in the voice range is transmitted over the telephone circuit. The local record is obtained by by-passing a portion of the outgoing current into the receiving portion of the unit. From a telegraph point of view 300 cycles is rather a low frequency, having too few cycles per dot or unit signal element, in this case 6, the missing of a cycle producing 16.7% distortion. The frequency must be kept off the 500 cycles used for ringing on the trunks also out of the 900 to 1200 range where the telephone receivers and the human ear are sensitive, on account of the fear of the cross-talk. It is possible that the frequency may be raised to the range 1300 to 1500 cycles per second.

Fig. 20 shows a table and teleprinter as supplied to a

FIG. 20.

renter for " Telex " working with A.C. mains supply. On the table is shown a Teleprinter 7A with Teleprinter-Telephone switch on right, Telephone 162, Teleprinter Plug and Socket, and Power Plug and Socket. Below the table (Fig. 21) is seen the converter, run from the mains. The converter

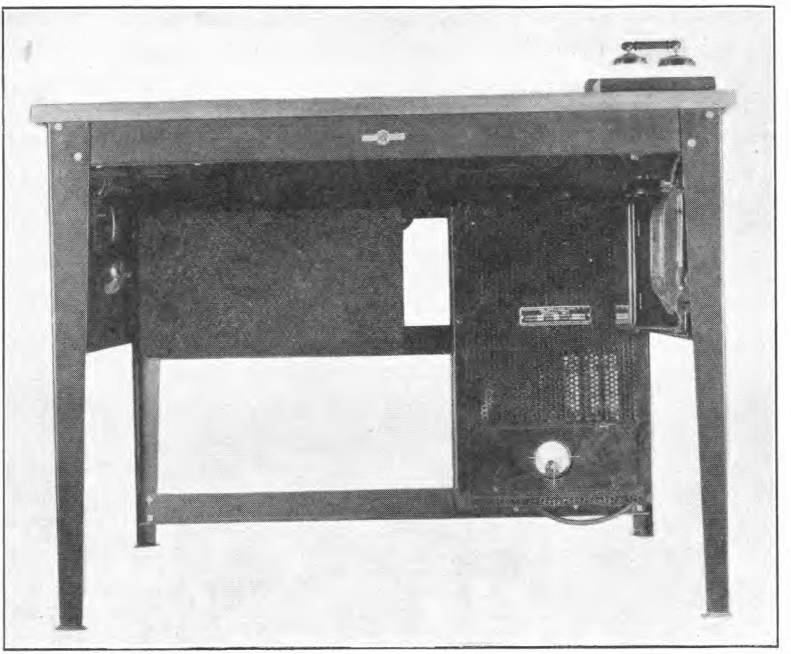


FIG. 21.

contains valves for supplying the 300 cycle tone and converting the received signals into current for operating the teleprinter electro-magnet. On the right is the rectifier for supplying direct current to the teleprinter motor.

Various switching systems have been and are being developed, especially for police use, whereby one teleprinter may broadcast a message to a number of other teleprinters simultaneously. Systems in use are those of the Metropolitan and also the Lancashire Police, with headquarters respectively at Scotland Yard and Preston. On the Continent Berlin has a very complete police system fitted with the Morkrum Tape printer. In this case the teleprinter is superposed on

the telephone loops connecting the police stations with headquarters stations. An interesting point is that although the telephone loops are fitted with transformers the telephones are fitted with dials, a form of alternating current dialling being used. Teleprinter services are in use on the Continent and in America for private renters and also for providing a connecting network in connection with commercial aviation services for providing weather reports, etc.

In conclusion the author wishes to state that as far as possible he has tried to avoid repeating information available in the current text-books and technical instructions, but in some cases this has been unavoidable.

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