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(54) IMPROVEMENTS IN OR RELATING TO SWITCHING NETWORKS FOR USE IN TELECOMMUNICATIONS SYSTEMS

(71) We, SIEMENS AKTIENGESELLSCHAFT, a German Company, of Berlin and Munich, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to switching networks for use in telecommunications systems and to circuit arrangements for such networks.

Switching networks for the selective interconnection of (subscriber) lines in telecommunications systems are known in the form of so-called triangular matrix crosspoint arrangements (see e.g. Proceedings of IEE, Part B Supplement, Nov. 1960, page 96). Switching networks of this type have advantages (in particular when the number of lines to be handled by a network is small) compared with networks which consist of rectangular or square matrix crosspoint arrangements requiring at least two crosspoints (and associated switches) to be involved in the interconnection of a pair of row lines or column lines. The number of crosspoints involved in a similar interconnection using a triangular matrix arrangement is less than or equal to the number involved using a rectangular crosspoint arrangement.

Where larger numbers of lines are to be handled by a network, it is favourable to employ a triangular matrix crosspoint arrangement in the last stages of switching networks of a reversed grouping, when the switching networks each have an odd-number of stages, the other first stages comprising rectangular matrix arrangements. This achieves a reduction in the danger of blockage in comparison to a construction comprising solely rectangular matrices in which the number of row lines differs from the number of column lines.

To make feasible the possibility of extending switching networks in stages without the need to provide spare capacity in the initial network, modular construction is desirable. Thus, for example, for a PCM t.d.m. switching arrangement it is known (German Specification No. 21 08 745.6), to assemble in one unit all the line-associated devices required for switch-through, including the crosspoint switches to which the line has direct access.

When the network is constructed in the form of a triangular matrix, modular construction is no longer readily possible since the individual crosspoint switch terminals can no longer be assigned row-wise to the inputs or outputs as in a rectangular or square matrix. In switching networks for t.d.m. systems, this results in particular difficulties in respect of the organisation of the holding sets responsible for the actuation of the cross-point switches.

According to this invention there is provided a circuit arrangement for a switching network for use in a telecommunications system, said circuit arrangement having means for interconnecting lines of selected pairs of a number N of lines which are to be accommodated for switching by the network, said interconnecting means including an array of crosspoints respectively for enabling said selected pair interconnections, N line members for connection to the N lines, each one of the line members being associated with, by having a common connection to, a sub-array comprising

$$\frac{N-1}{2}$$

crosspoints when N is an odd number and

$$\frac{N}{2}$$

crosspoints when N is an even number, and groups of intermediate connections, that are associated with the respective sub-arrays, each group being arranged for enabling selective interconnection between the associated one of the line members and a spatial sequence of others of the line members via respective ones of the crosspoints of the sub-array associated with said one line member, the sequence for each said one line member being arranged to be the same with respect to that one line member and being based on the same notional cyclic spatial sequence of the line members.

This invention also provides a switching network for use in a telecommunications system, said network including a circuit arrangement according to the immediately preceding paragraph above and switching means respectively connected between, so as to enable selective interconnection of, the crosspoints of each said one line member and said other line members.

Embodiments of this invention will now be described, by way of example, with reference to the accompanying drawing, in which:-

Figure 1 is a schematic diagram of a conventional triangular matrix switching network, and

Figures 2 and *3* are schematic diagrams of different respective switching networks embodying this invention.

The so-called triangular matrix switching network illustrated in Figure 1 possesses seven input/output terminals E/A1 to E/A7, and accordingly the switching network can handle the selective interconnection of seven lines connected to the respective terminals. Six of the terminals are connected to respective row lines Z1 to Z6 of the matrix. The latter also possesses six column lines S1 to S6, of which the column lines S2 to S6 are each connected to a row line. Thus, for example, a connection exists between the column line S6 and the row line Z2. In the case of the column line S1 and the row line Z1, there is merely a connection to the associated input/output terminal E/A7 and E/A1.

At the intersections or crosspoints of the column lines and row lines there are arranged crosspoints switches K1 to K21 via which a connection can in each case be established between column line and row line. With a number N of input/output terminals, the number of crosspoints (and associated switches) in such a triangular matrix arrangement amounts to

$$\frac{N(N-1)}{2}$$

Employing any selected one of these crosspoint switches, it is possible to establish a connection between a selected pair of the total number of input/output terminals. Thus, for example, E/A1 can be connected to E/A5 by the crosspoint switch K3, which connection extends along the column line S3 and the row line Z5.

As can be seen from Figure 1, each of the input/output terminals is connected to the same number of crosspoint switches, in the present case a group of six, but the groups are made up by switches connected to different combinations of row lines and column lines. Thus, for example, the crosspoint switches to which the input/output terminal E/A1 is directly connected, are connected to the row line Z1. Of the crosspoint switches to which the input/output terminal E/A5 is directly connected, two are connected to the row line Z5 and four to the column line S3. On account of this difference in associated combinations of matrix lines, a triangular matrix arrangement of this type cannot be readily organised to enable modular construction.

The switching network embodying this invention and schematically illustrated in Figure 2 likewise serves to handle the selective interconnection of seven lines which are connected respectively to input/output terminals E/A1 to E/A7.

These input/output terminals are associated with, by being directly connected to, respective line members Z1 to Z7 each having the same number (three) of crosspoints respectively associated with switches K1 to K21. In general, with an odd number of input/output terminals the number of crosspoints per line member is

$$\frac{N-1}{2},$$

and with an even number of input/output terminals in the number of crosspoints per line member is

$$\frac{N}{2}.$$

The switches K1 to K21 are arranged in switching units M1 to M7 respectively associated with the line members Z1 to Z7. The crosspoint switches associated with one of the line members have respective first switchable terminals connected in common to said one line member and have respective second switchable terminals connected to different respective ones of the other line members of the circuit arrangement.

The second switchable terminals of each switching unit (and associated with one of the line members) are connected to the same spatial sequence, (relative to that one line member and based on the same notional cyclic spatial sequence of switching units and their associated line members) directly to line members other than that one line member. Thus the crosspoint switches K1 to K3 of the switching unit associated with the input/output terminal E/A1 are connected (in the spatial sequence from K1 to K3) to the spatial sequence of line members connected to the input/output terminals E/A2 to E/A4. Similarly, the crosspoint switches K4 to K6 of the switching unit M2 associated with the input/output E/A2 are connected (in the spatial sequence K4 to K6) to the spatial sequence of line members connected directly to the input/output terminals E/A3 to E/A5. Finally, the crosspoint switches K19 to K21 of the switching unit M7 associated with the input/output terminal E/A7 are connected (in the spatial sequence K19 to K21) to the spatial sequence of line members connected directly to the terminals E/A1 to E/A3 (following the notional cyclic spatial sequence Z1 to Z7 to Z1 to Z7...)

The connection of each one line member to other line members is achieved via a group of intermediate connections (shown as oblique lines in Figure 2) associated with that one line member, the intermediate connections of each group extending between respective second switchable terminals of the associated switching unit and respective different line members of the appropriate spatial sequence for that one line member.

With this switching network, it is possible to connect selectively any input/output terminal to any other via only one single crosspoint switch, although there is in contrast to the triangular matrix arrangement, a standardised association between the crosspoints (and their associated switches) and the input/output terminals and a standardised spatial sequence of interconnection between one line member and other line members so that the network can be operated for switching in accordance with the principles for rectangular or square matrix arrangements and organisation of the circuit into an arrangement which can employ identical switching units (or modules) presents no difficulties.

Both this embodiment and that described below can employ a printed circuit (and multi-layer circuit) arrangement to provide the line members, crosspoints and intermediate connections and into which the switching units (or modules) can be plug-fitted via their terminals.

Figure 3 shows how a switching network embodying the invention can be constructed for the switch-through of four-wire t.d.m. lines of a PCM telecommunications system.

The crosspoints of this network comprise pairs of terminals 1 to 7, one (output) terminal of each pair being for transmission in one direction via a demultiplexer D*em* and the other (input) terminal of each pair being for transmission in the other direction via a multiplexer M*ux*. Accordingly switching units M1 to M15 which are respectively assigned to different line members associated with terminals for connection to 15 PCM t.d.m. lines PCM1 to PCM15, each possess, in addition to a timing stage Z and a holding circuit HZ which operates the latter, a demultiplexer D*em* and multiplexer M*ux* and a holding circuit HK for the operation thereof.

For each one of the line members, the connection of associated demultiplexer output terminals and multiplexer input terminals to PCM t.d.m. line members follows the same spatial sequence (relative to that one line member and based on the same notional cyclic spatial sequence of the line members). Also, as for the second switchable terminals in the embodiment shown in Figure 2, the connection by switching of terminals of each of the switching units to the associated timing stage and line member is effected in accordance with the same spatial sequence.

The demultiplexer output terminals and multiplexer input terminals of the units M1 to M15 are expediently designed as plugs and the connecting lines for these input and output terminals are expediently provided by a printed circuit or a multi-layer circuit.

To provide further explanation of the operation of the switching network shown in Figure 3, there will now be described the operations necessary in a few examples of the establishment of selective interconnections between t.d.m. lines connected to the network.

Firstly it will be assumed that a connection is to be made between a subscriber A who is assigned a time slot on the PCM t.d.m. line PCM5 and a subscriber B who is assigned a time slot on the PCM t.d.m. line PCM8. In this case there is a difference B−A=3 between the associated line numbers of the relevant t.d.m. lines which is arranged to mean that in the case of the unit M5 which is assigned to the t.d.m. line PCM5 on which the subscriber A is assigned a time slot, it is necessary to activate the crosspoint formed by the demultiplexer output 3 and multiplexer input 3, whereas the corresponding demultiplexer output and multiplexer inputs of the unit M8 are allowed to remain inactive. Thus the connection extends in one transmission direction from the timing stage Z in the unit M5 via the demultiplexer output 3, the intermediate connection which connects this output to the line member associated with the timing stage of the unit M8, and hence to the outgoing pair of wires of the t.d.m. line PCM8. In the other transmission direction, the connection extends from the line member and timing stage associated with the unit M8, via the appropriate intermediate connection to the multiplexer input 3 of the unit M5, to the timing stage and line member associated with the unit M5 and hence to the outgoing pair of wires of the t.d.m. line PCM5.

If the subscriber A is assigned a time slot on the t.d.m. line PCM2 and the subscriber B is assigned a time slot on the t.d.m. line PCM10, the difference B−A produces a value which is greater than seven, (i.e. greater than half the total number of t.d.m. lines which can be handled by the network). In this case it is necessary to form the complementary value, i.e. 15−B+A=7, of the difference to the maximum number of lines that can be handled by the network (here 15) and to arrange that in the unit which is assigned to the PCM line on which a time slot is formed for the subscriber B, in the unit M10 in this example the demultiplexer output 7 and the multiplexer input 7 must be activated. The corresponding output and input in the unit M2 are allowed to remain inactive, however.

If the subscriber A is assigned a time slot on the t.d.m. line PCM5 and the subscriber B is assigned a time slot on the t.d.m. line PCM3, the difference B−A will produce a negative value. In this case the difference A−B=2 is formed and it is arranged that in the unit M3 which is assigned to the t.d.m. line on which the subscriber B is assigned a time slot, the demultiplexer output 2 and the multiplexer input 2 are activated.

If a connection is to be established between a subscriber A who is assigned a time slot on the t.d.m. line PCM12 and a subscriber B who is assigned a time slot on the t.d.m. line PCM3, again a negative value of the difference B−A occurs. The difference A−B=9 is therefore formed instead. As this value is greater than seven (thus greater than the number of crosspoints associated with one switching unit), the complementary value to the number 15, thus 15−A+B=6, is formed. In this case, in the unit M12 the demultiplexer output 6 and the multiplexer input 6 must be activated whereby a connection is established via the appropriate intermediate connections to the timing stage of the unit M3 in both transmission directions.

The above described examples illustrate one scheme by which the switching network can be arranged to carry out its switching operations and it can be appreciated that such a network can be constructed on the basis of modular organisation (e.g. as regards the organisation of the holding circuit for the activation of the demultiplexers and multiplexers) without any insuperable difficulties.

In the switching networks described above, (N odd) as in a triangular matrix form of network, each of the lines can be connected to any other employing only one single crosspoint and the overall number of crosspoint switches required for the construction of the network is the same as for the triangular matrix form. Furthermore, as in a rectangular or square matrix, there exists a clearly defined and repeated association of the individual crosspoint switches with the input and output terminals, so that modular construction of the networks presents no particular difficulties.

In the embodiments described above the number N of line members is odd (seven and fifteen). When N is even then, as mentioned above, the number of crosspoints associated with each line member is N/2. It will be appreciated that this leads to duplication of the connections between some (N/2) of the line members so that certain ones of the switches will be redundant (although they can be used to provide back-up for the associated connections).

WHAT WE CLAIM IS:-

1. A circuit arrangement for a switching network for use in a telecommunications system, said circuit arrangement having means for interconnecting lines of selected pairs of a number N of lines which are to be accommodated for switching by the network, said interconnecting means including an array of crosspoints respectively for enabling said selected pair interconnections, N line members for connection to the N lines, each one of the line members being associated with, by having a common connection to, a sub-array comprising

$$\frac{N-1}{2}$$

crosspoints when N is an odd number and

$$\frac{N}{2}$$

crosspoints when N is an even number, and groups of intermediate connections, that are associated with the respective sub-arrays, each group being arranged for enabling selective interconnection between the associated one of the line members and a spatial sequence of others of the line members via respective ones of the crosspoints of the sub-array associated with said one line member, the sequence for each said one line member being arranged to be the same with respect to that one line member and being based on the same notional cyclic spatial sequence of the line members.

2. A circuit arrangement according to Claim 1 wherein each crosspoint has an associated terminal to be connected via a

switch when provided to the associated line member and the groups of terminals respectively associated with the sub-arrays each form the same geometrical arrangement and are connected in another spatial sequence, which is the same for all the terminal groups, to said other line members.

3. A circuit arrangement according to Claim 2 wherein said spatial sequences each comprise consecutive members.

4. A circuit arrangement according to Claim 2 or Claim 3 wherein each crosspoint comprises a pair of said terminals so that interconnection of t.d.m. lines can be achieved for both transmission directions.

5. A circuit arrangement according to any one of the preceding Claims and comprising a printed circuit arrangement of a multilayer circuit arrangement.

6. A circuit arrangement for a switching network for use in a telecommunications system, said circuit arrangement being substantially as described herein with reference to Figure 2 or Figure 3 of the accompanying drawings.

7. A switching network for use in a telecommunications system, said network including a circuit arrangement according to any one of the preceding Claims and switching means respectively connected between, so as to enable selective interconnection of, the crosspoints of each said one line member and said other line members.

8. A switching network according to Claim 7 as appendent to Claim 2 wherein said switching means provide terminal groups respectively associated with said sub-arrays, said groups comprising identical geometrical arrangements of first switchable terminals connected to the crosspoints of the associated sub-arrays and of second switchable terminals connected to said other line members in accordance with the same spatial sequence for all the groups.

9. A switching network according to Claim 8 wherein said switching means comprise identical switching units respectively associated with said sub-arrays.

10. A switching network according to any one of Claims 7 to 9 as appendent to Claim 4 wherein said switching means each comprise a switching unit including a multiplexer and a demultiplexer, one terminal of each of said pairs being connected to an input of the multiplexer and the other terminal of the pair being connected to an output of the demultiplexer.

11. A switching network according to Claim 10 wherein each said switching unit includes a first holding circuit arranged to control a timing stage which controls access of the multiplexer and demultiplexer to the line member, and a second holding circuit arranged to control the multiplexer and demultiplexer.

12. A switching network for use in a telecommunications system and substantially as described herein with reference to Figure 2 or Figure 3 of the accompanying drawings.

13. A telecommunications system including subscriber lines connected to respective line members of a switching network according to any one of Claims 7 to 11.

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1588150 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1

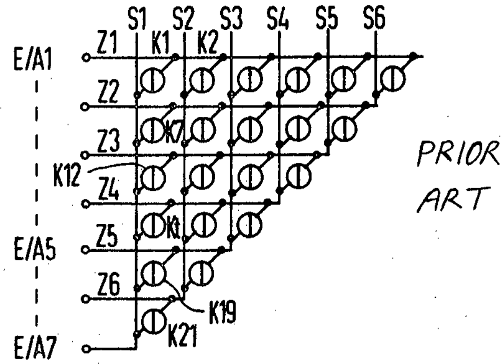
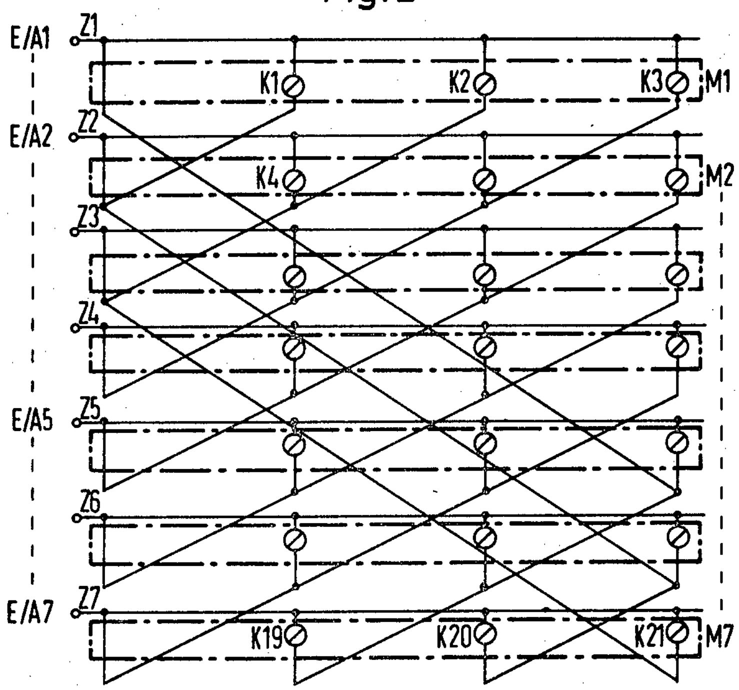
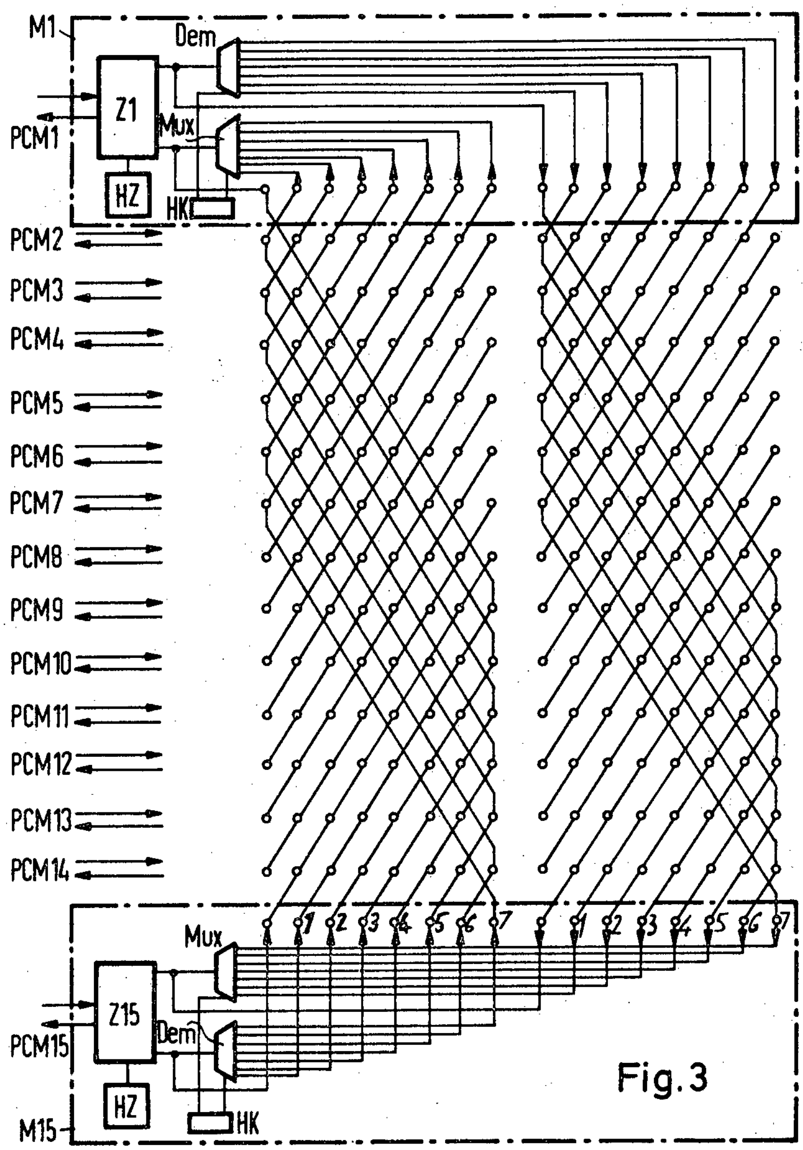


Fig. 2




M1
Dem
Z1
Mux
PCM1
HZ
HK
PCM2
PCM3
PCM4
PCM5
PCM6
PCM7
PCM8
PCM9
PCM10
PCM11
PCM12
PCM13
PCM14
1 2 3 4 5 6 7
1 2 3 4 5 6 7
Mux
Z15
Dem
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HZ
HK
M15

Fig.3