Jan. 24, 1967 R. J. LEMIEUX 3,299,686

STRAND EXTRUDER

Filed Jan. 13, 1964

FIG. 1

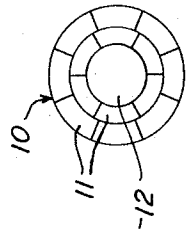


FIG. 2

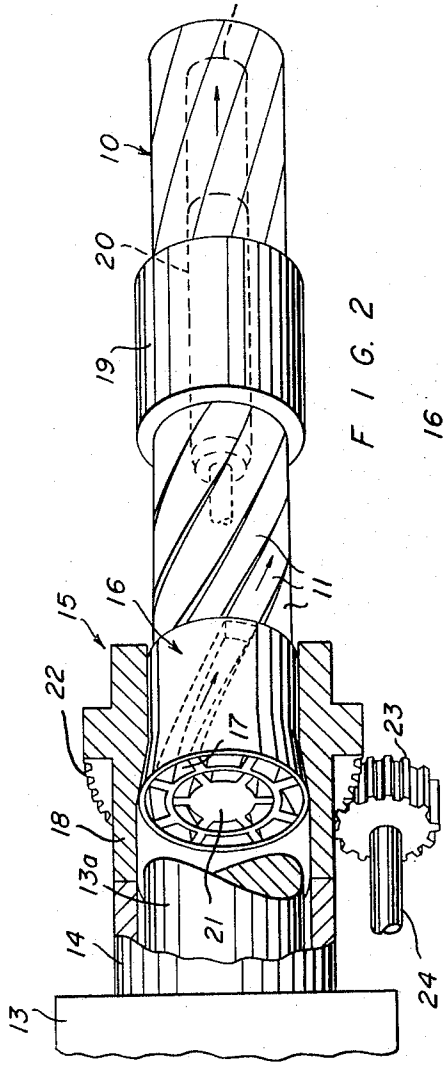
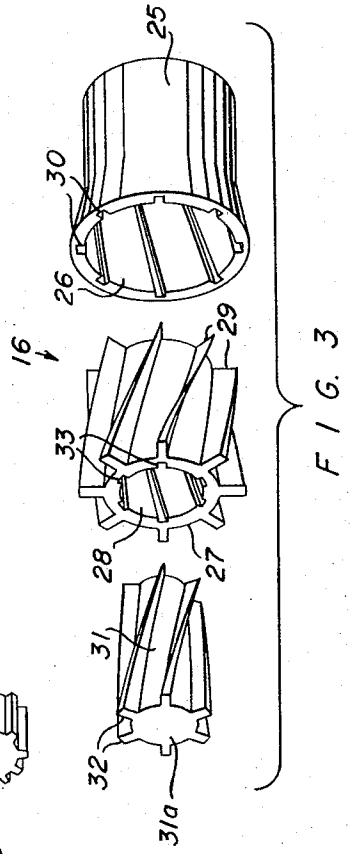


FIG. 3



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STRAND EXTRUDER

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This invention relates to a method and apparatus for simultaneously producing a plurality of metal strands to form a flexible cable.

When flexible cables are intended for use as, for example, electrical conductors, it is sometimes desirable to form them from strands having shaped cross-sections. Typical of shaped strand cross-sections are the sector (pie-shape) and the segment (keystone-shape), and their purpose is to achieve a cable having the same cross-sectional area of metal as a cable of circular strands, but having a smaller diameter than the cable composed of circular strands.

The conventional method of manufacturing such a cable includes the steps of stranding together a plurality of individual wires to form a circular strand, drawing the strand through a shaping die to compress the wires into the desired cross-sectional shape, and stranding, or as this step is more commonly referred to, closing, a plurality of such strands together to form the cable. Although each strand is usually drawn through the shaping die as it is stranded from the individual wires, this manufacturing method comprises at least four independent operations when drawing and annealing of the wires is taken into account. Separate apparatus is required for each operation together with the attendant operating space and expense. In addition, handling of the cable components between each of these independent manufacturing operations is necessitated.

A further disadvantage of this conventional manufacturing procedure is that the severe deformation of the strands during the shaping and closing operations results in high internal stresses in the strands of the completed cable. Inasmuch as it is usually impractical to anneal the shaped strands or the cable, these internal stresses remain in the cable and impair its flexibility. In addition, the strands have a tendency to unravel from their helical positions in the cable which results in the cable being "live" and difficult to handle.

The present invention in its broadest aspect provides a method, and an apparatus for carrying out the method, in which the plurality of strands for the flexible cable are extruded simultaneously in the approximate configuration which the strands assume in the finished cable with each of the strands having the same shape and dimensions as desired in the finished cable. Thereafter, the strands are closeds to form the flexible cable.

This method permits in an single operation the manufacture of flexible cables which previously required at least four independent operations. Accordingly, considerable reductions in the operating space and expense may be realized. Because the strands are extruded in their final shape, virtually no internal stresses are present to impair the flexibility of the cable or to give the strands a tendency to unravel. The fact that the strands are made of solid metal has little effect, if any, on the flexibility of the cable since in the conventionally produced cable the wires of a shaped strand are compressed during the shaping operation to an extent whereby the strand is effectively solid.

This invention also provides an extrusion die for use in the method of the invention. The die basically comprises a die housing having a bore, with an inlet end and an outlet end, and a die insert having a plurality of longitudinally extending fins projecting therefrom. The die insert is adapted to be inserted into the bore of the die housing through the inlet end with the fins engaging corresponding grooves in the inner surface of the die housing. Each of the fins and corresponding grooves tapers in width toward the outlet end of the bore such that the die insert is wedged in the bore in operative position whereby extrusion passages are formed between the die housing and the die insert.

The extrusion die of this invention is unique not only in that it has multiple passages for simultaneously extruding the strands in such a manner that the strands have minimum internal stresses when they are closed together to form the cable, but also in the wedging fit of the fins in the grooves in the inner surface of the die housing. This feature makes it possible to position and lock the die insert in the bore of the die housing without the necessity of separate fastening means and thereby permits simplified manufacture of an otherwise complicated die structure. Because the wedging fit of the fins in the grooves is toward the outlet end of the die, the extrusion forces serve to maintain the die insert in locked engagement with the die housing. Disassembly of the die parts for cleaning and maintenance is facilitated since it is necessary only to force the die insert toward the inlet end of the die sufficiently to break the wedging fit of the fins in the grooves whereafter the die insert may be withdrawn from the bore through the inlet end of the die.

The method and apparatus of this invention have a further advantage in the particular case where the cable consists of two or more concentric layers of strands having the same helix angles and direction. To prevent structural weakness of the cable, it is important that the lines of contact between adjacent strands in one layer be staggered with respect to the lines of contact between adjacent strands in the adjacent layer. Proper staggering of the lines of contact in a cable produced by the conventional manufacturing method is difficult to ensure since considerable movement often occurs during manufacture between the adjacent strand layers. In view of the fact that the extrusion die of the present invention is constructed with the proper staggering and in view of the fact that the strands are immediately closed to form the final cable upon issuance from the extrusion die, the strands produced by the method of this invention are maintained in the desired arrangement.

The preferred embodiment of the method and apparatus of this invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a cross-section of a typical cable composed of segment-shaped strands;

FIGURE 2 is a diagrammatical illustration, partly in section 1 of an apparatus adapted to perform the method of this invention; and

FIGURE 3 is an exploded view of an extrusion die for use in the apparatus of FIGURE 2 for producing the strands of the cable shown in FIGURE 1.

The cable **10** shown in FIGURE 1 comprises two concentric layers of segment-shaped metal strands **11** forming a hollow core **12** for passage of a fluid under pressure after a suitable insulation and sheathing has been applied to the exterior of the cable. The segment shapes of the strands impart a self-supporting characteristic to the cable structure, thereby obviating the necessity of special means in the cable for maintaining the hollow core.

Referring now to FIGURE 2, block **13** represents a conventional metal extrusion apparatus for heating strand metal to at least an extrudable plastic state, and for forcing the heated metal **13***a* through an outlet **14** to an extrusion die assembly designated generally at **15**. An

extrusion die **16**, which forms part of the die assembly, consists of separate extrusion passages **17**. Each extrusion passage **17** has the desired cross-section and longitudinal helical shape of the strand to be extruded therethrough and together the extrusion passages are arranged in the same configuration as the strands in cable **10**. The die **16** is mounted in a die holder **18** which is in sealing engagement with the outlet **14** of the extrusion apparatus **13**.

As the strands **11** issue from the extrusion passages **17**, they pass through a closing die **19** having an axial bore of the same diameter as the cable **10**. Closing die **19** closes or brings the individual strands **11** into contact to form the desired cross-section of the cable as shown in FIGURE 1. A mandrel **20** is positioned concentrically within the bore of closing die **19** to provide internal support for the strands **11** to ensure that they seat properly in their respective positions to form the cable **10**. The mandrel **20** is supported by a solid axial portion **21** of the extrusion die **16** which corresponds to the hollow core **12**.

In order that the strand on issuing from extrusion passages **17** be rigid enough to retain their shape, it is preferably that the strands be cooled as they pass through extrusion die **16**. Any conventional cooling arrangement (not shown) such as a cooling jacket in the die holder **18** may be provided.

To facilitate further operations, such as winding of cable **10**, the cable preferably should not rotate about its longitudinal axis. This is accomplished by rotating the extrusion die **16** oppositely to the helix direction of the outer layer of strands **11** and at a speed determined by the helix angle and the extrusion speed of cable **10**. Accordingly, the die holder **18** is rotatably supported and driven at the required rotational speed in the proper direction by means of a ring gear **22** mounted thereon, the ring gear being driven by a pinion gear **23** through a shaft **24** from a suitable driving means (not shown).

To minimize the sliding friction between strands **11** and the bore surface of closing die **19**, the latter is arranged so that it has no rotational movement relative to the cable **10**.

It is preferable to supply metal to the extrusion apparatus **13** in the form of a billet which is heated therein to a plastic state and thereafter forced from outlet **14** to extrusion die **16**. In such case, the extrusion apparatus would consist of a conventional heated extrusion cylinder and plunger arrangement (not shown). Assuming a rotating extrusion die **16** is used it would, of course, be necessary to rotate the billet in synchronism therewith. This could be accomplished by rotating the extrusion cylinder. In such case, die holder **18** would be rigidly coupled to outlet **14** of extrusion apparatus **13** and the driving means (not shown) could be connected either to the extrusion cylinder (not shown) or die holder **18** or both.

The extrusion die illustrated in the exploded view of FIGURE 3 is particularly adapted for use in the above described apparatus for producing the strands **11** of a cable **10** having the cross-sectional configuration of FIGURE 1. The die, designated generally at **16**, comprises a die housing **25** having an axial bore **26** decreasing in diameter from the left end to the right end of the die **16**, as viewed in FIGURE 3 (which are the inlet and outlet ends respectively). The outer surface of the die housing is suitably arranged for mounting in the die holder **18** of FIGURE 2. A first die insert **27** of circular cross-section and decreasing in diameter from the inlet end to the outlet end of die **16** is adapted to be concentrically received in the bore **26**. The die insert has an axial bore **28** and a plurality of equally spaced longitudinally extending fins **29**. Each fin **29** is helically formed in the longitudinal direction to match the helix of the strands **11** in the outer strand layer of cable **10**, and the sides of each fin **29** are

parallel in the radial direction but taper continuously from the inlet end of the die **16** to the outlet end.

A plurality of helical grooves **30** are formed in the surface of bore **26** of the die housing **25** to correspond in size and helical twist to fins **29**. These grooves **30** decrease in width toward the outlet end of die **16** to match the tapering sides of fins **29**. The die insert **27** is positioned in bore **26** by inserting the former into the inlet end of die **16** with the fins **29** sliding in grooves **30** until they are wedged therein. Thus, die insert **27** together with the surface of bore **26**, forms an annular chamber which is divided by fins **29** into a plurality of strand extrusion passages **17**, as shown in FIGURE 2. These extrusion passages have the same cross-sectional and helical shapes as strands **11** and are arranged in the same configuration as the strands in the outer strand layer of cable **10**. The tapering of the die insert **27**, the bore **26**, and the fins **29** is to effect a decrease in the cross-sectional areas of the extrusion passages as is common in metal extrusion and results in convergence of the extrusion passages toward the longitudinal axis of the die **16** which facilitates smooth entry into the closing die **19**.

A second die insert **31** is adapted to be concentrically positioned within bore **28** of the first die insert **27** to form therewith the remaining extrusion passages **17** of FIGURE 2 for the strands **11** in the inner layer of cable **10**. The die insert **31** has equally spaced longitudinally helical fins **32** adapted to be received in helical grooves **33** in the surface of bore **28** in the same manner as described above with respect to the positioning of die insert **27** in die housing **25**. Unlike die insert **27**, however, the die insert **31** has a solid axial portion **31***a* to produce cable **10** having a hollow core **12**.

Because of the wedging engagement of the fins of both die inserts in their respective grooves, the die inserts are held firmly in place by the extrusion forces without the aid of separate fastening means. Removal of the die inserts is easily accomplished when desired by simply applying a sufficient force on the inserts in a direction opposite to the extrusion direction to free the fins from their wedging engagement with the grooves.

Although not shown, all portions of die housing **25** and die inserts **27** and **31** which form the walls of the extrusion passages **17** would be suitably shaped at the inlet end of the die **16** to facilitate entry of the heated strand metal into the extrusion passages.

While the strands have been referred to in the foregoing description of the present invention as having either a sector or a segment shape, particularly the latter, it is to be understood that the invention may be utilized for the production of flexible cables having strands of any shape or combination of shapes.

What I claim as my invention is:

1. An apparatus for producing a flexible cable comprising extrusion means for simultaneously producing a plurality of metal strands in the approximate configuration which the strands assume in the finished cable, said extrusion means being adapted to produce each strand in the same shape and dimensions as desired in the finished cable, and closing means for drawing said strands together to form said flexible cable, said extrusion means including an extrusion die comprising a die housing having a bore, said bore having an inlet end and an outlet end, a die insert having a plurality of longitudinal fins projecting radially therefrom, said die insert being adapted to be inserted into the bore of the die housing through said inlet end with said radially extending fins engaging corresponding grooves in the inner surface of the die housing, each of said fins in corresponding grooves tapering in width toward said outlet end of said bores such that said die insert is wedged in said bore in operative position whereby extrusion passages are formed between the die housing and the die insert.

2. An apparatus for producing a hollow core flexible cable made of metal strands having segment shaped cross-

section in which the longitudinal axis of each strand defines a helix comprising:

(a) extrusion means adapted to produce a plurality of said metal strands in the same shape and dimensions as desired in the finished cable including an extrusion die having separate extrusion passages for said strands decreasing in cross-sectional area in the extrusion direction of said strands

(b) drive means for rotating said extrusion die oppositely to the helix direction of the strands

(c) closing means for drawing said strands together to form said flexible cable

(d) a mandrel mounted on said extrusion means adapted to be disposed within said hollow core to support said cable internally at said closing means.

3. An apparatus as defined in claim **2** wherein said extrusion die comprises a die housing having a bore of circular cross-section, said bore having an inlet end and an outlet end, a die insert of circular cross-section having a plurality of longitudinal fins helically curved in the longitudinal direction and projecting radially from said die insert, the sides of said fins being parallel in the radial direction, said die insert being adapted to be inserted into the bore of the die housing through said inlet end with said radially extending fins engaging corresponding grooves in the inner surface of the die housing, each of said fins and corresponding grooves tapering in width toward said outlet end of said bore such that said die insert is wedged in said bore in operative position whereby extrusion passages are formed between the die housing and the die insert.

4. An extrusion die for use in the simultaneous extrusion of metal strands for a flexible cable, comprising a die housing having a bore, said bore having an inlet end and an outlet end, a die insert having a plurality of longitudinal fins projecting radially therefrom, said die insert being adapted to be inserted into the bore of the die housing through said inlet end with said radially extending fins engaging corresponding grooves in the inner surface of the die housing, each of said fins and corresponding grooves tapering in width toward said outlet end of said bore such that said die insert is wedged in said bore in operative position whereby extrusion passages are formed between the die housing and the die insert.

5. An extrusion die as defined in claim **4** for strands having segment shaped cross-sections, said die insert and the bore in the die housing being circular in cross-section, and the sides of said fins being parallel in the radial direction.

6. An extrusion die as defined in claim **4** for strands in which the longitudinal axis of each strand in the finished cable defines a helix, the radially extending longitudinal fins on said die insert being helically curved in a longitudinal direction whereby the longitudinal axis of the extrusion passage corresponding to said strand corresponds to said helix.

7. An extrusion die as defined in claim **6**, said die insert and the bore in the die housing tapering toward said outlet end whereby said extrusion passages decrease in cross-sectional area and converge on the longitudinal axis of the die toward said outlet end.

8. A method of producing a flexible cable having a plurality of metal strands comprising the steps of heating metal from which the strands are to be formed to at least an extrudable plastic state, simultaneously extruding said strands along separate helical paths in the approximate configuration which the strands assume in the finished cable, each of said strands as extruded being of the same longitudinal and cross-sectional shape and dimensions as desired in the finished cable, cooling said strands during extrusion such that they retain such shape and dimensions, and thereafter closing said strands to form said flexible cable.

9. A method as defined in claim **8**, including the step of reducing the cross-sectional area of said strands along said respective helical paths.

10. A method as defined in claim **8**, for producing the strands of a cable having a hollow core including the step of supporting the strands internally as they are closed to form the cable.

11. A method as defined in claim **8** wherein said strands are extruded from a die having separate extrusion passages for said strands, including the step of rotating the extrusion die to prevent rotation of the cable about its longitudinal axis.

12. An apparatus for producing a flexible cable comprising a die for simultaneously producing a plurality of metal strands in the approximate configuration which the strands assume in the finished cable, said die having separate extrusion passages for said strands, and being adapted to produce each strand in the same shape and dimensions as desired in the finished cable so that the longitudinal axis of each strand defines a helix, the longitudinal axis of the extrusion passage for said strand corresponding to said helix, and closing means for driving said strands together to form said flexible cable.

13. An apparatus as defined in claim **12**, said extrusion passages decreasing in cross-sectional area in the extrusion direction of said strands.

14. An apparatus as defined in claim **12**, including drive means for rotating said extrusion die oppositely to the helix direction of the strands forming the outer surface of said flexible cable whereby to prevent rotation of said outer surface about the longitudinal axis of said cable.

15. An apparatus as defined in claim **12** for producing a flexible cable having a hollow core, said apparatus comprising means adapted to be disposed within said hollow core to support said cable internally at said closing means.

16. An apparatus as defined in claim **15**, said means for supporting said hollow core cable internally comprising a mandrel mounted on said extrusion means.

References Cited by the Examiner

UNITED STATES PATENTS

2,098,922	11/1937	McKnight	205—16
2,142,704	1/1939	Sparks	72—261
2,638,213	5/1953	Clark	72—269
3,063,560	11/1962	Edgecombe	72—468
3,089,804	5/1963	Gutierez	18—12
3,150,773	9/1964	Richter	72—261
3,174,364	3/1965	Sims	18—8

FOREIGN PATENTS

958,287	2/1957	Germany.
330,960	6/1930	Great Britain.

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