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(54) **Wire harness manufacture.**

(57) Wire harnesses are assembled by preparing wires in a first region (11) and assembling the harnesses in a second region (12). The harnesses are assembled in the second region by conveying the harnesses from one end of a conveyor (23) to the other, by providing multiple work stations (15) along the conveyor for manual work functions, by providing local supplies (32) of wires at some work stations, by providing local supplies (40) of connectors at some work stations, and by connecting some of the wires to some of the connectors at some of the work stations and integrating them into a wire harness (8). The local supplies of wires at some work stations are provided by transporting the wires from the first region to the work stations. The conveyor is incremented periodically and the work functions at the various work stations are preselected to require substantially equal time to perform. The prepared wires for the harnesses are stored in channel trays (20) and may be transported and supported on mobile carriages. The channel trays are U-shaped and may be oriented horizontally or vertically. The conveyor includes, near its upstream end, a trough (50, 52) along one or both sides to permit the embryonic harness to be arranged transversely of the conveyor with portions hanging and/or supported in the trough(s). The harness may be carried by fingers on the conveyor and in which the harness is placed. Some loom tables (36) are provided adjacent respective ones of the work stations. Some of those loom tables are pivotally mounted for rotation between operating and idle positions to facilitate assembly operations at the work stations. A taping arrangement adjacent the mechanized conveyor provides a taping machine (38) which is mounted for convenient manual displacement. The machine may be on a pivotable platform which also includes a clamp mechanism for supporting and tensioning a wire harness for taping. The machine is constructed to fully enclose the harness being taped, and includes a two-piece housing which may be opened and closed and a similar two-piece orbiting plate which moves within and opens and closes with the housing. A terminal assembling tool (42) connects multiple terminated

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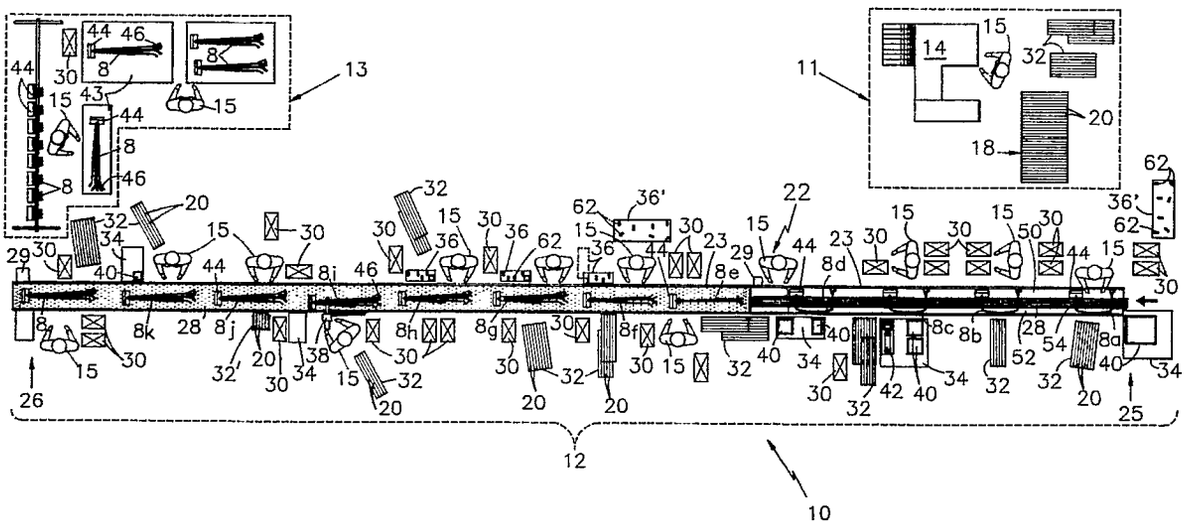
wires with a common bus connector. The tool includes first and second jigs which pre-position the wires and the connector and are movable between a load/unload position and a connecting position. The jig for the connector includes a retainer member which interacts with the connector to assist in removing the terminated wires from the other jig following connection.

FIG. 1



The invention relates generally to the fabrication of wire harnesses and more particularly to methods and equipment for the manufacture of wire harnesses as well as a system including certain equipment for the manufacture of wire harnesses. This equipment relates generally to taping arrangements and more particularly to arrangements for the mechanized wrapping of tape about an elongated object, such as a bundle of wires undergoing fabrication into a wire harness. The invention relates even still more particularly to a taping machine for use in a taping arrangement. This equipment further relates generally to a terminal assembling tool and more particularly to a terminal assembling tool for connecting terminated wires to a common bus connector. The equipment also relates to loom tables.

The manufacture or fabrication of wire harnesses has assumed many forms and used various techniques, ranging from being highly manual-labor intensive to the use of a relatively significant level of automation. The former may be acceptable only if a low cost source of labor is available, whereas the latter requires significant capital expenditure and may be relatively inflexible. The manufacture of high quality, cost-effective wire harnesses for motor vehicles may be a challenge, particularly where the high initial cost of equipment and variations in harnesses because of differing models of automobiles serve to argue against a high degree of automation. Yet the relatively high cost of the labor available also dictates against an inefficient use of such labor.

Thus, while it may be desirable for the sake of flexibility to retain a manual system of manufacture, it is important that the procedures and machinery employed be as efficient and effective as possible in order to be cost competitive.

Systems used in the prior art have involved different persons or workers performing respective different batch functions at different locations, i.e., one person cutting wires, another person doing subassembly and another doing gross assembly. More recently this has been improved by a flow process in which one worker might perform multiple functions, as for instance cutting wires, preparing subassemblies and preparing final wire harness assemblies. However this technique might also require considerable expenditure of time and physical effort by a worker or operator because of the amount of walking required at a work station. Moreover, the time required to train a worker to perform all of these functions can be considerable.

Since the incorporation of numerous wires in various routing arrangements is at the heart of wire harness fabrication, the efficient handling of those wires during the fabrication process is particularly important.

In the manufacture of wiring harnesses and other bundles of elongated objects, it is often necessary to maintain the compactness of the bundle by winding tape about it. In the formation of wire harnesses, it has been common to perform the taping of the wire bundle by manually winding the tape about the bundle. Depending upon the size of the bundle, the character of the tape and the number of times the operation must be performed, such operation may be extremely tiring and perhaps even painful to the person performing it. In that regard, motor driven taping machines have been provided for the mechanized application of tape to a wiring bundle. Those taping machines typically include a framework or housing, a driving motor and some form of orbiting mechanism within the housing which is driven by the motor and causes a spool of tape to orbit about a bundle of wires. To permit ingress and egress of the wire bundle to the center region of the machine, it has been common to provide one portion of the machine with a permanently open mouth to that central region. An example of such taping machine is the ISOTAP BABY 040 which is marketed by Design Equipments Representation France Internacional (DERFI) of Cormeilles en Parisis, France. Such a machine may be suspended by a cable or slideably mounted on rails for the necessary translational movement along the wire bundle.

While such taping arrangements may be generally satisfactory, further refinement of the taping arrangement generally, and of the taping machine specifically, are desirable to contribute to the ease, efficiency and accuracy with which wire harnesses and the like may be taped.

In the formation of wired circuits it is often necessary or desirable to connect a number of conductor wires to the same potential. This may often be effected by connecting those wires to a common bus, or common bus connector. Further, the common bus connector may include a plurality of terminals to which the individual wires, themselves being terminated, are respectively connected. Such connection of several terminated wires to a common bus connector often occurs in the formation of wiring harnesses, as for instance wiring harnesses for automotive vehicles.

The operation of connecting terminated wires to the respective terminals of a common bus connector has often been performed manually, particularly where it is included as one of the steps in the formulation of a wiring harness via a significant use of manual labor. The manual interconnection of terminated wires with the terminals of the common bus connector may prove to be tiring to the operator, particularly where respective terminals are individually connected via the application of opposed manual forces. This may be further com-

plicated if the positions of terminals on the connector are closely adjacent one another such that they interfere with or complicate the manual insertion of terminals.

Some types of wire harness manufacturing processes of the prior art have employed one or more so-called loom tables which are constructed to facilitate the formation of portions of the wire harness thereon. Those loom tables typically include various supports positioned thereon in a pattern which assists in establishing the formation of the wire harness. Typically also, those loom tables are large, stationary and serve to establish the location of a work station, and they may be positioned at various locations within the fabrication area.

Accordingly, it is a principal object of the invention to provide improved method system and apparatus for the cost efficient manufacture of wire harnesses of high quality.

It is a further object to provide such method and apparatus with an acceptable degree of flexibility to accommodate changes in the design of the wire harness.

It is a still further object to provide method and apparatus for the efficient handling of wires used, and to be used, in the process of fabricating wire harnesses.

It is an additional object to provide such apparatus which facilitates the assembly and handling of wire harnesses, and especially the formation of subassemblies for inclusion in those wire harnesses.

It is an additional further object to provide such apparatus in efficient combination with an improved general system for the fabrication of wire harnesses.

It is a further additional object to provide such apparatus which facilitates the assembly and handling of wire harnesses during the formative stages.

Further, it is an object of the invention to provide a terminal assembling tool for facilitating the connection of multiple terminated wires to a common bus connector.

Still further, it is an object to provide such terminal assembling tool which is capable of interconnecting female terminations on the respective wires with respective male terminals on the common bus connector.

Additionally it is an object to provide an improved terminal assembling tool which reduces the amount and complexity of manual involvement in the interconnection of terminated wires with the common bus connector.

It is still an additional further object of the invention to provide an improved arrangement for the mechanized wrapping of tape about an elongated bundle of wires undergoing fabrication into a wire harness. Included in this object is the provision of apparatus, including a taping machine, which affords relatively easy and accurate application of tape to a wire harness bundle.

It is still an additional object to provide an improved taping machine which conveniently and positively retains a wire harness bundle therewithin for ease and accuracy of the wrapping of tape thereabout.

There is provided an improved method for assembling wire harnesses which includes the steps of, in a first region, precutting and terminating quantities of the various wires of which a harness is comprised, and in a second region, assembling the wire harnesses via the steps which include providing a conveyor line for conveying the harnesses substantially from inception in embryonic form at an upstream end to completion at a downstream end; providing a multiplicity of local work stations along the conveyor at which operators perform various manual assembly functions, those functions being variable as required; providing local supplies of wires at various of the work stations for use in the assembly functions thereat, including transporting wires from the first region to the respective work stations to provide the local supplies; providing local supplies of connectors at various of the work stations for use in the assembly function thereat; and connecting various of the wires to various of the connectors at various of the work stations and integrating the wires and connectors into respective wire harnesses.

The conveyance of the harnesses on the conveyor line is, typically, generally linear. the conveyor is advanced periodically, and the connecting and integrating steps are performed in the interval between such periodic advancing of the conveyor. The assembly functions to be performed at each of the work stations are preselected to require substantially equal times to accomplish.

There is provided an improved system for the fabrication of wire harnesses having multiple wires. The system includes a mechanized conveyor of particular width having relative upstream and downstream portions and multiple work stations thereabout for the progressive formation of the harnesses from embryonic to completed states respectively. It also includes means proximate at least some of the work stations for providing wires, including some terminated wires, for inclusion in a wire harness. The length of at least some of the wires is substantially greater than the particular width of the conveyor. Still further, the system includes a trough adjacent at least one side of the conveyor along at least the upstream portion thereof whereby the wires of an embryonic harness may extend transversely of the conveyor beyond its particular width and into the trough.

The conveyor includes means affixed thereto

for positively engaging and moving the embryonic harness therewith. The harness engaging means comprises a pair, and typically a number of pairs, of fingers extending upwardly from the conveyor. The fingers of each said pair are spaced from one another in the direction in which the conveyor moves, and each pair of fingers is spaced from the other pairs in the direction in which the conveyor moves.

The embryonic harness includes a junction box connected thereto, and the width of the trough is sufficient to receive the junction box therewithin. The conveyor may also include another, or second, trough on the side thereof opposite the first trough.

The embryonic harness may cross the conveyor in generally U-shaped form, with the two arms of its U-shape being engaged respectively by two pairs of fingers extending upwardly from the conveyor, and the nexus portion of the U-shape being disposed in one of the troughs and the other ends of the U-shape being in the other of the troughs.

The local supplies of wires for use in the fabrication of wire harnesses are stored and dispensed at the respective work stations in a convenient manner. The wires are precut to various appropriate lengths and wires of a respective length are stored in a respective channel tray. The channel tray is configured to facilitate manual removal of wires therefrom. A number of such channel trays may conveniently be supported on a stand or mobile carriage and positioned at a respective work station. The mobile carriage is further suited to moving wire-laden channel trays from the first precutting and terminating region to the region of the conveyor line and a particular work station. The channel trays are generally U-shaped and opened at an end to provide manual access for removing a wire. The base of the U-shaped channel tray is, in one embodiment, generally flat to facilitate an even distribution of the wires contained therein. Some of the stands or mobile carriages are provided with supports which orient the channel trays generally horizontally. Yet other stands or mobile carriages may be configured and the channel trays oriented thereon, such that the channel trays are substantially vertical and the wires disposed in the channels extend beyond and hang from the upper end of the channel to facilitate removal. Particularly for channel trays in such vertical orientation, a clamp arrangement is affixed thereto near the discharge end for releasably retaining the group of wires in that channel. The supports for the wheels or rollers on the mobile carriages may be adjustable to permit a reduced cross-sectional area to the carriage base.

There is provided an improved system for the fabrication of wire harnesses each having multiple wires. The system includes a mechanized conveyor having multiple work stations therealong for the progressive manual formation of the harnesses. Means are provided proximate at least some of the work stations for providing wires, some being terminated, for inclusion in the wire harnesses. Further, the system includes one or more loom tables each adjacent a respective work station for facilitating the fabrication of a multiwire harness subassembly thereat for inclusion in the wire harness at the respective work station. Still more specifically, one or more of the loom tables is pivotally mounted for selective displacement between an operating position and an idle position. That operating position disposes the loom table so as to facilitate the fabrication of a harness subassembly and the idle position is displaced from the operating position and serves to dispose the loom table in a substantially non-interfering relation at the work station for operations thereat other than the fabrication of the harness subassembly.

The loom table comprises a platform member and a plurality of wire supporting members, or jigs, mounted to and extending from the platform member for receiving, supporting and routing various wires of the multiwire subassembly. The wire supporting members each extend upwardly from the generally-horizontal platform member and include respective bifurcations at their upper ends for receiving the wires therebetween. The conveyor includes a supporting frame and the loom tables are each pivotally mounted to the frame. A mechanism may be provided for detenting or locking the pivotable loom table alternatively in either the operating or the idle position.

In accordance with the invention there is a provided a taping arrangement for the mechanized wrapping tape about an elongated bundle of wires undergoing fabrication into a wire harness and disposed on a conveyor. The taping arrangement is disposed at a work station adjacent the conveyor and includes a mounting means for the taping machine to facilitate its manual displacement longitudinally of the wire bundle to be taped and wherein the mounting means and the taping machine are positioned adjacent to the conveyor at least during the taping of a wire bundle.

More particularly, the taping machine includes a housing, a drive motor connected to the housing, an orbiting mechanism supported by the housing and driven by the motor in an orbital path about a central region in which the wire bundle is disposed, and tape dispensing means mounted on the orbiting mechanism for dispensing tape to the wire bundle as the mechanism orbits about the wire bundle. The taping arrangement is supported on a support platform which is positioned adjacent to the conveyor and which may be pivotally mounted to

the conveyor frame. The taping machine may be slideably mounted via a bracket to one or more rails supported by the support platform. Adjustable stops may be positioned on the rail to limit the displacement of the taping machine. A manually actuatable clamp may be mounted, as for instance to the support platform, for gripping the wire bundle sufficiently to resist its longitudinal displacement during application of a tensile force thereto during taping.

The taping machine is preferably constructed such that its housing is annular and defines an annular race and comprises two complementary arcuate portions joined in hinged relation and moveable between relatively open and closed positions. Moreover, the machine's orbiting mechanism comprises an annular plate having a central opening and being divided into two separate complementary arcuate portions which substantially coincide with the complementary housing portions and which are capable of being moved with the housing portions between the open and the closed positions. The motor, which may be pneumatically powered, drives a pinion which in turn is in driving engagement with an arcuate gear formed on the face of the arcuate portions of the plate. More specifically, the pinion is in driving engagement with the gear on first one and then the other of the arcuate portions of the plate, with the arcuate portion of the plate which is not in engagement with the pinion being pushed and driven by the one which is in engagement with the pinion.

The machine further includes a detector for sensing a particular position of rotation of the arcuate plate portions with respect to the portions of the housing and for providing a signal representative of that position. Means responsive to that signal are provided for stopping the rotation of the arcuate plate portions to substantially coincide with the complementary housing portion. The complementary housing portions are provided with respective complementary locking means for releasably locking the housing portions in the closed position.

There is provided a terminal assembling tool for facilitating the connection of multiple terminated wires to a common bus connector. The terminated wires each include a terminal, typically a female terminal, and the common bus connector includes multiple terminals, typically male terminals, extending therefrom in substantially the same direction for interconnection with the terminated wires. The tool includes a first jig for receiving the multiple terminated wires, a second jig for receiving the common bus connector, at least one of the first and second jigs being movable relative to the other between relative proximate and distant positions which respectively correspond with a connecting position and a load/unload position, and means, such as a pneumatic actuator, for actuating the one of the first and second jigs between the connecting and the load/unload positions. Further, the first jig includes means for pre-positioning the terminated wires and the second jig includes means for prepositioning the common bus connector, such that upon actuation of one of the first and second jigs the terminated wires are accurately and completely connected to respective ones of the terminals on the common bus connector.

The terminal assembling tool includes a base member and a pneumatically powered linear actuator mounted via a respective housing to the base member. The first jig is substantially fixedly mounted to the base member and the second jig is connected to the actuating arm of the actuator for reciprocation between the connecting and the load/unload positions.

The common bus connector includes a common base portion having the multiple male terminals extending forwardly therefrom and further having a pair of end fingers disposed at opposite ends thereof and extending forwardly therefrom. The second jig is disposed for actuation in the horizontal plane and includes a cavity therein open at the top and at most of the front end for receiving/discharging the common bus connector via vertical motion thereof and for closely orienting that connector when received in the cavity. The second jig further includes a retainer which extends transversely of the forward end of the common bus connector end fingers so as to engage the end fingers and move the common base portion and connected terminated wires rearwardly in unison for unloading when the second jig is actuated from the connecting position to the load/unload position.

The first jig includes multiple, substantially parallel slots in the upper surface thereof, a respective slot existing for each of the terminated wires. The slots are substantially aligned with respective male terminals on the common bus connector, and each of the slots is contoured at its forward end to retain a respective female terminal therein in alignment with a respective male terminal.

The invention will now be described by way of example with reference to the accompanying drawings, wherein:

Fig. 1 is a plan view in general diagrammatic form, of a wire harness assembling arrangement in accordance with the invention;

Fig. 2 is a perspective view of a portion of the wire harnesses assembling arrangement, taken at the upstream end of Fig. 1;

Fig. 3 is a perspective view of a carriage and channel trays for wire storage and delivery, as used in the wire harness assembling arrangement of Fig. 1;

Fig. 4 is an enlarged view of a hinged double

channel tray, as seen in Fig. 3;
Fig. 5 is a perspective view depicting an alternate embodiment of the carriage and channel trays of Fig. 4;
Fig. 6 is a perspective view of a portion of the wire harness assembling arrangement of Fig. 1, showing a pivotable loom table:
Fig. 7 is a side elevation view of a terminal assembly tool employed in the wire harness assembling arrangement of Fig. 1;
Fig. 8 is a top view of the terminal assembly tool of Fig. 7, showing terminated wires and a common bus connector prior to connection;
Fig. 9 is an enlarged perspective view of a portion of Fig. 8 showing a jig, the terminated wires and the common bus connector;
Fig. 10 is a perspective view of a portion of the wire harness assembling arrangement of Fig. 1, showing a taping machine in a taping arrangement;
Fig. 11 is a view of a taping machine of Fig. 10, as viewed looking relatively upstream ; and
Fig. 12 is a sectional view of a part of the taping machine, taken along line 12-12 of Fig. 11.

Best Mode(s) For Carrying Out the Invention

Referring to the figures and initially to Fig. 1, there is depicted in plan view and general diagrammatic form, a wire harness assembling arrangement or system 10 in accordance with the invention. Typically the harness assembling arrangement 10 will be situated in a common area including at least a first region 11 for certain preliminary functions and a second region 12 throughout which the harness assembling function occurs. A third testing region 13 might also be included.

The preliminary functions performed within the first region 11 result in precut, terminated wires 4, and typically include the large scale cutting of wires to predetermined lengths, appropriate stripping of insulation and the application and crimping of terminals 6 (seen in other figures) to one or both ends of most wires. This is done by wire cutting, stripping and terminal crimping machinery 14 of conventional design, as for instance the Komax 40S. The machinery 14 may prepare one or both ends of a wire for receiving a terminal 6 or other termination without actually making the termination. A human operator 15 typically controls the operation of cutting and terminating machinery 14. These wire cutting and terminating functions might be undertaken as batch operations.

Adjacent to the wire cutting and terminating machinery 14 there is also provided initial storage capacity for the temporary storing of wires 4 which have been precut and terminated. This storage is represented by the wire storage shelving 18. The precut and terminated wires 4 stored in shelving 18 are stored in channel trays 20 to be described hereinafter in greater detail. The precut and terminated wires 4 are placed in respective channel trays 20 in accordance with their respective length, gauge, and/or type of termination.

Referring now to the wire harness assembling region 12, there is depicted a mechanized conveyor system 22. The conveyor system 22 consists of one or typically a number of motorized conveyors 23, arranged in a serial or continuous fashion. More specifically, the conveyors 23 are arranged so as to form a line of continuous mechanized transport from an upstream end thereof designated 25 to a downstream end designated 26. In many respects, the conveyors 23 are of conventional design, including supporting framework 27 (seen in Figs. 2 and 3), moving belts or the like 28, and associated motors 29 for advancing the belts 28 in accordance with a desired schedule. The motors 29 are typically controlled by a controller of known design which is preprogrammed to provide the desired schedule of control. Typically such controllers also possess the capability of manual override and control if such is desired.

A number of local work stations are situated or located along conveyor 23 of conveyor system 22. Since the present wire harness assembling system 10 relies principally upon a number of human operators 15 interacting with various types of tooling and machinery along the conveyor system 22, those work stations will, for convenience herein, be represented by the same symbols and reference numbers which represent the presence of a human operator 15. It should be understood, however, that a work station 15 might also be represented in certain limited instances by machinery capable of automated operation and/or by manually operated machinery to which an operator 15 moves from a different work station.

At each work station 15, wire harness manufacturing and assembly equipment of various types and capability is located depending upon the one or more functions to be performed thereat. Representative of such equipment are the terminal dispensing and crimping machines 30, the stands or mobile carriages (carts) 32 which typically support a number of the channel trays 20 which in turn contain the respective precut and terminated wires 4, stationary worktables 34, loom tables and particularly pivotable looms 36, one or more taping machines 38 and various receptacles or containers 40 containing the appropriate hardware to be included in the wire harness at that location. Certain types of assembly tooling, as for instance the terminal assembling tool 42, may also be located at the work station 15, and located upon a respective

worktable 34.

It should be mentioned at this juncture that the arrangement of the work stations 15 along the conveyor system 22 and the work functions performed thereat, are designed to minimize or eliminate the need for the operator 15 at that work station to have to walk more than a step or two. In many instances, the operator 15 may be able to be seated at the work stations. In some instances, of course, it will be necessary for the operator 15 to take a step or two in performing the respective work function, but such movement is generally quite limited. This characteristic exists because most of the equipment required at a work station 15 is closely arranged about that work station on one or both sides of the conveyor 23 and further, because conveyor belt 28 is advanced only periodically so as to move the work in process from one work station to the next.

The wire harness 8 undergoing fabrication at any particular work station 15 is, generally speaking, at rest while at that work station. For this reason, it will be noted that the spacing between successive work stations 15 along conveyor 23 is substantially the same in most instances. It will be understood, however, that some variation in this spacing may occur to accommodate two operators at one or two work stations 15 performing functions on the same wire harness 8, but at opposite ends thereof. In the system depicted herein, the space between successive work stations is approximately 2-3 meters, the number of work stations is in the range of 8-12, and the conveyor belt 28 is incremented or advanced from one work station 15 to the next at intervals of several minutes.

It will be understood that optimum efficiency is obtained if each operator just completes their allotted functions at the respective work station 15 immediately prior to the conveyor belt 28 being incremented. This of course requires a judicious balancing of the numbers and types of functions to be performed at a work station 15, as well as a consideration of the capabilities of the respective operator 15 thereat. Because much of the equipment at each work station 15 is mobile or relatively light weight, it may be easily moved from one work station to another during setup of the wire harness assembling 10 for the manufacture of a particular type of wiring harness. Indeed, it is the aforedescribed flexibility of the present wire harness assembling system 10 which enables it to be employed economically to manufacture wire harnesses of various sizes and configurations at different times. Although the present system does rely significantly upon acceptably-priced manual labor, it does reduce the large capital cost and inflexibility of a more automated system. Further, the program of work flow and the equipment employed herein provide the economies and flexibility desired.

In Fig. 1, the wire harness 8 is depicted in its completed form at or near the downstream end 26 of the conveyor 23. Wire harness 8 has its beginning or inception at the upstream end 25 of conveyor 23, where, in its earliest "embryonic" form it is identified as wire harness 8a. The wire harness takes on additional form and detail at each of the successive work stations and thus, is identified by a successive alphabetical suffix following the basic wire harness reference numeral 8. Moreover, the portrayal of the wire harness assembling system 10 in Fig. 1 depicts the conveyor 23 at the moment just prior to it being advanced from one work station 15 to the next. Thus, the wire harness at each work station 15 is depicted in the condition or stage representing completion of the work provided at that work station. When the completed wire harness 8 appears at the downstream end 26 of conveyor 23, an operator 15 removes the harness from the conveyor and transports it to a suitable test board 43 in testing region 13 where it is tested for electrical accuracy and integrity. In the illustrated embodiment, the finished harness 8 is synonymous with an unused reference suffix 81.

The completed wire harness 8 often includes 200-300 wires and may be more than 2 meters in length. The harness 8 typically includes a number of different "arms" or "branches", each being comprised of differing numbers of wires. Typically, those branches are physically, if not also electrically, collected in a common region represented by a junction box 44 through which most of the circuits pass. The junction box 44 may sometimes also be referred to as the "head" of the harness 8. Still further, many of the branches of the completed wire harness 8 terminate at their opposite ends in respective multi-terminal connectors 46 of differing types and configurations. It will be appreciated that the embryonic harness 8a includes a junction box 44 and relatively few wires and is, accordingly, relatively supple, deformable and of light weight. On the other hand, as formation of the harness 8 progresses, it becomes heavier and is relatively less supple.

Referring further to Fig. 1, and additionally to Fig. 2, it will be seen that the conveyor system 22 is provided with at least a primary trough 50 and perhaps also a secondary trough 52 on respectively opposite sides of the conveyor 23 along that portion of the conveyor toward its upstream end 25 in which the embryonic wire harness 8a, 8b, 8c, etc. is formed. Troughs 50 and 52 extend along the upstream portion of conveyor 23 to permit the embryonic wire harnesses 8a, 8b, etc. to extend across, or transversely, of the conveyor belt 28 in a back and forth U-shape or serpentine fashion in which parts of the wire harness extend beyond the

sides of the conveyor and hang or depend into the troughs 50, 52. It has been found most convenient to arrange the first two or three work stations 15 on one particular side of the conveyor 23 and to provide the primary trough 50 along that same side of the conveyor.

The primary trough 50 is of a generally deep U-shape in cross section and may typically extend 1.5-1.66 meter below the surface of the conveyor belt 28. Primary trough 50 is sufficiently wide to conveniently accommodate a large junction box 44 resting therein as depicted in Fig. 2. Moreover, the trough 50 is sufficiently wide and smooth to facilitate the sliding of the embryonic harnesses 8a, 8b and associated junction boxes 44 therewithin as the conveyor belt 28 advances. The depth of primary trough 50 is sufficiently shallow that various parts of the embryonic harness 8a, 8b and/or random components to be affixed to the harness may rest upon the bottom of the trough and are within reach of the operator 15 thereat. Further, the vertical walls inside of troughs 50 and 52, and particularly those walls adjacent conveyor 23, are relatively smooth and preferably continuous so as to prevent interference of the conveyor frame 27 with the embryonic harness 8a and junction box 44 as the conveyor belt 28 advances and to prevent chafing of the harness on the troughs.

The secondary trough 50 on the opposite side of conveyor 23 is somewhat more optional than the primary trough 50, and serves to facilitate the smooth flow of the embryonic harness 8a, 8b as it moves along the conveyor 23. Moreover, trough 52 serves to "catch" any components which may chance to fall free of the harness on that side of the conveyor. Since it is contemplated that the larger elements of the embryonic wire harness 8a, such as the junction box 44, will be in trough 50, the secondary trough 52 need not be as wide as trough 50.

The troughs 50 and 52 may be formed of any suitable material such as sheet metal, plastic or fiberglass which is contoured to the appropriate shape. The troughs 50 and 52 are affixed to the conveyor frame 27 in a suitable manner, as by screws, bolts and/or brackets such that they are adequately supported at a level providing a smooth transition of the embryonic harness 8a, 8b from the conveyor belt 28 into and out of the troughs 50, 52. In fact, troughs 50, 52 may be provided with curved lips at their uppermost ends to prevent chafing and cutting the wire harnesses 8a, 8b and/or the operators 15.

Referring to the initial construction of wire harness 8a, a junction box 44 is taken from a storage container 40 at the upstream end 25 of the conveyor. Various wires 4 are taken from various ones of the channel trays 20 supported on carriage 32 also located near the upstream end 25 of conveyor 23. The wires 4 are then connected with the junction box 44 by the first operator 15 to form the embryonic harness 8a. It will be understood that additional operations on the wire harness 8a at that work station may include the application of additional terminals to one or more of the wires 4 via the terminal dispensing and crimping machines 30. One or more other containers 40 near the upstream end 25 of conveyor 23 may contain various types of connectors 46 for connection with the terminals at the opposite ends of some of the wires 4 connected to junction box 44.

Because the embryonic harnesses 8a, 8b may be arranged across the conveyor belt 28 and thus compressed in the longitudinal direction, the entire length of the harness is easily within the reach of a single operator 15 at the respective work station. Thus, a single operator 15 may perform work functions on the entire length of the embryonic harness 8a without needing to move a significant distance within the work station. Moreover, the longitudinal extent of the conveyor belt 28 occupied by the embryonic harnesses 8a,8b, etc. is considerably less than will be required in the later stages of formation farther downstream.

Because portions of the embryonic harnesses 8a, 8b, etc. extend transversely of the conveyor belt 28, it has been found helpful to provide members on the conveyor belt 28 in that region for engaging the harness to assist with its positioning while work functions are performed and to further assist with moving the harness with the conveyor belt 28 when it is advanced. These engaging elements may take the form of the pairs of fingers 54 seen most clearly in Fig. 2. Each finger pair 54 is affixed at its base to the conveyor belt 28, as by a suitable bonding agent and/or mechanical fasteners, and includes a pair of fingers spaced from one another in the direction of conveyor belt travel. In this way, a portion of the harness 8a extending transversely of the conveyor belt 28 may be positioned between the fingers of member 54. Each finger pair member 54 may be formed of rubber or a rubberlike material and the dimensioning and structure of the fingers is such that they may resiliently engage the harness therebetween. The spacing between successive finger pair members 54 may be about 0.5 meter, more or less. Since the principal advantage of the finger pairs 54 described above is in the embryonic formation of the wire harness 8a, 8b, 8c, etc., they may be omitted from the conveyor belt 28 downstream if the conveyor system is formed of multiple separate conveyors 23 and associated conveyor belts 28, as is typically the case.

Additional consideration is now given to the structure and function of the channel trays 20 and

the associated stands or carriages 32 upon which they are supported, with particular reference to Figs. 3-5. Each channel tray 20 typically receives precut terminated wires 4 of a particular type and length. In this way, there is no mixing of wires 4 of different types within a single channel tray 20. Channel trays 20 are generally U-shaped, are elongated and are open at least at a discharge end, and preferably at both ends. The channel trays 20 may be of differing lengths, depending principally upon the length of wires 4 to be stored therein, with the majority ranging in length between 1 and 2 meters although they may be shorter or longer. While the classic rounded U-shape of continuous curvature is a suitable contour for the cross section of channel trays 20, as depicted specifically with respect to channel tray 20a in Fig. 3, it has been found preferable to employ a modified U-shape which includes a flattened bottom and substantially vertical sides, as the majority of such trays are depicted in the various figures. Such flat-bottom U-shape configuration appears to afford a more even distribution of the wires 4 contained therein and reduces the incidence of tangling which would interfere with the removal of individual wires from the tray. Perhaps the curved cross section of channel tray 20a results in a greater number of wires 4 being at the center of the tray and thus contributes somewhat to tangling. The channel trays 20 are formed of any suitable, relatively rigid and durable material, as for instance, metal, plastic or fiberglass.

If the wires 4 in a particular channel tray 20 are terminated at only one end, it is that terminated end which is presented to the operator 15 when the tray 20 is supported in position on a carriage 32 adjacent to a particular work station. It will be understood that supported channel trays 20 may be positioned on either, or both, sides of the conveyor 22 relative to the position of the operator 15 who will be drawing wires 4 from those trays. Perhaps the most common arrangement and that which permits easiest access by operator 15 to a relatively large number of channel trays 20, is that in which the carriage 32 supporting those trays is positioned opposite the operator 15 across the conveyor 23, as seen specifically in Figs. 2 and 6.

In certain instances in which the length of a wire 4 is unusually long and greatly exceeds the length of a single channel tray 20, a pair of such trays may be joined at their respective forward ends by a suitable connector or fastener, such as hinge 55, to form a double tray designated 20′ in Figs. 3 and 4. In that instance, one portion of each of the long wires 4 is contained in one of the channel trays and the remaining portion is contained in the other, with the wires transitioning between trays just beyond the forward ends of the trays in the region of the hinge 55 so as to be readily available for removal by an operator 15. The connecting hinge 55 provides a convenient means for joining the two trays 20 forming the combined unit 20′ for ease of handling during loading and transport.

The stands or carriages (carts) 32 upon which the various channel trays 20 are supported may be of relatively simple design and inexpensive construction. In some few instances, the stands 32 may be permanently stationary and thus have no requirement for mobility. In most instances, however, it has been found desirable for the stands or carriages 32 to be mobile, and thus some form of rollers or wheels 56 are provided on cross-members 57 at the base of carriage 32. In some instances it may be desirable to reduce or "sweep" the profile of the cross-members 57 and wheels 56, as by making them adjustable via struts 59 in the manner depicted in broken line in Fig. 3.

The channel trays 20 are simply rested upon crossarms or shelves 58 which form part of the rigid structural framework of the carriage. The flat base of channel tray 20 may simply rest upon a flat surface of a horizontal crossarm 58. In the event the curved U-shape channel tray 20a is to be employed, it may be appropriate to provide curved recesses on or in the crossarms 58 to accommodate the curved bases of those trays or alternatively, curved brackets might be attached to the crossarms 58. To provide adequate support for a tray 20, it is only necessary that there be a pair of simple crossarms spaced fore and aft on carriage 32 such that they support the channel tray. A number of channel trays 20 may be supported in side by side relation on any one crossarm 58, and the carriages 32 typically also include crossarms 58 at several levels to accommodate channel trays at those differing elevations.

Although the carriages 32 described above provide horizontal orientation of the associated channel trays 20, a carriage 32′ is constructed such that the trays 20 are supported thereby in a near vertical orientation, as depicted in Fig. 5. These stands or carriages 32′ may be of somewhat simpler construction than the carriages 32 and, because of the vertical orientation of trays 20, will occupy relatively less floor space. On the other hand, in such vertical orientation it is generally preferable to have only one row or level of trays 20 and their length will be limited to that which is within a reasonable height range of the operators 15.

It has been found useful to mount resilient clamps 60 on at least those channel trays 20 which are intended for vertical orientation, for the purpose of retaining the forward or upper ends of the wires 4 in position for easy access by an operator 15.

More specifically, clamps 60 may be mounted to the undersurface of trays 20 at or near the forward, upper, or discharge end thereof for engaging a bundle of wires 4 which hangs over that same end of the channel tray. In this way the wires are prevented from falling down within the channel tray 20 when it is in its vertical orientation and the ends are conveniently presented for easy removal.

During the assembly of the wire harness 8, it is occasionally necessary or desirable to provide additional work surface for the connection of wires 4 to conneotors 46 in the formation of various subassemblies and to facilitate the integration of such subassemblies into the main harness appearing on the conveyor belt 28 at that work station 15. In some instances, that work may be accommodated on simple stationary worktables 34 if they are positioned sufficiently near the operator 15. Also, additional work surface is provided by loom tables 36 and 36′.

Each of the loom tables 36, 36′ includes a number of wire or harness-supporting jigs 62 mounted on the upper surface thereof in a predetermined pattern for aiding in the formation of the harness 8 or, more likely, a subassembly or branch to become part of the main harness. The jigs 62 typically include a base portion 63 which is mounted to the loom table 36 or 36′, and a vertical support portion 64 extending upwardly therefrom and being bifurcated at its upper end to form a pair of harness-supporting fingers 65. The arrangement of the jigs 62 on loom tables 36, 36′ is such as to define multiple wiring and branch paths during the formation of the harness or a harness subassembly. The loom tables 36′ are typically on wheels to permit easy positioning and repositioning of the tables in the region of the conveyor 23. In the system diagram depicted in Fig. 1, movable loom tables 36′ are positioned sufficiently close to the conveyor 23 that relatively few steps are required by an operator 15 to move a harness or a harness subassembly between the conveyor and the respective loom table. On the other hand, it will be noted and understood that the wheeled loom table 36′ is capable of general movement in the region of a work station and may in fact be positioned such that an operator/work station 15 is positioned between the loom table 36′ and the conveyor 23.

On the other hand, the loom table 36 may be even closer to the conveyor 23 and is capable of certain limited displacement by an operator 15, as by being pivoted, between an operating position and an idle position, as depicted in Figs. 1 and 6 adjacent wire harness 8f. In Fig. 6, the loom table 36 is illustrated at its idle position in solid line, and at its idle position in broken line. In this instance, the operating position places the loom table 36 closely adjacent and parallel to the conveyor 23, whereas the idle position is achieved when the table 36 is rotated approximately 90 degrees away from the conveyor about a pivot axis 66 which is remote from the operator 15 and generally near the conveyor 23. In its operating position, the loom table is positioned for easy access by the operator 15 to perform the various work functions on the harness or harness subassembly as required. On the other hand, when such work is completed, the harness or subassembly may be conveniently removed from the loom table 36 and placed on the conveyor belt 28, and the loom table may be pivoted to its idle position, thereby affording the operator increased spaced for the performance of other work functions at that particular work station.

It has been found particularly convenient to mount the loom table 36 to the frame 27 of conveyor 23 for pivotal rotation about pivot axis 66. More specifically, a journal or gudgeon 68 may be mounted to the conveyor frame 27 and a pivot pin or pintle 69 extends downwardly from the underside of loom table and through the gudgeon 68 to provide the pivot axis 66. It may be desirable to provide some form of lock or clamp or detent associated with gudgeon 68 and pintle 69 so as to retain the table 36 at a selected position about the pivot axis. One relatively simple way of providing the detent is to provide a pin or dog extending radially from the pintle 69 near its upper end and to contour the upper end of the gudgeon so as to provide detenting recesses for the pin at desired angular locations thereabout.

Referring to Figs. 7-9, further attention is given to a particular item of assembly tooling, that being the terminal assembling tool 42. Tool 42 is designed to easily and accurately accomplish the connection of several terminated wires 4 to a common bus connector 70. Common bus connector 70 is utilized to connect those several wires to a common electrical potential, as for instance B+ or ground in an automotive electrical system. In fact, the current-carrying capacity of the wires 4 which are connected to bus connector 70 is typically greater than that of many of the other wires in the wiring harness 8. The terminals 6 on the ends of the respective wires 4 are of a female-type, and are adapted to receive and be connected to the male, spade-type terminals 71 of bus connector 70. The bus connector 70 in the illustrated embodiment includes three such male terminals 71 extending forwardly from a common base portion 72 in substantially coplanar parallel relation. Side or end fingers 73 extend forward from each end of the common base 72 of connector 70. For the illustrated connector 70, each of the male terminals 71 extends from an edge of the common base portion 72, whereas the end fingers 73 are created by respective 90 degree bends in that base portion

and thus extend in respective planes which are perpendicular to the plane containing the male terminal 71. The end fingers 73 may themselves subsequently be placed in electrical connection with other conductive members.

The terminal assembling tool 42 aids in accurately positioning the terminals 6 relative to the male terminals 71 of common bus connector 70 and further contributes not only to the easy connection of those elements but also, to the removal of the connected terminals from that tool. Tool 42 includes first and second jigs 75 and 77 respectively. Jig 75 is structured to receive the terminated ends of several wires 4. Jig 77 is structured to receive the common bus connector 70 oriented in a substantially horizontal disposition. Jigs 75 and 77 are mounted on a base member 78 in a manner allowing one of the jigs to move relatively toward and away from the other between relative proximate and distant positions respectively corresponding with a connecting position and a load/unload position. In this embodiment, jig 75 remains stationary and jig 77 is capable of linear motion transversely of base 78.

A pneumatic actuator, such as the piston and cylinder 80, is connected with the base member 78 and the jig 77 to effect and control the displacement of that jig relative to jig 75. The piston arm 81 of actuator 80 is positively connected to jig 77, as by welding or threaded engagement or the like, to positively reciprocably displace that jig. The cylinder of actuator 80 is rigidly mounted and provides significant lateral stability to jig 77. However, to the extent that further lateral guidance of that jig is required, a raceway may be machined in the base member 78 to assure alignment with jig 75.

At the forward end of jig 77 there is provided a chamber or cavity 82 which is open in both the forward and upward directions. The cavity 82 is adapted to receive a common bus connector 70 deposited from above, and is open at its forward end to permit mating engagement with the terminals 6 supported in jig 75. With the common bus connector 73 disposed horizontally as depicted in Fig. 7b, a clearance exists beneath the undersurfaces of the male terminal 71 sufficient to permit the insertion thereon of the female terminals 6.

Jig. 75 includes several longitudinally extending slots 83 in the upper surface thereof for receiving the respective wires 4. More specifically, the grooves or slots 83 define sidewalls 84 which are undercut near their forward ends to provide seats 85 for the terminals 6. The undercut in the walls 84 is such that the terminal seats 85 contain the terminals 6 captive in both a vertical and lateral direction when inserted and seated therein as depicted in Figs. 8 and 9.

In Figs. 7-9, jig 77 is shown in its load/unload position, displaced from jig 75. Thus, the terminal 6 of a terminated wire 4 may be loaded into jig 75 by disposing the terminal forwardly of the forward end of jig 75 and moving the terminal and the wire 4 downward until the terminal is at the level of the terminal seat 85. Rearward tensioning of wire 4 then serves to seat the terminal 6 in terminal seat 85. This same operation is repeated for the other two terminated wires (not shown) with respect to the other two slots 83 in jig 75. Similarly, the common bus connector 70 is loaded into jig 77 by dropping it into cavity 82 in the orientation depicted in Fig. 7b. The rear and sidewalls of jig 77 which define cavity 82 are sized and configured to orient common bus connector 70 such that its terminal 71 are in constant alignment with the female terminals 6. Aotuation of jig 77 via actuator 80 serves to bring the male terminals 71 into mated engagement with the female terminals 6, thus completing the connection.

Retaining elements 86 are formed at the forward end of the jig 77 by a pair of projections extending transversely a short distance toward one another to provide a partial closure to the forward end of cavity 82. More specifically, retaining elements 86 extend across the forward ends of the end fingers 73 on the common bus connector 70. Following connection of the terminals 6 and their associated wires 4 to the common bus connector 70, actuator 80 operates to withdraw arm 81 and move jig 77 rearward to the load/unload position. During that motion, the retaining members 86 on jig 77 engage the end fingers 73 and the common bus connector 70 rearward also. Such rearward displacement of a common bus connector 70 dislodges the female terminals 6 from their seated positions in jig 75, thus facilitating removal of the connected wires and connector from tool 42 by a simple lifting upward of the several wires 4 in unison to remove connector 70 from cavity 82.

At various stages in the formation of wire harnesses 8, it is desirable and necessary to gather and bind certain ones of the wires to form branches within the harness. In some instances, those branches will terminate in connectors or other types of electrical termination. To bind the branches of a wire harness 8, it has been conventional to bind or wrap adhesive tape in a helical pattern about the collection of wires which form the branch. In some instances the tape is wound entirely manually, but in other instances mechanized devices have been used. In the present system, an improved taping arrangement is depicted at the work station containing taping machine 38 and adjacent to which the harness 8i is positioned. Both the taping machine 38 and the arrangement of which it is a part are of improved design, as discussed in the following description with particu-

lar reference to Figs. 10-12.

Referring to Fig. 10, there is depicted the taping machine 38 mounted for translation along a pair of rails 87 which are in turn mounted to and supported by a platform 88. The platform 88 is pivotally mounted to and supported by the frame 27 of conveyor 23 in the same way as pivotable loom tables 36, as by a gudgeon 68 and pintle 69 of the type earlier described. The work platform 88 may be long and narrow and formed of a rigid material such as metal, wood or plastic. Toward one end of the platform 88 there is mounted a bifurcated harness support 65 of the same general type as earlier described with respect to the loom tables 36. Relatively near the other end of the work platform 88, there is positioned a mechanism for gripping or clamping the harness, such as the clamping mechanism 89.

The clamping mechanism 89 is rigidly mounted to platform 88 and extends upwardly therefrom for releasably engaging a bundle of wires which form a branch of harness 8i, to permit the application of a tensioning force to the harness branch during the taping thereof. The clamping mechanism 89 may be of any suitable construction and typically includes a pair of jaws 90a, 90b, one or both of which are movable vertically between clamping and release positions by means of a manual actuating arm 9. Conveniently, the lower jaw 90a is stationary and the upper jaw 90b is moved vertically by actuation of the arm 91 in a vertical plane about a horizontal pivot axis. Actuating arm 91 may be pivoted downward from its release position shown in Fig. 10 to some over-center locked position in which jaws 90a and 90b firmly grip a branch of the harness placed therebetween. The jaws 90a, 90b may be concavely contoured to the general circular shape of a harness branch. Further, a spring or other bias element is typically associated with one or both of the jaws 90a, 90b such that they resiliently and yieldably engage harness branches of differing diameters.

Platform 88 serves as a mounting frame for the parallel rails 87, which in turn support the taping machine 38 in sliding relation therewith via slide bracket 92 which slides along the rails between a pair of adjustable stops 93 positioned toward relative opposite ends thereof. The stops 93 may be positioned on only one of the rails 87 and are manually adjustable as by thumbscrews.

Referring to Fig. 11, the taping machine 38 is considered in greater detail. Generally speaking, taping machine 38 includes a two-piece housing 94, a two-piece orbiting disc or plate 95 and a tape dispensing arrangement, such as the spool of tape 97 mounted on orbiting plate 95 via spindle 98.

The orbiting plate 95 is driven by motor 96 via a pinion 100 in driving engagement with an annular bevel gear 99 on the face of plate 95. The orbiting plate 95 includes a circular central opening 102 through which the branch of the wiring harness to be taped extends during the taping operation. The plate 95 may be of a suitable material such as metal, plastic or a composite.

Although the housing and/or the orbiting plate 95 might be formed such as to be non-opening, it will be appreciated that the harness branch to be taped would require both insertion and removal axially through the center opening 102. This may be both cumbersome and limits the size of connectors that may have been previously connected to an end of that branch. Instead, as depicted in Fig. 11, both the housing 94 and the orbiting plate 95 are formed of two pieces, and the housing is hinged to permit being opened at a forward end to create a mouth 104 through which a wire harness branch may be admitted to and removed from the central opening 102 without requiring axial movement of the branch. In the illustrated embodiment, the lower portion of housing 94 and of orbiting plate 95 are angularly coextensive and are less than 180 degrees, whereas the respective upper portions of each are somewhat greater than 180 degrees. The lower portion of housing 94 is connected to the upper portion via a hinge mechanism 106. Hinge 106 is in turn connected to a pneumatic actuator 108 via linkage 109. Operation of the actuator 108 serves to move the lower portion of housing 94 up and down between closed and open positions respectively.

As best seen in Fig. 12, the housing 94 is C-shaped in cross section to provide a housing and raceway for the two-piece plate 95 which orbits therewithin. The outer circumference of the two-piece orbiting plate 95 is sufficiently narrow to fit within the housing 94, but sufficiently wide to include several slots extending radially therein about the circumference for the mounting of several respective roller bearings 110. The roller bearings 110 are mounted in position by respective pins 112 which extend in an axial direction through plate 95 and upon which the bearings are mounted for rotation. The roller bearings 110 provide the principal supporting contact between the housing 94 and the orbiting plates 95. Additionally, to retain each of the orbiting plates 95 captive within the respective housing portion 94 when the housing is open, there are provided axially extending notches 114 in the opposite sidewalls of the orbiting plates 95, and retaining pins 116 mounted in the opposed sidewalls of the housing 94 extend therefrom into the notches 114. A connecting bracket 118, seen in Fig. 11, spans the two halves of the housing 94 and includes a slotted keyway 119 in which a key (not shown) associated with one of the halves

slides in order to glide a relative opening and closing motion between the halves.

It will be understood that although the orbiting plate 95 is formed in two complementary portions, the portion which is being driven at any moment by pinion 100 serves to drive or push the other plate portion such that it follows. Pinion 100 spans both halves of the orbiting plate 95 at the two positions of interface therebetween. Thus, when the two halves of housing 94 are closed as shown in in broken line in Fig. 11, the operation of motor 96 drives the pinion 100 which in turn drives the orbiting plates 95, to thereby impart orbital motion to the spool of tape 97 about the wire harness branch positioned within the central opening 102. Assuming the adhesive surface of the tape has first been placed in engagement with the wire harness branch, such orbital motion of the tape spool 97 effects wrapping of the tape about the branch.

To ensure that the housing 94 of taping machine 38 remains closed during operation, there is provided an engaging hinge having a female fastener member 120 on one lip of the housing and a locking pin 121 controlled by pneumatic actuator 122 positioned on the other lip of the housing. Control of the actuator 122 serves to move the locking pin 121 into and out of locking engagement with the female fastener member 120.

For the taping machine 38 to operate correctly, it is important that the two portions of the orbiting plate 95 each stop in positions which are angularly coextensive with the two halves of the housing 94 when the taping machine is to be opened. This assures that the opening of mouth 104 is relatively wide and further, that there is little or no likelihood of the orbiting plate portions becoming separated from the respective housing portions. To accomplish this end, provision has been made for detecting the angular orientation of the orbiting plate 95 within the housing 94 and for stopping rotation of the plate at precisely the correct angle. Detection of the angle is accomplished by an inductive detector 124 mounted on the housing 94 for detecting a specific angular position on the circumference of the orbiting plate 95. That position may be indicated by including a piece of metal 125 on the orbiting plate periphery for appropriate electromagnetic interaction with the detector 124 in a known manner. This form of detection is particularly suited to use with a plate 95 formed of non-metallic material.

Operating in conjunction with the detector 124 is a pneumatic cylinder 126 positioned on the upper portion of the housing 94. Cylinder 126 operates to apply a braking/locking force to the upper orbiting plate 95 to lock it in correct angular position as detected by detector 124. Pneumatic cylinder 126 may act to move a brake or lock member into and out of braking and/or locking engagement with the orbiting plate 95.

Preferably, the motor 96, and the actuator cylinders 108, 122 and 126 are pneumatically driven and are controlled in accordance with an electric program control provided by an OMRON C28K Controller (not shown) in a manner commensurate with the present description. Inputs to that control are provided by START/STOP and OPEN/CLOSE control buttons (not shown) controlled by an operator 15 and additionally by an electrically input from the inductive detector 124. Appropriate actuation of the OPEN/CLOSE control buttons effects the respective opening or closing of the taping machine 38 via actuator 108 and the respective unlocking or locking of fastener 120, 121 via actuator 122. Similarly, appropriate actuation of the START control commences the orbital motion of the tape spool 97 to wind tape about a wiring harness branch, and actuation of the STOP control serves, via detector 124, motor 96 and cylinder 126 to stop the orbiting plate 95 at the correct position.

Thus, to effect the taping of a branch of wire harness 8i, the work platform 88 will typically be pivoted to a position adjacent the conveyor 28 and one end of the branch to be taped will be clamped in the clamping mechanism 89. The harness branch will then be moved through the open mouth 104 of taping machine 38 into the central opening 102 and the other end of that branch may then be supported in the bifurcated support 65. The operator 15 may provide a manual tensioning of the harness branch against the resisting clamping force of the mechanism 89. The taping machine 38 is then closed, the tape 97 is led to the harness branch and the motor 96 is then energized to begin the taping operation. The taping machine 38 is manually moved along the rails 87 from one stop limit 93 to the other to perform the tape winding operation. Upon reaching the other limit 93, the operator actuates the STOP button, then severs the tape, as with a knife, and opens the taping machine 38 to permit the removal of the harness branch and its return to the conveyor belt 28.

Although this invention has been shown and described with respect to detailed embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail thereof may be made without departing from the spirit and scope of the claimed invention.

Claims

1. The method of assembling wire harnesses comprising the steps of:
in a first region, precutting and terminating quantities of the various wires of which a harness is

comprised; and
in a second region, assembling the wire harnesses via the steps including:
providing a mechanical conveyor line for conveying the harnesses substantially from inception in embryonic form at an upstream end to completion at a downstream end;
providing a multiplicity of local work stations along the conveyor at which operators perform various manual assembly functions, said functions being variable as required;
providing local supplies of wires at various of said work stations for use in the assembly function thereat, including transporting wires from said first region to said respective said work stations to provide said local supplies;
providing local supplies of connectors at various of said work stations for use in the assembly function thereat; and
connecting various of said wires to various of said connectors at various of said work stations and integrating said wires and connectors into respective wire harnesses.

2. The method of claim 1 including the steps of advancing the conveyor periodically and performing said connecting and integrating steps in the interval between said advancing of said conveyor.

3. The method of claim 2 including the step of preselecting the assembly functions at each of said work stations to require substantially equal times to accomplish.

4. A system for the fabrication of wire harnesses according to the method of claim 1, each having multiple wires, comprising:
a mechanized conveyor of particular width having relative upstream and downstream portions and multiple work stations therealong for the progressive formation of said harnesses from embryonic to completed states respectively;
means proximate at least some of said work stations for providing wires, including some terminated wires, for inclusion in a wire harness, the length of at least some of said wires being substantially greater than said particular width of said conveyor; and
a trough adjacent at least one side of said conveyor along at least said upstream portion thereof whereby said wires of a said embryonic harness may extend transversely of the conveyor beyond its said particular width and into said trough.

5. The system of claim 4 wherein said conveyor includes means affixed thereto for positively engaging and moving said embryonic harness therewith.

6. The system of claim 5 wherein said harness engaging means comprises at least one pair of fingers extending upwardly from said conveyor, the fingers of a said pair being spaced from one another in the direction in which the conveyor moves.

7. The system of claim 6 wherein said conveyor includes multiple pairs of said fingers, each said pair of fingers being spaced from the other said pairs in the direction in which the conveyor moves.

8. The system of claim 4 wherein said trough depends from the conveyor a distance greater than said width of said conveyor, thereby to receive a significant portion of said harness.

9. The system of claim 4 wherein said embryonic harness includes a junction box connected thereto and wherein the width of said trough is sufficient to receive said junction box therewithin.

10. The system of claim 9 wherein said conveyor includes first and second said troughs, said first trough being adjacent one side of the conveyor and said second trough being adjacent the other side of said conveyor thereby to each receive a portion of said embryonic harness therein.

11. The system of claim 6 wherein said conveyor includes multiple pairs of fingers, the fingers of a respective said pair being spaced from one another in the direction in which the conveyor moves and said pairs of fingers being spaced from one another also in the direction in which the conveyor moves, each said pair of fingers being adapted to engage and move said embryonic harness therewith, and said embryonic harness may cross said conveyor in generally U-shape form, with the two arms of the U-shape being engaged respectively by two pairs of fingers, the nexus portion of the U-shape being in one of said troughs and the ends of said U-shape being in the other of said troughs.

12. A wire storage and dispensing arrangement for use in a system for the fabrication of wire harnesses according to the method of claim 1, the fabrication system including a mechanical conveyor having multiple work stations therealong, comprising:
means for (respectively) temporarily storing quantities of wires at various ones of said working stations, said wires being precut to various appropriate lengths, said storing means being so configured and said wires being so disposed therein as to facilitate manual removal of respective said wires for use at a work station, each said storage means comprising a plurality of channel trays supported on a carriage, said wires being of various different function-type, the wires of a respective said function-type being stored in a respective one of said channel trays.

13. The arrangement of claim 12 wherein most of said carriages are mobile.

14. The arrangement of claim 13 wherein said channel trays are each generally U-shaped and open at an end to provide manual access thereto for removing a wire in a direction longitudinally of said channel.

15. The arrangement of claim 14 wherein each said

channel tray includes a base and a pair of generally opposed side walls, the base portion connecting said side walls being generally flat thereby to facilitate even distribution of wires therein.

16. The arrangement of claim 14 wherein at least some of said carriages each include horizontal shelves at several levels, and respective channel trays are freely supported horizontally on the respective said shelves at various said levels.

17. The arrangement of claim 14 wherein said channel trays are oriented substantially vertically on at least some of said carriages and said wires disposed in said channel trays extend beyond and hang from the upper end therefrom to facilitate said manual removal.

18. The arrangement of claim 17 wherein said channel trays each include respective clamp means affixed thereto near the respective upper end thereof for releasably retaining the wires in the respective channel trays in position for convenient manual access.

19. The arrangement of claim 14 wherein a hinge connects a pair of said channel trays at one end in adjacent parallel relation, thereby to store in the pair wires of greater length than the length of a single channel tray of the pair.

20. The arrangement of claim 13 wherein said carriages include base cross members at opposite ends, rolling means being affixed to said base cross members, and wherein at least one of said base cross members is adjustable toward the other.

21. A system for the fabrication of wire harnesses according to the method of claim 1, each having multiple wires, comprising:

a mechanized conveyor having multiple work stations therealong for the progressive manual formation of said harnesses;

means proximate at least some of said work stations for providing wires, some of which are terminated, for inclusion in wire harnesses; and

one or more loom tables each adjacent a respective work station for facilitating the fabrication of a multiwire harness subassembly thereat for inclusion in the wire harness at the respective work station.

22. The system of claim 21 wherein one or more of said loom tables is pivotally mounted for selective displacement between an operating position and an idle position, said operating position disposing said loom table so as to facilitate said fabrication of a said harness subassembly and said idle position being displaced from said operating position and disposing said loom table in substantially non-interfering relation at the work station for operations thereat other than said fabrication of said harness subassembly.

23. The system of claim 22 wherein a said loom table comprises a platform member and a plurality of wire supporting members mounted to and extending from the platform member for receiving, supporting and routing various wires of said multiwire subassembly.

24. The system of claim 23 wherein said platform member is horizontal and each said wire supporting member extends upwardly therefrom and includes a respective bifurcation at its upper end for receiving wires therebetween.

25. The system of claim 22 wherein said conveyor includes a supporting frame and said loom tables are each pivotally mounted to said frame.

26. A tapering arrangement for the mechanized wrapping of tape about an elongated bundle of wires undergoing fabrication into a wire harness according to the method of claim 1 and disposed on a conveyor, comprising, at a work station adjacent the conveyor:

a taping machine, including a housing, a drive motor connected to the housing, an orbiting mechanism supported by the housing and driven by the motor in an orbital path about a central region in which the wire bundle is disposed, and tape dispensing means mounted on the orbiting mechanism for dispensing tape to the wire bundle as the mechanism orbits about the wire bundle;

mounting means for the taping machine to facilitate manual displacement of the machine longitudinally of the wire bundle to be taped; and

the mounting means and taping machine being positioned adjacent to the conveyor at least during taping of a wire bundle.

27. The taping arrangement of claim 26 further including at least one gripping means mounted to resist motion longitudinally of the wire bundle to be taped, said gripping means being adapted to releasably engage and grip the wire bundle to be taped sufficiently to resist displacement of the wire bundle during application of a tensile force thereto during taping.

28. The taping arrangement of claim 27 wherein said gripping means comprises a clamp which is manually actuatable between clamping and release positions.

29. The taping arrangement of claim 28 wherein said taping machine mounting means includes support platform, said support platform being positioned adjacent to the conveyor, and said clamp being mounted on and supported by said support platform.

30. The taping arrangement of claim 29 wherein said support platform is mounted for pivotable motion relatively toward and away from the conveyor between respective operating and idle positions.

31. The taping arrangement of claim 30 wherein said conveyor includes a stationary frame and said support platform is pivotally mounted to said conveyor frame.

32. The taping arrangement of claim 31 wherein said mounting means for said taping machine further includes a mounting frame, a pair of parallel rails joined to and supported by the mounting frame, and a bracket sliceably disposed on said parallel rails for longitudinal motion therealong, said bracket being connected to and providing the support for said taping machine.

33. The taping arrangement of claim 32 including selectively adjustable stop means positioned on at least one of said rails for limiting the longitudinal displacement of the bracket and thereby the taping machine, supported by said bracket.

34. The taping arrangement of claim 26 wherein said drive motor is pneumatically powered.

35. The taping arrangement of claim 26 wherein said taping machine housing includes an annular and substantially continuous race and said orbiting mechanism comprises annular disc means having a central opening at the central region through which the wire bundle may extend.

36. The taping arrangement of claim 35 wherein said orbiting annular disc means includes an annular pattern of gear teeth on one face thereof, and wherein said motor includes a pinion in driving engagement with the gear teeth of said orbiting annular disc means for translating the axis of rotary motion between the motor and the orbiting annular disc means.

37. The taping arrangement of claim 26 wherein said mounting means for said taping machine includes a mounting frame, at least one rail joined to and supported by the mounting frame, and a bracket sliceably disposed on said rail for longitudinal motion therealong, said bracket being connected to and providing the support for said taping machine.

38. A taping machine for use in fabrication of wire harness according to the method of claim 1, said taping machine having housing, a motor, an orbiting mechanism supported by the housing and driven by the motor, and tape dispensing means mounted on the orbiting mechanism for dispensing tape to an object to be taped as the mechanism orbits about the object, and wherein the housing is annular and comprises two complementary arcuate portions joined in hinged relation and movable between relatively open and closed positions and the orbiting mechanism comprises an annular plate having a central opening and being divided into two separate complementary arcuate portions substantially coinciding with said complementary housing portions and being capable of being moved with said housing portions between said open and said closed positions.

39. The taping machine of claim 38 wherein the motor includes a pinion connected thereto in driven relation, each of said arcuate portions of said plate includes a respective arcuate gear in a face thereof and wherein said pinion is in driving engagement with said gear on at least one of said arcuate portions of said plate, the other of said arcuate portions of said plate being pushed and driven by said one.

40. The taping machine of claim 39 further including means for detecting a particular position of rotation of said arcuate plate portions with respect to said portions of said housing and for providing a signal representative of that position, and means responsive to said signal for stopping rotation of said arcuate plate portions to substantially coincide with said complementary housing portions.

41. The taping machine of claim 39 including complementary locking means affixed to respective ones of said complementary housing portions for releasably locking said housing portions in said closed position.

42. The taping machine of claim 39 wherein said motor is a pneumatic motor.

43. A terminal assembling tool for facilitating the connection of multiple terminated wires to a common bus connector in the fabrication of wire harness according to the method of claim 1, the terminated wires each including a terminal for receiving a terminal of complementary type, and the common bus connector including multiple terminals of said complementary type extending therefrom in substantially the same direction, comprising:

a first jig for receiving said multiple terminated wires;

a second jig for receiving said common bus connector;

at least one of said first and second jigs being movable relative to the other between relative proximate and distant positions respectively corresponding with a connecting position and a load/unload position;

means for actuating said one of said first and second jigs between said connecting and said load/unload positions;

said first jig including means for pre-positioning said terminated wires; and

said second jig including means for pre-positioning said common bus connector,

whereby upon said actuation of said one of said first and second jigs said terminated wires are accurately and completely connected to respective ones of said terminals on said common bus connector.

44. The terminal assembling tool of claim 43 wherein said jig actuating means comprises a pneumatically-powered liner actuator.

45. The terminal assembling tool of claim 44 including a base member and wherein said actuator includes a housing and a reciprocable actuating arm, said base member housing and said first jig

being substantially fixedly mounted to said base member and said second jig being connected to said actuating arm of said actuator for reciprocation between said connecting and load/unload positions.

46. The terminal assembling tool of claim 43 wherein said terminals on said wires are of a female type, said common bus connectors are of a male type and said common bus connector includes a common base portion, said multiple male terminals extending forwardly from said base portion, and a pair of end fingers being disposed at opposite ends of said base portion and extending forwardly therefrom, and wherein said second jig further includes retaining means extending transversely of said common base portion end fingers and forwardly thereof to engage said end fingers and move said common base portion and connected terminated wires rearwardly in unison for unloading when said second jig is actuated from said connecting position to said load/unload position.

47. The terminal assembling tool of claim 46 wherein said second jig is disposed for actuation in the horizontal plane and said pre-positioning means thereof comprise a cavity therein open at the top and at the front of said second jig for receiving/discharging the common bus connector via vertical motion thereof and for closely orienting the common bus connector when received in the cavity.

48. The terminal assembling tool of claim 47 wherein said first jig includes multiple, substantially parallel slots in the upper surface thereof, a respective said slot existing for each of said terminated wires, said slots being substantially aligned with respective said male terminals on said common bus connector, and wherein each of said slots is contoured at its forward end to retain a respective female terminal therein in alignment with a respective said male terminal.

49. The terminal assembling tool of claim 48 wherein said male terminals are of the spade type and extend in a horizontal plane when disposed in said second jig.

FIG. 1

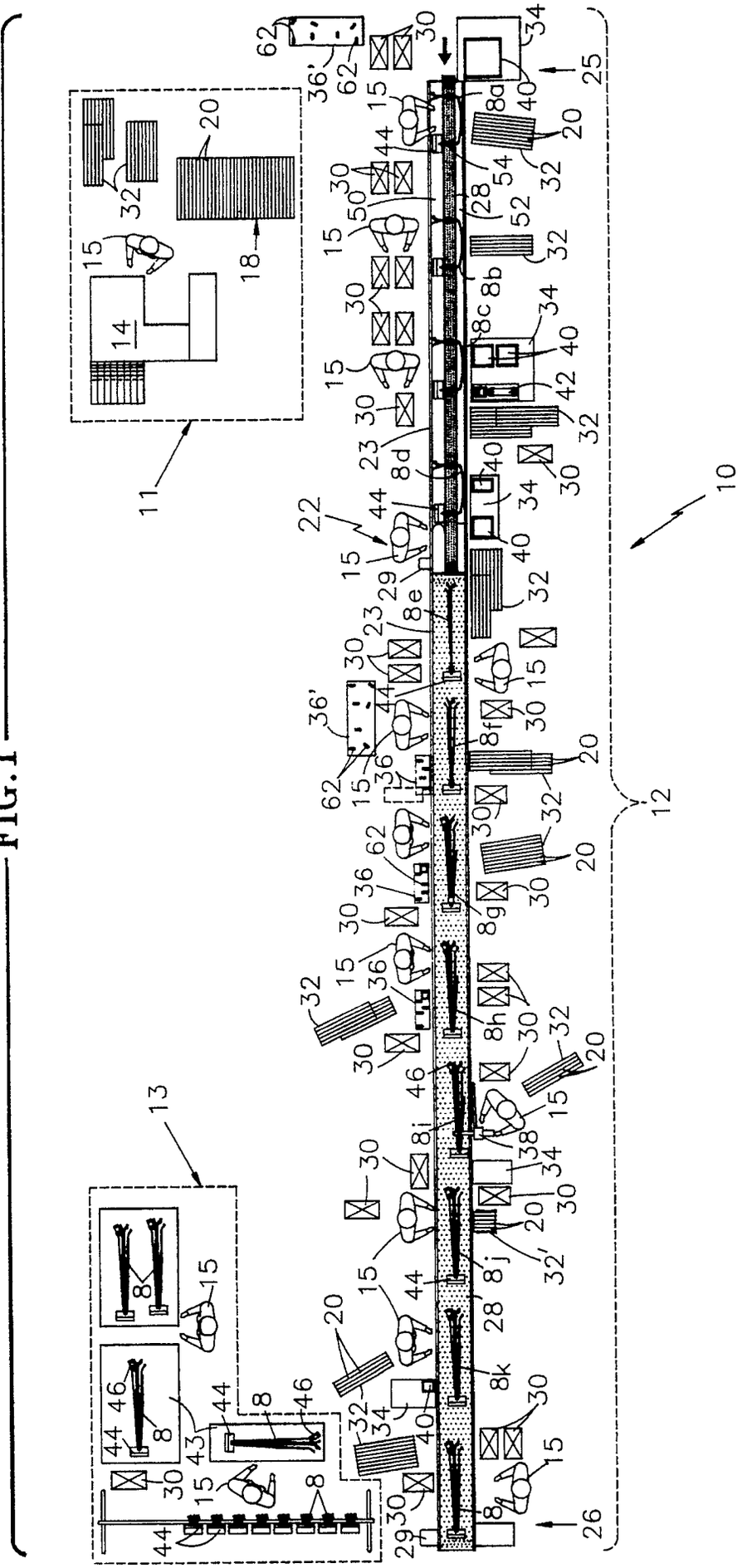

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FIG.2

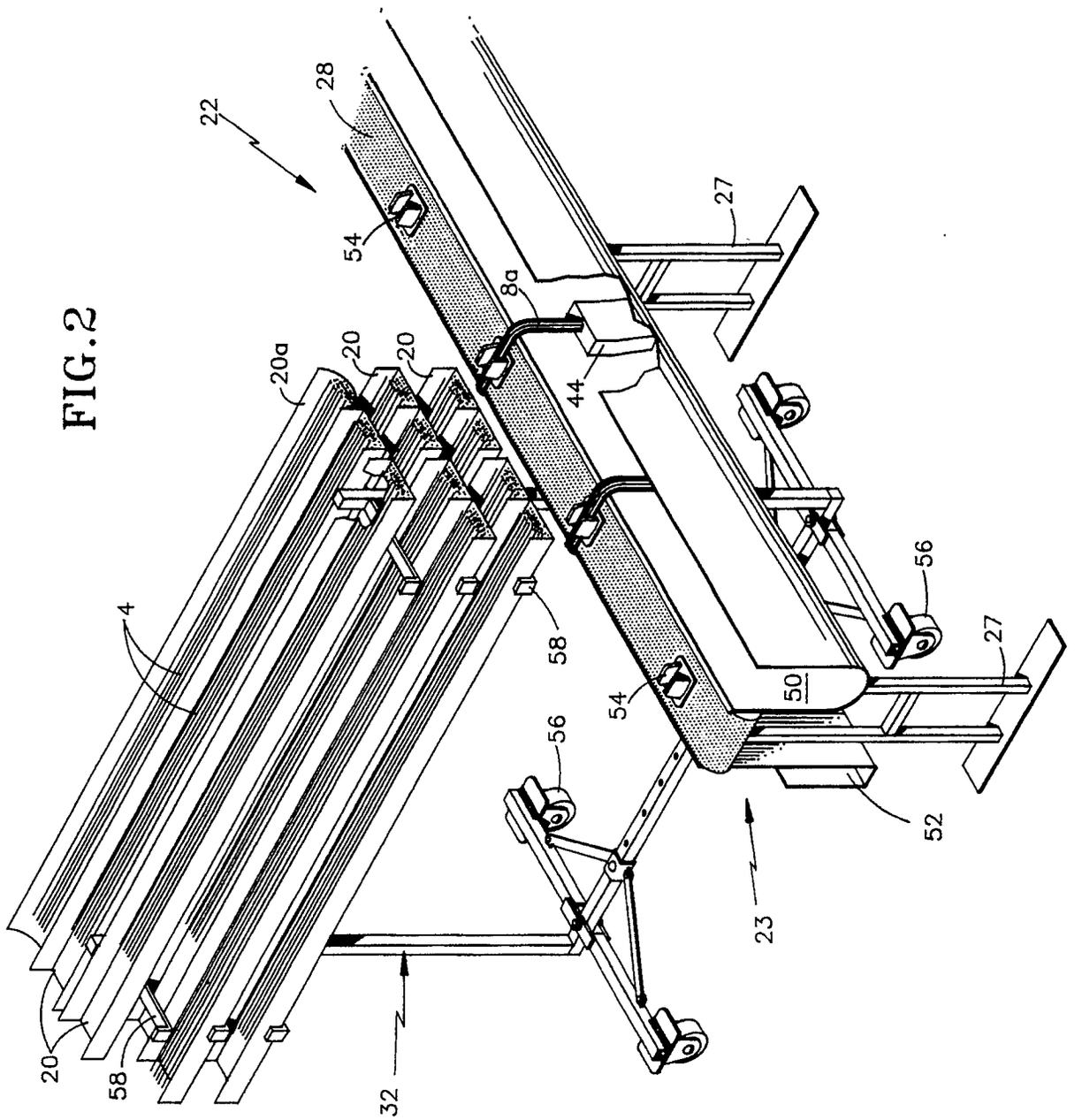


FIG.5

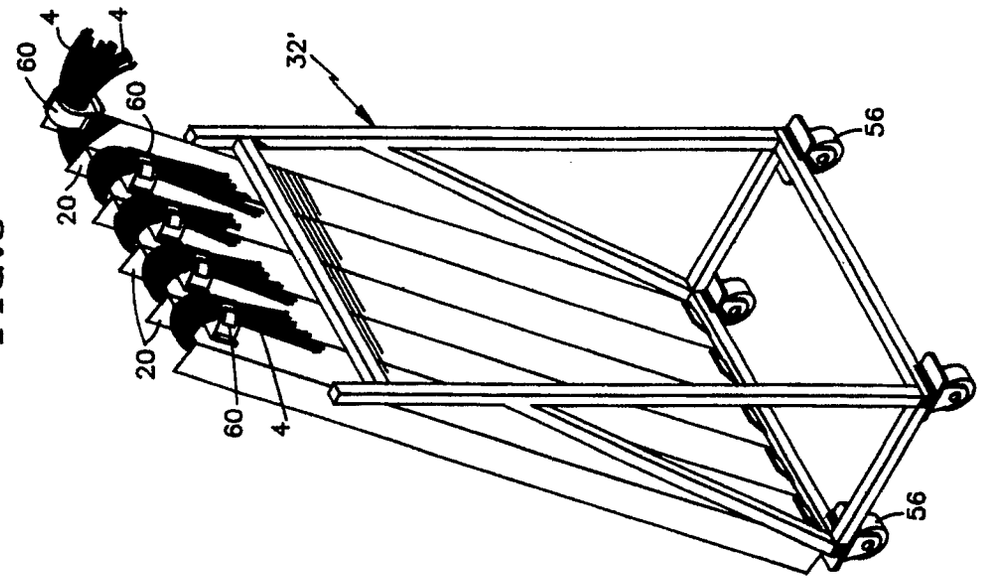
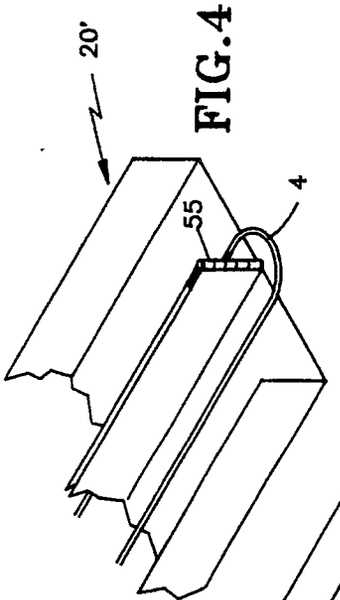


FIG.4



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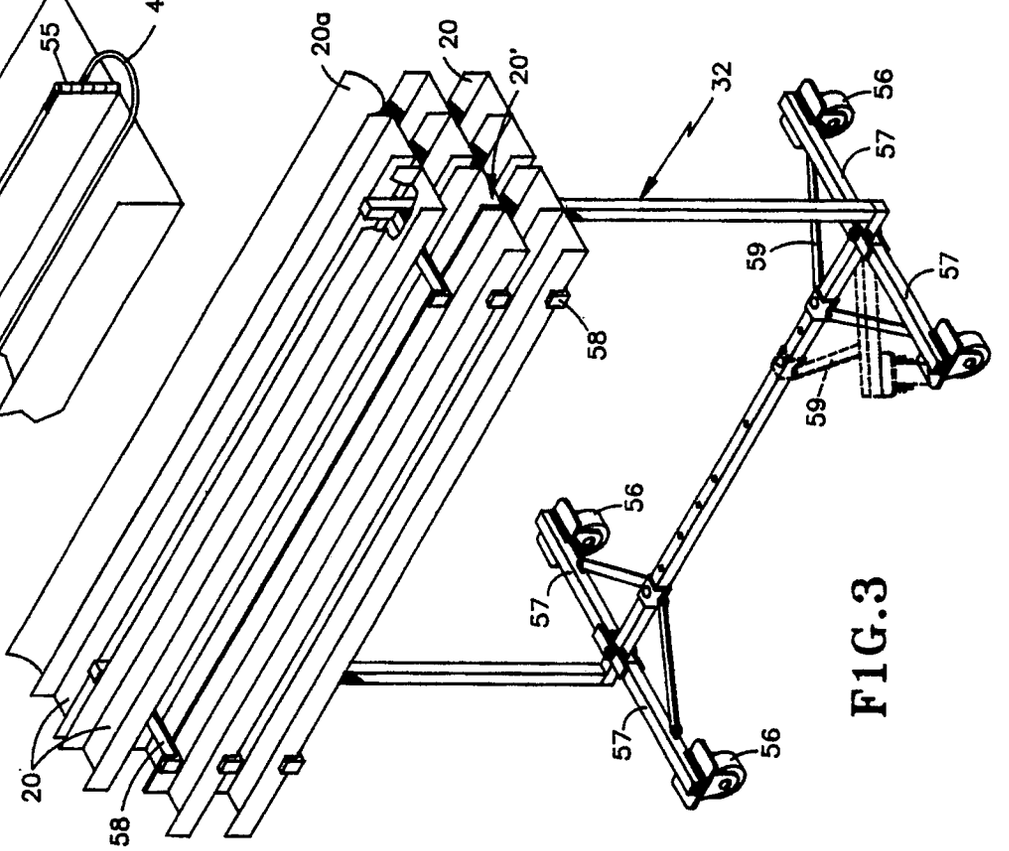
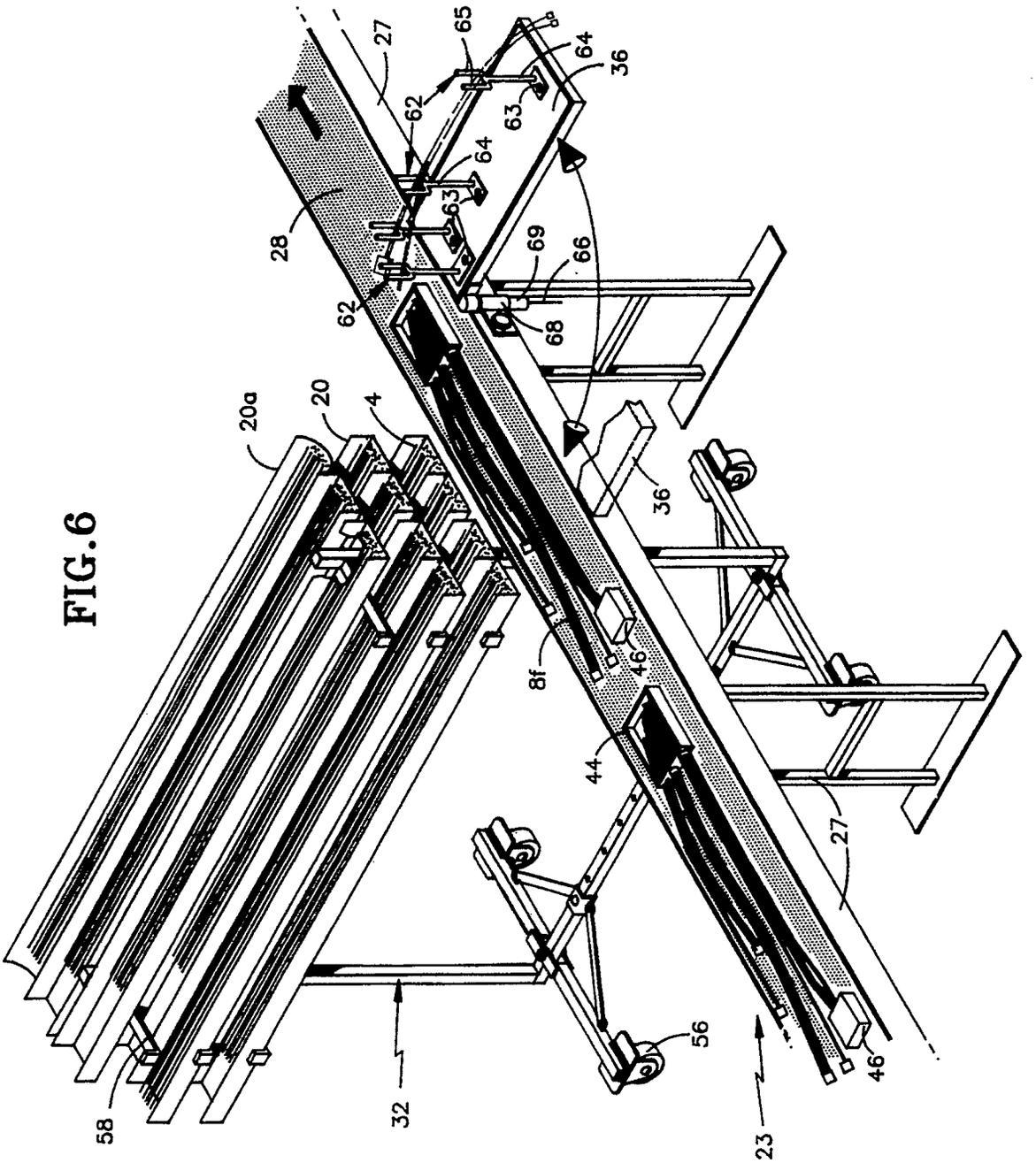


FIG.6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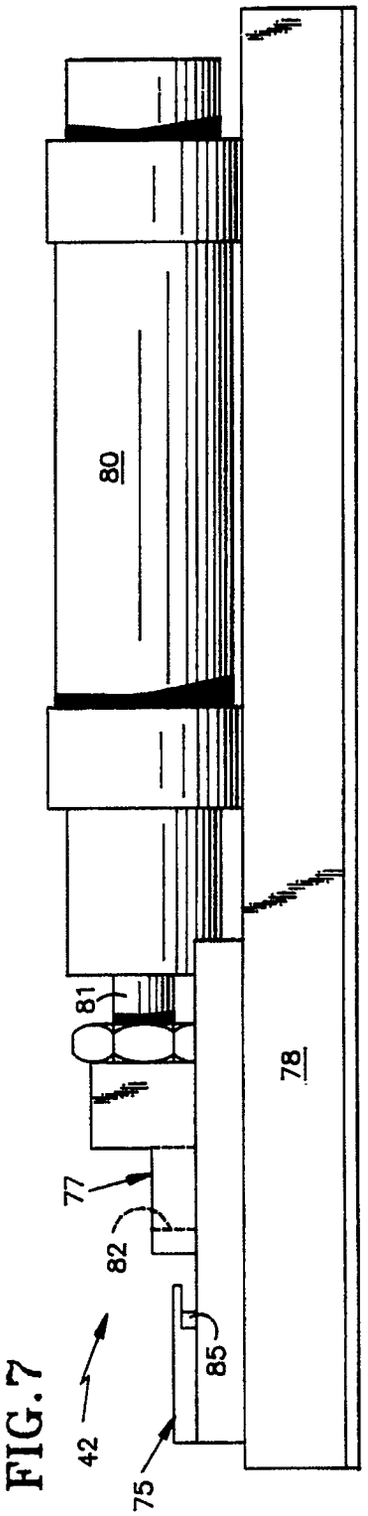
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FIG.7

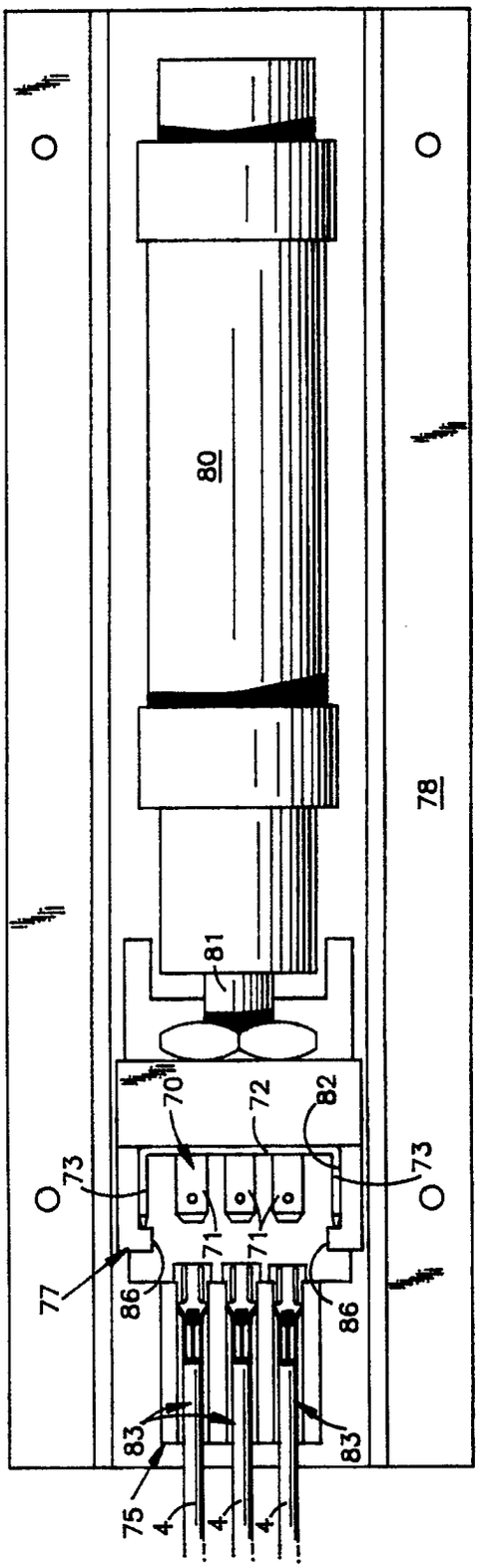
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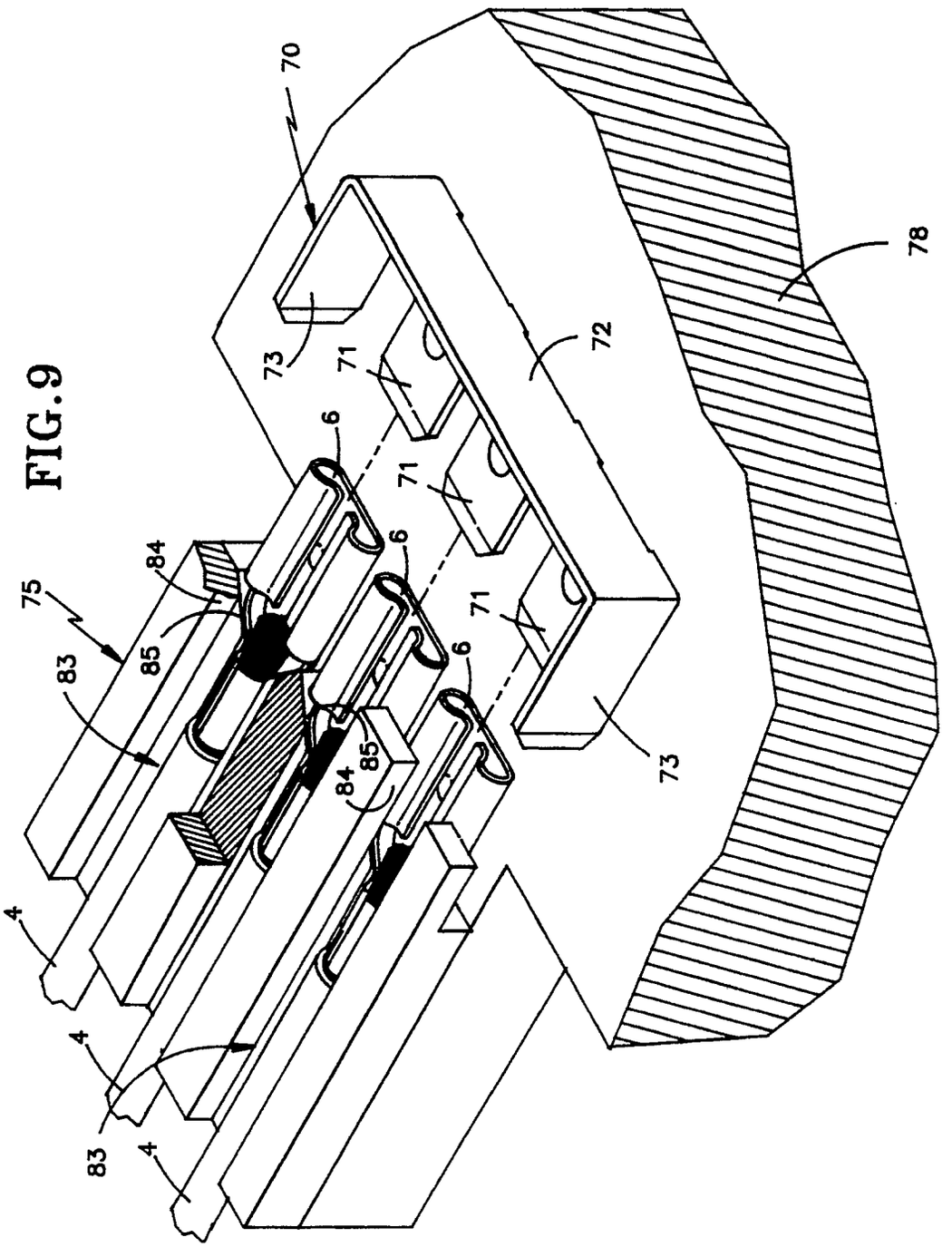
FIG.8

FIG.9



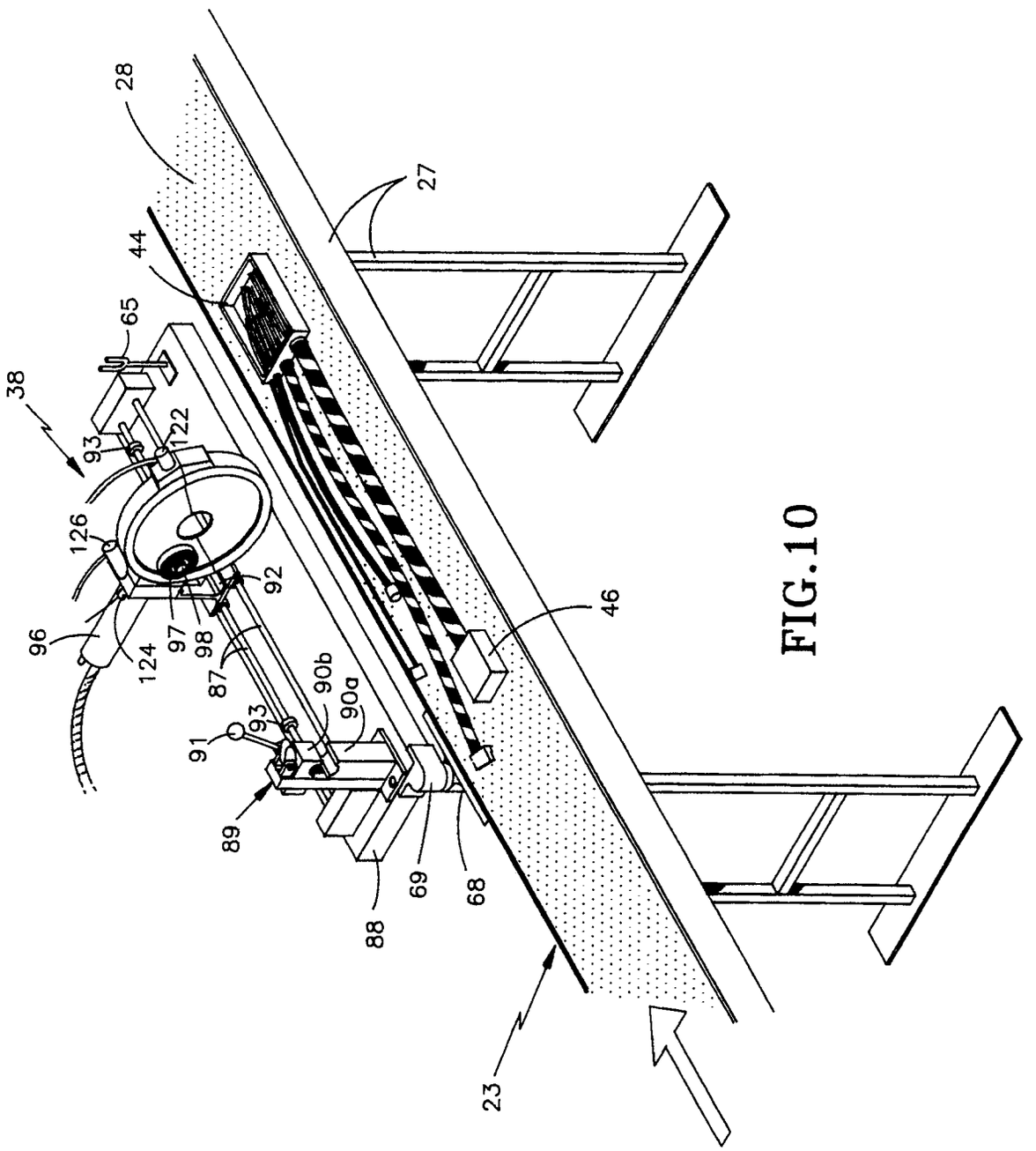

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FIG.10

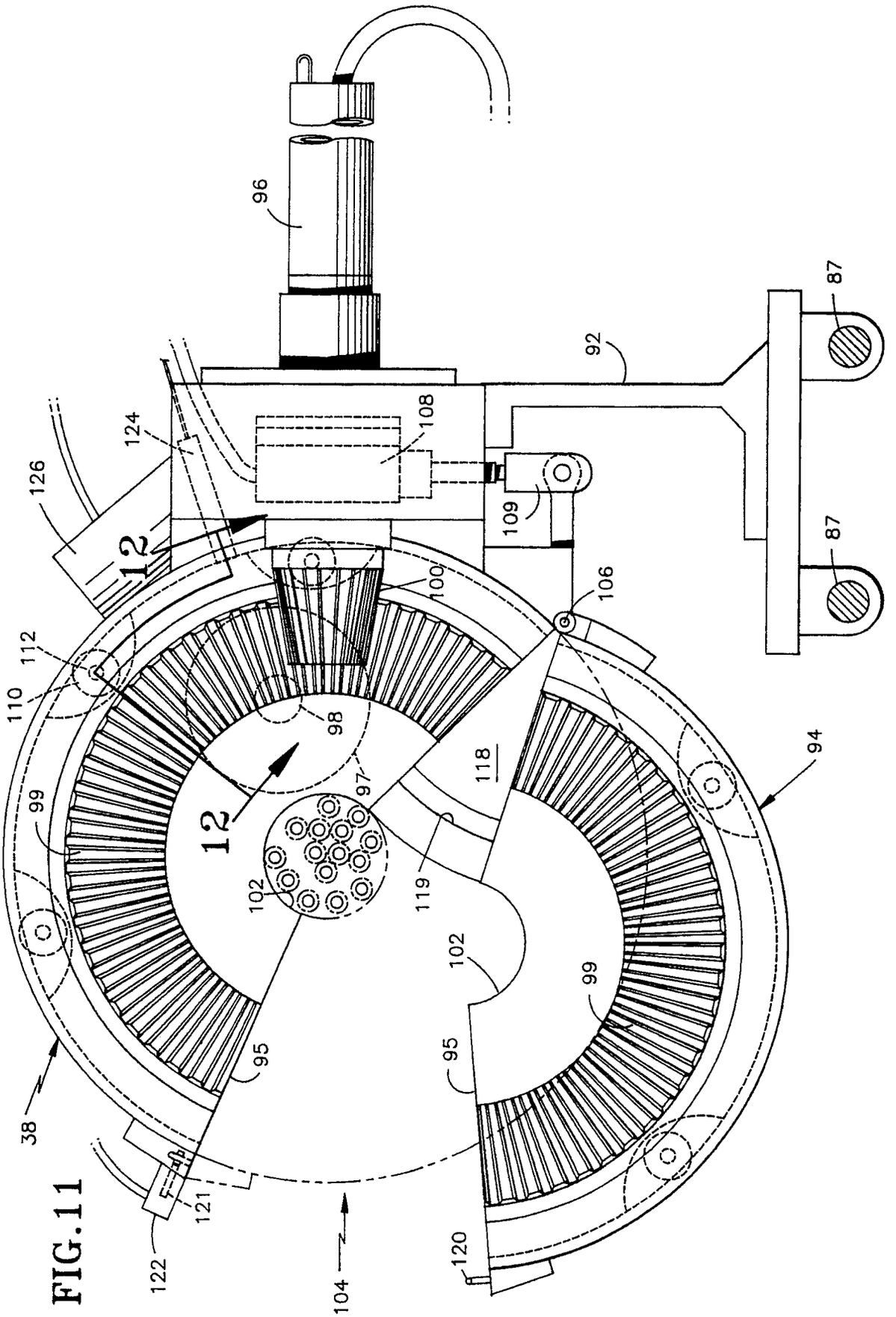
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FIG. 11

FIG.12