COMMUNICATIONS SWITCHING NETWORK

Filed Jan. 22, 1963 8 Sheets-Sheet 1

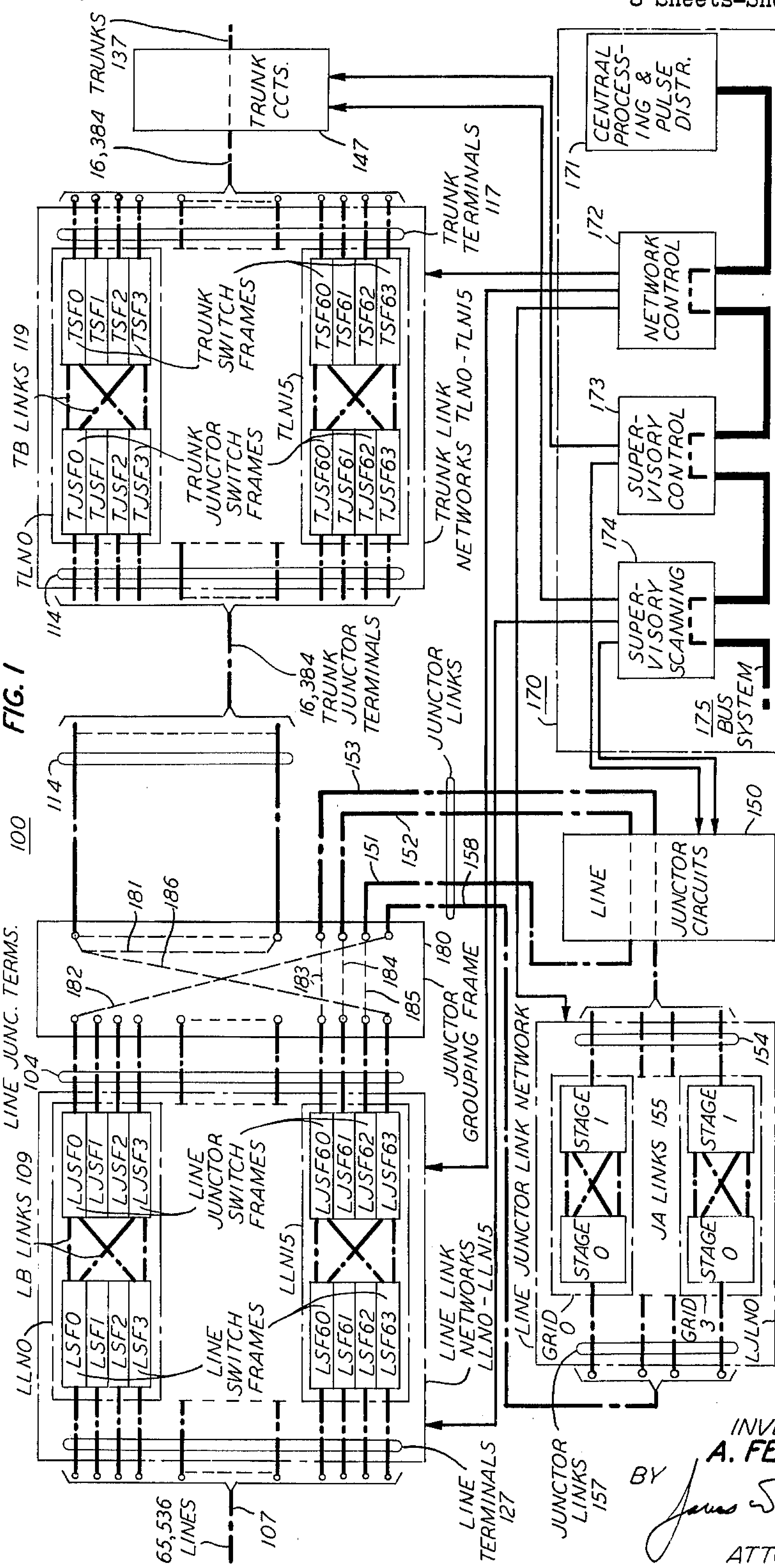

FIG. 1

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FIG. 2

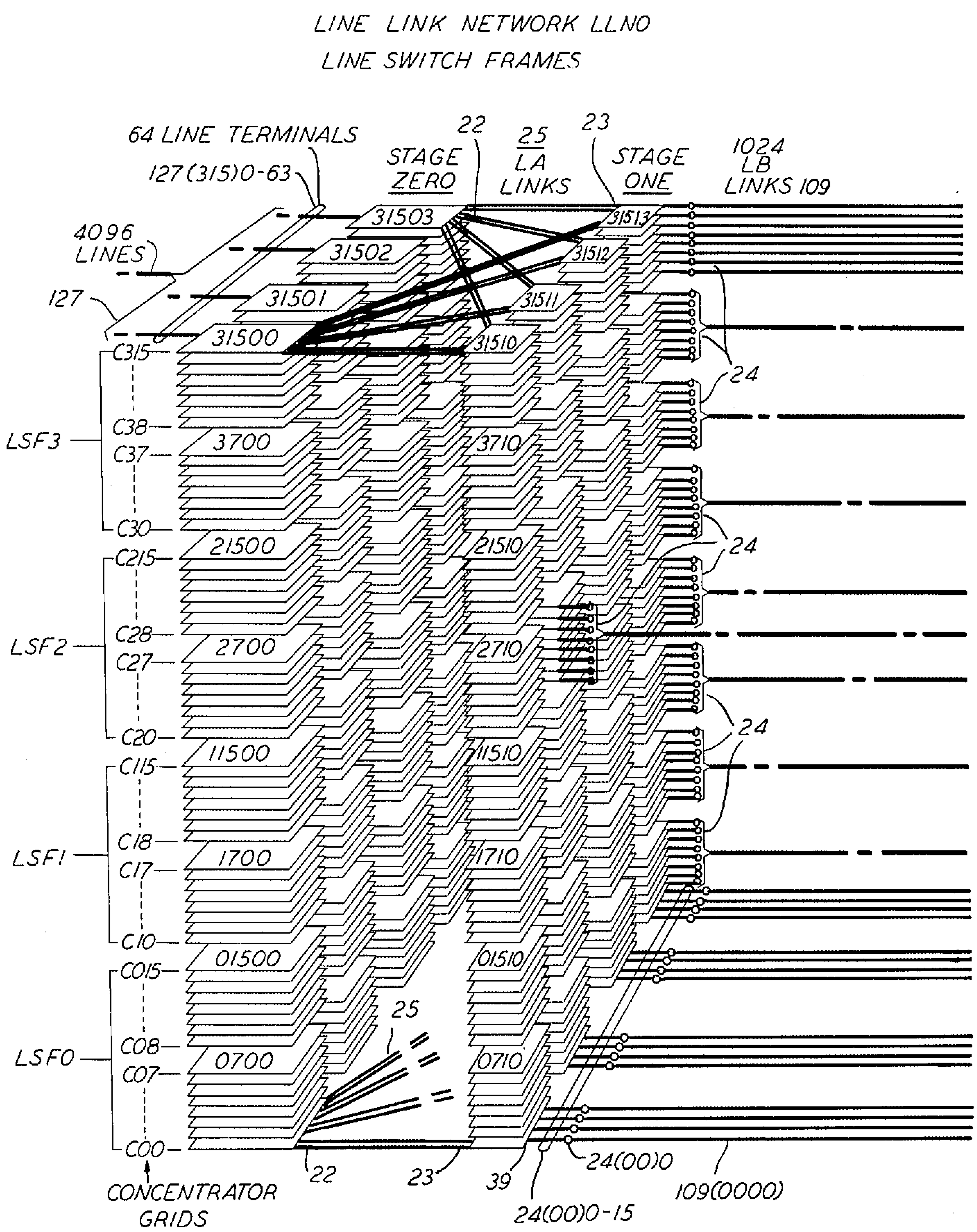
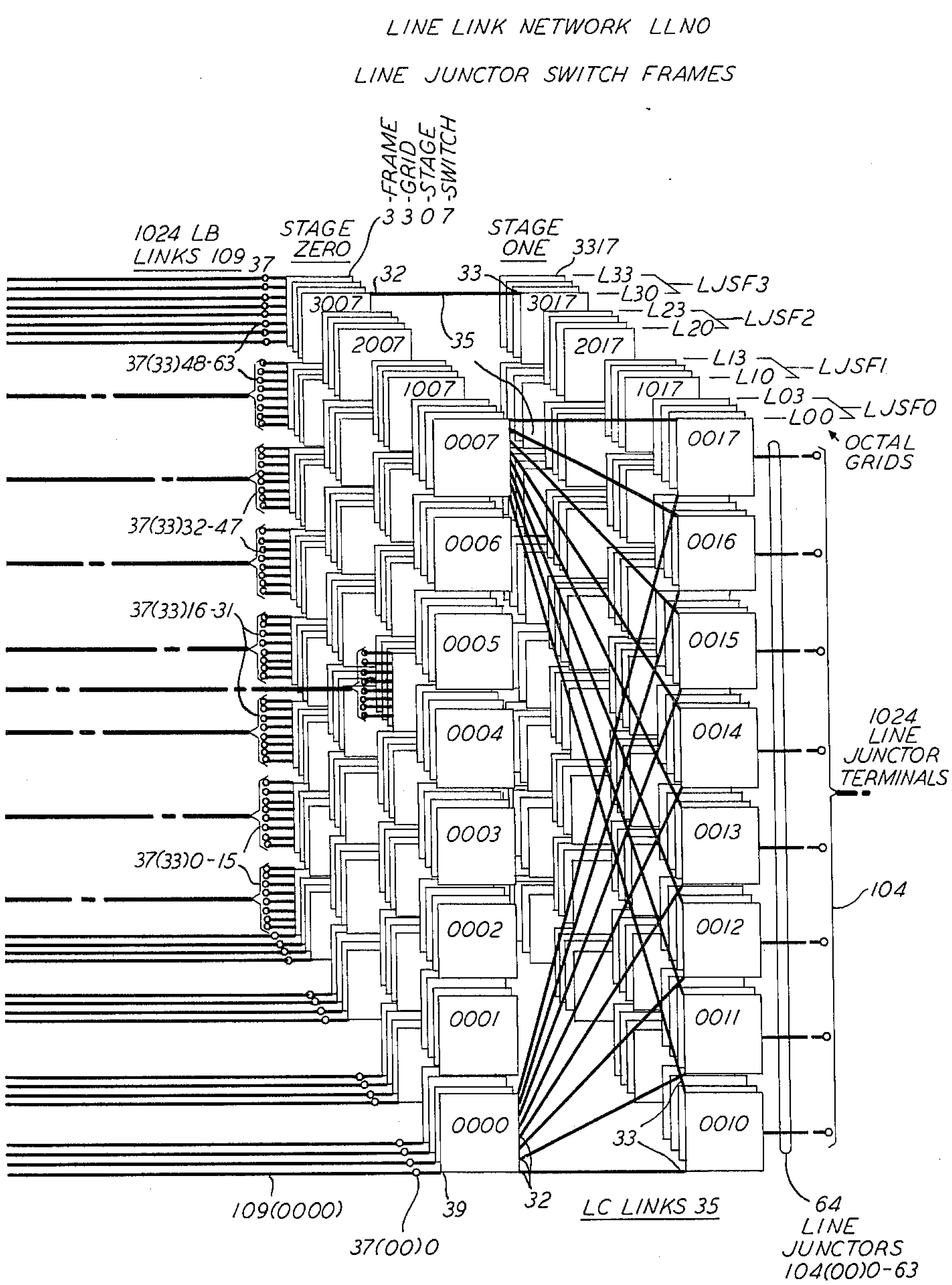
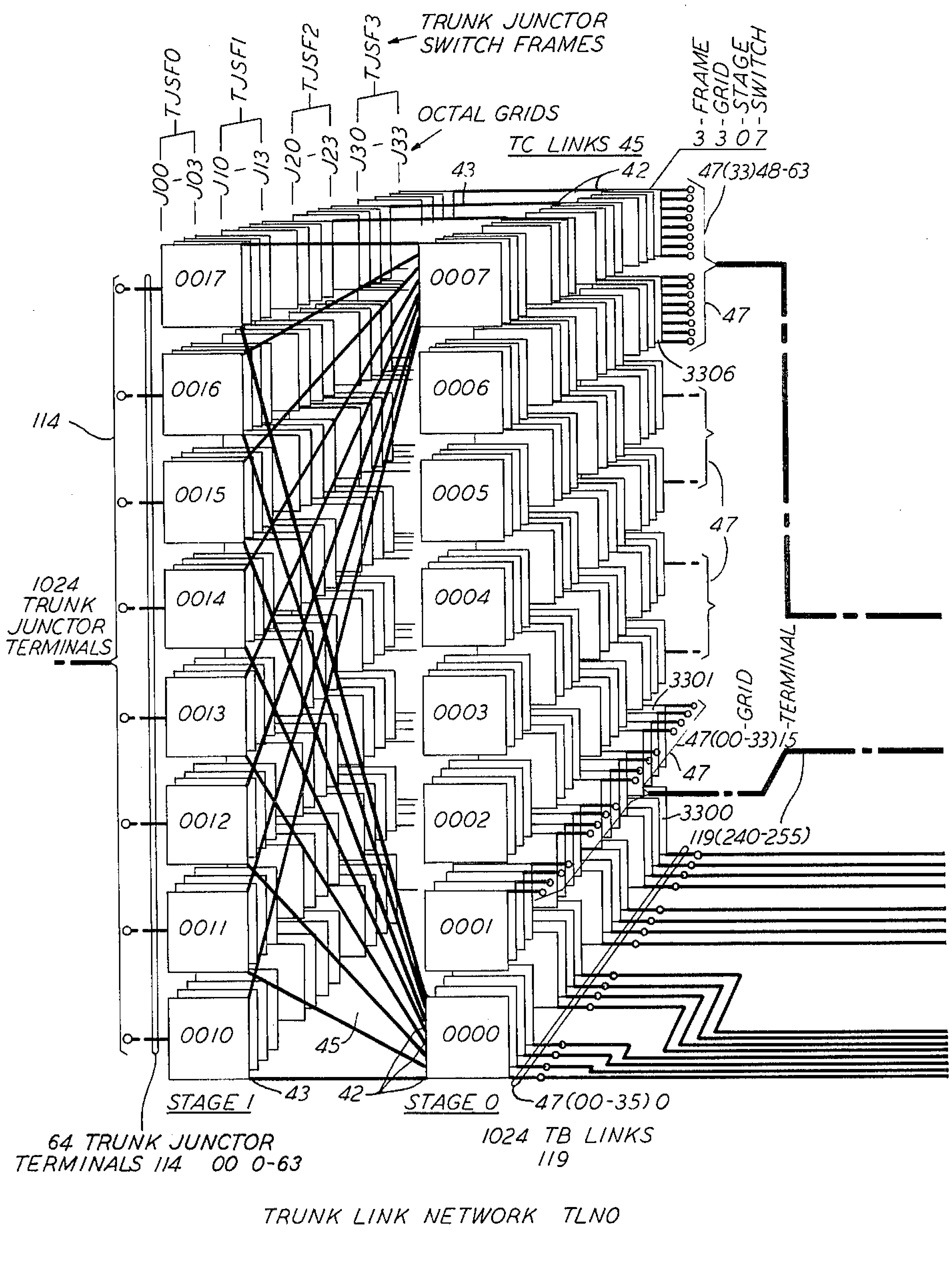

LINE LINK NETWORK LLNO
LINE SWITCH FRAMES
64 LINE TERMINALS
127(315)0-63
4096 LINES
127
22
25 LA LINKS
23
STAGE ZERO
STAGE ONE
1024 LB LINKS 109
31503
31502
31501
31500
31513
31512
31511
31510
C315
C38
C37
C30
LSF3
3700
3710
24
C215
C28
C27
C20
LSF2
21500
21510
2700
2710
C115
C18
C17
C10
LSF1
11500
11510
1700
1710
C015
C08
C07
C00
LSF0
01500
01510
0700
0710
25
CONCENTRATOR GRIDS
22
23
39
24(00)0
24(00)0-15
109(0000)

FIG. 3



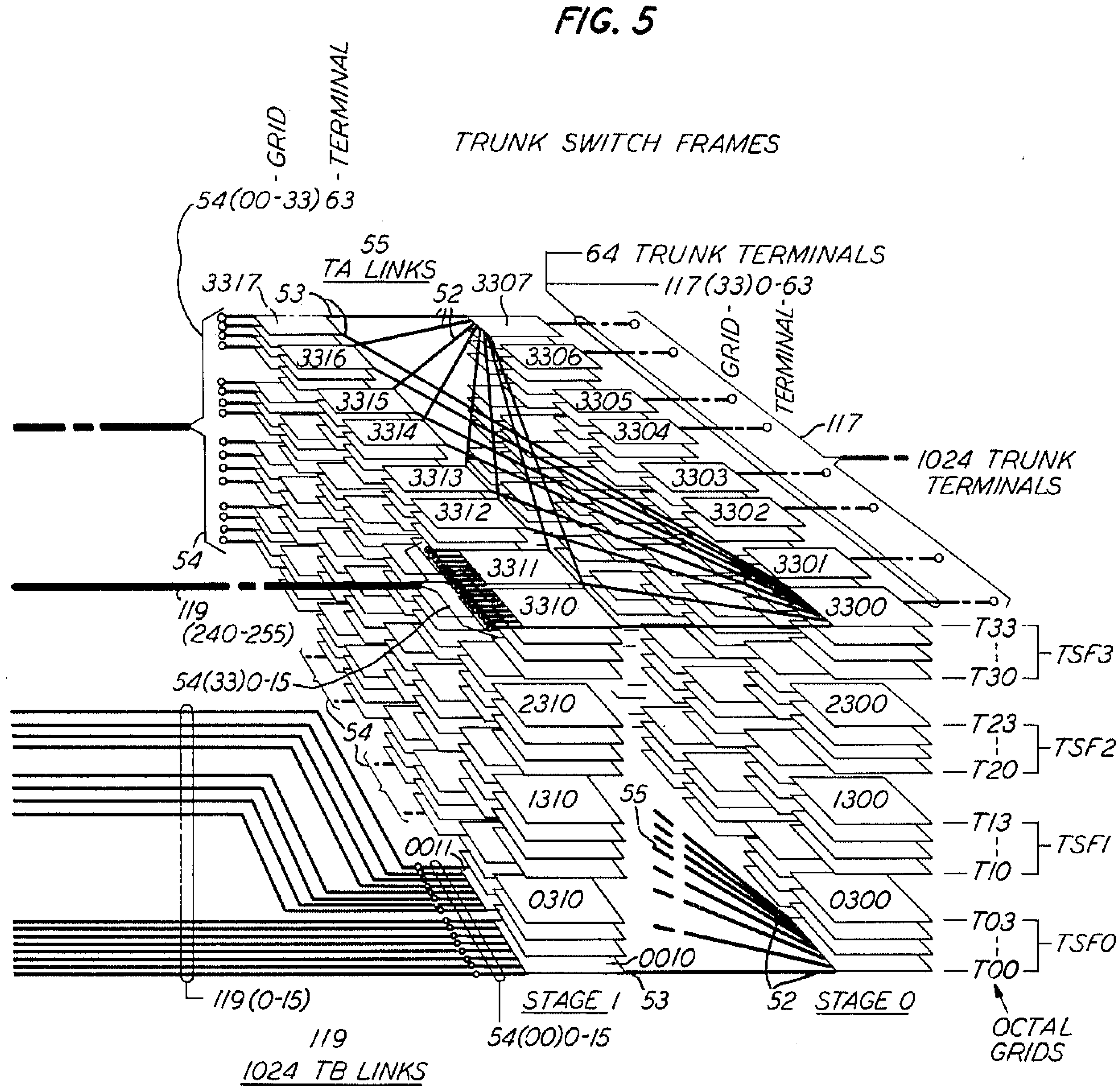
LINE LINK NETWORK LLNO
LINE JUNCTOR SWITCH FRAMES
-FRAME
-GRID
-STAGE
-SWITCH
3 3 0 7
1024 LB LINKS 109
STAGE ZERO
STAGE ONE
3317
37
32
33
L33
L30
LJSF3
L23
L20
LJSF2
L13
L10
LJSF1
L03
L00
LJSF0
OCTAL GRIDS
3007
2007
1007
3017
2017
1017
35
37(33)48-63
37(33)32-47
37(33)16-31
37(33)0-15
0007
0006
0005
0004
0003
0002
0001
0000
0017
0016
0015
0014
0013
0012
0011
0010
1024 LINE JUNCTOR TERMINALS
104
33
109(0000)
37(00)0
39
32
LC LINKS 35
64 LINE JUNCTORS 104(00)0-63

FIG. 4



TRUNK LINK NETWORK TLN0

FIG. 5



TRUNK LINK NETWORK TLNO

June 21, 1966 A. FEINER 3,257,513

COMMUNICATIONS SWITCHING NETWORK

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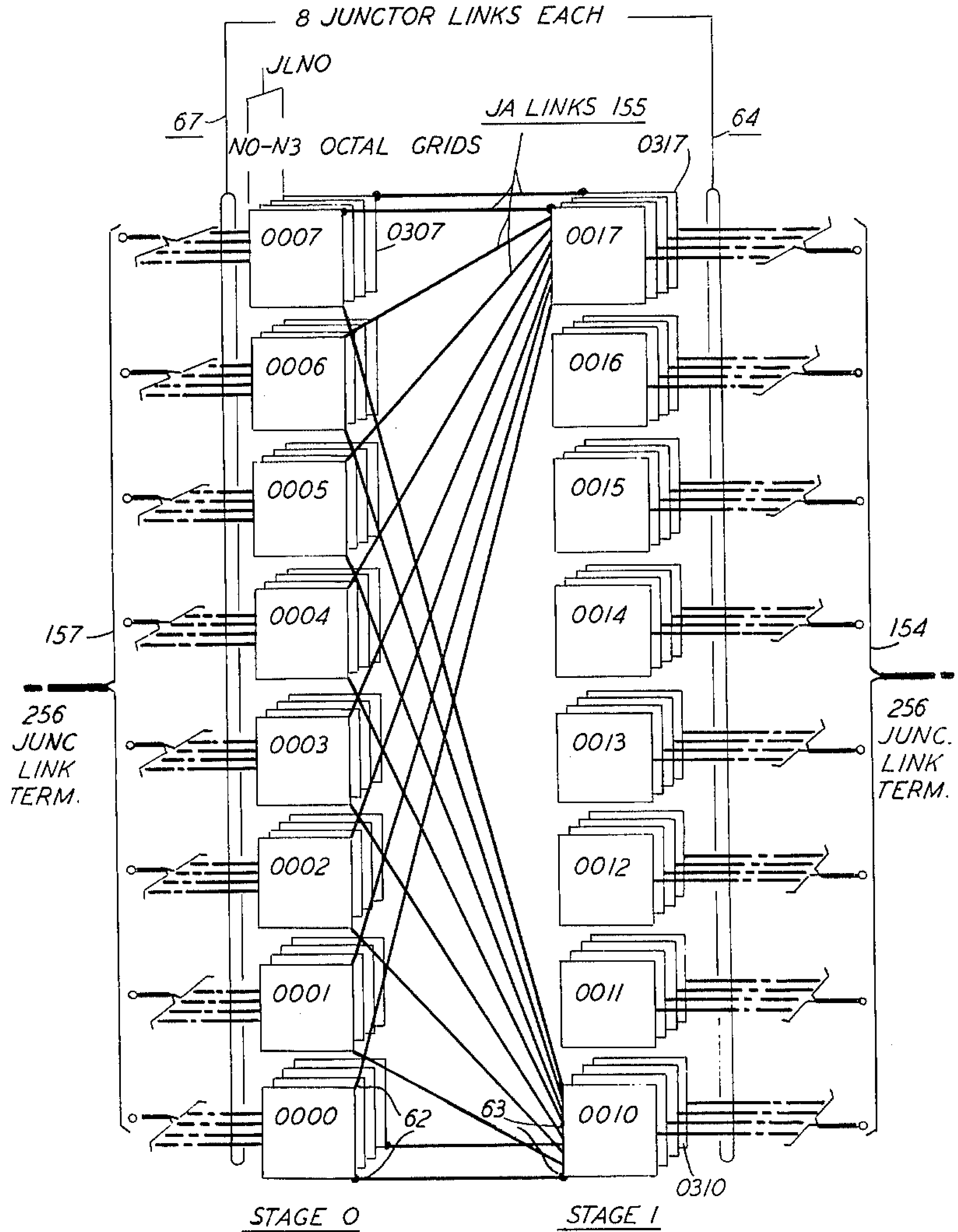
FIG. 6



LINE JUNCTOR LINK NETWORK LJLNO

June 21, 1966 A. FEINER **3,257,513**

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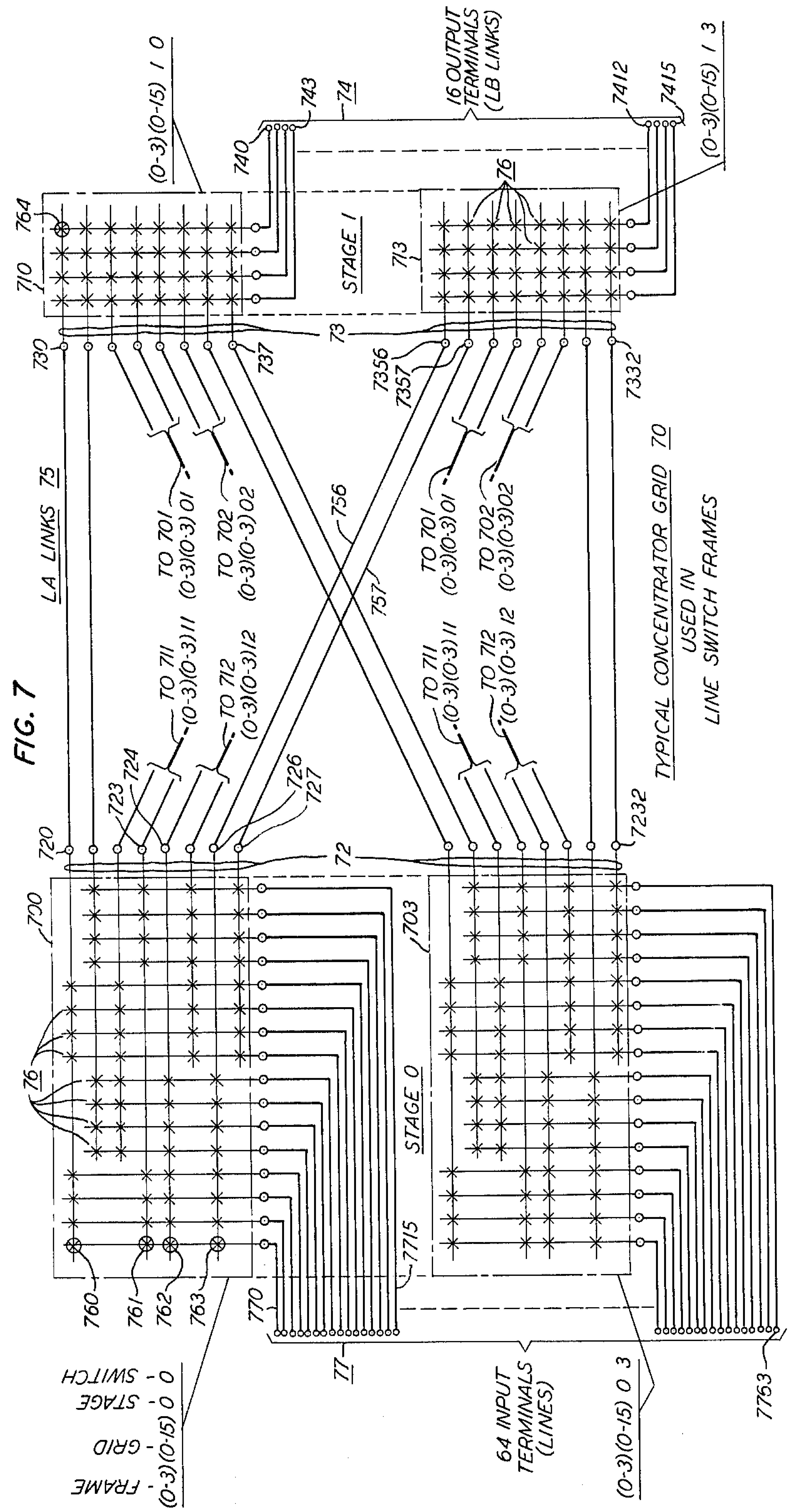

FIG. 7

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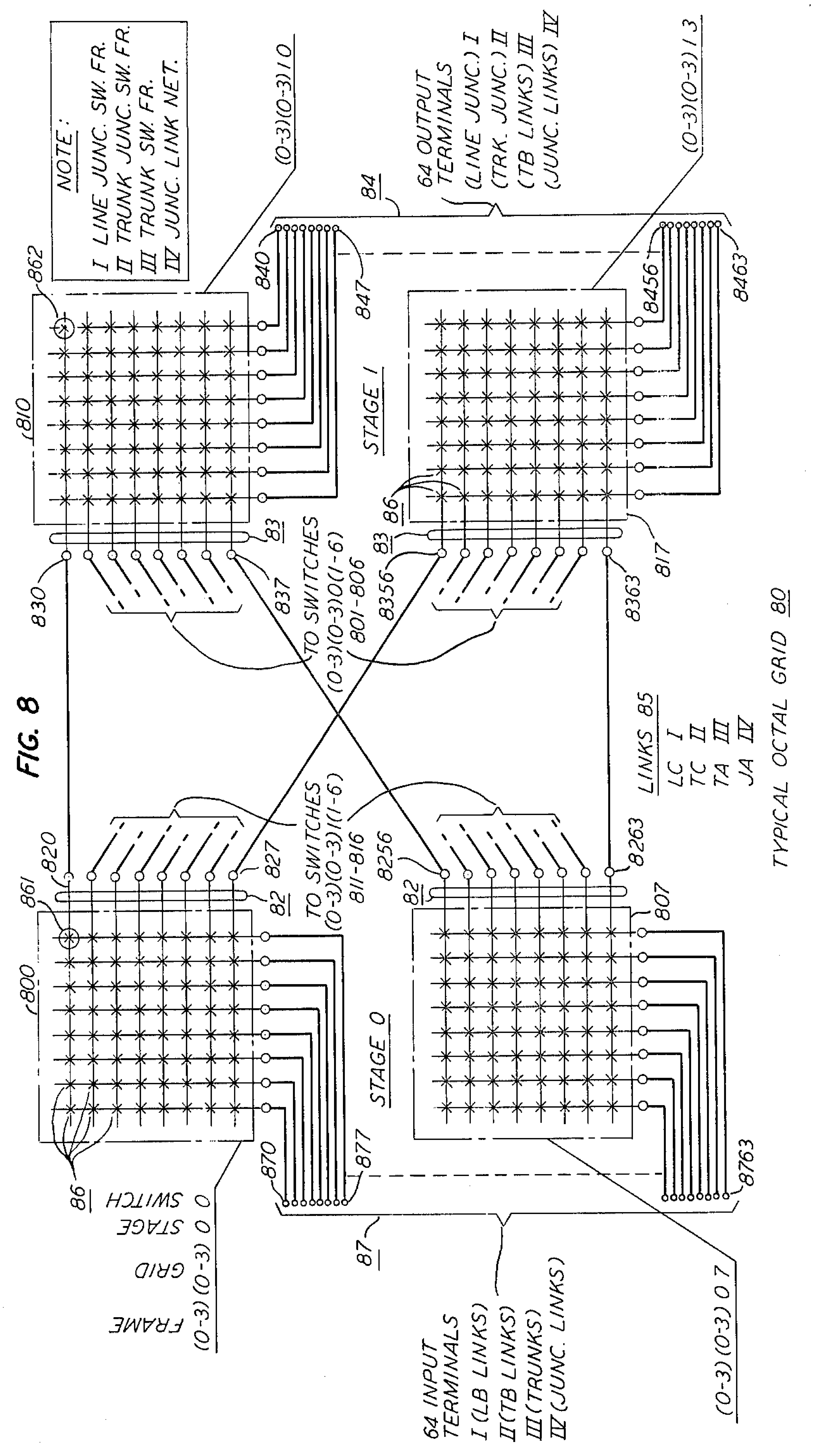

United States Patent Office

3,257,513

Patented June 21, 1966

3,257,513

COMMUNICATIONS SWITCHING NETWORK

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Filed Jan. 22, 1963, Ser. No. 253,083
13 Claims. (Cl. 179—18)

This invention relates generally to communications switching networks and more particularly to large, multistage, communication networks which are adaptable to electronic control.

Telephone switching systems generally provide for the selective interconnection of lines and trunks. Control of switching systems is characterized as progressive, as in the well-known step-by-step switching system, or centralized, as in the well-known Bell System crossbar switching systems. Switching systems having centralized control normally comprise a switching network, through which interconnection of lines and trunks is accomplished; common control circuitry for determining and generating commands; supervisory circuitry for monitoring and controlling the operations of line and trunk circuits; and access circuitry for selectively energizing selected portions of the switching system in accordance with commands generated by common control circuitry.

The number of lines and trunks which may be efficiently served by a switching system is dependent upon the cooperative efficiencies of the above system components. Prior art switching systems have generally been limited to 20,000 lines and associated trunks per network due to a decrease in efficiency of system operation when this number of lines was exceeded. This invention is directed to a switching network configuration suitable for use with a greatly enlarged number of lines and trunks, which configuration makes advantageous use of highly efficient common control circuitry and network access circuitry.

The switching network of a switching system provides selectable connecting paths between the lines and trunks served by the switching system. Lines provide access to the switching network from local sources of communication, such as telephone stations and data terminal equipment. Trunks provide access to the network from other remote switching networks. Each demand for a connection through a network is termed a call, and a plurality of calls is known as traffic. Among the various types of traffic which must be processed by a switching system are line to line calls, trunk to trunk calls, line to trunk calls and trunk to line calls. In addition, administrative traffic, requiring connection of lines or trunks to tone sources, signal transmitters, signal receivers, coin supervisory circuits, ringing circuits, maintenance circuits and the like, must be processed. The amount of traffic through a switching network is a direct function of, among other factors, network size and the rate at which calls are initiated from the lines and trunks terminated on the network.

Switching system common control circuitry, which selects and directs the establishment of connecting paths through the switching network, may comprise a multiplicity of identical control units or a single control unit. Multiple control units are provided when the speed at which a single control unit can process a call is insufficient to allow processing of all traffic through a switching network without unsatisfactory delays in sequential call completion. An example of a multiple control unit switching system is the well-known No. 5 crossbar switching system wherein multiple "markers" are utilized to provide efficient traffic processing.

On the other hand, electronic, data processing type, control units have been developed which obviate, except

for system reliability, the need for multiple control units and which individually are capable of processing a massive amount of traffic.

The switching network access circuitry through which the common control circuitry exerts control over the switching network generally is of a space divided type, a time divided type or a combination thereof. Where multiple control units are utilized, the network access circuitry is space divided so as to avoid conflicts between individual control units as they seek to exert control over the same portion of the switching network. Such access circuitry generally comprises a lockout type circuit which prevents connection of more than one control unit to any portion of the network at any given time. As a result of this lockout operation, one control unit may be forced to await the release of another control unit before completing its function, thereby delaying call completion and further delaying the processing of subsequent calls.

A switching system of the type with which my invention may be utilized may be characterized by the asynchronous time sharing of a high-speed, command generating circuit by a large number of diverse, low-speed, command executing circuits. The network access circuitry of this type of system does not require lockout type circuits to space divide multiple control units since there are no competing control units. Interference between multiple control units and resultant delays in traffic processing are therefore avoided.

As previously mentioned, the number of lines which may be efficiently served by a single switching network is determined by the efficiency of cooperation between the switching network, the common control circuitry and the network access circuitry. The traffic generated by 20,000 lines and associated trunks has generally, heretofore, been the maximum amount of traffic that could be efficiently processed by prior art switching systems. Electronic telephone systems of the type discussed above are capable of processing traffic generated by over 65,000 lines and associated trunks A switching network through which over 65,000 lines and associated trunks may be selectively interconnected presents many problems not previously encountered in the smaller switching networks of the prior art.

It is, therefore, a general object of this invention to fully utilize the extensive traffic processing capabilities of a high-speed, common control circuit in association with time-divided, network access circuitry by means of a large, highly flexible and versatile switching network through which all types of traffic may be completed.

Switching networks have been characterized as unidirectional, bidirectional or a combination thereof. In a unidirectional switching network, connections are established in only one direction. Separate switching networks are provided for originating traffic and terminating traffic. These separate networks are interconnected to provide for line to line and for trunk to trunk traffic. Each bidirectional input circuit (one from which calls may originate and at which calls may terminate) must be terminated twice, i.e. on both originating and terminating networks, to provide for the completion of both originating and terminating calls.

A bidirectional switching network permits the establishment of connections in either direction, and only one such network need be provided for completion of both originating and terminating types of calls. Bidirectional input circuits to a bidirectional switching network require only one termination since, in such a network, it makes no difference in which direction a connection must be established. However, the use of unidirectional input circuits, such as incoming and outgoing trunks, is not precluded in a bidirectional network.

Some switching networks, such as that of the well-known step-by-step switching system, are fully unidirectional. However, most prior art switching networks exhibit a configuration having both unidirectional and bidirectional characteristics. A combined unidirectional and bidirectional switching network is exemplified in the well-known No. 5 crossbar switching system. In this network, trunk to trunk connections can be established through the network in one direction only, whereas all other connections may be established in either direction. Trunks which may be used in trunk to trunk connections accordingly require two terminations—one termination for traffic originating through the trunk and another termination for traffic terminating through the trunk.

The presence of any unidirectional characteristic in a switching network serving the number of lines and trunks which are contemplated by this invention would compound the dual termination requirement for bidirectional input circuits so as to increase the number of network input terminals required for full flexibility beyond all proportions.

It is, accordingly, another object of this invention to eliminate all undesirable unidirectional characteristics from a large switching network configuration and to thereby more efficiently utilize all input terminals thereof.

The original installation of a switching system is seldom, if ever, of maximum size. Generally allowance is made for future growth in switching network terminations. Further, in a switching network of the size contemplated herein, it is highly probable that traffic patterns within the network will change from time to time. For example a network which is originally designed and engineered to process a majority of line to line traffic, as compared to other types of traffic, may very well be called upon to process a majority of line to trunk traffic or trunk to trunk traffic at some future time due to variation in the character of the lines and trunks served by the network or the addition of other lines and trunks thereto.

The procedures for rearranging traffic patterns in prior art networks have generally required extensive circuit changes in several portions of the network. If prior art networks were sufficiently enlarged to assume the relatively massive proportions of the switching network contemplated herein, the aforenoted circuit changes would be multiplied accordingly. Traffic pattern rearrangements in such networks would become excessively ponderous and time consuming.

Accordingly, it is a further object of this invention to facilitate and simplify the rearrangement of traffic patterns within a switching network in accordance with changes in the ratio between the various types of traffic for which the switching network provides connections.

These and other objects of the invention are attained in one specific illustrative embodiment thereof wherein a multistage, space-division, switching network is divided into serially interconnected, bidirectional, sub-networks. Lines are terminated on the input terminals of a first type of sub-network (called herein a line link network) which provides for the selective interconnection of all lines terminated thereon via wired junctor interconnections of selected output terminals thereof (designated line junctor terminals). Trunks are terminated on the input terminals of a second type of sub-network (called herein a trunk link network) which provides for the selective interconnection of all trunks terminated thereon via wired junctor interconnections of selected output terminals thereof (designated trunk junctor terminals). The serial combination of a line link network and a trunk link network provides for the selective interconnection of all lines and trunks terminated thereon via wired junctor connections between selected line junctor terminals and selected trunk junctor terminals.

All line junctor terminals and trunk junctor terminals are located, in accordance with an aspect of my invention, at a central cross connection facility (called herein a junctor grouping frame) which provides for full flexibility of interconnection thereof in accordance with current network traffic requirements.

A plurality of line link networks and trunk link networks may be provided. Selected line junctor terminals and trunk junctor terminals of each respective line link network and trunk link network are connected via junctor cross connections on the junctor grouping frame to selected line junctor terminals and trunk junctor terminals of all other line link networks and trunk link networks in accordance with existing traffic requirements to provide full flexibility of sub-network interconnection.

By means of the junctor grouping frame, selected line junctor terminals are interconected via line junctor links, each of which includes facilities (designated a line junctor circuit) whereby supervisory services for line to line connections may be accomplished. When, as a result of total network size or network traffic patterns, a large amount of line to line traffic must be switched, I provide, in accordance with another aspect of my invention, a third type of sub-network (called herein a line junctor link network) on which selected line junctor links are terminated, to increase the flexibility of line junctor terminal interconnection. A trunk junctor link network may be similarly provided to increase the flexibility of trunk junctor terminal interconnection.

In this specific illustrative embodiment of my invention common control circuitry advantageously selects specific paths through the network. To implement this selection function, a record of the busy and idle states of network interconnection links and a record of the entire path of every established or reserved network connection may be maintained by the common control circuitry. Commands, which comprise addresses and orders defining new network connections, are determined by the common control and transmitted to network control units which control the establishment of new connections through the network and the release of existing connections through the network.

In accordance with a feature of my invention, line to line calls are routed via interconnected line junctor terminals thereby bypassing the switching stages of the trunk line networks.

In accordance with a further feature of my invention, trunk to trunk calls are routed via interconnected trunk junctor terminals thereby bypassing the switching stages of the line link networks.

Switching networks have been characterized as folded and nonfolded. A fully folded network is one wherein all lines and trunks are terminated on the input terminals of the first switching stage thereof. The output or junctor terminals of the last switching stage are permanently interconnected. Interconnection of lines and trunks is accomplished by establishing a U-shaped path which includes a first connection through the network from a first stage input terminal to a last stage output terminal, the permanent connection from the last stage output terminal to another last stage output terminal and a second connection through the network from the other last stage output terminal to a first stage input terminal. Full bidirectional flexibility of interconnection of lines and trunks is available in a fully folded network. However, the requirement of two connections through the network for the completion of each call exerts some limitation upon the traffic handling capacity of this type of network.

A fully nonfolded network is one wherein lines and trunks are terminated at opposite ends of the network. Lines generally are terminated on the first stage of the network, and trunks generally are terminated on the last stage of the network. A connection between a line and a trunk is accomplished by establishing a single path through the network from the line to the trunk. A fully nonfolded network provides for bidirectional flexibility in connecting lines to trunks. However, this type of network does not provide for line to line connections and trunk to trunk connections.

In accordance with another feature of my invention a first partially folded network (the line link network) and a second partially folded network (the trunk link network) are serially connected at selected output terminals (junctor terminals) thereof, to provide full bidirectional flexibility of interconnection of lines and trunks.

In accordance with a further feature of my invention, all trunk junctor terminals and line junctor terminals may be selectively interconnected in accordance with current traffic requirements by means of readily rearrangeable junctor cross connections at a single, central location.

It is still another feature of my invention that a third sub-network is interposed in the output junctor connections of one of the other sub-networks for increasing the amount of traffic that may be switched between the input terminals of that one sub-network without utilizing any of the facilities of the other sub-network. Thus it is a feature of my invention that line to line traffic may be switched through a line sub-network, a junctor sub-network, and again through the line sub-network without utilizing the trunk sub-network of the switching system.

Further it is a feature of my invention that the junctor terminals of this third sub-network also all be available at the single cross-connection frame for interconnection with line junctor terminals of the line sub-network.

The above and other objects and features of my invention will be more readily understood from the following description when read with respect to the drawing in which:

FIG. 1 is a block diagram of one illustrative switching network organized in accordance with my invention;

FIGS. 2 and 3, when placed side by side, are a perspective type block diagram illustrating the organization of a typical line link network;

FIGS. 4 and 5, when placed side by side, are a perspective type block diagram illustrating the organization of a typical trunk link network;

FIG. 6 is a perspective type diagram illustrating the organization of a typical line junctor link network;

FIG. 7 is a schematic representation of a typical concentrator grid; and

FIG. 8 is a schematic representation of a typical octal grid.

The following description of one illustrative embodiment of my invention is divided into a number of parts. Following a general introduction including a discussion of the type of network switching devices that may be advantageously employed there is set forth a description of a block diagram of a multistage network incorporating my invention including distinct sub-networks. Following this there is set forth a description of the basic switching grid units of which the various sub-networks of this embodiment are composed. Lastly there are set forth, in distinct sections, descriptions of each of the three sub-networks of this specific embodiment.

INTRODUCTION

A communication switching network is comprised of a plurality of selectively energizable switching devices which, when energized, connect associated transmission paths through the switching network. Prior art switching networks have utilized both electronic and electromechanical switching devices as transmission path connecting elements. One example of an electromechanical switching device, which may be advantageously used in the illustrative switching network to be described herein, is disclosed inter alia in an article "The Ferreed—A New Switching Device" by A. Feiner et al., Bell System Technical Journal, January 1960 at page 1 and my copending patent application Serial No. 862,811, filed December 30, 1959. This device is known as the "ferreed." An arrangement for selectively controlling the operation of a coordinate array of ferreeds is disclosed in the copending patent application of W. S. Hayward, Jr., Serial No. 206,055, filed on June 28, 1962, now Patent 3,110,772 issued November 12, 1963. Although the switching network described herein below may advantageously be comprised of this type of switching device, other electromechanical and electronic switching devices are equally suitable for use in a switching network organized in accordance with my invention.

Switching network of my invention (FIG. 1)

FIG. 1 is a block diagram of an illustrative embodiment of a switching network **100** organized in accordance with my invention and of its associated control and supervisory circuitry **170**. The illustrative switching network **100** provides for the selective, bidirectional, interconnection of up to 65,536 lines **107** and up to 16,384 trunks **137** via eight stages of switching.

Although I depict in FIG. 1 a full size switching network **100**, it is to be understood that less than a full size network may be provided in accordance with my invention, as described hereinbelow.

The illustrative eight stage switching network **100** comprises two basic types of four stage sub-networks which are respectively designated line link networks **LLN0–LLN15** and trunk link networks **TLN0–TLN15**. Each line link network **LLN0–LLN15**, as described below with reference to FIGS. 2 and 3, provides for selectively connecting each of 4,096 line input terminals **127** to any of 1,024 line junctor terminal outputs **104** through four switching stages. Thus in the drawing each input terminal **127** represents 1,024 terminals and each line junctor terminal **104** represents 256 such terminals. Each trunk link network **TLN0–TLN15**, as described below with reference to FIGS. 4 and 5, provides for selectively connecting each of 1,024 trunk input terminals **117** to any of 1,024 trunk junctor terminal outputs **114** through four switching stages. Thus again in the drawing each input terminal **117** represents 256 such terminals and each junctor terminal **114** represents 256 such terminals. The number of line link networks **LLN0–LLN15** and trunk link networks **TLN0–TLN15** of which a switching network in accordance with my invention is comprised may be varied in accordance with the number of switching network terminations required. Although at least one line link network and at least one trunk link network must be provided, the number of line link networks and trunk link networks need not be equal.

As described further below with reference to FIGS. 2 and 3, each line link network **LLN0–LLN15** comprises four line switch frames **LSF0–LSF63** and four line junctor switch frames **LJSF0–LJSF63**. The four line switch frames **LSF0–LSF63** and line junctor switch frames **LJSF0–LJSF63** within each respective line link network **LLN0–LLN15** are connected via LB links **109** in a full access pattern, as hereinafter further described, to allow any line input terminal **127** of a particular line link network **LLN0–LLN15** to be selectively connected to any line junctor terminal output **104** of the same line link network **LLN0–LLN15**. Line link networks **LLN0–LLN15** may be partially equipped with fewer than the full complement of four line switch frames and four line junctor switch frames if a full size line link network is not required.

As described further below with reference to FIGS. 4 and 5, each trunk link network **TLN0–TLN15** comprises four trunk switch frames **TSF0–TSF63** and four trunk junctor switch frames **TJSF0–TJSF63**. The trunk switch frames **TSF0–TSF63** and trunk junctor switch frames **TJSF0–TJSF63** within each respective trunk link network **TLN0–TLN15** are connected via TB links **119** in a full access pattern, as hereinafter further described, to allow any trunk input terminal **117** of a particular trunk link network **TLN0–TLN15** to be selectively connected to any trunk junctor terminal output **114** of the same trunk link network **TLN0–TLN15**. Trunk link networks may also be partially equipped if a full size trunk link network is not desired.

In accordance with an aspect of my invention, all line junctor terminals **104** and trunk junctor terminals **114** appear on a junctor grouping frame **180**. The junctor grouping frame **180** allows for easy rearrangement of traffic patterns and specifically provides junctor cross connection facilities whereby any trunk junctor terminal **114** may be directly connected via junctor across connections **181** to any other trunk junctor terminal **114** to provide bidirectional, folded network paths through a trunk link network or networks **TLN0–TLN15** for completing trunk to trunk calls; whereby any trunk junctor terminal **114** may be directly connected via junctor cross connections **186** to any line junctor terminal **104** to provide bidirectional, nonfolded network paths through a line link network **LLN0–LLN15** and a trunk link network **TLN0–TLN15** for completing line to trunk and trunk to line calls; and whereby any line junctor terminal **104** may be connected to any other line junctor terminal **104** via first junctor cross connections **184**, line junctor circuits **150** and their respectively associated junctor links **151** and **152** and second junctor cross connections **185** to provide bidirectional, folded network paths through a line link network or networks **LLN0–LLN15** for the completion of line to line calls. The pattern in which the above typical junctor cross connections **181, 184, 185** and **186** are made, and the selection of the particular line junctor terminals **104** and trunk junctor terminals **114** to be interconnected are determined in accordance with the estimated traffic requirements of the switching network **100**. Rearrangement of junctor cross connections on the junctor grouping frame **180** to comply with future changes in traffic requirements, in networks incorporating this aspect of my invention, are easily accomplished at this central cross connection facility.

Junctor grouping frame **180** includes a cross-connection field in which semipermanent cross-connections are made between selected line junctor terminals **104**, trunk junctor terminals **114** and junctor link terminals **151, 152, 153** and **158**. Each representative junctor and junctor link terminal comprises a group of conductor terminals equal in number to the parallel transmission conductors of which a transmission path through the switching network **100** is comprised. Cross-connections, such as **181–186**, are included in multiconductor cross-connecting cables equipped at both ends with receptacle units adapted to fit the respective junctor and junctor link terminals in plug-in fashion. Cross-connecting cables include facilities for interconnecting a plurality of conductor terminal groups since junctor terminals and junctor link terminals are generally interconnected in selected groups.

Line junctor circuits **150** are advantageously interconnecting relay circuits providing scanning points for supervision of the connected paths and relay contacts for making the final connection to establish the path, as is known in the art. As the type of circuit involved, as well as the types of scanning, supervision, and control, form no part of my invention, which is directed to aspects of the transmission path configurations of a large switching network, these aspects of this illustrative embodiment will not be further detailed.

It will be noted that each line link network **LLN0–LLN15** exhibits a partially folded network configuration for the completion of line to line calls and a partially nonfolded network configuration for the completion of line to trunk calls. Each trunk link network **TLN0–TLN15** exhibits a partially folded network configuration for the completion of trunk to trunk calls and a partially nonfolded network configuration for the completion of line to trunk calls. The folded or nonfolded configuration of the trunk link networks **TLN0–TLN15** and the line link networks **LLN0–LLN15** is determined by the pattern in which junctor cross connections **181–186** are made between line junctor terminals **104** and trunk junctor terminals **114** at the junctor grouping frame **180**.

To provide for fully flexible interconnection of lines **107**, it is advantageous to have at least one line junctor terminal **104** of each line junctor switch frame **LJSF0–LJSF63** connected to at least one line junctor terminal **104** of itself and all other line junctor switch frames **LJSF0–LJSF63**. For example, one line junctor terminal of line junctor switch frame **LJSF0** should be connected to at least one line junctor terminal **104** of itself **LJSF0** and to at least one line junctor terminal **104** of all other line junctor switch frames **LJSF1–LJSF63**. In a relatively small switching network, i.e. one having fewer than eight line link networks containing a total of thirty-two line junctor switch frames, wherein a reasonable amount of line to line traffic is expected, the number of line junctor terminals **104** which must be interconnected will not so decrease the number of other line junctor terminals **104** which are available for connection to trunk junctor terminals **114** as to unduly reduce the facilities for line to trunk and trunk to line traffic. However, as the switching network grows in size and more line junctor switch frames are added, the number of line junctor terminals **104** of each line junctor switch frame which must be connected to other line junctor switch frames will increase proportionately. Therefore, the number of line junctor terminals **104** available from each line junctor switch frame for connection to trunk junctor terminals **114** is accordingly decreased. Further, as the switching network grows, the amount of line to trunk and trunk to line traffic will increase. As a result, fewer line junctor terminal **104** to trunk junctor terminal **114** junctor cross connections **186** are available than may be required to complete this traffic, and line to trunk calls may be blocked due to a lack of sub-network interconnecting facilities.

In accordance with an aspect of my invention, a third type of sub-network, which is designated a line junctor link network **LJLN0**, is provided in the illustrative switching network **100** to alleviate the above-described problem of line junctor terminal availability. Each of the line junctor circuits **150** has two junctor links **151** and **152** or **153** and **158** associated therewith. Those of junctor circuits **150** having junctor links **151** and **152** associated therewith are used, as previously described, for direct interconnection of line junctor terminals **104** via the junctor grouping frame **180**. Those of line junctor circuits **150** having junctor links **153** and **158** associated therewith are used, as hereinafter described, for interconnection of line junctor terminals **104** via the junctor grouping frame **180** and the line junctor link network **LJLN0** which is serially inserted in junctor links **158** to achieve greater flexibility of sub-network interconnection with a reduced number of line junctor terminals **104**.

To illustrate the utility of a line junctor link network **LJLN0** in accordance with my invention the following example is given. Assuming that a full size, 65,536 line switching network **100** is provided without line junctor link network **LJLN0**, sixty-four line junctor terminals **104** of each of the sixty-four line junctor switch frames **LJSF0–LJSF63** are required to connect each line junctor switch frame **LJSF0–LJSF63** to itself and to all other line junctor switch frames **LJSF0–LJSF63** via line junctor circuits **150** and their associated junctor links **151** and **152**. By my provision of a line junctor link network **LJLN0**, I reduce the number of line junctor terminals **104** from each of the sixty-four line junctor switch frames **LJSF0–LJSF63** required to connect each line junctor switch frame **LJSF0–LJSF63** to itself and to all other line junctor switch frames **LJSF0–LJSF63** from sixty-four to eight line junctor terminals **104** per line junctor switch frame **LJSF0–LJSF63**.

Four line junctor terminals **104** of each line junctor switch frame **LJSF0–LJSF63** are connected via junctor cross connections **182** to four of the junctor links **158** which are terminated as inputs **157** of line junctor link network LJLN**0**. Four other line junctor terminals **104** of each line junctor switch frame LJSF**0**–LJSF**63** are connected via junctor cross connections **183** to four junctor links **153**. The output terminals **154** of line junctor link network LJLN**0** are connected to those of line junctor circuits **150** which have junctor links **153** associated therewith.

As described further below with reference to FIG. 6, a line junctor link network **600** provides selectable, bidirectional, connecting facilities between each of two hundred fifty-six junctor link input terminals **157** and any of two hundred fifty-six junctor link output terminals **154** through two switching stages. Line junctor link network LJLN**0** provides four, selectable, connecting paths between each line junctor switch frame LJSF**0**–LJSF**63** over which the respective lines **107** may be interconnected. Without line junctor link network LJLN**0**, only one selectable path was provided between each of the line junctor switch frames LJSF**0**–LJSF**63**. Line junctor link network LJLN**0** has provided sufficient added switching flexibility to introduce universality to the line junctor terminals of each line link network LLN**0**–LLN**15**, which would otherwise be respectively limited in access to a single specific one of line junctor link frames LJSF**0**–LJSF**63** within a single specific line link network LLN**0**–LLN**15**.

Although not shown in FIG. 1, a trunk junctor link network may be provided to increase the flexibility of interconnection between trunk junctor switch frames TJSF**0**–TJSF**63** in a manner similar to the illustrated provision of line junctor link network LJLN**0**.

A suggested arrangement of control and supervisory circuitry **170** with which the illustrative switching network **100** may advantageously be blended is shown in FIG. 1. Central processing and pulse distribution circuit **171** determines and generates commands which are transmitted on an asynchronous time division basis via a peripheral bus system **175** to a network control circuit **172**, supervisory control circuit **173** and supervisory scanning circuit **174**.

The various commands which are transmitted to network control **172** are executed thereby in the appropriate line link network LLN**0**–LLN**15**, trunk link network TLN**0**–TLN**15** or line junctor link network LJLN**0**. The various commands transmitted to supervisory scanning **174** initiate the scanning of line terminals **127** and trunk circuits **147** to detect new service requests therefrom, and the scanning of junctor circuits **150** and trunk circuits **147** to ascertain which of the existing connections through the switching network **100** may be released. Other scanning functions may be similarly performed by supervisory scanning **174** responsive to commands transmitted thereto. The commands transmitted to supervisory control **173** initiate appropriate execution thereby in the trunk circuits **147** and the junctor circuits **150**. These initiate, among other functions, the final "cut-through" of a call connection through the switching network **100** and the initial "opening" of an established connection through the switching network **100**.

Basic switching grid units (FIGS. 7 and 8)

FIGS. 7 and 8 illustrate the organization of the transmission path connecting contacts, **76** and **86** respectively, into a plurality of coordinate switch arrays **700–703**, **710–713** and **800–807**, **810–817** to form the basic switching grid units **70** and **80** utilized in the sub-networks of the embodiment of FIG. 1. Only the switching device contacts are shown, since the means whereby the contacts are controlled forms no part of this invention. It is assumed that the switching device contacts, for example contacts **86** of FIG. 8, may be selectively closed and opened responsive to control thereof by their respectively associated switching devices. For purposes of simplicity, a single connecting path through the switching grid units shown in FIGS. 7 and 8 is representative of a transmission path comprising any number of parallel conductors.

The numerical designations of the various components of the grid units **70** and **80**, shown in FIGS. 7 and 8, do not have any functional meaning. However, the last digit of the respective numerical designations will be used whenever possible to designate similar components of similar grid units in the remainder of the other figures of the drawing. For example, the output terminals of the octal grid **80** shown in FIG. 8 are designated **84**. The output terminals of all octal grids shown in FIGS. 3, 4 and 5 are designated **104**, **114** and **54**, respectively. It will be noted that the last digit of each of the above designations assigned to the output terminals of an octal grid is the digit 4. This system of numbering is used to facilitate cross referencing to FIGS. 7 and 8 from the other figures.

FIG. 8 illustrates the organization of an "octal grid" **80**. The switching device contacts **86** are arranged in a plurality of coordinate switch arrays **800–807** and **810–817**, of which only the first arrays **800** and **810** and last arrays **807** and **817** are shown. Each coordinate switch array, for example array **800**, has eight input terminals **870–877** in one coordinate thereof and eight output terminals **820–827** in the other coordinate thereof. Each of the eight input terminals **870–877** is connectable through a selectively closed contact **86** to any of the eight output terminals **820–927** of the same switch array **800**. For example, input terminal **877** may be connected to output terminal **820** by closing contact **861**. This type of switch array is designated an "8 x 8" switch.

An octal grid **80** comprises sixteen 8 x 8 switches **800–807** and **810–817** which are arranged in two switching stages **0** and **1**, each having eight 8 x 8 switches. The output terminals **82** of each first stage switch **800–807** are connected via links **85** to one input terminal **83** of each second stage switch **810–817**. This full access type pattern of link distribution permits the selective connection of each of the sixty-four input terminals **87** of an octal grid **80** to any of the sixty-four output terminals **84** of the same octal grid **80**. For example, input terminal **877** may be connected to output terminal **840** by closing contacts **861** and **862**.

It will be noted that, in addition to the numerical designations **800–807** and **810–817**, each 8 x 8 switch is further designated with a four digit number to indicate its position within the octal grid **80**. This four digit number also indicates the number of the particular switch frame and the number of the particular octal grid in which the switch is used. For example, switch **800** is also designated switch (**0**–3)(**0**–3)**00**. The first digit (**0**–3) of this designation indicates the number of the switch frame, i.e. **0**, **1**, **2** or **3**. The second digit (**0**–3) of this designation indicates the number of the octal grid, i.e. **0**, **1**, **2** or **3**, within that switch frame. The third digit **0** of this designation indicates the switching stage, i.e. **0** or **1**, within the octal grid. The last digit **0** of the designation indicates the number of the particular switch, i.e. **0**, **1**, **2**, **3**, **4**, **5**, **6** or **7**. To illustrate, a four digit switch designation **3210** would indicate switch **0**, of switching stage **1**, of octal grid **2**, of switch frame **3**. The use of this four digit switch designation will be more apparent when FIGS. 2–6 are described herein below.

The octal grid **80** is a basic switching unit which is utilized in various portions of my illustrative switching network. The particular portions in which it is used are indicated in the note on FIG. 8. These areas of use are cross referenced from the note on FIG. 8 by Roman numerals I, II, III and IV to the various input terminal **87**, output terminal **84** and link **85** designations which are applicable to these components of the octal grid **80** when it is used in the respectively indicated areas of the switching network of FIG. 1 described above. Reference to these designations will be made hereinafter.

FIG. 7 illustrates the organization of a "concentrator grid" **70**. A concentrator grid **70** comprises four, first stage, partial access, concentrating switch arrays **700–703**, and four, second stage, full access, concentrating switch arrays **710–713**. Each first stage array, for example array **700**, has sixteen input terminals **770–7715** in the vertical coordinate thereof and eight input terminals **720–727** in the horizontal coordinate thereof. The switching device contacts **76** are so arranged that each of the sixteen input terminals **770–7715** is selectively connectable to only four of the eight output terminals **720–727**. For example, input terminal **770** of switch **700** may be connected to output terminals **720, 723, 724** or **726** by selectively closing contacts **760, 761, 762** or **763**, respectively. This type of array is designated as a "16 x 4/8 switch."

Each second stage array, for example array **710**, has eight input terminals **730–737** in the horizontal coordinate thereof and four output terminals **740–743** in the vertical coordinate thereof. Each input terminal **730–737** is selectively connectable to any output terminal **740–743** of array **710**. For example, input terminal **730** may be connected to output terminal **740** by closing contact **764**. This type of array is designated as an "8 x 4 switch."

The eight output terminals **72** of each first stage switch **700–703** of a concentrator grid **70** are connected in consecutive pairs via LA links **75** to two input terminals **73** of each second stage switch **710–713**. For example, output terminals **726** and **727** of switch **700** are connected via LA links **756** and **757** to input terminals **7356** and **7357** of switch **713**. This provides a full access pattern of LA link distribution which permits the selective connection of each of the sixty-four input terminals **77** of a concentrator grid **70** to any of the sixteen output terminals **74** thereof. For example, input terminal **770** may be connected to output terminal **740** by closing contacts **760** and **764**.

It will be noted in FIG. 7 that switch designations indicating the position of a particular switch within the switching network are shown which are similar to the four digit switch designations shown on FIG. 8. As previously described with reference to FIG. 8, the first digit of these designations indicates a switch frame number, **0, 1, 2** or **3**; the second digit or digit pair indicates a concentrator grid number, **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14** or **15**; the third digit indicates a switching stage number **0** or **1**; and the last digit indicates a switch number **0, 1, 2** or **3**.

The concentrator grid **70** provides a four-to-one concentration ratio between the sixty-four input terminals **77** thereof and the sixteen output terminals **74** thereof. This ratio may be varied by appropriate changes in the contact arrangement of the respective switch arrays **700–703** and **710–713**. In the embodiment of my invention depicted in FIG. 1, concentrator grids are used only in the line switch frames of the switching network, as described hereinbelow.

Although the octal grid **80** and the concentrator grid **70**, as described above, are the basic switching units of the illustrative switching network described herein, numerous other uints having varying configurations are equally compatible for use in a switching network organized in accordance with this invention.

Line Link network (FIGS. 2 and 3)

FIGS. 2 and 3 depict, in the form of a perspective breakdown, an illustrative organization of concentrator grids CO0–C315 and octal grids LO0–L33 into one illustrative type of sub-network, which is depicted in the line link network LLN**0** of FIG. 1. As discussed above with reference to FIG. 1, line link network LLN**0** provides selectable, bidirectional connecting facilities between each of 4,096 line input terminals **127** thereof and any of 1,024 line junctor output terminals **104** thereof.

Line link network LLN**0** includes four line switch frames LSF**0**–LSF**3**, each of which comprises sixteen concentrator grids CO**0**–C**315**, for example, concentrator grids CO**0**–CO**15** of line switch frame LSF**0**. Thus, a total of sixty-four concentrator grids CO**0**–C**315** are included in a full size line link network **200**. Sixty-four lines are terminated as inputs **127** of each concentrator grid CO**0**–C**315**. Sixteen "LB" links **109** are terminated as outputs **24** of each concentrator grid CO**0**–C**315**. Each concentrator grid CO**0**–C**315** provides selectable, bidirectional, connecting facilities between each of the sixty-four line input terminals **127** thereof and any of the sixteen LB link output terminals **24** thereof.

The sixty-four concentrator grids CO**0**–C**315** of the four line switch frames LSF**0**–LSF**3** shown in FIG. 2 are respectively represented by sixty-four horizontal planes arranged in a vertical stack. Each horizontal plane within the stack represents four 16 x 4/8 first stage switches, for example switches **31500–31503** of concentrator grid **316**; four 8 x 4 second stage switches, for example switches **31510–31513** of concentrator grid **315**; and the LA links **25** which connect the output terminals **22** of the first stage switches **31500–31503** to the input terminals **23** of the second stage switches **31510–31513**.

Each switch within each concentrator grid CO**0**–C**315** is assigned a multi-digit designation which indicates its position within the four line switch frames LSF**0**–LSF**3** of line link network LLN**0**. For example, switch **31501** is the second switch **1**, of the first switching stage **0**, of the sixteenth concentrator grid **15**, of the fourth line switch frame LSF**3**, of the line link network LLN**0**. This system of numbering was previously described with reference to FIG. 7.

The LA link distribution pattern, as previously described with reference to FIG. 7, is representatively shown in the uppermost horizontal plane of the stack. This plane represents concentrator grid C**315**, which is the sixteenth concentrator grid, of the third line switch frame LSF**3**, of the line link network LLN**0**. This LA link distribution pattern is duplicated, although not shown, in all other concentrator grids CO**0**–C**314** of the line link network LLN**0**, as represented by the other horizotnal planes in the stack.

For purposes of clarity, only representative line input terminals **127(315)0–63** and LB link output terminals **24(00)0–15** of the respective concentrator grids C**315** and CO**0** have been indicated in FIG. 2. Sixty-four line input terminals **127(315)0–63** are indicated for the uppermost plane of the stack, which represents concentrator grid C**315**. Each of the other concentrator grids CO**0**–C**314** of the line link network **200** similarly have sixty-four line input terminals **127**. Sixteen LB link output terminals **24(00)0–15** are indicated for the lowermost plane of the stack, which represents concentrator grid CO**0**. Each of the other concentrator grids CO**1**–C**315** of the line link network **200** similarly have sixteen LB link output terminals **24**.

Line link network LLN**0** further includes four line junctor switch frames LJSF**0**–LJFS**3**, each of which comprises four octal grids LO**0**–L**33**, for example octal grids LO**0**–LO**3** of line junctor switch frame LJSF**0**. Thus, a total of sixteen octal grids LO**0**–L**33** are included in a full size line link network **200**. Sixty-four LB links **109** are terminated as inputs **37** of each octal grid LO**0**–L**33**. Sixty-four line junctor terminals comprise the outputs **104** of each octal grid LO**0**–L**33**. Each octal grid LO**0**–L**33** of the line link network LLN**0** provides selectable bidirectional, connecting facilities between each of the sixty-four LB link input terminals **37** thereof and any of the sixty-four line junctor output terminals **104** thereof.

The sixteen octal grids LO**0**–L**33** of the four line junctor switch frames LJSF**0**–LJSF**3** shown in FIG. 3 are respectively represented by sixteen vertical planes arranged in a horizontal stack. Each vertical plane within the stack represents eight 8 x 8 first stage switches, for example switches 0000–0007 of octal grid LO0; eight 8 x 8 second stage switches, for example switches 0010–0017 of octal grid LO0; and the LC links 35 which connect the output terminals 32 of the first stage switches 0000–0007 to the input terminals 33 of the second stage switches 0010–0017.

The switches included in octal grids LO0–L33 of FIG. 3 are numbered with four digit designations, the meaning of which was previously described with reference to FIG. 8.

The LC link distribution pattern, as previously described with reference to FIG. 8, is partially exemplified in the foremost vertical plane of the stack. This plane represents octal grid LO0, which is the first octal grid, of the first line junctor switch frame LJSF0, of the line link network 200. This LC link distribution pattern is duplicated, although not shown, in all other octal grids LO1–L33 of the line link network LLN0, as represented by the other vertical planes in the stack.

For purposes of clarity, only representative LB link input terminals 37(33)0–63 and line junctor output terminals 104(00)0–63 of the respective octal grids L33 and LO0 have been indicated in FIG. 3. Sixty-four LB link input terminals 37(33)0–63 are indicated for the rearmost vertical plane, which represents octal grid L33. Each of the other octal grids LO0–L32 of the line link network LLN0 similarly have sixty-four LB link input terminals 37. Sixty-four line junctor terminal outputs 104(00)0–63 are indicated for the foremost vertical plane, which represents octal grid LO0. Each of the other octal grids LO1–L33 of the line link network LLN0 similarly have sixty-four line junctor terminal outputs 104.

The illustrative LB link distribution pattern, shown in FIGS. 2 and 3, is so arranged that each of the sixteen output terminals 24 of each concentrator grid CO0–C315 is connected via an LB link 109 to an input terminal 37 of each of the sixteen octal grids LO0–L33. Although, for purposes of clarity, the illustrative LB link distribution pattern is only partially indicated, the full pattern may be completed by extending the sixty-four respective horizontal planes representing the concentrator grids CO0–C315 in FIG. 2 to intersect the sixteen respective vertical planes representing the octal grids LO0–L33 in FIG. 3. Each point at which a vertical plane intersects a horizontal plane indicates the location of an LB link connection 109 between the concentrator grid and the octal grid respectively represented by the two intersecting planes. For example, the horizontal plane representing concentrator grid CO0 will, when extended, intersect the vertical plane representing octal grid LO0 at a point 39, which corresponds to the first output terminal 24(00)0 of concentrator grid CO0 and the first input terminal 37(00)0 of octal grid LO0. This indicates that an LB link connection 109(0000) is made between the first output terminal 24(00)0 of concentrator grid CO0 and the first input terminal 37(00)0 of octal grid LO0. This particular illustrative LB link distribution pattern provides a single, selectable, bidirectional, connecting path between each of the 4,096 line input terminals 127 of the various concentrator grids CO0–C315 of a line link network 200 and each of the 1,024 line junctor terminal outputs 104 of the various octal grids LO0–L33 thereof.

The above-described LB link distribution pattern provides a four-to-one concentration ratio between the line input terminals 127 and the line junctor terminal outputs 104 of the line link network LLN0. Variations of this distribution pattern may be made to achieve other concentration ratios if desired.

Although a full size typical line link network LLN0 is shown in FIGS. 2 and 3, a line link network may be partially equipped with fewer than the full complement of four line switch frames and four line junctor switch frames. Line switch frames and line junctor switch frames need not be provided in equal number.

The horizontal planes, which represent the concentrator grids CO0–C315 in FIG. 2, are arranged in groups of eight, with each line switch frame LSF0–LSF3 including two such groups. For example, line switch frame LSF0 includes a first group of eight concentrator grids CO0–CO7 and a second group of eight concentrator grids CO8–CO15. Line switch frames may be partially equipped with a single group of eight concentrator grids, if desired.

The ability to partially equip a line link network and to further partially equip a line switch frame within a line link network permits the initial provision of only as many line link network terminations as may then be required. As growth in required network terminations occurs, additional line link network equipment may be added until a full size line link network is provided. As further described above with reference to FIG. 1, a plurality of line link networks may be advantageously combined within a single switching sub-network in accordance with embodiments of my invention.

Trunk link network

FIGS. 4 and 5 depict, in the form of a perspective breakdown, an illustrative organization of octal grids TO0–T33 and JO0–J33 into another type of sub-network, which is illustrated by trunk link network TLN0. A full size trunk link network TLN0 provides selectable, bidirectional, connecting facilities between each of 1,024 trunk input terminals 117 thereof and any of 1,024 trunk junctor terminal outputs 114 thereof, as described above with reference to FIG. 1.

The full size trunk link network TLN0 includes four trunk switch frames TSF0–TSF3 each of which comprises four octal grids, for example octal grids T30–T33 of trunk switch frame TSF3; and four trunk junctor switch frames TJSF0–TJSF3 each of which comprises four octal grids, for example octal grids JO0–JO3 of trunk junctor switch frame TJSF0. Thus, a total of thirty-two octal grids TO0–T33 and JO0–J33 are included in trunk link network TLN0.

Sixty-four trunks are terminated as inputs 117 of each octal grid TO0–T33 of each trunk switch frame TSF0–TSF3. Sixty-four TB links 119 are terminated as outputs 54 of each octal grid TO0–T33 of each trunk switch frame TSF0–TSF3. Each octal grid TO0–T33 of each trunk switch frame TSF0–TSF3 provides selectable, bidirectional, connecting facilities between each of the sixty-four trunk input terminals 117 thereof and any of the sixty-four TB link output terminals 54 thereof.

Sixty-four TB links 119 are terminated as inputs 47 of each octal grid JO0–J33 of each trunk junctor switch frame TJSF0–TJSF3. Sixty-four trunk junctor terminals compirse the outputs 114 of each octal grid JO0–J33 of each trunk junctor switch frame TJSF0–TJSF3. Each octal grid JO0–J33 of each trunk junctor switch frame TJSF0–TJSF3 provides selectable, bidirectional, connecting facilities between each of the sixty-four TB link input terminals 47 thereof and any of the sixty-four trunk junctor terminal outputs 114 thereof.

The sixteen octal grids TO0–T33 of the four trunk switch frames TSF0–TSF3 shown in FIG. 5 are respectively represented by sixteen horizontal planes arranged in a vertical stack. Each horizontal plane within the stack represents eight 8 x 8 first stage switches, for example switch 3300–3307 of octal grid T33; eight 8 x 8 second stage switches, for example switches 3310–3317 of octal grid T33; and the TA links 55 which connect the output terminals 52 of the first stage switches 3300–3307 to the input terminals 53 of the second stage switches 3310–3317. The TA link distribution pattern, as previously described with reference to FIG. 8, is partially exemplified in the uppermost horizontal plane of the stack. This plane represents octal grid T33, which is the fourth octal grid, of the four trunk switch frame TSF3, of trunk link network TLN0. This TA link distribution pattern is duplicated, although not shown, in all other octal grids TO0–T32 of the four trunk switch frames TSF0–TSF3 of trunk link network TLN0, as represented by the other horizontal planes in the stack.

Each 8 x 8 switch of the four trunk switch frames TSF0–TSF3 is designated with a four digit numerical designation which indicates the position of the switch within the trunk switch frames TSF0–TSF3. This system of numbering and the interpretation of the four digit numerical designations was previously described with reference to FIGS. 3 and 8.

For purposes of clarity, only representative trunk input terminals **117(33)0–63** and TB link output terminals **54** of the respective octal grids T33 and TO0 have been indicated in FIG. 5. Sixty-four trunk input terminals **117(33)0–63** are indicated for the uppermost horizontal plane which represents octal grid T33. Each of the other octal grids TO0–T32 of the four trunk switch frames TSF0–TSF3 similarly have sixty-four trunk input terminals **117**. Representative TB link output terminals **54** are shown for the lowermost horizontal plane, which represents octal grid TO0. Each of the other octal grids TO1–T33 similarly have sixty-four TB link output terminals **54**.

The sixteen octal grids JO0–J33 of the four trunk junctor switch frames TJSF0–TJSF3 shown in FIG. 4 are respectively represented by sixteen vertical planes arranged in a horizontal stack. Each vertical plane within the stack represents eight 8 x 8 first stage switches, for example switches **0000–0007** of octal grid JO0; eight 8 x 8 second stage switches, for example switches **0010–0017** of octal grid JO0; and the TC links **45** which connect the output terminals **42** of the first stage switches **0000–0007** to the input terminals **43** of the second stage switches **0010–0017**. The TC link distribution pattern, as previously described with reference to FIG. 8, is partially exemplified in the foremost vertical plane of the stack. This plane represents octal grid JO0, which is the first octal grid, of the first trunk junctor switch frame TJSF0, of trunk link network TLN0. This TC link distribution pattern is duplicated, although not shown, in all other octal grids JO1–J33 of the four trunk junctor switch frames TJSF0–TJSF3 in trunk link network TLN0, as represented by the other vertical planes in the stack.

The numbering system used to designate the particular switches of the four trunk junctor switch frames TJSF0–TJSF3 is similar to the previously described four digit numbering system used to designate the respective switches of the trunk switch frames TSF0–TSF3 (FIG. 5) and line junctor switch frames LJSF0–LJSF3 (FIG. 3).

For purposes of clarity, only representative TB link input terminals **47** and trunk junctor terminal outputs **114** of the respective octal grids JO0–J33 have been indicated in FIG. 4. Representative TB link input terminals **47** are shown to indicate the sixty-four TB link input terminals **47** of each octal grid JO0–J33 of the four trunk junctor switch frames TJSF0–TJSF3. Sixty-four trunk junctor terminal outputs **114(00)0–63** are shown for the foremost vertical plane which represents octal grid JO0. Each of the other octal grids JO1–J33 similarly have sixty-four trunk junctor terminal outputs **114**.

The illustrative TB link distribution pattern shown in FIGS. 4 and 5 is so arranged that four of the sixty-four output terminals **54** of each octal grid TO0–T33 of each trunk switch frame TSF0–TSF3 are connected via a TB link **119** to four of the sixty-four input terminals **47** of each octal grid JO0–J33 of each trunk junctor switch frame TJSF0–TJSF3. Although the illustrative TB link distribution pattern is only partially indicated, the pattern may be understood from the following description thereof with reference to FIGS. 4 and 5.

As previously described with reference to FIG. 8, each 8 x 8 switch of an octal grid has eight output terminals. Accordingly, each pair of 8 x 8 switches has a total of sixteen output terminals. The four trunk junctor switch frames TJSF0–TJSF3 of trunk link network TLN0 comprise sixteen octal grids JO0–J33. In the illustrative TB

link distribution pattern of FIGS. 4 and 5, each of the sixteen output terminals **54** of each of the four pairs of second stage 8 x 8 switches of the four trunk switch frames TSF0–TSF3 are respectively connected to one of the input terminals **47** of each of the sixteen octal grids JO0–J33 of the four trunk junctor switch frames TJSF0–TJSF3. For example, the sixteen output terminals **54(00)0–15** of the lowest numbered pair of second stage 8 x 8 switches **0010** and **0011** of octal grid TO0 are respectively connected via TB links **119(0–15)** to the first output terminal **47(00–33)0** of the lowest numbered pair of first stage switches **0000–3300** and **0001–3301** of each of the sixteen octal grids JO0–J33 of the four trunk junctor switch frames TJSF0–TJSF3. The sixteen output terminals **54(33)0–15** of the lowest numbered pair of second stage switches **3310** and **3311** of octal grid T33 of trunk switch frame TSF3 are respectively connected via TB links **59(240–255)** to the last input terminals **47(00–33)15** of the lowest numbered pair of first stage switches **0000–3300** and **0001–3301** of each of the sixteen octal grids JO0–J33 of the four trunk junctor switch frames TJSF0 and TJSF3. This distribution pattern is repeated between the sixteen output terminals **54(01–32)0–15** (not shown) of the lowest numbered pair of second stage switches **0110–3210** and **0111–3211** of octal grids TO1–T32 and the intermediate, corresponding input terminals **47(00–33)1–14** (not shown) of the lowest numbered pair of first stage switches **0100–3200** and **0101–3201** of each of the sixteen octal grids JO0–J33. An identical pattern of connection is shown between the last output terminals **54(00–33)63** of the highest numbered pair of second stage switches **0017–3317** and **0016–3316** of each octal grid TO0–T33 and the sixteen input terminals **47(33)48–63** of the highest numbered pair of first stage switches **3307** and **3306** of octal grid J33. The identical pattern is used to connect the output terminals **54** of the intermediate pairs of second stage switches **0012–3312** and **0013–3313**; **0014–3314** and **0015–3315** of all octal grids TO0–T33 of the four trunk switch frames TSF0–TSF3 to the input terminals **47** of the corresponding intermedate pairs of first stage switches **0005–3305** and **0004–3304**; **0003–3303** and **0002–3302** of all octal grids JO0–J33 of the four trunk junctor switch frames TJSF0–TJSF3.

In the above-described illustrative pattern of TB link distribution, a one-to-one relationship exists between the trunk input terminals **117** and the trunk junctor terminal outputs **114** of the trunk link network TLN0. This ratio may be varied by selective rearrangement of the TB link distribution pattern. Since each octal grid TO0–T33 of each trunk switch frame TSF0–TSF3 is connected via four TB links **119** to each octal grid JO0–J33 of each trunk junctor switch frame TJSF0–TJSF3, four, selectable, bidirectional, connecting paths are provided between each trunk input terminal **117** and each trunk junctor terminal output **114** of trunk link network TLN0. The number of available paths between input and output terminals **117** and **114** of trunk link network TLN0 may also be varied by TB link rearrangement.

Although a full size trunk link network TLN0 is shown in FIGS. 4 and 5, a trunk link network may be partially equipped with fewer than the full complement of four trunk switch frames and four trunk junctor switch frames in embodiments of my invention. Trunk switch frames and trunk junctor switch frames need not be provided in equal number. This ability to partially equip a trunk link network permits the initial provision of only the number of trunk link network terminations as may then be required. As growth in required trunk link network terminations is experienced, additional trunk and trunk junctor switch frames may be added until a full size trunk link network is provided. As above described with reference to FIG. 1, a plurality of trunk link networks may be combined within a single switching sub-network in accordance with embodiments of my invention.

Line junctor link network (FIG. 6)

FIG. 6 depicts, in the form of a perspective breakdown, an illustrative organization of octal grids **N0–N3** into a further type of sub-network in accordance with my invention, namely line junctor link network **LJLN0**. Line junctor link network **LJLN0** provides selectable, bidirectional, connecting facilities between each of 256 junctor link input terminals **157** and 256 junctor link output terminals **154**.

The line junctor link network **LJLN0** includes one junctor link switch frame **JLN0**, which comprises four octal grids **N0–N3**. Sixty-four junctor links **157** are terminated as inputs **67** of each octal grid **N0–N3**, and sixty-four junctor links **154** are terminated as outputs **64** of each octal grid **N0–N3**.

A comparison of FIG. 6 with FIG. 5 will indicate that the organization of junctor link frame **JLN0** is identical to that of a single trunk switch frame **TSF0**. It therefore is felt unnecessary to further describe junctor link frame **JLN0**.

The utility of a line junctor link network **LJLN0** in accordance with my invention has been set forth above with reference to FIG. 1.

The specific illustrative switching grid units and the organization thereof into sub-networks, as described hereinabove, may be varied in configuration and organization without departing from the scope of this invention. Numerous other switching devices may be arranged in varying network patterns by those skilled in the art without departing from the inventive concepts disclosed herein.

What is claimed is:

1. A communications switching network having a first switching portion comprising a first, partially folded, multistage, sub-network having an initial bidirectional switching stage upon which a first group of input terminals appear and a last bidirectional switching stage; a second switching portion comprising a second, partially folded, multistage, sub-network having an initial bidirectional switching stage upon which a second group of input terminals appear and a last bidirectional switching stage; bidirectional connecting means for connecting said first and second switching portions; said first switching portion controllable independent of said second switching portion to interconnect selectively said first group of input terminals; said second switching portion controllable independent of said first switching portion to interconnect selectively said second group of input terminals; and said first and second switching portions further controllable in combination to interconnect selectively said first and second input terminals by way of said connecting means.

2. A communications switching network in accordance with claim **1** wherein only said initial stages have input terminals thereon and said connecting means connect said last bidirectional switching stage of said first sub-network to said last bidirectional switching stage of said second sub-network.

3. A communications switching network in accordance with claim **1** wherein said first input terminals have subscriber lines terminated thereon and certain of said second input terminals have bidirectional interoffice trunks terminated thereon.

4. A communications switching network comprising a first switching portion having an initial bidirectional switching stage with first input terminals appearing thereon, a last bidirectional switching stage with first junctor terminals terminated thereon and controllable switching means for selectively connecting said first input terminals and said first junctor terminals; a second switching portion having an initial bidirectional switching stage with second input terminals terminated thereon, a last bidirectional switching stage with second junctor terminals terminated thereon and controllable switching means for selectively connecting said second input terminals and said second junctor terminals; first connecting means for connecting a first group of said first junctor terminals to a first group of said second junctor terminals; second connecting means for connecting a second group of said second junctor terminals to a third group of said second junctor terminals; and third connecting means for connecting a second group of said first junctor terminals to a third group of said first junctor terminals.

5. A communications switching network in accordance with claim **4** further comprising supervisory circuit means serially included in said third connecting means for supervising established connections between input terminals of said first group and input terminals of said second group.

6. A communications switching network in accordance with claim **4** further comprising a third switching portion serially included in said third connecting means, said third switching portion comprising an initial bidirectional switching stage with said second group of said first junctor terminals connected thereto, a last bidirectional switching stage with said third group of said second junctor terminals connected thereto and controllable switching means for selectively connecting said second group of first junctor terminals to said third group of second junctor terminals.

7. A communications switching network in accordance with claim **4** further comprising single cross-connection field means for selectively arranging said first, second and third connecting means in accordance with network traffic requirements.

8. A communications switching network comprising a first switching portion having line terminals, line junctor terminals and controllable switching means for connecting said line terminals to said line junctor terminals; a second switching portion comprising trunk terminals with bidirectional interoffice trunk circuits terminated thereon, trunk junctor terminals and controllable switching means for connecting said trunk terminals to said trunk junctor terminals; said trunk junctor terminals having a first group of said line junctor terminals directly connected thereto; and supervisory circuit means through which a second group of said line junctor terminals are connected to a third group of said line junctor terminals.

9. A communications switching network according to claim **8** further comprising a third switching portion interposed between said second group of line junctor terminals and said circuit means, said third switching portion controllable selectively to establish connections through said supervisory circuit means between said second group of line junctor terminals and said third group of line junctor terminals.

10. A communications switching network according to claim **8** further comprising junctor grouping frame means through which said first, second and third groups of line junctor terminals, said trunk junctor terminals and said circuit means are selectively cross-connected.

11. A communications switching network according to claim **10** further comprising a third switching portion having first junctor link terminals, second junctor link terminals and controllable switching means for connecting said first junctor link terminals to said second junctor link terminals; said first junctor link terminals having said circuit means directly connected thereto; and said second and third groups of line junctor terminals having said second junctor link terminals and said circuit means selectively cross-connected thereto through said junctor grouping frame means.

12. A multi-stage, space-division telephone switching network comprising a first sub-network having line and junctor terminals; a second sub-network having trunk and junctor terminals; a third sub-network having input and output junctor terminals; and central cross-connection means for interconnecting said junctor terminals; first of said first sub-network junctor terminals connected directly to certain of said second sub-network junctor terminals by said cross-connection means; and second of said first sub-network junctor terminals connected to third of said first sub-network junctor terminals by said cross-connection means and said third sub-network.

13. A multi-stage switching network comprising a first partially folded sub-network having junctor terminals, a second partially folded sub-network having junctor terminals, means including a cross-connection frame for serially connecting selected of said first and second sub-network junctor terminals, and a third sub-network having input and output terminals connected to other of said first sub-network junctor terminals by said connecting means.

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