United States Patent

Rowe et al.

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[54] **APPARATUS FOR EXTRUDING CYLINDRICAL MAGNETS**

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[52] **U.S. Cl.** **425/114,** 425/3, 425/446

[51] **Int. Cl.** **B29f 3/00**

[58] **Field of Search** .... 335/284, 302, 303, 304, 306, 335/285; 29/608; 18/DIG. 33, 12 M, 12 PM, 12 PR, 15 R, 14 A

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[57] **ABSTRACT**

An apparatus for aligning magnetic particles in a base material formed into a substantially cylindrical member, comprising a soft magnetic core adapted to be positioned within the confines of the member, and means positioned to apply an orienting magnetic field through the walls of the member while it is positioned about said core.

11 Claims, 12 Drawing Figures

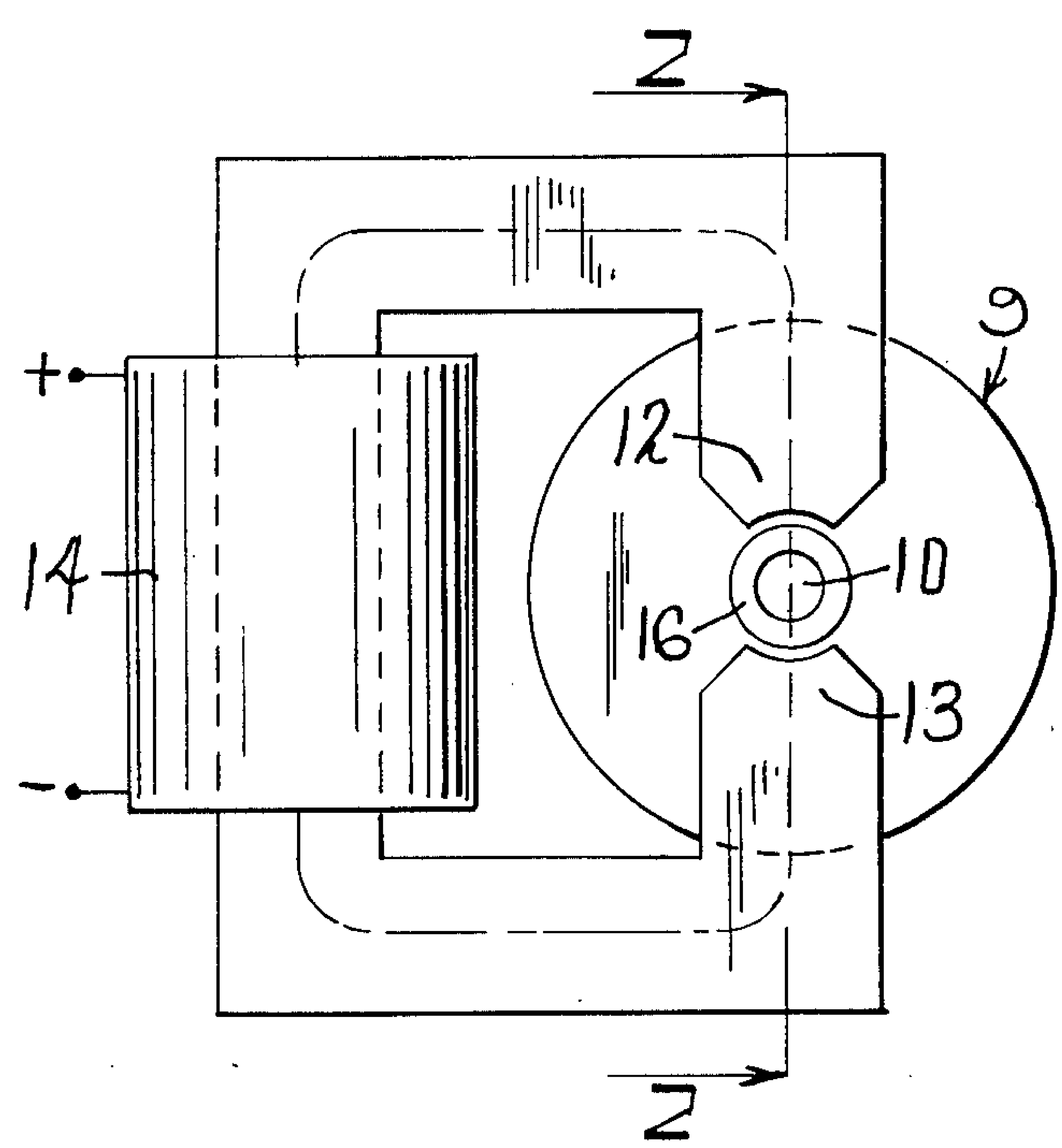

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Fig. 1.

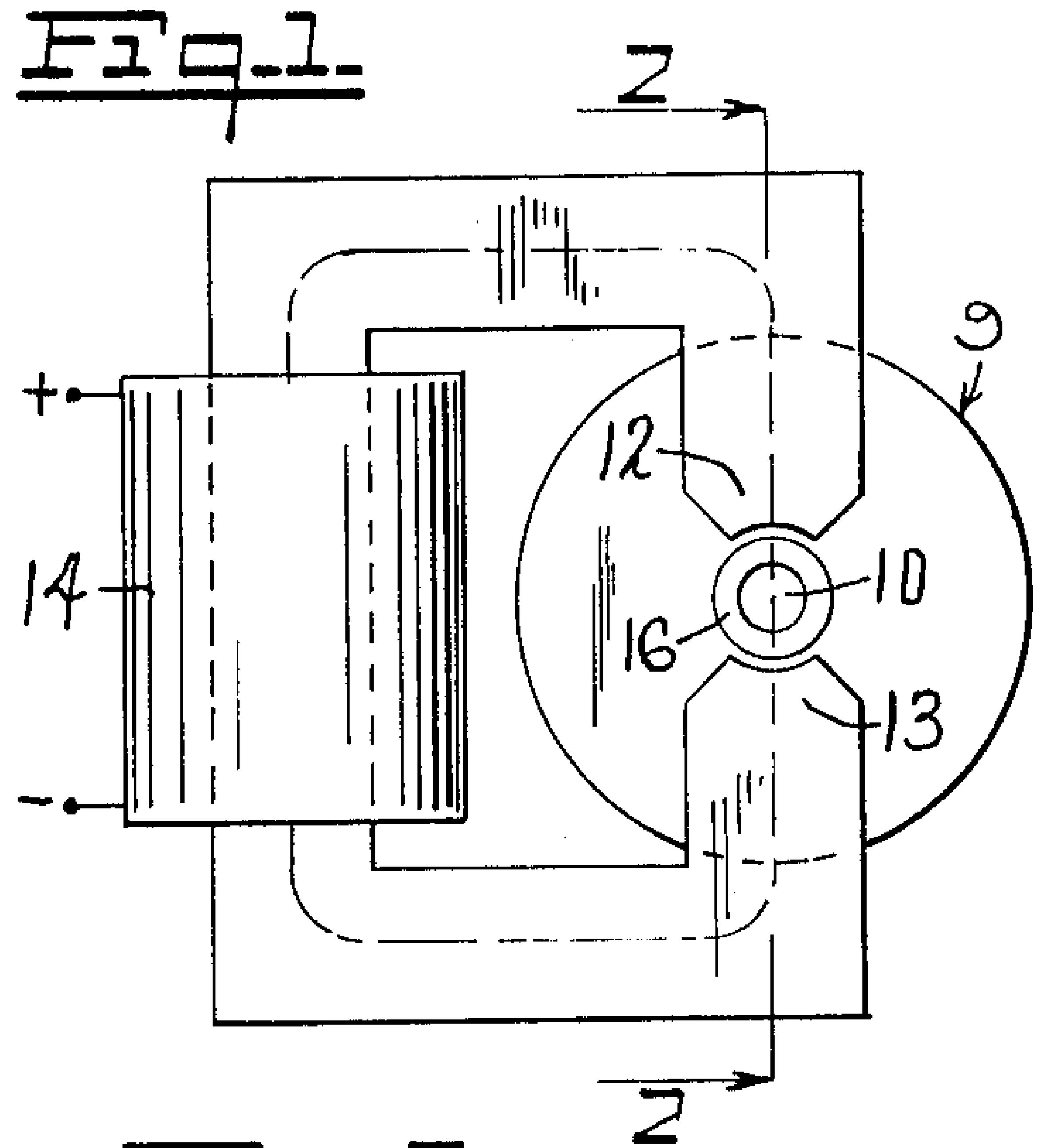


Fig. 2.

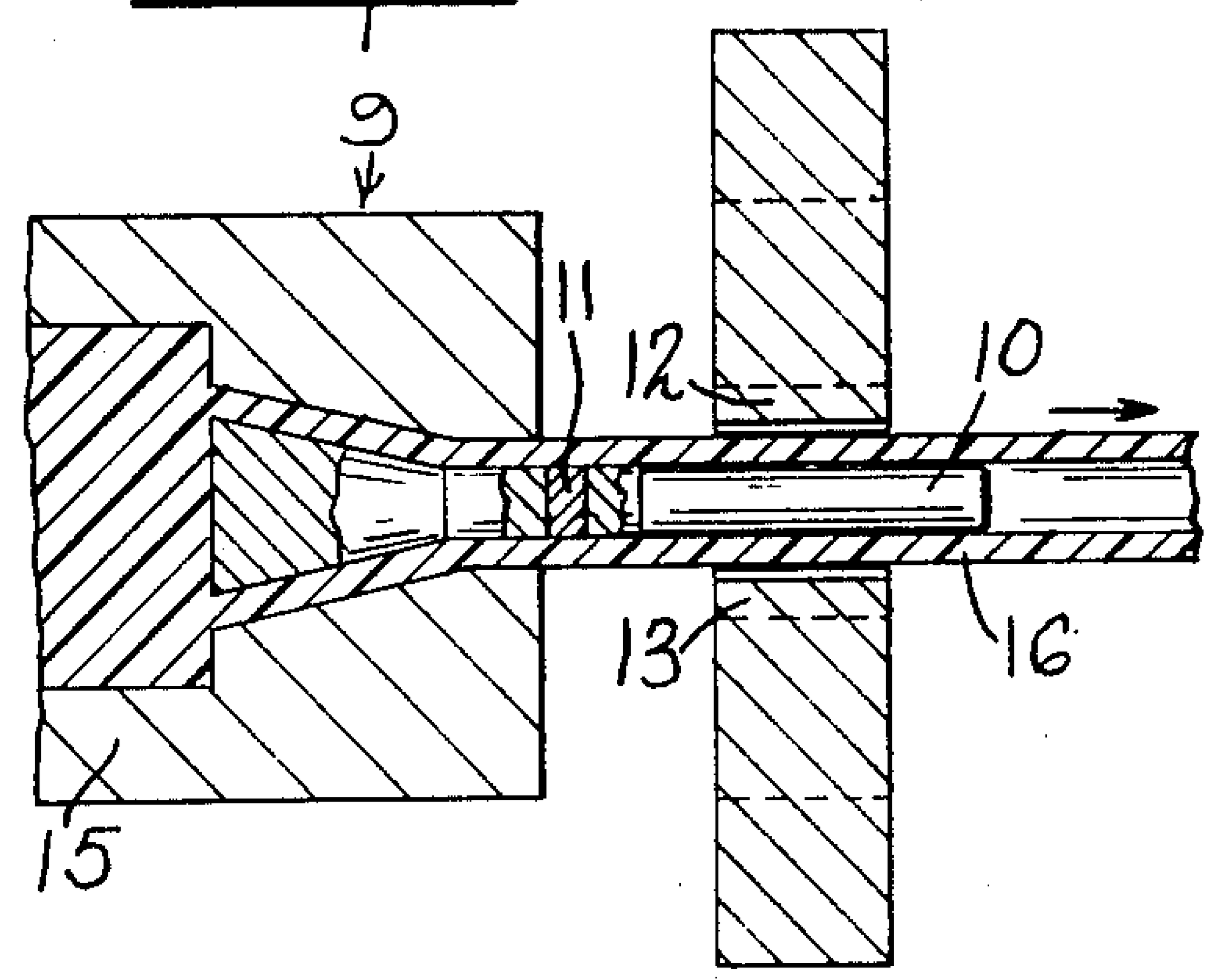


Fig. 3.

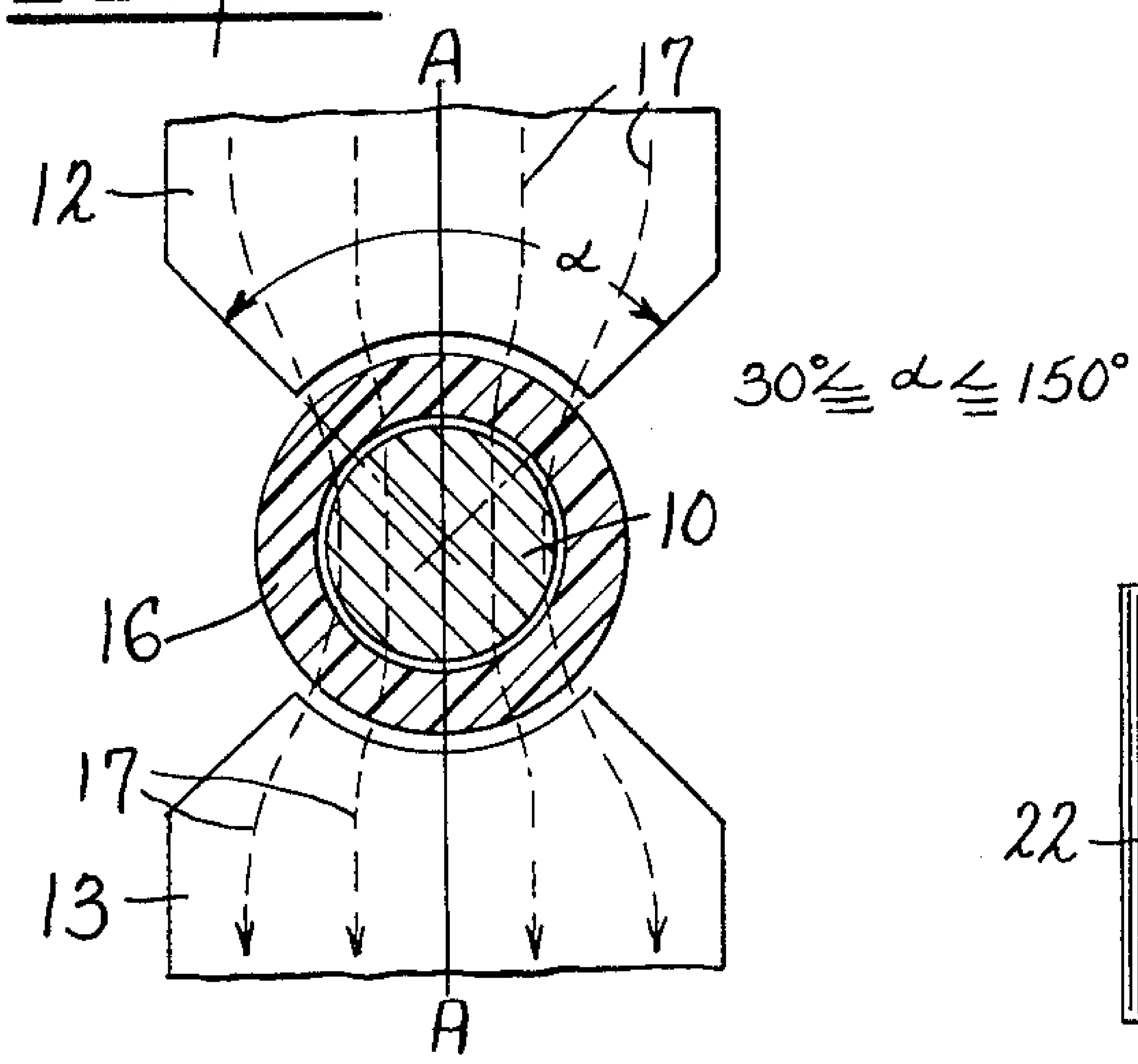
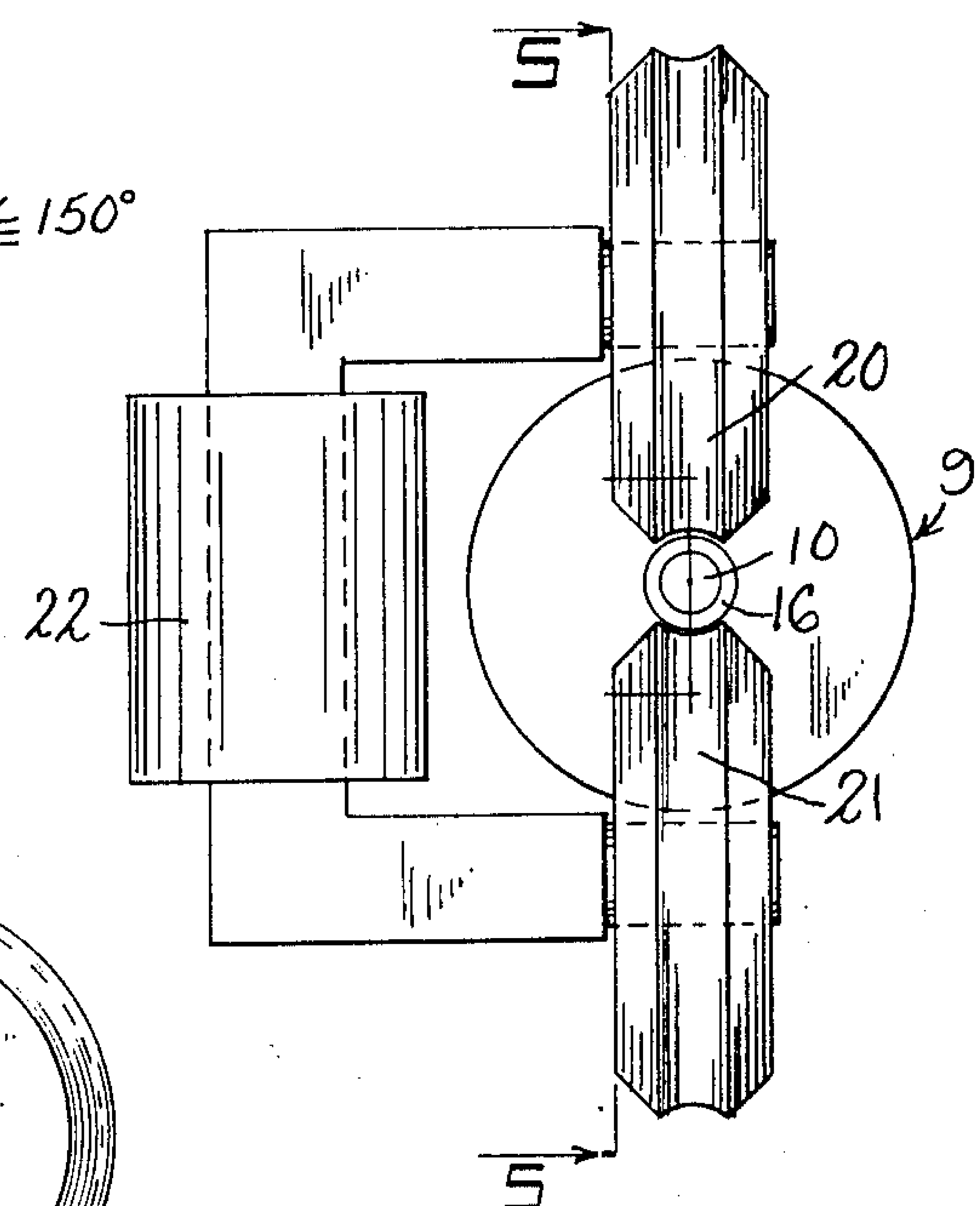


Fig. 4.



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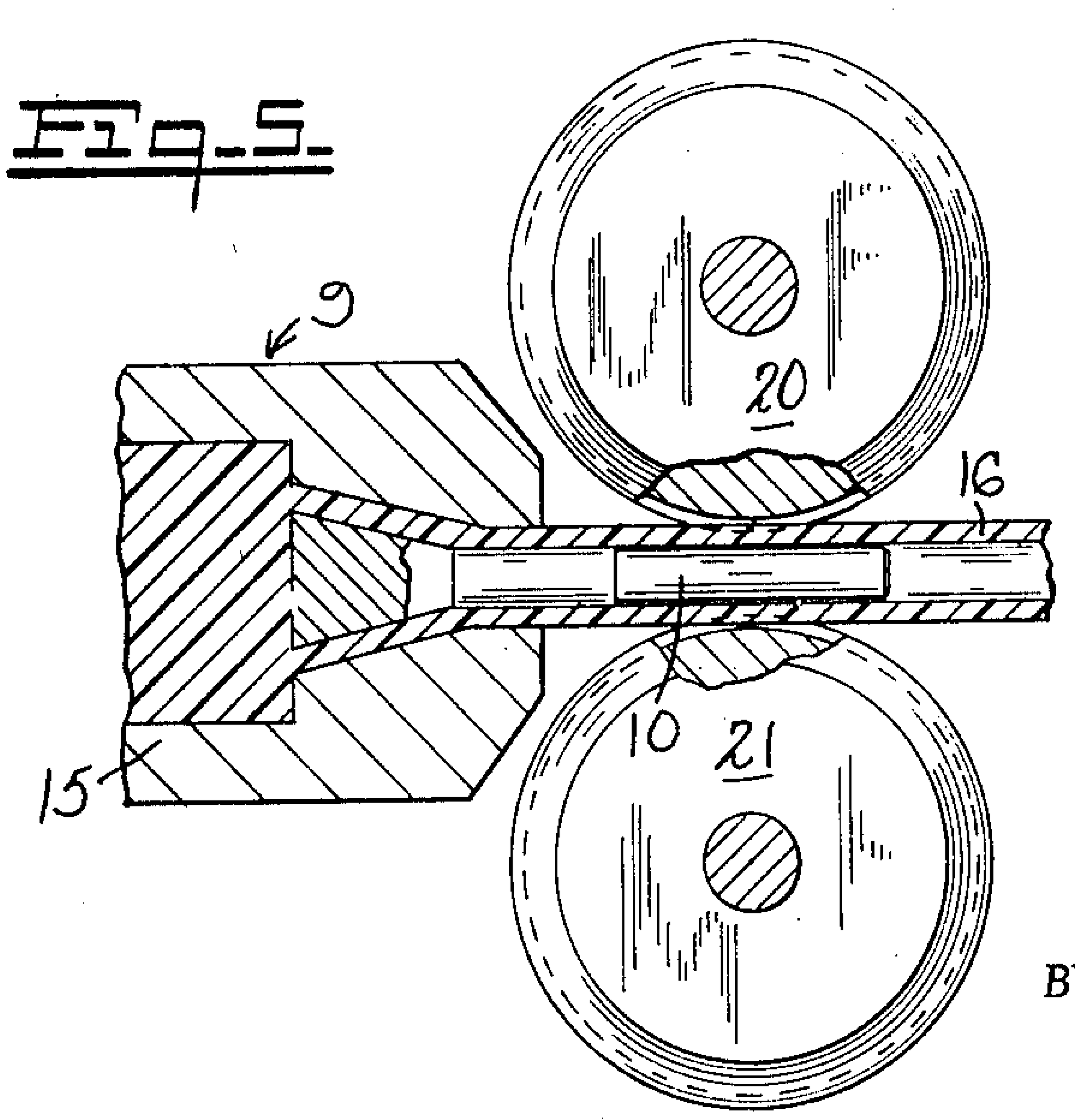

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Fig. 6.

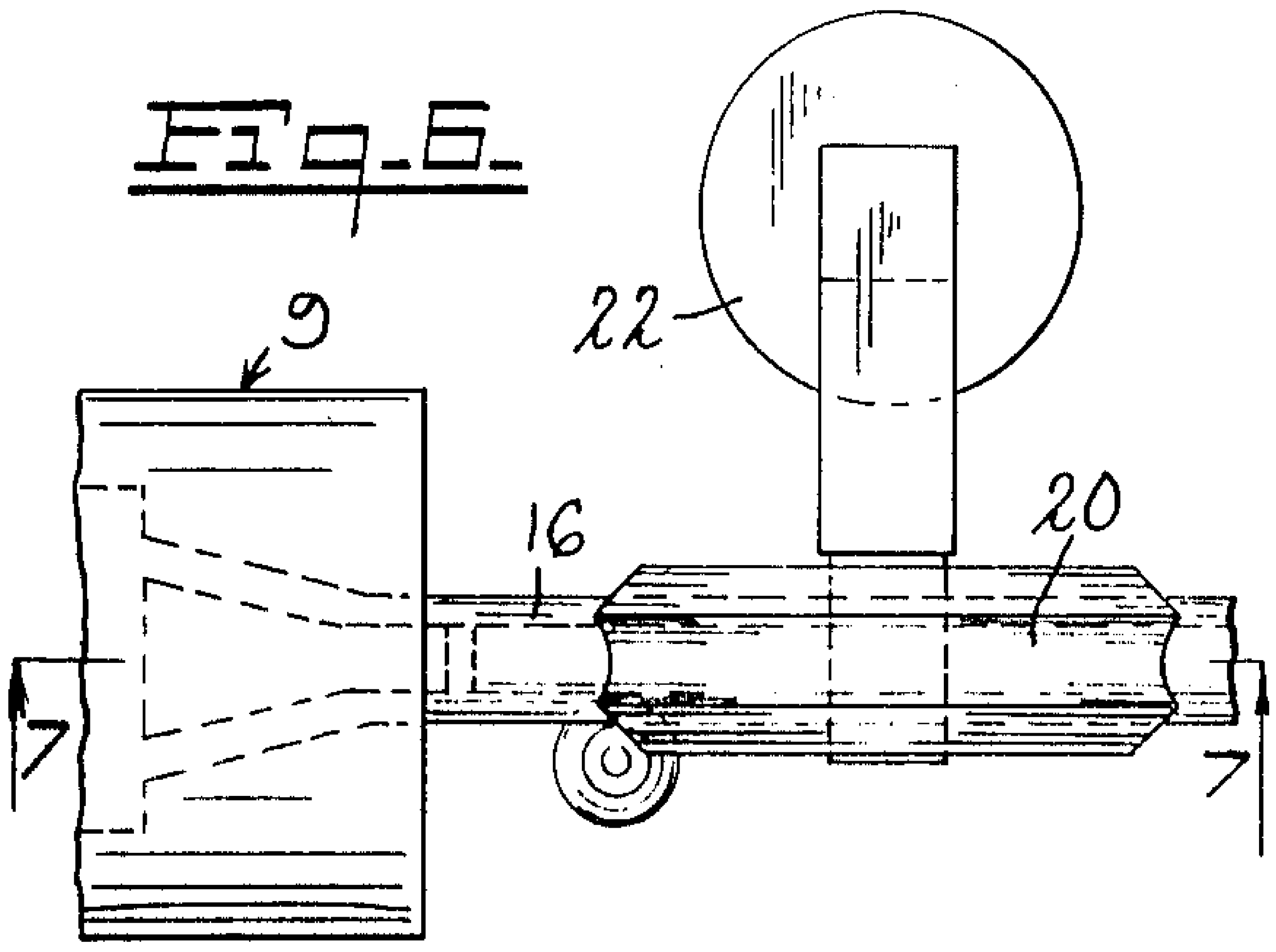


Fig. 7.

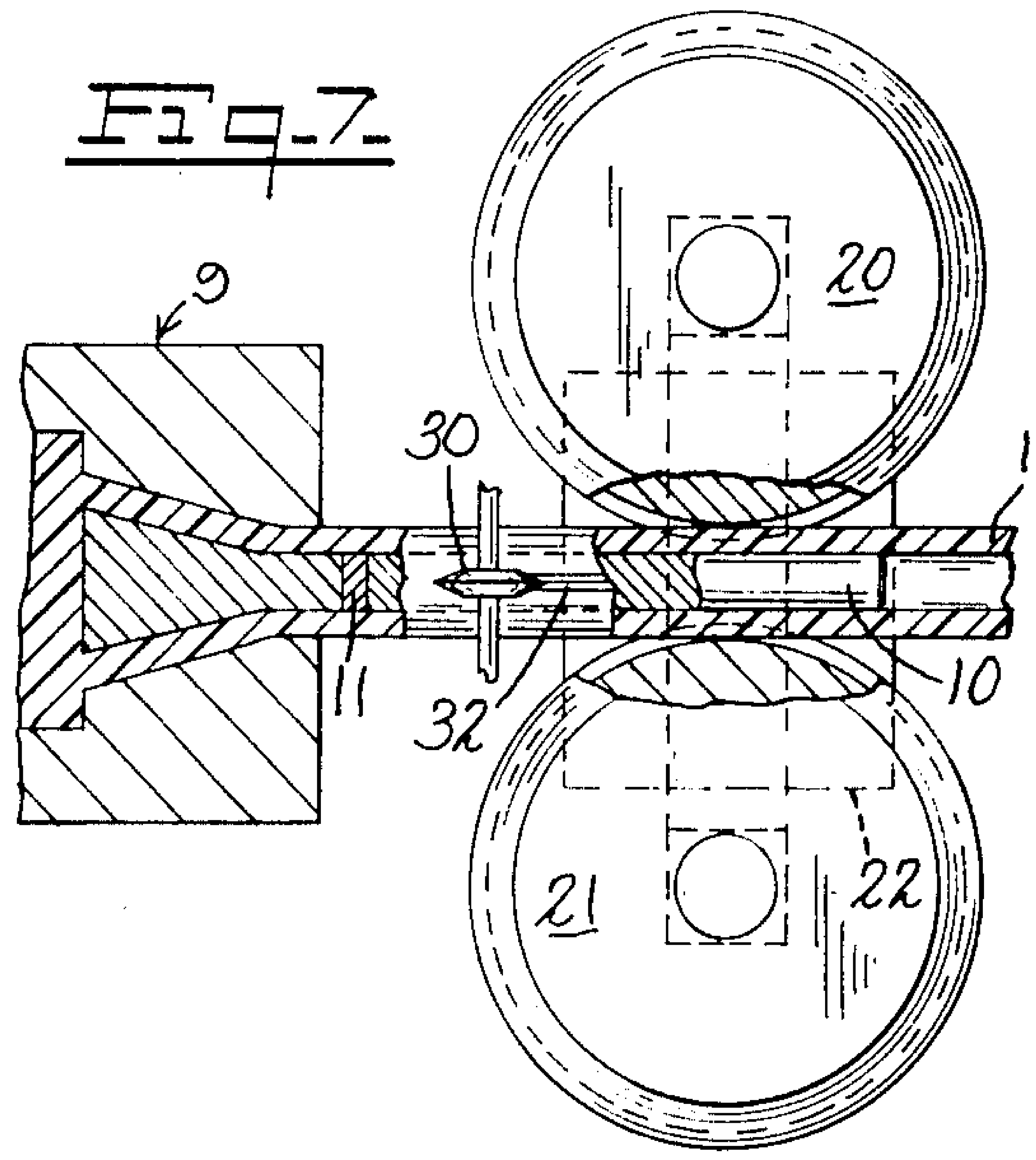


Fig. 8.

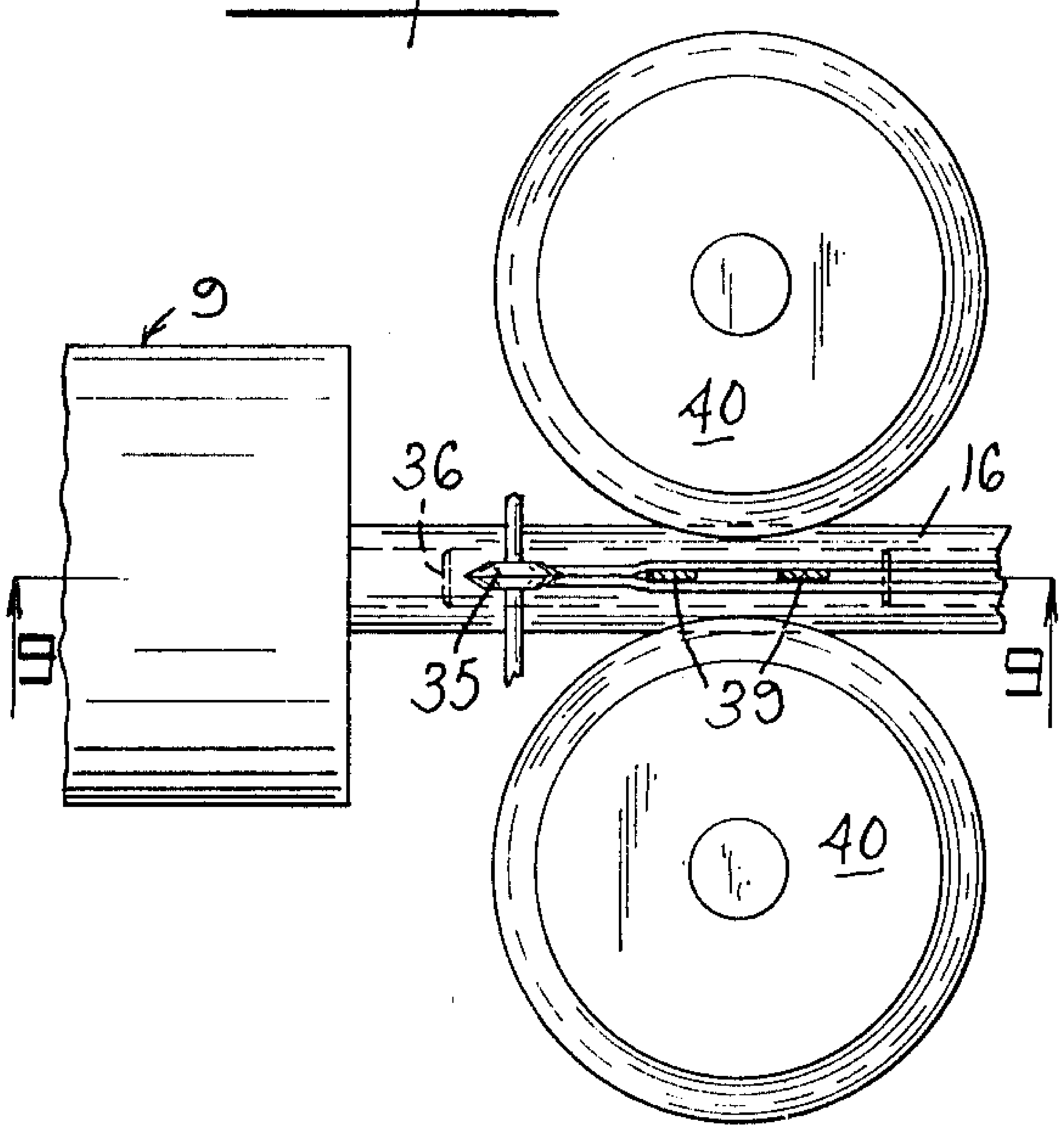


Fig. 9.

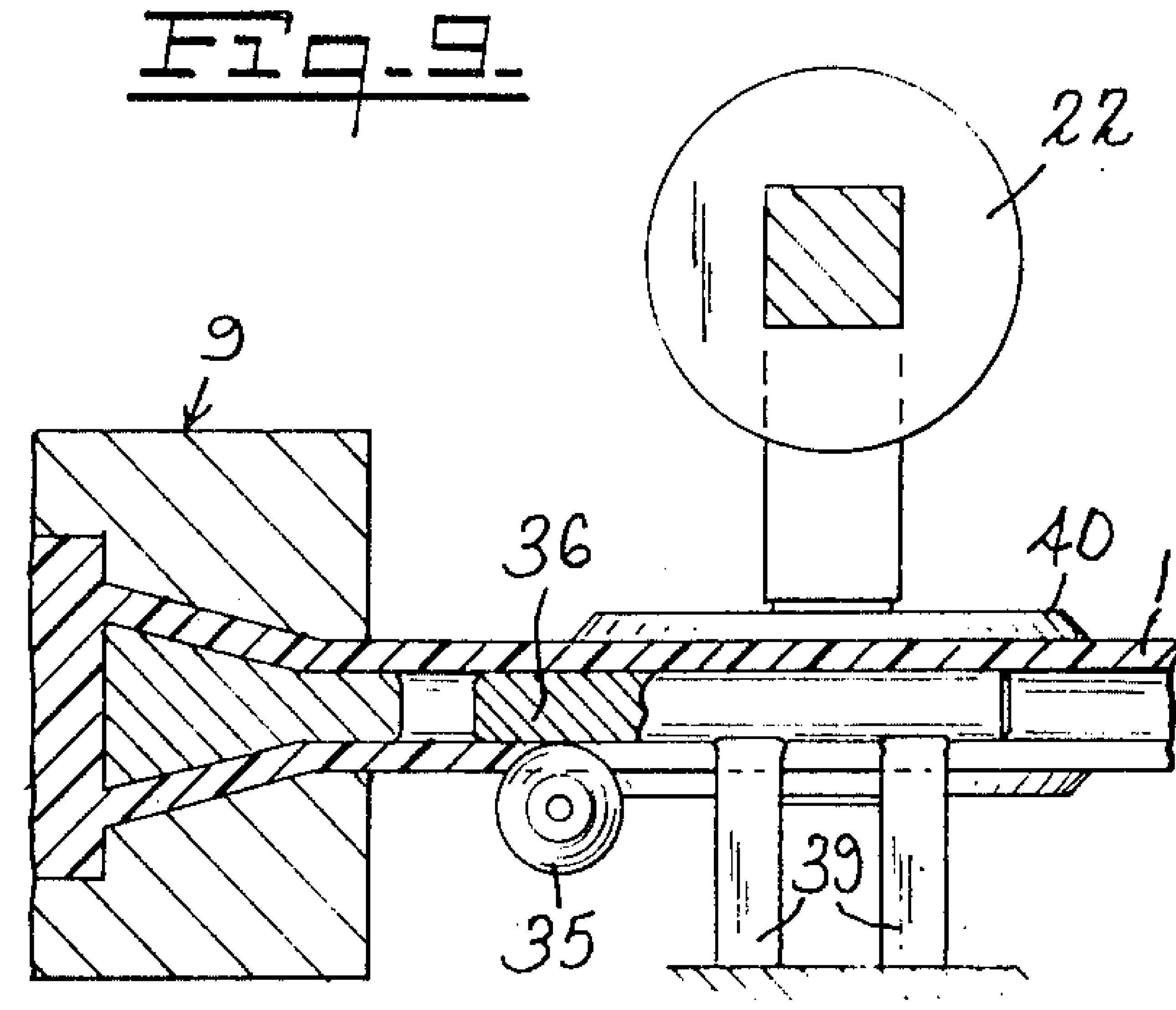


Fig. 12.

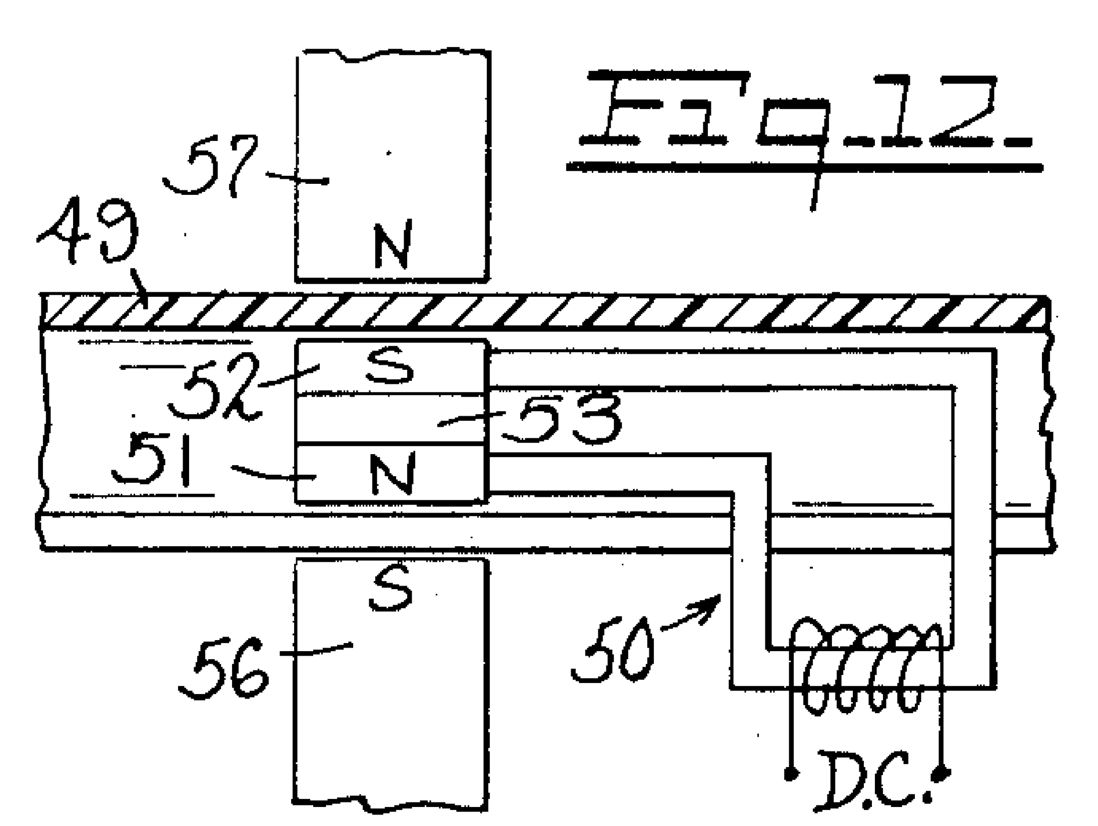


Fig. 10.

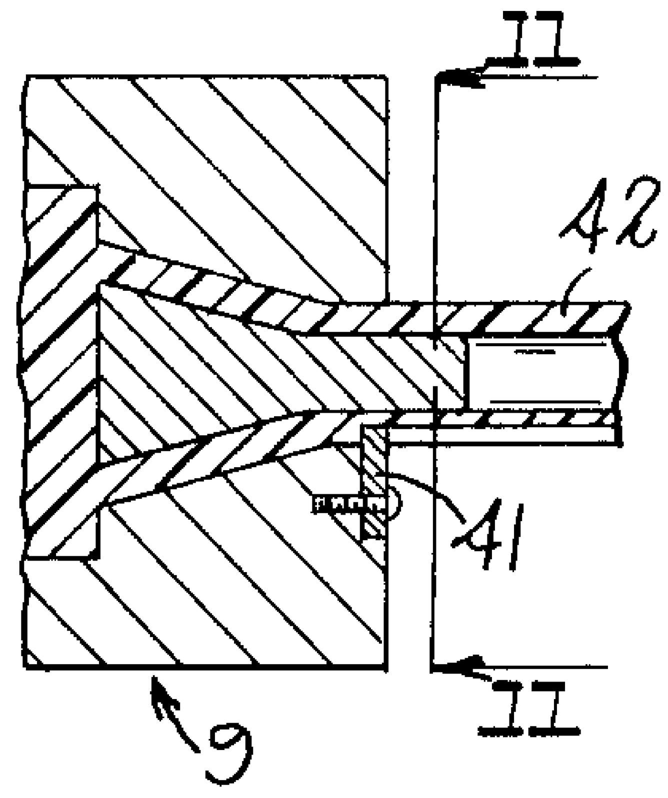
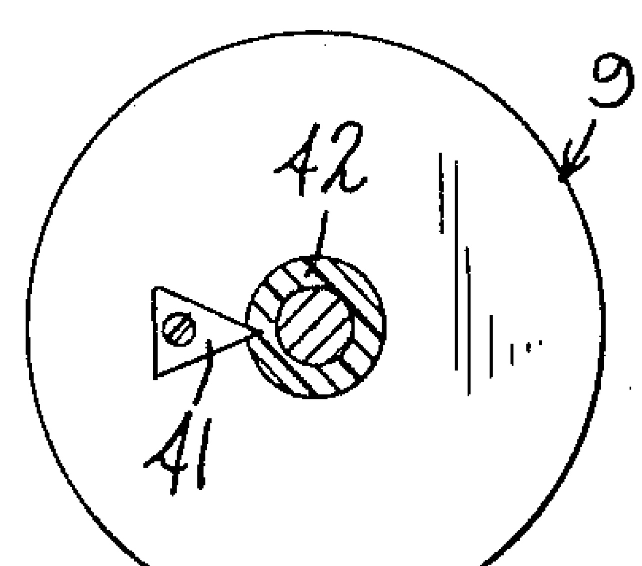


Fig. 11.



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APPARATUS FOR EXTRUDING CYLINDRICAL MAGNETS

This invention relates to magnets and more particularly to improvements in the manufacture of cylindrical magnets suitable for use in small motors.

Cylindrical magnets of the above-mentioned type are of a shape which conveniently fit within the housing of a small motor, so as to act as a permanent field for the motor. This is accomplished by cutting sections of the cylindrical magnet from a long length of the material and thereafter slipping the cylindrical magnet into the housing of the motor. The armature of the motor is then placed in the housing, such that it is free to rotate within the field provided by the cylindrical magnet.

In the art of cylindrical magnets, it is known that they may be produced by the utilization of an extrusion technique wherein a mixture of magnetic particles and a base carrier is processed through the extruding machine. The final step of the extruding process consists of passing the material through a special die which gives the finished material its final shape. In the past, the cylindrical magnets so produced had relatively weak field strength which appeared to be the result of random orientation of the magnetic domains embedded within the base carrier material.

In order to increase the field strength of the cylindrical magnet, applicants have provided a new and improved apparatus and method for aligning magnetic particles carried in a base material formed in the shape of a cylinder. In its broadest aspects, this invention makes use of the fact that a material provided from an extruder is generally soft and flexible, with a doughlike consistency for a short period of time after exiting from the extruder. Basically, a hollow cylindrical magnet of superior characteristics is provided in the preferred embodiment of this invention by the use of means for providing a magnetic field through the walls of the cylinder while a soft magnetic core is positioned within the confines of the hollow cylinder.

In view of the foregoing, it is an object of this invention to provide a new and improved method and apparatus for manufacturing cylindrical magnets.

Another object of this invention is to provide a new and improved apparatus adapted to manufacture high field strength hollow cylindrical magnets suitable for use as the permanent field of a DC motor.

A further object of this invention is to provide a new and improved method for orienting domains of magnetic particles dispersed within a nonmagnetic base material.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others and the apparatus embodying the features of construction, combination of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following disclosure and the scope of the invention will be indicated in the claims.

For a fuller understanding of the invention, reference is had to the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is a front view of an apparatus for preferentially orienting magnetic particles according to this invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is an enlarged view of a portion of FIG. 1;

FIG. 4 is a front view of an alternate embodiment of this invention;

FIG. 5 is a sectional view taken along line 5—5 of FIG. 4;

FIG. 6 is a top view of another embodiment of this invention, including means for forming a guide in the cylindrical magnet;

FIG. 7 is a side sectional view taken along line 7—7 of FIG. 6;

FIG. 8 is a side view of another embodiment according to this invention, including means for severing the wall of the cylindrical magnet;

FIG. 9 is a sectional view taken along line 9—9 of FIG. 8;

FIG. 10 is a sectional view of an extrusion die including means for forming a guide in the cylindrical magnet being extruded;

FIG. 11 is a sectional view taken along line 11—11 of FIG. 10; and

FIG. 12 is a sectional view of a further embodiment according to the invention.

Referring to FIGS. 1-3, there is illustrated a typical arrangement for making oriented extruded cylindrical magnets. The extruder die is generally shown at **9** and is preferably made of an essentially nonmagnetic material such as carbide steel. In the preferred embodiment of this invention, a soft magnetic core is generally shown at **10**, this core being preferably separated from the extruder by a nonmagnetic material such as carbide steel, plastic, or the like, shown at **11**. The core **10** is preferably of an iron material composition, such that it has good magnetic properties.

Two diametrically opposite orienting heads **12** and **13** are placed in close proximity to the die, these heads forming part of an electromagnet, including a coil shown at **14**, and adapted to be connected to a direct current source. The material to be formed into the cylindrical magnet preferably comprises anisotropic magnetic particles such as ferrites of barium, lead strontium and manganese-bismuth or iron in combination with the above. The magnetic material is in the form of small-dimensioned material and is preferably commutated or ground to ultrafine particles of the order of about 0.5 microns in diameter. The particles behave as elementary magnet units called single-magnetic domains.

As a base or carrier material in which the magnetic material is mixed prior to its being placed within the extruder **15**, materials such as polymers, elastomers, rubbers, plastics and other nonmagnetic materials, including plasticizers as a part thereof, may be used. For example, materials such as polyvinylchloride, methylmethacrylate, ureaformaldehyde, vinylacetate, vinylformaldehyde, buna N and polyethylene may be used, as well as other nonmagnetic materials not confined to plastics, such as silicon materials and other nonmagnetic metallic materials, could be used.

The magnetic particles and the nonmagnetic base material are mixed together in the extruder in the normal manner and are thereafter expelled in a normal manner in a cylindrical shape, as shown at **16**. In the preferred embodiment, the extruded material is in a soft state due to the heating of the material as it is being extruded (per the conventional manner of extruding). As the cylinder passes through the magnetic field, the domains are preferentially rearranged to produce anisotropy in the cylinder along the diameter AA (FIG. 3). By the use of the soft core material **10** which extends into the magnetic field, the soft core being positioned within the confines of the wall of the cylinder **16**, the airgap between the magnetic heads **12** and **13** is thus minimized, resulting in a substantial improvement in orientation of the magnetic particles. Without the core, the airgap would in effect be the diameter of the extruded cylinder. With the core, the airgap is effectively reduced to the thickness of the cylinder wall. Lines of force, as provided by the magnetic heads, are shown at **17** (FIG. 3). With the use of the magnetic heads, generally shown in FIGS. 1-3, the portion of the head closest to the wall of the cylinder preferably suspends an arc of 30° to 150°, accordingly the orientation preferably takes place most strongly in the portions of the cylinder also suspending an arc of about 30° to 150°. Thus, there are provided preferential volumes of the cylinder between the inner and outer cylinder walls forming, in this case, a two-pole magnet and having a higher degree of orientation than the material in the two other portions of the cylinder.

Now referring to FIGS. 4 and 5, there is shown another embodiment of this invention. In place of the stationary magnetic heads **12** and **13**, rotating heads **20** and **21** are provided. These rotating heads are part of an electromagnet **22** of the type generally described with reference to FIGS. 1-3. This configuration assists maintaining a uniform linear feed-through of the extruded cylinder. Also, if desired, the heads could be somewhat lowered to provide additional force sufficient to mechanically deform the material to further aid in the orientation of the magnetic particles within the cylinder. The cylindrical magnet of this embodiment is also shown at **16** as in FIGS. **1–3**. Portions of the heads **20** and **21** which engage the outer wall of the cylinder **16** each preferably suspend an arc of about 30° to 150°.

FIGS. **6** and **7** of the drawings illustrate a further embodiment of the invention, in which a member **30** in the form of a wheel is utilized and which is supported in such a manner as to form a small guide or indentation in the magnetic cylinder. The purpose of this guide is to orient the material when it is placed within the motor housing. By placing a dimple or guide in the interior of the motor housing, which cooperates with the guide **32** (FIG. **7**), it is possible to insure that the orientation of the cylinder within the motor housing is correct at all times. This alleviates the necessity for testing the magnet before it is placed within the motor housing or marking the magnet so that the operator assembling the motor will place it in the housing in the correct position. The guide **32** is preferably not cut through the entire sidewall, but just penetrates to a point above the inner wall of the cylinder.

With reference to FIGS. **8** and **9**, there is shown another type of means for supporting the cylinder as it is being magnetized. In this embodiment, the cylindrical magnet is first cut by a cutting wheel **35** as it comes out of the extruder. A support or mandrel **36** (preferably of soft iron, but which may also be of a nonmagnetic material) is supported by rods **39** which pass through the severed wall of the cylinder. In this manner the cylinder is supported under magnets **40**.

Referring now to FIGS. **10** and **11**, there is shown still another means for forming a guide or slit in the cylinder wall. In this embodiment, a portion of the die is used to support a cutting member **41** positioned at the outlet of the die, such that a guideway or slit is formed within the cylinder **42**.

Referring now to FIG. **12**, there is shown a further apparatus for aligning magnetic particles in a base material formed into the shape of a cylinder. Instead of the core of FIGS. **1–11**, a second magnet is provided, preferably an electromagnet, shown at **50**, the legs of which pass through a slit formed in the cylinder **49** produced by the cutter **35** shown in FIGS. **8** and **9** as it leaves the extruder shown at **9**. Preferably, the poles of the electromagnet, shown at **51** and **52**, are spaced apart by a nonmagnetic material portion **53** such as plastic, brass, etc. The poles **51** and **52** are aligned with the poles of electromagnets **56** and **57** (of the type shown in FIG. **1** or FIG. **4**), such that across the cylinder walls there is provided a localized aligning field. In this manner it is possible to achieve greater effective alignment of the magnetic particles. It should also be understood that magnetic bottles or the like may be produced, using this technique, by rotating the magnets or the cylinder.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description are efficiently attained and since certain changes may be made in carrying out the above method and in the constructions set forth without departing from the spirit and scope of the invention, it is intended that all matter contained in the foregoing description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

We claim:

1. An apparatus, to be used in combination with an extruder die for producing continuous lengths of tubular polymeric strip containing elemental magnets substantially oriented in the same polar direction, comprising

a. a core member located in a fixed position adjacent the face of said extruder die so that said tubular polymeric strip passes about its external surface, and

b. first magnetizing means positioned about said core member so as to apply unidirectional lines of force on a portion of tubular polymeric strip located about said core,

wherein said die is constructed of an essentially nonmagnetic material, and wherein said core is supported on the face of said die so that as the tubular strip passes out of said die it slides over said core and such that said core is connected to said face by a rod of nonmagnetic material.

2. An apparatus according to claim **1**, including cutting means located adjacent said face of the die for cutting a slit through a wall of said tubular strip, and wherein said core is connected to support members passing through said slit and connected to a frame member.

3. An apparatus according to claim **1**, wherein said first magnetizing means comprises a plurality of rotating magnetic heads having grooves therein for engaging a portion of the wall of said tubular strip.

4. An apparatus according to claim **3**, including marking means positioned on said face of said die for forming a guideway in the wall of said tubular strip.

5. An apparatus according to claim **1**, in which said first magnetizing means for applying an orienting magnetic field comprises at least two electromagnetic heads each having a portion in the shape of an arc which lies adjacent said tubular strip, said arc being from 30° to 150° in length.

6. An apparatus according to claim **1**, including marking means located adjacent said face of the die for forming a guide groove in the external surface of said tubular strip.

7. An apparatus according to claim **1**, wherein said magnetizing means comprises two rotating electromagnetic members positioned on opposite sides of said tubular strip for engaging a portion of the outer wall of said tubular strip which lies over said core.

8. An apparatus according to claim **3**, including cutting means positioned between said face of the die and said magnetizing means for cutting a slit through the wall of said tubular strip, and wherein said core member which is constructed from a soft magnetic material is positioned by support means passing through said slit.

9. The apparatus of claim **1** for aligning said magnets in said base material, wherein said core comprises second magnetizing means positioned within the confines of said tubular strip and said first magnetizing means is positioned adjacent and external of said tubular strip, said first and second magnetizing means cooperating to align said elemental magnets in a single direction.

10. An apparatus according to claim **9**, wherein said first and second magnetizing means are electromagnets.

11. An apparatus according to claim **1** wherein said core is a soft magnetic material.

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