May 25, 1971 T. H. FAIRBANKS 3,579,729

APPARATUS FOR EXTRUDING NET-LIKE STRUCTURES

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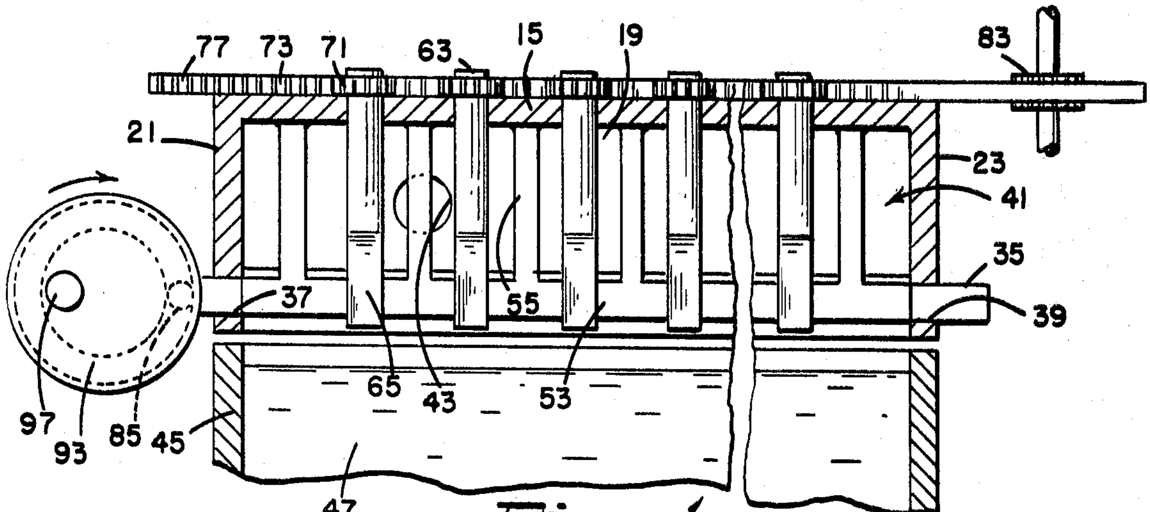

Fig. 1

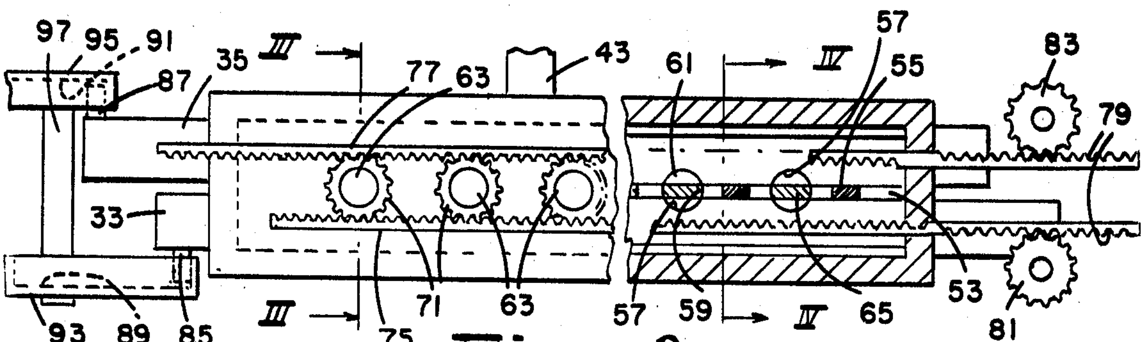

Fig. 2

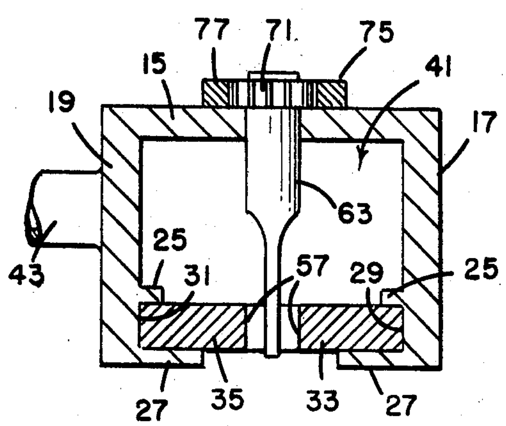

Fig. 3

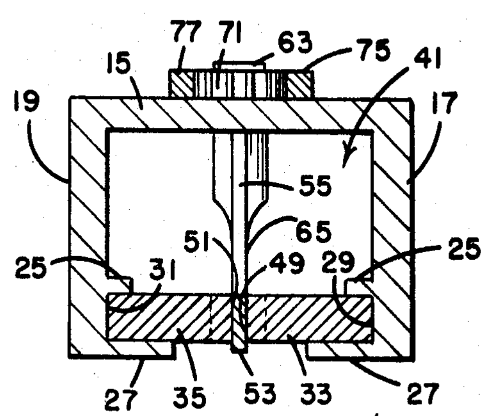

Fig. 4

APPARATUS FOR EXTRUDING NET-LIKE STRUCTURES

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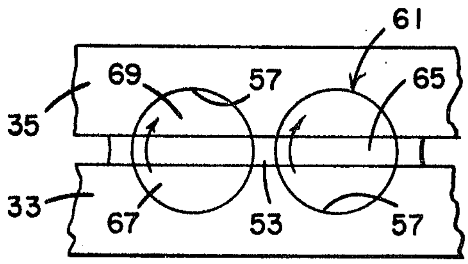

Fig. 5

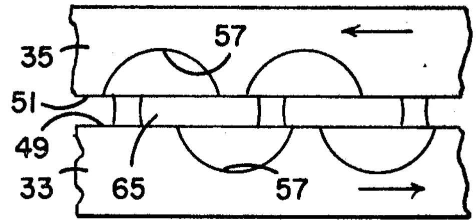

Fig. 6

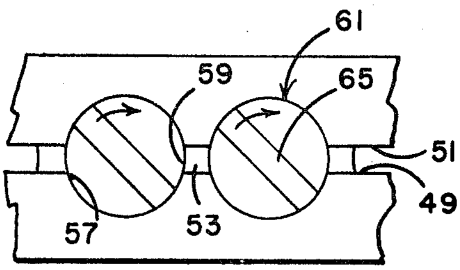

Fig. 7

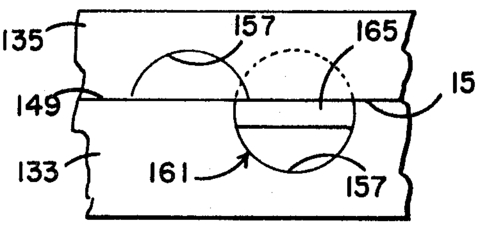

Fig. 9

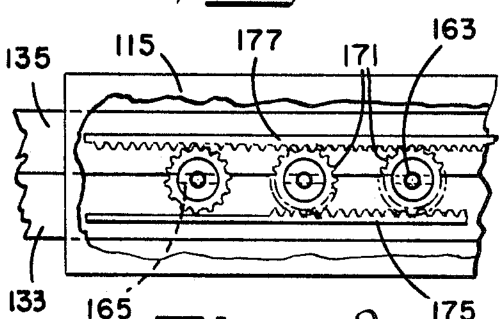

Fig. 8

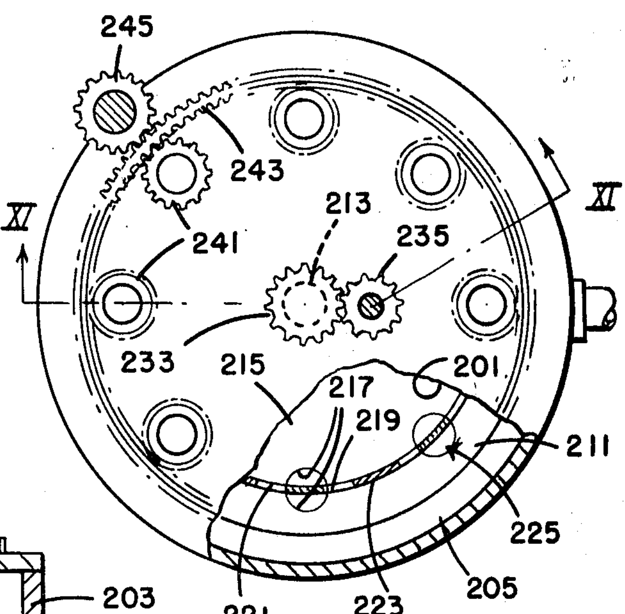

Fig. 10

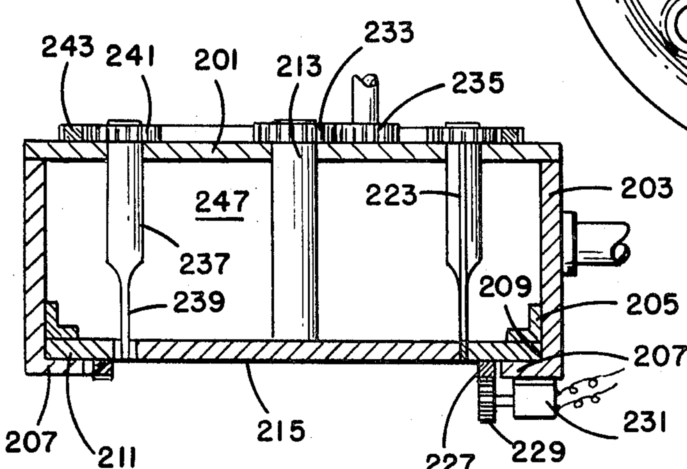

Fig. 11

United States Patent Office

3,579,729

Patented May 25, 1971

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APPARATUS FOR EXTRUDING NET-LIKE STRUCTURES

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Filed May 16, 1969, Ser. No. 825,212
Int. Cl. B29f 3/01
U.S. Cl. 18—12 10 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus in which flowable strand-forming material is extruded through recesses formed along opposing edges of relatively movable plates and including means for interlacing strands formed from such streams and/or twisting the extruded streams alternately with relative movement of the plates to provide net-like structures.

The present invention is directed to an extrusion apparatus for making net-like structures having strands which are interlaced and/or twisted together at their locations of crossing.

In U.S. Pat. No. 3,331,903 there is disclosed a method and apparatus for making a net from plastic material by extruding a plurality of pairs of filaments of plastic material in such a manner that the filaments in each pair are spaced from each other in a first direction and the pairs of filaments are spaced from each other a given distance in a second direction. The filaments of each pair of filaments are revolved at the moment of their extrusion, and before being solidified, about an axis extending between the filaments of each pair of filaments so as to twist the filaments of each pair together and to thus integrally connect the filaments. One of the filaments of each pair of filaments is then moved in a second direction a distance equal to the spacing between pairs of filaments while continuing the extrusion of the filaments, after which pairs of filaments are again revolved as herefore described. By continuously repeating the above steps and setting of the extruded filaments of plastic material, a net-like structure is provided.

In my U.S. patent application entitled Method for Continuously Extruding Net-Like Structures, Ser. No. 825,-210, filed May 16, 1969 there is disclosed a method of making net-like structures by extruding streams of strand-forming material and concomitantly interlacing or braiding the strands or filaments formed from such extruded streams. The method disclosed in this pending application employs apparatus which is somewhat similar to that described in the above-mentioned Pat. 3,331,903.

A primary object of this invention is the provision of a new and improved and more satisfactory apparatus for extruding net-like structures having strands which are interlaced and/or twisted together at their points of crossing.

Another object of this invention is an improved extrusion apparatus which is capable of making net-like structures having fine mesh openings.

Still another object is to provide an apparatus for making tubular woven or braided net-like structures by extrusion.

A further object is the provision of an improved extrusion apparatus for making net-like structures having a variety of strand or filament patterns.

A still further object is to provide an improved extrusion apparatus which is simple in construction and use for making net-like structures having strands which are interlaced and/or bonded at their points of crossing.

These and other objects are accomplished in accordance with the present invention by an apparatus which comprises means defining a plurality of spaced, substantially like circular openings, with such means including a pair of plates which are supported with edges thereof disposed in opposing relationship and with recesses, having arcuate walls of like radius, formed at spaced intervals along each of such opposing edges. Means are provided for relatively moving the plates to selectively align recesses therein whereby at least portions of the peripheries of such openings are defined by the arcuate walls of aligned recesses.

An individual blade extends longitudinally of each of the circular openings, with the longitudinal axis of each blade being concentric with the center of a circular opening. The blades each have a width substantially equal to the diameter of such openings and serve to partition the respective openings into two separate extrusion orifices. Means are provided for periodically moving each of the blades about its respective longitudinal axis, and more particularly, for rotating such blades about their individual longitudinal axes at intervals which alternate with the relative movement of the recessed plates.

Flowable strand-forming material is continuously delivered to each of the extrusion orifices and issues therefrom as a separate stream which is set by suitable means, as for example, cool water or air in the case of molten thermoplastic strand-forming material. Setting of the streams of strand-forming material is effected immediately as they leave the extrusion orifices or after a predetermined delay, depending upon whether it is desired that the strands formed from such streams be interlaced or bonded to each other at their points of crossing in the resulting net-like structure.

The apparatus of the present invention may be employed, for example, in practicing the method as described in my above-noted United States pending application as well as the method as described in U.S. Pat. 3,331,903. More particularly, with the recesses in the plates of the described apparatus in aligned relationship, flowable strand-forming material is continuously delivered to and issues from each pair of aligned extrusion orifices as separate streams. Relative movement of such plates causes the streams of strand-forming material issuing from orifices which were once aligned with each other to move, for example, in opposite directions until different orifices in such plates are placed in aligned relationship. With the plates held in stationary positions the blade located between each pair of aligned extrusion orifices is now turned or rotated about its longitudinal axis. By continuously repeating the above sequence of steps and setting of the extruded streams, a net-like structure is provided.

It is essential that blade rotation be equal to a multiple of 180°; that is, only 180° or a further multiple thereof. Blade rotation through an angle of only 180° will cause opposing streams which are being extruded to exchange extrusion orifices from which their extrusion is continued. In this instance, the direction of blade rotation is reversed after each relative movement of the recessed plates and the streams are set into strands immediately after being exruded; that is, prior to contact between the extruded streams, a net-like structure having interlaced or woven strands is provided. Setting of the extruded streams into strands may be delayed until after they have contacted each other so that the strands in the resulting net-like structure will be bonded to each other.

Rotation of the blades 360°, or a further multiple of 180°, together with a delayed setting of the extruded streams into strands, will cause the extruded streams to be twisted together prior to the setting thereof and thus provide strong, integral junctions between strands of the resulting net-like structure. While rotation of blades between aligned recesses in the relatively movable plates must be equal to a multiple of 180°, the angle of such rotation and the rate at which the extruded streams are set may be varied throughout the method so that net-like structures may be made having interlaced and bonded strands at different areas thereof.

In the apparatus of the present invention the plates may be of elongated construction, having recesses formed along substantially parallel opposing edges thereof for making generally flat net-like structures. Alternatively, the plates may be of annular configuration, with the recesses formed along opposing peripheral edges thereof for making tubular net-like structures. As heretofore mentioned, the recesses formed along opposing edges of such plates are of like radius. Preferably, the recesses formed along the edges of the respective plates are equally spaced from each other.

Relative movement of the recessed plates of the apparatus of the present invention may be effected by moving only one of such plates or by moving both of the plates in opposite directions relative to each other. For example, plates which are of elongated construction may be reciprocated in opposite directions, while plates which are of annular construction, may be moved either by being oscillated in opposite directions, or by rotating both such plates in opposite directions relative to each other. As heretofore mentioned, relative movement of such plates is effected alternatively with the movement or rotation of the blades. During relative movement of the plates, the blades are prevented from rotating while during rotation of the blades the plates are held stationary.

The opposing edges of the plates, whether of elongated or annular configuration, may be disposed in abutting relationship with the recesses along such edges, when aligned, together defining the circular openings. In this instance, the centers of the openings are offset from the abutting edges of the plates a distance equal to substantially one-half of the thickness of the blades which extend therethrough. As heretofore mentioned, each blade is positioned with its longitudinal axis concentric with the center of the circular opening through which it extends and thus its longitudinal axis will also be offset from the opposing edges of the recessed plates. In this embodiment of the apparatus, the blades are mounted to travel with at least one of the plates during relative movement thereof and during such travel will each be located within the confines of an arcuate recess of one of such plates.

In another and more preferred embodiment, stationary spacers may be positioned between and be engaged by the opposing edges of the plates, which again may be either of elongated or annular configuration. Such spacers each have a width equal to the distance between adjacent recesses in the respective plates, a thickness substantially equal to that of the blades and are formed with arcuate longitudinal edges; that is, transversely concave edges, which define portions of the peripheries of adjacent of the circular openings. In this embodiment, the blades remain stationary and are aligned with the spacers during relative movement of the plates.

The apparatus of the present invention may be employed with a variety of materials, which are referred to by the terms "plastic" or "strand-forming materials," including materials which are thermoplastic, such as polyamides or superpolyamides, polyesters, polyvinyl chloride, copolymers thereof, polyolefins, cellulose acetates, etc., natural or synthetic rubbers, thermosetting materials or wet-spinnable materials, such as viscose, cuproammonium cellulose, or carboxymethyl cellulose. Such materials may include various additives such as stabilizers, dyes, foaming agents, etc., if so desired. It will be apparent that the manner by which the extruded streams are set will depend upon the particular material which is being employed.

For a greater understanding of this invention, reference is made to the following detailed description and drawing in which FIG. 1 is a vertical section taken longitudinally of one embodiment of the apparatus of the present invention;

FIG. 2 is a top view of the apparatus shown in FIG. 1, with a portion thereof shown in section;

FIG. 3 is a section taken transversely of the apparatus substantially along the line III—III of FIG. 2;

FIG. 4 is a view similar to FIG. 3 taken along the line IV—IV of FIG. 2;

FIGS. 5, 6 and 7 are diagrammatic illustrations showing elements of the apparatus in different positions during the operation thereof;

FIG. 8 is a plan view of a portion of a modified form of the apparatus of the present invention;

FIG. 9 is a view similar to FIGS. 5–7 illustrating the operation of elements of the apparatus shown in FIG. 8;

FIG. 10 is a plan view of a still further embodiment of the apparatus of the present invention; and

FIG. 11 is a vertical section taken substantially along the line XI—XI of FIG. 10.

With reference to the drawing, the apparatus of the present invention includes a housing having a top wall **15**, side walls **17** and **19** and end walls **21** and **23**. Vertically spaced flanges **25** and **27** project from opposite surfaces of the side walls **17** and **19** and form channels **29** and **31**. Elongated plates **33** and **35** are slidably mounted within the channels **29** and **31** and extend through suitable openings **37** and **39** in the end walls **21** and **23** and, together with such end walls, top wall **15**, and side walls **17** and **19**, define a chamber **41**.

Flowable strand-forming material is continuously delivered under pressure into the chamber **41** through a conduit **43** from a suitable source, not shown. Gaskets are provided in the areas of the end wall openings **37** and **39** to prevent leakage of strand-forming material during sliding movement of the plates **33** and **35**. A tank **45**, containing a suitable setting liquid **47**, is located below the plates **33** and **35**.

In the specific embodiment illustrated in FIGS. 1–7, the opposing longitudinal edges **49** and **51** of the plates **33** and **35** are separated by spacers **53**, each of which includes an extension **55** which in turn is fixed to the underside of the top wall **15**. A series of recesses **57** of like radius are formed at spaced intervals along each of the opposing longitudinal edges **49** and **51** of the plates **33** and **35**, and together with the adjacent edges **59** of the spacers **53**, define circular openings **61**.

A plurality of rotatable shafts **63** are aligned with and project into the circular openings **61** and extend through openings in the housing top wall **15**. Preferably, the lowermost ends of the shafts **63** project slightly below the lower faces of the plates **33** and **35**, as shown in FIGS. 1 and 3. The lowermost ends of the shafts **63** are each in the form of a blade **65** which has a thickness substantially equal to the thickness of the spacers **53**, a length greater than the thickness of the plates **33** and **35** and a width equal to the diameter of a circular opening **61**. The longitudinal edges of the blades **65** are of convex shape in the transverse direction so as to conform with the periphery of the circular openings **61** and thus fit snugly yet rotatably within such openings. As shown in FIGS. 2, 3 and 6, the blades **65** partition the openings **61** which are formed by aligned recesses in the plates **33** and **35** into two separate extrusion orifices **67** and **69**.

In making net-like structures having fine mesh openings, the shafts **63** may be, for example, a series of closely spaced conventional sewing needles which have been flattened at their lowermost ends to provide blades **65**.

Fixed to the uppermost end of each of the shafts **63** is a gear **71** which is adapted to engage with teeth **73** formed along the opposing sides of racks **75** and **77**. Teeth **79** are also provided along the outermost sides of the racks **75** and **77** and mesh with gears **81** and **83**. When recesses **57** are in aligned relationship with each other and the blades **65**, as shown in FIG. 2, the gears **81** and **83** are turned by suitable means, not shown, to reciprocate the racks **75** and **77** and thereby rotate the shafts **63**. The racks **75** and **77** of the apparatus shown in FIG. 2 are designed to rotate the shafts **63** through an angle of only 180°.

Pins **85** and **87** project from adjacent ends of the plates **33** and **35** and ride along grooves **89** and **91** of cams **93** and **95**, respectively. The cams **93** and **95** are of like construction and are fixed in 180° out-of-phase relationship to a shaft **97** which is supported by bearings and intermittently driven by suitable means, not shown.

In the operation of the above-described apparatus, flowable strand-forming material is delivered under pressure into the chamber **41** and, with the various elements of the apparatus in positions as shown in FIG. 2, the strand-forming material passes continuously through the recesses **57** in the plates **33** and **35**. As best shown in FIG. 5, the blades **65** are located between aligned recesses **57** and cooperate with such aligned recesses to provide extrusion orifices **67** and **69** from which the flowable strand-forming material issues as separate streams. With the embodiment of the apparatus shown in FIGS. 1–7, the extruded streams of strand-forming material are rapidly set, before any contact therebetween, by the liquid **47** in the tank **45**.

With the blades **65** held stationary, the cams **93** and **95** are turned to shift the plates **33** and **35** in opposite directions as shown in FIG. 6, as for example, a distance substantially equal to one-half the center-to-center spacing of the recesses **57** so that different recesses in such plates are now aligned with each other. The plates **33** and **35** are now held stationary while the gears **81** and **83** are turned to shift the racks **75** and **77** in opposite directions and thereby rotate only those shafts **63** which are between aligned recess **57** through an angle of only 180°. As shown in FIG. 7, by the rotation of the shafts **63** and their blades **65**, the streams of each pair of opposing aligned streams of strand-forming material issuing from the apparatus are caused to exchange recesses from which their extrusion is continued. There is no interruption in the extrusion of such streams merely an exchange of positions of their orifices of extrusion.

Once this 180° movement of the shafts **63** is completed, the blades **65** are again aligned with the spacers **53**. The plates **33** and **35** are then shifted as heretofore described, but in directions opposite to their previous movement until different recesses **57** in such plates are aligned with each other. Preferably, this movement of the plates **33** and **35** is such as to return the same to their starting positions. The blades **65** located between such aligned recesses are now turned through an angle of 180° by moving the shafts **63** as heretofore explained, but with the shafts **63** and their blades **65** being rotated in a direction opposite to that of their prior movement. By repeating the above sequence of steps, a net-like structure having interlaced or braided strands is provided.

Using the above-described apparatus, setting of the extruded streams of strand-forming material may be delayed, as by lowering the tank **45** relative to the plates **33** and **35**, so that the extruded streams are bonded to each other at their locations of crossing to form integral junctions.

Net-like structures having strands which are twisted and bonded together to form integral junctions may also be made with the described apparatus by causing the blades **65** which are between aligned recesses **57** in the plates **33** and **35** to move through an angle of 360° of further multiple of 180° during each rotation thereof. In this particular method, the direction of blade movement is not critical and thus need not be reversed, as in the method first described. Blade rotation through 360° or more may be effected by having the racks **75** and **77** exert a driving motion on the shafts **63** during only one direction of their travel, for example, by employing a cam clutch or similar one-way acting clutch between the gears **71** and their respective shafts **63**.

The second embodiment of the apparatus is generally the same as that heretofore described in detail, with FIGS. 8 and 9 illustrating essential differences between these structures. More particularly, spacers **53** employed in the apparatus shown in FIGS. 1–7 are omitted in the embodiment shown in FIGS. 8 and 9. Thus, plates **133** and **135**, corresponding to plates **33** and **35** in FIGS. 1 and 2, are disposed with their opposing edges **149** and **151** in contacting relationship and with the recesses **157** therein, when aligned, together defining circular openings **161**. The shafts **163** have blades **165** at their lowermost ends and, at their uppermost ends, include gears **171** which are in turn driven by racks **175** and **177** in much the same manner as heretofore described. In this embodiment, the racks **175** and **177** extend into the housing through suitable openings in its side walls, and are slidably supported by guides, not shown, suspended from the housing top wall **115**.

The centers of the openings **161** are offset from the abutting edges of the plates **133** and **135** a distance equal to one-half of the thickness of the blade **165**. The shafts **163** are mounted with their longitudinal axes concentric with the respective openings **161** which are defined by aligned plate recesses **157**. Thus, the blades **165** are each adapted to lie within the confines of one of the opposing recesses **157** when positioned as shown in FIG. 9.

The operation of the apparatus shown in FIGS. 8 and 9 is substantially the same manner as that shown in FIGS. 1–7, with the exception that the shafts **163** travel together with the plates **133** and **135** during the reciprocating movement of such plates. Thus, the racks **175** and **177**, together with their driving means, are mounted for reciprocation with the plates **133** and **135** so that no relative movement occurs between the shafts **163** and such plates during movement of the latter.

The embodiment of the apparatus of the present invention shown in FIGS. 10 and 11 is designed to produce tubular net-like structures having interlaced, bonded and/or twisted strands. This apparatus includes a top wall **201** and a cylindrical wall **203**. An angle iron **205** of circular configuration is fixed to the inner surface of the wall **203** and, together with a flange **207** projecting from the lower end of the wall **203**, provides a channel **209** within which is slidably mounted an annular plate **211**. A shaft **213** extends through the top wall **201** and has fixed to its lower end, a circular plate **215**. Recesses **217** of like radius, and preferably of like spacing, are formed along the opposing edges **219** and **221** of the respective plates **211** and **215**. Fixed arcuate spacers **223** are supported from the top wall **201** and are located between the opposing plate edges **219** and **221**. The spacers **223** correspond to the spacers **53** and are of width substantially equal to the edge-to-edge spacing between the plate recesses **217**. When the plate recesses **217** are in aligned relationship, the arcuate walls thereof and the edges of adjacent spacers **223** together define circular openings **225**.

The plates **211** and **215** are adapted to be moved relative to each other in their common plane. To facilitate this movement, a circular rack **227** is fixed to the underside of the plate **211** and is engaged by a gear **229** which is driven by a motor **231**. Additionally, a gear **233** is fixed to the uppermost end of the shaft **213** and is driven by a gear **235** which is turned by suitable means, not shown.

Shafts **237** extend through openings in the top wall **201** and are each formed with an arcuate blade **239** at their lowermost ends. The blades **239** each have a thickness substantially equal to that of the spacers **223**, a width equal to the diameter of the openings **225** and a length greater than the thickness of the plates **211** and **215**. A gear **241** is fixed to the upper end of each shaft **237** engaged with a ring gear **243** which is in turn driven by gear **245**, turned by a driven gear **243**.

The top wall **201**, cylindrical wall **203**, and plates **211** and **215** together define a chamber **247** into which flowable strand forming material is continuosly delivered under pressure. The operation of this embodiment is essentially the same as that shown in FIGS. 1–7, with the plates being oscillated or rotated relative to each other alternately with the rotation of the shafts **237** when plate recesses **217** are in aligned relationship. In the embodiment illustrated in FIGS. 10 and 11, however, rotation of the shafts **237** is equal to 360° or further multiple of 360°, to insure that the blades **239** return to their original positions; that is, with their concave sides facing the center of the apparatus.

I claim:

1. Apparatus for extruding net-like structures comprising means defining a plurality of spaced, substantially like cirichlar openings, said means including a pair of plates supported with edge portions thereof disposed in opposing relationship, recesses having arcuate walls of like radius formed at spaced intervals along each of the opposing edges of said plates, means for relatively moving said plates to selectively align recesses in said plates whereby at least portions of the peripheries of said openings are defined by the arcuate walls of aligned recesses, an individual blade extending longitudinally of each of said ciricular openings with its longitudinal axis concentric with the center of the respective opening, said blades each having a width substantially equal to the diameter of said openings and serving to partition each of said openings into two separate extrusion orifices, means for delivering flowable strand-forming material to said extrusion orifices, means for moving each of said blades about its respective longitudinal axis, and means for setting the strand-forming material extruded from said orifices.

2. Apparatus as defined in claim **1** wherein said plates are of elongated configuration and said recesses are formed along substantially parallel, opposing longitudinal edges thereof.

3. Apparatus as defined in claim **1** wherein said plates are of annular configuration and said recesses are formed along opposing peripheral edges thereof.

4. Apparatus as defined in claim **2** wherein said means for relatively moving said plates includes means for re-

ciprocating said elongated plates longitudinally and in opposite directions relative to each other.

5. Apparatus as defined in claim **3** wherein said means for relatively moving said plates includes means for oscillating said annular plates about a common axis and in opposite directions relative to each other.

6. Apparatus as defined in claim **1** wherein said means for relatively moving said plates and said means for moving each of said blades about its respective longitudinal axis are operative in alternate relationship with each other and wherein said means for moving each of said blades about its respective longitudinal axis includes means for rotating said blades through an angle equal to a multiple of 180°.

7. Apparatus as defined in claim **6** wherein said rotating means move said blades through an angle of only 180° and the direction of rotation of said blades is reversed after each relative movement of said plates.

8. Apparatus as defined in claim **1** wherein said opposing edges of said plates are in abutting relationship and wherein the centers of said openings are offset from the abutting edges of said plates a distance equal to substantially one-half of the thickness of said blades and further including means for moving said blades concomitantly with one of said plates during relative movement of said plates.

9. Apparatus as defined in claim **1** further including spacers positioned between and engaged with said opposing edges of said plates, said spacers each have a thickness substantially equal to that of said blades and arcuate longitudinal edges which define portions of the peripheries of adjacent of said circular openings.

10. Apparatus as defined in claim **9** wherein said spacers and blades remain stationary during relative movement of said plates.

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FRANK T. YOST, Primary Examiner