# PATENT SPECIFICATION

Application Date: Jan. 30, 1941. No. 33107/39. **549,002**

Complete Specification Accepted: Nov. 3, 1942.

COMPLETE SPECIFICATION

## Improvements in and relating to Electrical Communication Systems

We, TELEPHONE MANUFACTURING COMPANY LIMITED, a British Company, of Hollingsworth Works, Martell Road, West Dulwich, London, S.E.21, and LESLIE HAROLD PADDLE, a British subject, of "Riverdale", St. Paul's Cray, Orpington, Kent, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by following statement:—

This invention relates to telephonic communication systems of the type in which subscribers, that is to say persons between whom communication may be established over the system, are afforded facilities for secret communication.

Such "secret" systems are known in which the signal to be transmitted is divided into timed portions, each of any consecutive two of which pertains to a different form of treatment in the course of transmission, with the object of rendering the transmitted signal more or less unintelligible. For example in some cases some or all of such time portions are subjected to the action of frequency modifying means, such as a frequency inversion means, in order to obtain a desired degree of secrecy. It is convenient to refer to such different forms of treatment, to which the signal is subjected during the course of its transmission, as transpositions and various arrangements have been proposed whereby the sequence of these transpositions may be established according to any one of a plurality of predetermined combinations.

Now, it is the object of the present invention to provide a telephone subscribers station equipment which includes means for effecting the desired transpositions and also means arranged under the control of the subscriber whereby the subscriber may select the sequence of the transpositions from any one of a plurality of predetermined combinations thereof.

Thus according to the invention there is provided a subscriber's station equipment for a telephonic communication system affording secret communication facilities, which comprises frequency modifying means enabling at least two different signal transpositions to be obtained, automatically operating switching means whereby the signal to be transmitted is divided into such different transpositions cyclically repeated, and switching means arranged under the control of the subscriber whereby the latter may select the order or timing of the cyclically repeated transpositions from a plurality of predetermined different orders or timings.

The two different signal transpositions may comprise normal signal transmission and frequency modified signal transmission respectively, although in preferred embodiments of the invention several frequency modified transpositions are provided for and in one such preferred embodiment, to be hereinafter more particularly described, the arrangement is adapted to provide four different signal transpositions obtained by the use of frequency modifying means.

Preferably the group of different signal transpositions which is adapted to be cyclically repeated comprises several unequal periods, the change over of the transpositions being obtained by step-by-step switching means adapted to be operated by impulse signals which are conveniently of sub-audio frequency, that is to say below the speech frequency range to be transmitted over the system. Such impulse signals are adapted to operate correspondingly step-by-step switching means at the receiving end of the system and thereby maintain the complementary equipment at the receiving end synchronised with the transmitter. The step-by-step means employed may comprise uni-selector switching means.

To enable two-way secret communication to be effected the subscriber's station equipment also comprises means for reconstituting an intelligible signal from the received signal transpositions and preferably the equipment also includes means whereby subscribers can establish communication in the normal manner and then, if and when desired, change over to secret communication, it being a desirable feature of the equipment that the secrecy

apparatus can be introduced at the will of a subscriber. In some cases the signal to be transmitted may be transmitted for short periods with frequency inversion and during intervening periods the signal may be transmitted with a form of frequency modification other than a simple inversion. One such form of frequency modification, as described in our co-pending application No. 5530/40 (Serial No. 539,940), may consist in dividing the spectrum of the frequencies to be transmitted into a plurality of bands and differently modifying the signal components which appear in the bands so produced.

In order that the invention more readily can be appreciated a preferred embodiment thereof will now be described, by way of example, with the aid of the accompanying drawings. This embodiment provides for two-way normal or secret telephonic communication between two stations, the equipment for one of which, shown diagrammatically in Figure 1, includes means for generating desired synchronising signals and is therefore termed the "master" equipment, whilst the equipment shown diagrammatically in Figure 2, for the other station, includes means responsive to such signals and is hereinafter termed the "subsidiary" equipment.

With the arrangement shown the facilities for secret communication comprise modification of the speech frequency band (considered as 100 to 3,000 c.p.s.) in four ways by modulation and filter processes hereinafter called "transpositions". Each cyclic group of transpositions consists of an arbitrary combination of six such transpositions and occupies a total time period of 12.5 seconds divided into unequal periods of 1.5 to 3 seconds for each transposition.

The change over of the transpositions is determined synchronously by the use of impulses of sub-audio frequency (below 100 c.p.s.) generated at the master equipment and transmitted therefrom at half-second intervals. These impulses control uni-selector switch means at each station equipment and the transposition periods are coextensive with integral numbers of such impulses determined by the permanent wiring on the switch banks and the particular group-sequence of transpositions selected by the subscribers, such selection being effected by the operation of switching means, which may be key operated, or as shown in the preferred embodiment comprise rotary switches. In the embodiment shown some 600 different combinations are possible. Normally such selection, which may conveniently be termed the code selection, would be made by one subscriber and information regarding it transmitted to the other subscriber.

Calling and supervision are facilitated by the inclusion of 500/20 c.p.s. ringer apparatus. Several arrangements are possible but that adopted gives a ring-down signal for the subsidiary equipment for calling purposes and a ring-down signal from the master equipment for clearing. Calling from the master equipment is effected by a 50 c.p.s. signal which also assures that the respective sending and receiving uni-selector switches aforesaid are in phase as regards their stepping by the half-second impulses.

If during conversation a condition of imperfect synchronism rises, due for instance to an impulse being lost on the line, the subscriber at the master equipment can restore synchronism by operating a key.

A better understanding of the construction, arrangement and operation of the equipment will be obtained from the following description.

MASTER EQUIPMENT.

If the handset of the master equipment is lifted, relay A operates over a line and is followed by the operation of relay B controlling contacts A1 and B1, B2, B3, B4, B5, respectively. The operation of relay B energises the heating element HE of a thermal relay controlling an ordinary electromagnetic relay T, said heating element controlling the contact HE1 and the relay T controlling contacts T1 . . . . T7, the relay T operating upon the closure of contacts HE1 which takes place about two seconds after the energising of the heating element HE and during this time a 50 cycle frequency calling signal is transmitted to line over contacts JA1 and JA2 of a relay JA arranged under the control of contacts B3 and T2. Upon the operation of the relay T contacts T2 open to release relay JA and transmission of the 50 cycle frequency to line is terminated.

The equipment contains a pulse generating circuit comprising a well known arrangement of thermionic valve devices VA and VB controlling a third valve device VC, in the anode circuit of which latter there is provided the winding of a relay JB. This pulse generating circuit is started upon the operation of relay T and the consequent operation of a relay ZA, the latter being under the control of contacts T3 and E1. The pulse generator will proceed to generate impulses in the winding of relay JB at intervals of half a second as soon as a secrecy key, comprising contacts SCK, is thrown. The relay JB controls contacts JB1, JB2 and JB3, the

latter controlling the operation of a relay JR, the operation of which is subject to a variable time lag imposed by a shunt circuit connected across one of its windings, the purpose of this shunt being to effect synchronism between impulses at each end of the line on account of the finite transmission time over the line. In accordance with this arrangement relay JB sends out pulses of low frequency to line which eventually control the receiving switch whilst the relay JR is adapted to step the sending switch hereinafter to be mentioned.

The subsidiary equipment is also provided with a secrecy key SCK and after the preliminaries of the conversation have been settled in non-secret speech, each party can throw his secrecy key to operate relay SCR to transpose the speech path from a through connection from a subset and line via back contacts of SCR1 . . . . SCR4 to a path passing through the modulating transpositions, which will hereinafter be described more fully, over front contacts of SCR1 . . . . SCR4. At the same time SCK starts the pulse generating system.

If at any time during a call a synchronising key SYNK is thrown relay T releases and causes a uni-selector switch SWC to run to its home position via T4, its interrupting contacts SWC (A) and its H bank SWC (H). The generation is stopped by the effect of T6. Relay JA operates to send a low frequency pulse to line and thereby cause the corresponding switch at the receiving or subsidiary equipment to run home. In the meantime the heating element HE is energised and eventually closes contact HE1 switching relay T to the operated condition, after which relay T locks and the heating element is disconnected and relay JA releases via contacts T2. The low frequency is also disconnected from line on the release of relay JA. In this way the operation of the synchronising key SYNK functions to restore the two corresponding switches to the common home position and after the thermal delay internal the pulse generator starts and the switch begin to step again in unison.

In the case of a call originating from the subsidiary equipment, such call is received at the master equipment in the form of a pulse of 500/20 c.p.s. which serves to operate a relay N having contacts N1 which control a relay NR having contacts NR1 and NR2, the operation of relay N thus serving to operate relay NR which locks and closes a signal circuit to the master equipment, said latter relay being released when the call is answered from the master equipment by the actuation of contacts B4, whereupon the master equipment functions in the manner hereinbefore described.

When the hand set of the master equipment is restored relay A and B release followed by the release of relay T. Relay ZA remains locked over the back contact of T3. Relay E operates and applies 500/20 c.p.s. to the line whilst the heating element of relay T is energised via ZA1 and after a period of two seconds, relay T is re-operated and locks to E3 and releases relay ZA and disconnects HE whereupon relay E is released by ZA2 and causes relay T to release and the circuit restores to normal. The release of the relay T causes switch SWC to run to its home position but the code setting switches CSA and CSB do not move. The purpose of the latter switches is to determine the sequence of the types of transpositions within the 12.5 second cycle and they remain stationary during a conversation.

These switches are controlled by a code setting device such as a rotary switch or a set of keys under the control of the subscriber. In the drawing a device is shown whereby the earth potential is extended over the rotary code setting switch to a point on the H banks of SWA and SWB.

The driving circuit of SWA and SWB extends over the interrupter contacts and contacts P1 and Q1 to contact B4. This ensures that when a call is initiated these switches will run to the position determined by the code setting switches at which point relays P and Q will operate over the H wipers of SWA and SWB and will cut further motion. Normally these switches will not move between calls until the code setting device is altered.

The four types of transpositions mentioned above are called 1, 2, 3 and 4 and corresponding to these transpositions there are four relays TA, TB, TC and TD.

There is also a group of relays W, X, Y, Z, which directly control the filters and modulating frequencies to be used. The relations between the two groups are as follows:—

Relay TA operates relays W and Y, TB operates X, TC operates X and Y and TD operates X and Z.

All transpositions move the lower half of the speech band into the position of the upper half and move the upper half of the speech band into the position of the lower. The difference between the various transpositions lies in the fact that one or both of the halves of the speech may be inverted.

Thus the transposition T1 inverts both halves of the speech band, and is equivalent to the plain inversion of the whole

band.

The method by which these operations are performed lies first in the division of the speechband by means of low pass and high pass filters FA and FB into two halves. Each half is then modulated through a balanced ring type modulator MA or MB, with carrier frequencies either of 1.5 Kc, corresponding to the mid point of the band, or 3 Kc corresponding to the uppermost frequency. The detailed paths are as follows:—

In transposition 1, the whole frequency band is modulated by 3 Kc in modulator MA and the modulation products routed through filter FE thus producing a simple inversion of the whole band which may be characterised by the symbol 3000−S.

In transposition 2, the lower speech band is modulated by 1.5 Kc in MA and the products pass through FC and FE in series which effectively form a band pass filter 1.5 Kc to 3 Kc, and therefore pass the sum of the speech and modulating frequencies characterised by the symbol 1500+S. The upper speech band is modulated by 1.5 Kc in MB, and passes through FD and FE in series, FD being a low pass filter cutting off at 1.5 Kc. The end product represents the difference between the speech and modulating frequencies characterised by the symbol S−1500.

In transposition 3, the lower speech band is modulated by 3 Kc, and the difference frequencies are passed to line, represented by 3000−S, while the upper side band is modulated by 1.5 Kc, and the difference frequencies S−1500 are passed to line.

In the transposition 4, the lower side band is modulated by 1.5 Kc, and the frequencies 1500+S are passed to line, while the upper side band is modulated by 3 Kc and the frequencies 3000−S are passed to line.

Unwanted components may be produced with certain of these transpositions by interaction between the speech frequencies and the second harmonics of the modulating frequencies, but owing to the balanced modulator circuits which inhibit even harmonics of the carrier, these unwanted components are reduced to a negligible level by proper choice of the levels of the speech and carrier.

The demodulating path for incoming speech is an exact copy of the modulating path and the necessary division between incoming and outgoing speech is performed by means of hybrid transformers HA and HB. The pads PD on each side of the modulators MA to MD serve the purpose of supplying a desirable non-inductive load to the modulators at all frequencies.

The contact SCR5 supplies a termination to the hybrid HA, in order to prevent singing when non-secret conversation is in progress.

An amplifier OA is placed at the output end of both the modulator and demodulator path, in order to compensate for the necessary loss during the modulation processes.

The coding operation will now be described assuming that switch SWC starts from its home position and that switches SWA and SWB are locked on definite points which will be taken as No. 10 and No. 20 respectively as an example.

The earth is extended from T7 and the A wiper of SWC via contact No. 1 to the A wiper of SWA located on the contact No. 10 of this band, and operates relay TB, since this contact is connected to the point, labelled 2, corresponding to transposition 2 and all such points are connected to relay TB.

Relay TB operates relay X via contacts B5 and TB1, and X locks over X1.

As SWC moves along contacts Nos. 1, 2, 3 and 4, at the rate of one contact per half second, relay TB remains operated. On contact No. 5 of SWC relay TB releases but the condition relay X remains locked until a definite change in transposition occurs.

This happens on the next contact of SWC which is No. 6. This contact is connected to wiper B of SWA and the contact No. 10 of the corresponding bank is connected to relay TC via the group of terminals labelled 3.

Relay TC operates the condition relay X and Y over TC1 and TC2, and this relay locks.

This group X and Y remains operated until SWC reaches contact No. 9, whereupon relay TA operates and operates relays W and Y and releases relay X via TA1.

W and Y remain operated until contact No. 14 of SWC at which point the earth is extended to wiper A of SWB. This wiper is standing on contact No. 20 and therefore relay TC is caused to operate via the group of contacts 3. Contacts TC1 and TC2 cause relay X to operate and W to release, leaving X and Y operated for the period of this section.

Continuing in this manner, we find that on reaching contact No. 17 of SWC, relay TB operates over wiper B of SWB causing relay X only to remain operated during this section, and on reaching contact No. 22 of SWC relay TD operates corresponding to relay XZ. The symbolic form therefore, the cycle of six transpositions corresponding to SWA at No. 10, SWB at

No. 20 may be written 2 3 1 3 2 4 and these are traced out as SWC moves over the 25 contacts of its bank at 2 per second. By pre-selecting other contacts of SWA and SWB other cycles of transposition can be obtained.

SUBSIDIARY EQUIPMENT.

The operation of the receiving end is very similar to that of the sending end, and the modulating paths and the method of control of the coding section is exactly the same.

The difference consists in the fact that the controlling impulses for stepping SWC are not generated at this end, but are received over the line. On receipt of a call from the master equipment the pulse of low frequency of 50 c.p.s. causes relay R to operate. This operates relay RR which has an operating lag of about 200 milliseconds, so that it will not operate on the synchronising pulses. The switch SWC runs to its home position via contacts RR2 and its interruptors on the H bank, in order to prepare for subsequent pulses.

Relay RA operates over RR1 and locks.

The subscriber is rung over the signal circuit through B1 and RA1. He lifts off his receiver and relays A and B lock over B3 and RA3.

After the preliminaries of the conversation the subscriber throws his secrecy key SCK and conversation proceeds controlled by the appropriate code intervals, the operating being as follows:—

About two seconds after the initial incoming pulse of low frequency from line arrives, it is cut off and relay R restores followed by relay RR.

The circuit is ready to receive impulses of low frequency over the line, and these are of such length that relay RR does not operate. Hence, the switch SWC is stepped from each pulse of R via R2 and RR2, but the incoming synchronising impulses have no other effect.

This stepping is in synchronism with the corresponding switch at the master equipment.

The code setting switches having been set to the same position as the similar switches at the master end, the transposition sequence in the cycle will be identical.

The stepping will proceed independently of whether SCK is operated, and the two terminals of the circuit are in synchronism in preparation for the secret conversation.

The operation of the transposition sequence is precisely the same as that described for the master equipment.

At the end of the conversation, the clearing signal is received from the line, consisting of a pulse of 500/20 c.p.s. which operates relay M. This causes RA to release and relay MR to operate and lock. When the subscriber of the subsidiary terminal restores his handset, relay A releases followed by relays B and MR and the circuit restores to normal.

If the subscriber at the subsidiary terminal wishes to initiate a call, he takes off his handset and relays A and B operate. This causes relay S to operate, and a pulse of 500/20 c.p.s. is sent out over the line calling the master terminal.

When the master terminal replies, the initial pulse of low frequency is returned which causes relay R, RR and RA to operate. Relay RA releases S and the pulse of 500/20 c.p.s. is no longer transmitted to the line. Relay RA locks during the conversation until released by M, and the remaining operations are as described above.

Having now particularly described and ascertained the nature of our said invention, and in what manner the same is to be performed, we declare that what we claim is:—

1. A subscriber's station equipment for a telephonic communication system affording secret communication facilities, comprising frequency modifying means enabling at least two different signal transpositions to be obtained, automatically operating switching means whereby the signal to be transmitted is divided into such different transpositions cyclically repeated, and switching means arranged under the control of the subscriber whereby the latter may select the order or timing of the cyclically repeated transpositions from a plurality of predetermined different orders or timings.

2. A subscriber's station equipment as claimed in claim 1, wherein the said automatically operating switching means comprises step-by-step switches adapted to effect the desired switching of the transpositions in response to impulse signals.

3. A subscriber's station equipment as claimed in claim 1 or 2, including means for obtaining impulse signals having a frequency below the speech frequency to be transmitted over the system and means whereby such impulse signals are adapted to actuate the said automatically operating switch means.

4. A subscriber's station equipment as claimed in any of the preceding claims, including means operative to reconstitute an intelligence signal from received signal transpositions.

5. A subscriber's station equipment as claimed in claim 4, wherein said re-constituting means includes automatically operating switching means which are complementary to the automatically operating switch means whereby the signal to be

transmitted is divided into different transpositions cyclically repeated.

6. A subscriber's station equipment as claimed in claim 5, wherein both the automatically operating switching means are adapted to be actuated by impulse signals, said signals serving to maintain said switching means in synchronism.

7. A subscriber's station equipment as claimed in any of the preceding claims, wherein the said automatically operating switch means comprises uni-selector switches.

8. A subscriber's station equipment as claimed in any of the preceding claims, comprising rotary switch means arranged under the control of a subscriber whereby the group-sequence of the different transpositions may be selected from a plurality of predetermined different combinations thereof.

9. A subscriber's station equipment as claimed in any of the preceding claims, including means whereby the frequency spectrum of the signal to be transmitted is divided into bands and one at least of said bands is subjected to frequency modifications.

10. A subscriber's station equipment as claimed in any of the preceding claims, including means whereby a subscriber may establish communication in the normal manner and, at will, may introduce the secrecy means.

11. A subscriber's station equipment constructed, arranged and adapted to operate substantially as herein shown or described.

Dated this 30th day of January, 1941.

A. A. THORNTON,
Chartered Patent Agents,
7, Essex Street, Strand, London, W.C.2,
For the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1942.

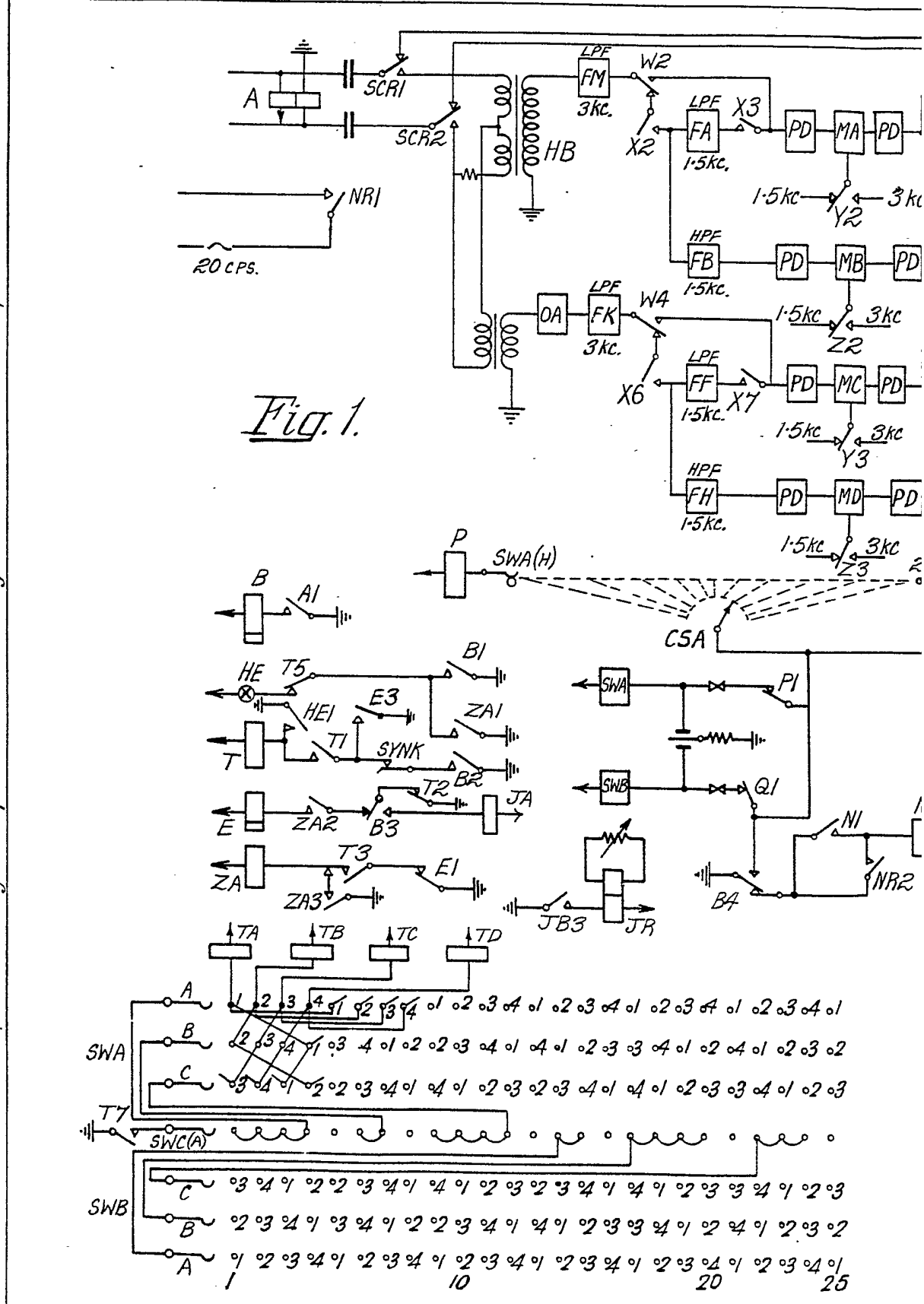
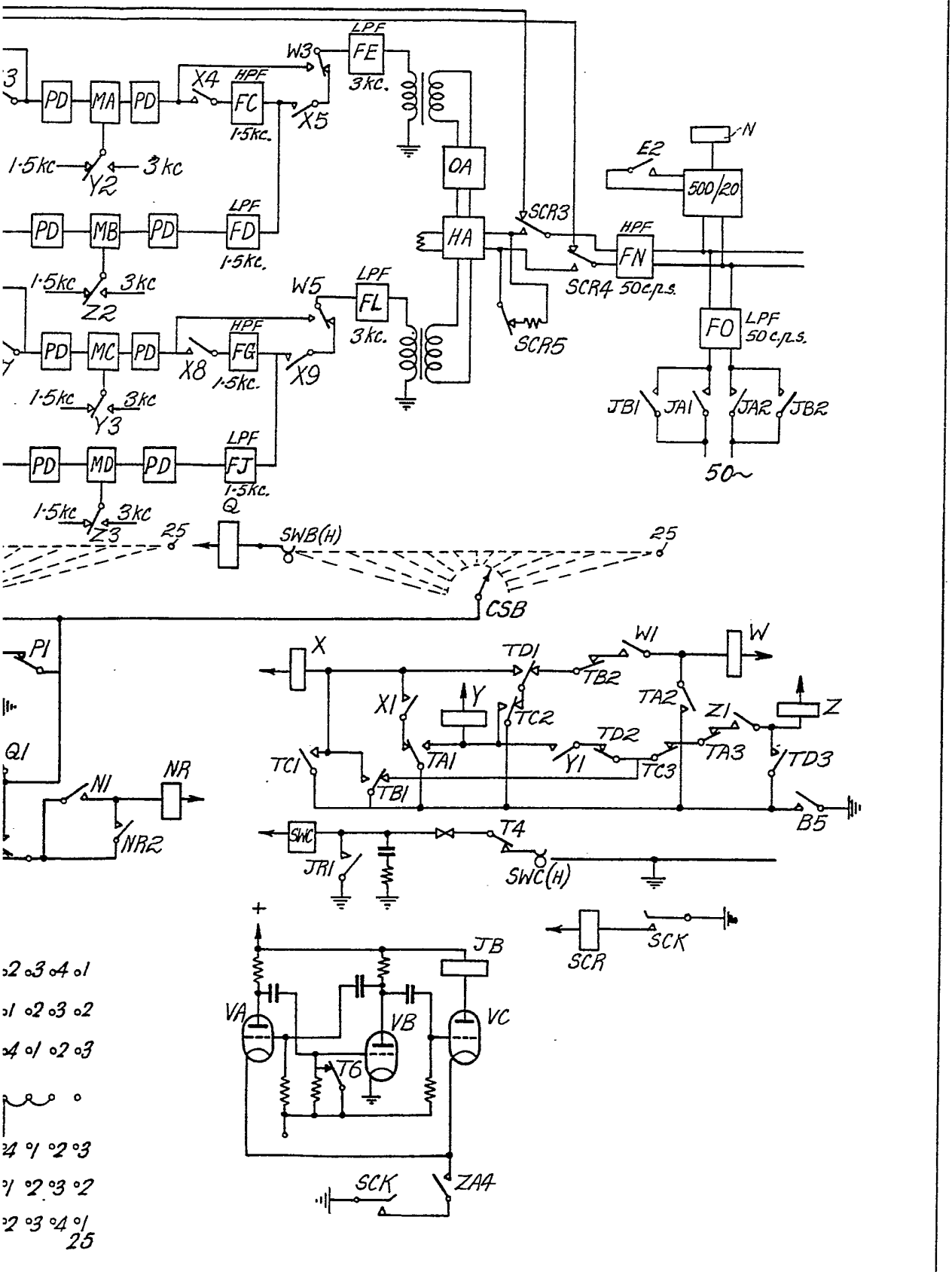
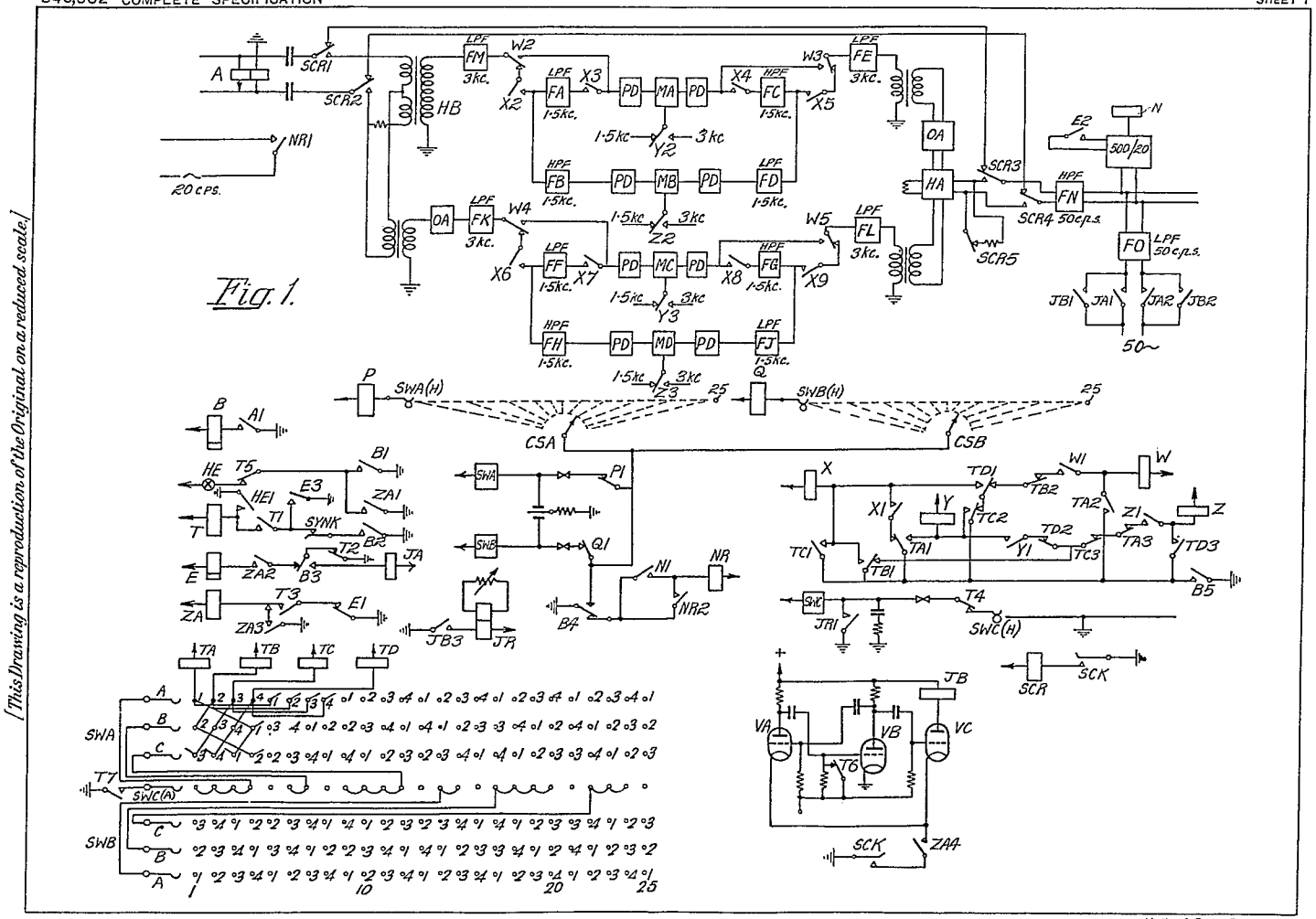



Fig. 1.




Malby & Sons, Photo-Lith




Malby & Sons, Photo-Lith

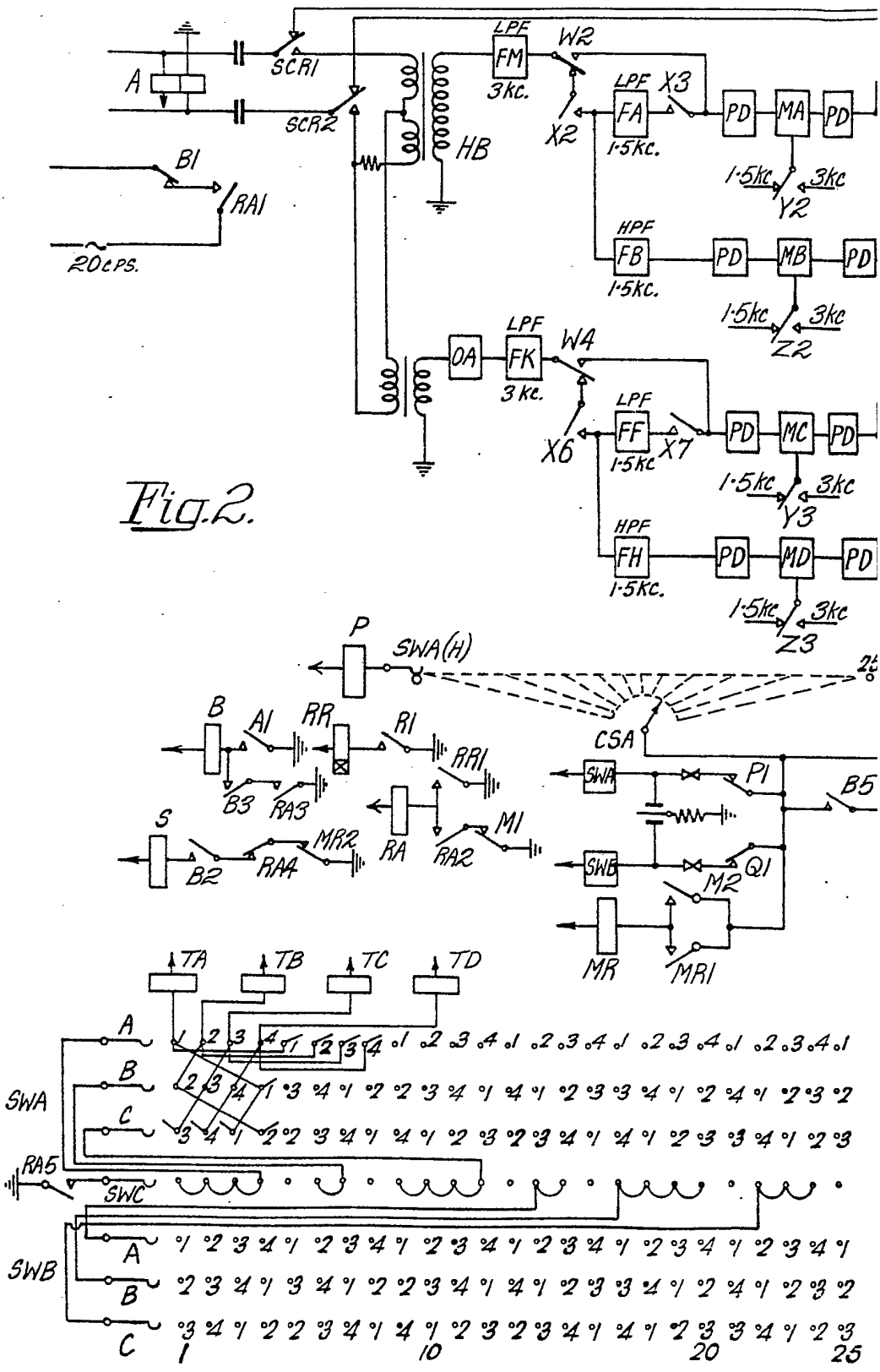
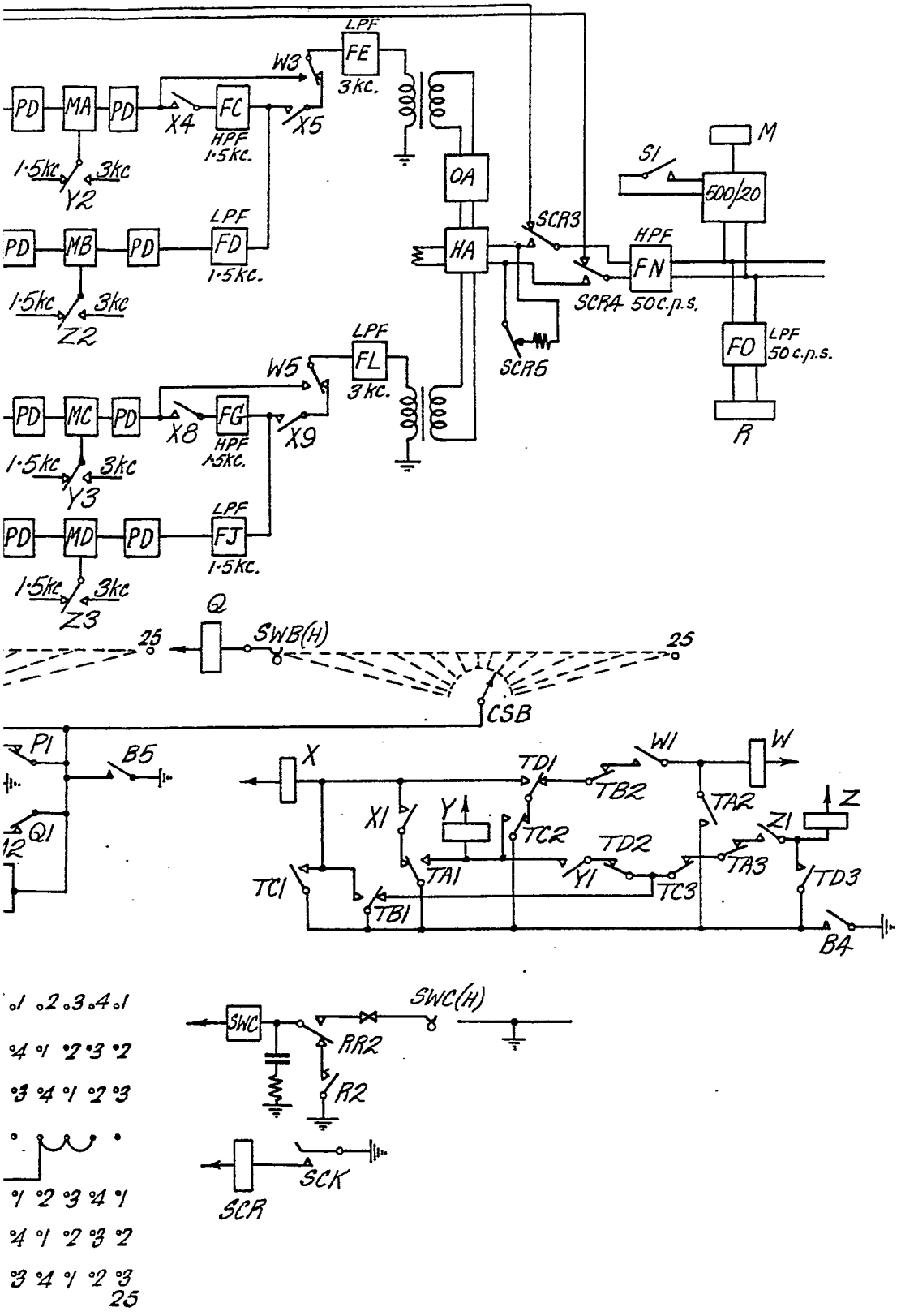
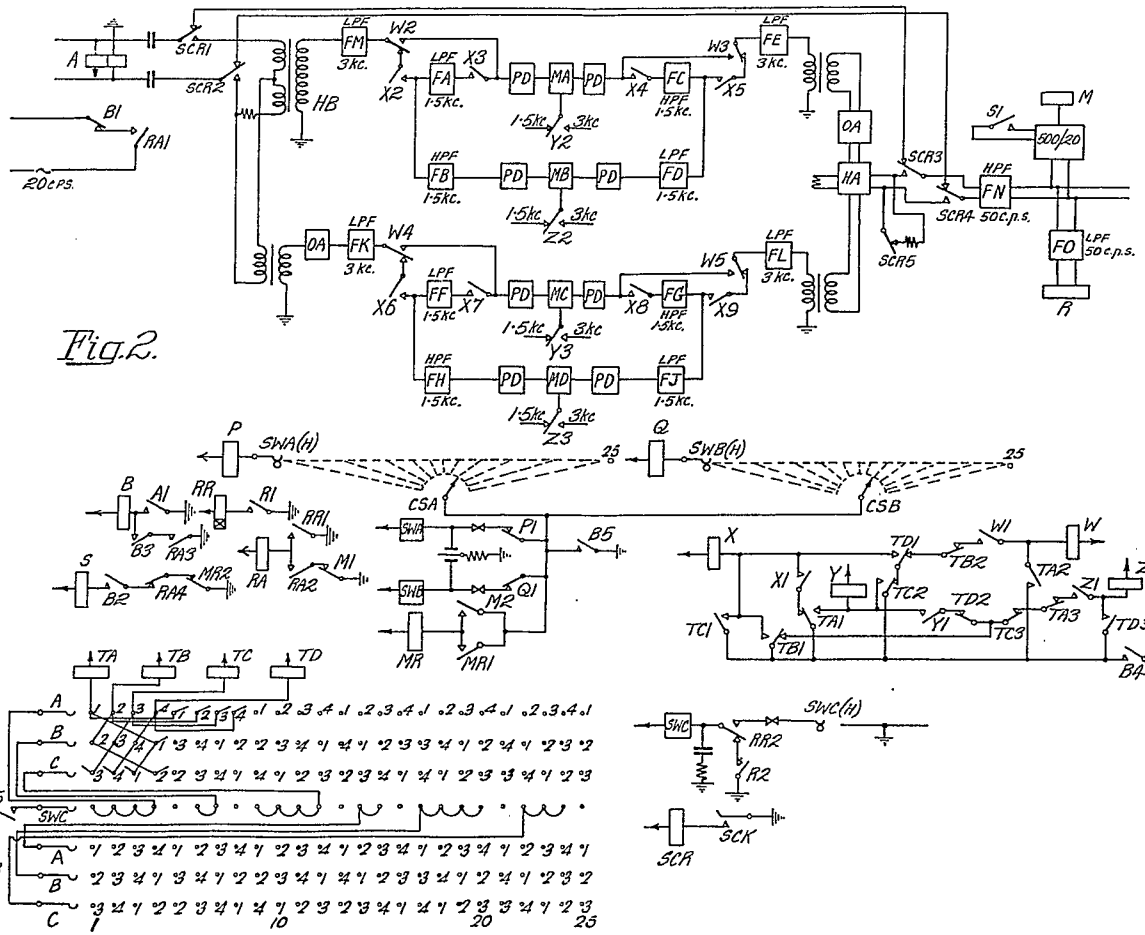



Fig.2.


LPF
W3
FE
3kc.
PD
MA
PD
X4
FC
HPF
1·5kc.
X5
1·5kc
3kc
Y2
OA
M
SI
500/20
SCR3
PD
MB
PD
LPF
FD
1·5kc.
HA
HPF
FN
SCR4
50c.p.s.
1·5kc
3kc
Z2
SCR5
LPF
W5
FL
3kc.
FO
LPF
50 c.p.s.
PD
MC
PD
X8
FG
HPF
1·5kc.
X9
R
1·5kc
3kc
Y3
PD
MD
PD
LPF
FJ
1·5kc.
1·5kc
3kc
Z3
Q
25
SWB(H)
25
CSB
PI
B5
Q1
12
X
TD1
W1
W
TB2
TA2
XI
Y
Z
ZI
TC2
TD2
TA3
TD3
TA1
Y1
TC3
TC1
TB1
B4
SWC(H)
SWC
RR2
R2
SCK
SCR
25




Malby & Sons, Photo-Lith