July 19, 1966

M. J. LAVERTY

3,261,481

MAGNETIC FEED AND POSTIONING MEANS FOR AUTOMATIC ASSEMBLY MECHANISM

Filed May 6, 1964

4 Sheets-Sheet 1

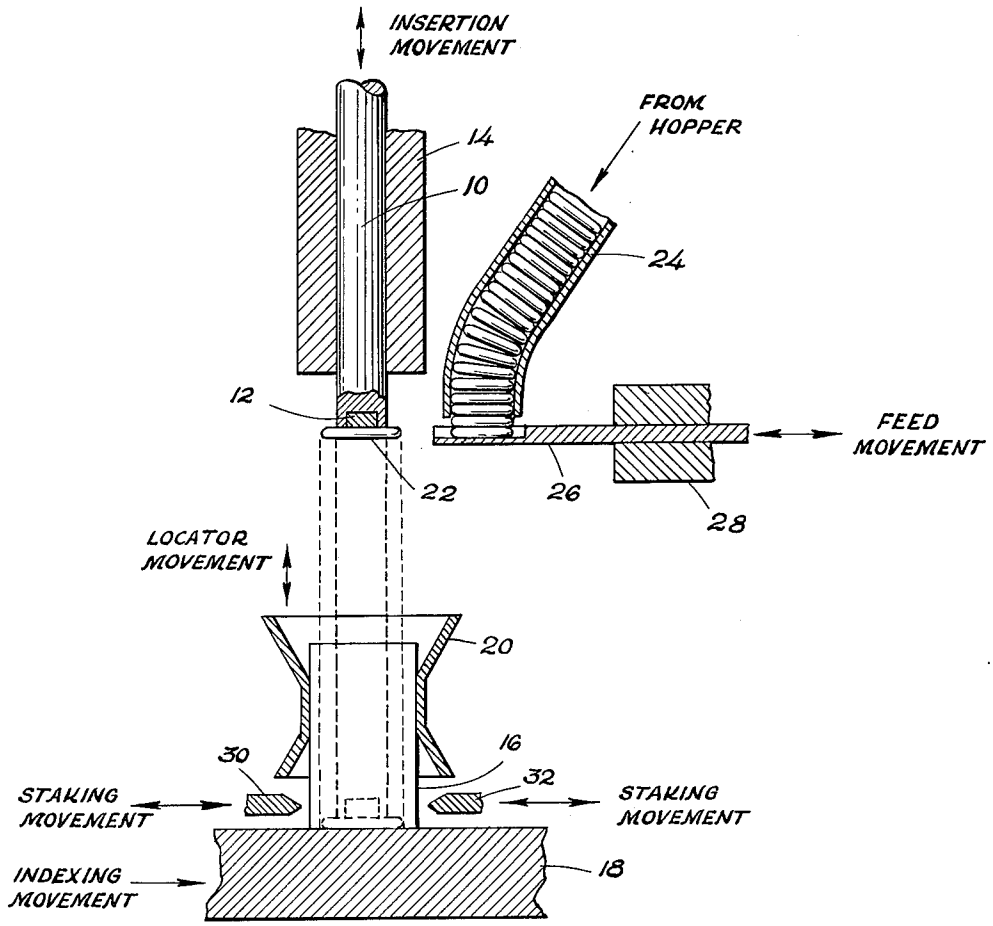


Fig. 1 (PRIOR ART)

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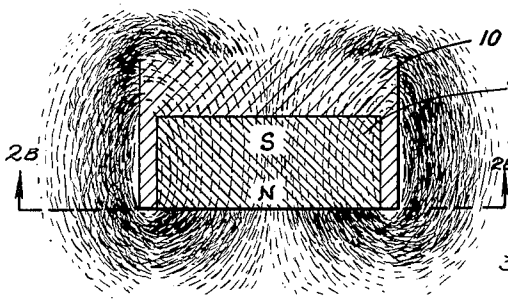


Fig. 2A

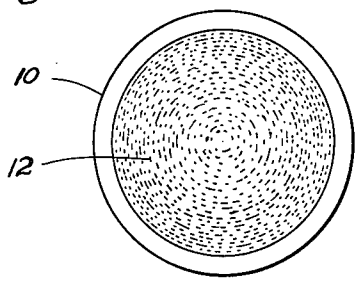


Fig. 2B

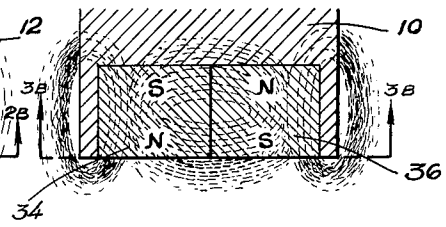


Fig. 3A

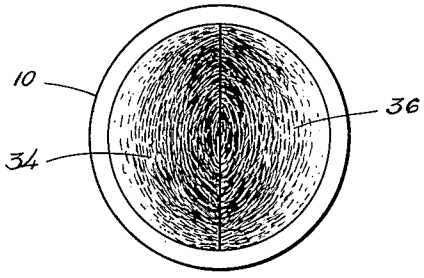


Fig. 3B

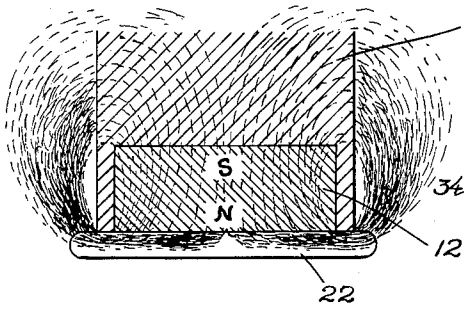


Fig. 4A

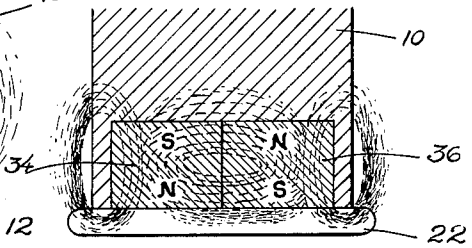


Fig. 4B

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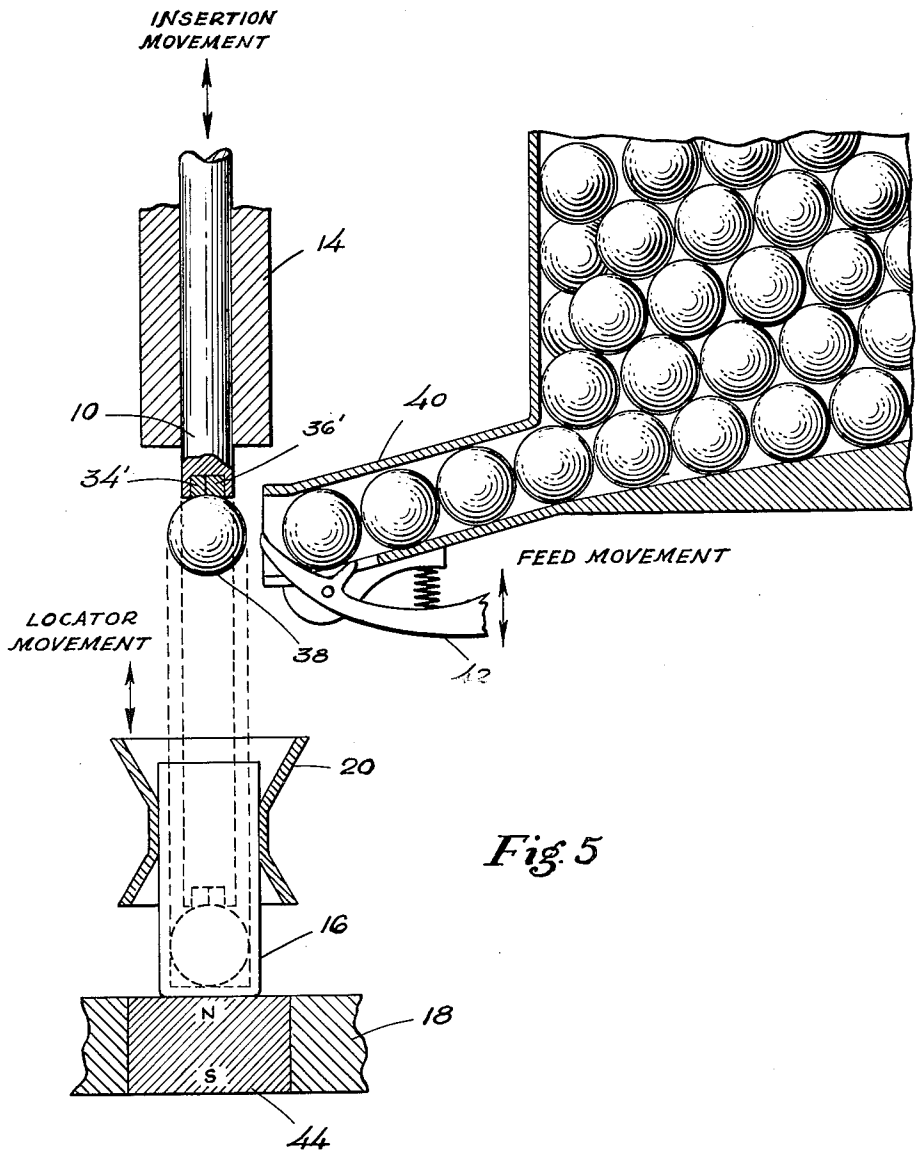


Fig. 5

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MAGNETIC FEED AND POSTIONING MEANS FOR AUTOMATIC ASSEMBLY MECHANISM

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Fig. 6A

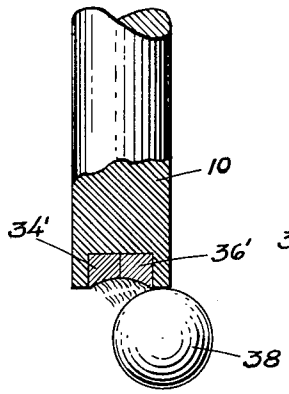


Fig. 6B

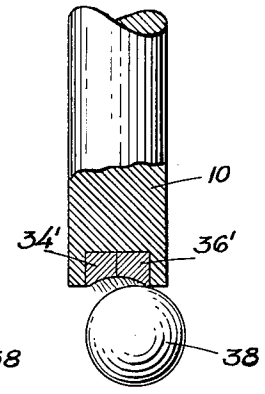


Fig. 6C

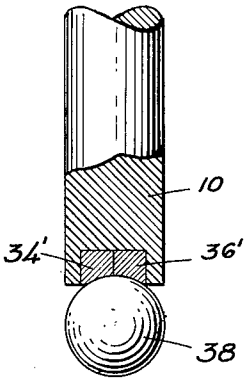


Fig. 7A

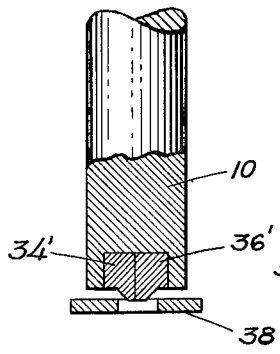


Fig. 7B

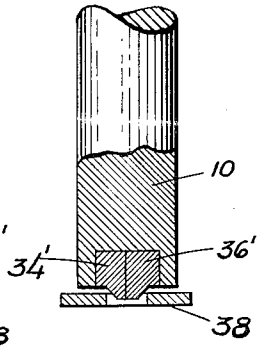
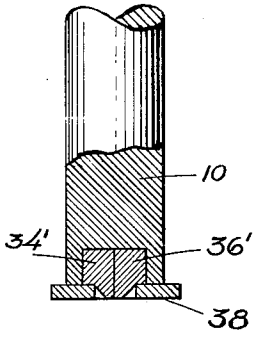


Fig. 7C



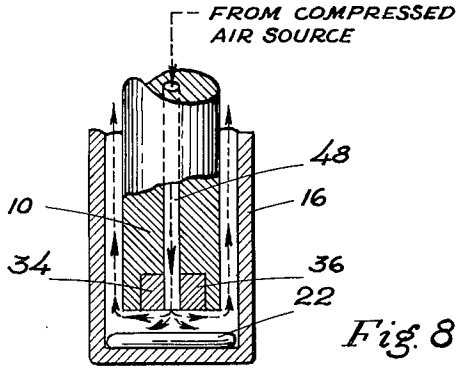


Fig. 8

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MAGNETIC FEED AND POSITIONING MEANS FOR AUTOMATIC ASSEMBLY MECHANISM

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3 Claims. (Cl. 214—1)

This invention relates to magnetic means for feeding and accurately positioning close tolerance parts in automatic assembly mechanisms. Although the invention is applicable to a wide range of automatically assembled devices, it is particularly useful in tube and pole piece assemblies such as described in U.S. Patent No. 3,037,800, which was issued to M. J. Laverty et al. on June 5, 1962, for a "Tube and Pole Piece Assembly." Accordingly, the invention will be described in connection with tube and pole piece assemblies. It should be understood, however, that the invention can be used to feed and position any suitably dimensioned part that is made of or contains ferromagnetic material.

The above noted U.S. patent discloses a tube and pole piece assembly which is used in certain electrical circuit breakers. The tube-pole piece assembly comprises a hydraulically sealed non-magnetic tube. Contained within the tube are a movable magnetic pole piece and a spring for retarding the movement of the pole piece towards an end of the tube, to which there is internally affixed another magnetic pole piece.

In the circuit breaker, the tube-pole piece assembly is mounted within a coil of wire through which the circuit breaker current flows, so that the pole piece is exposed to a magnetic field that varies in accordance with the magnitude of current flow through the circuit breaker. The stiffness of the spring and the viscosity of hydraulic dampening fluid within the tube-pole piece assembly are chosen so that there is practically no tendency for the pole piece to travel during normal current flow. During overload conditions, however, the magnetic field increases in strength, causing the movable pole piece to travel towards the fixed pole piece with a rate proportional to the overload current. When the two pole pieces reach closest proximity to each other, the reluctance of the magnetic circuit is considerably reduced, thereby causing a corresponding increase in the magnetic flux through the pole pieces. This increase in flux serves to trip a magnetic armature near the tube-pole piece assembly and opens the electrical contacts of the circuit breaker, thereby interrupting the current flow. It will be apparent from the foregoing description that the tube-pole piece assembly acts as a time-delay device which permits a continuous overload condition to exist for a predetermined time before interrupting the circuit. Thus, in the industry, the tube-pole piece assembly is known as a hydraulic-magnetic time delay tube.

It is desirable automatically to assemble the fixed pole piece within the tube, to reduce the cost of the circuit breaker. One particular problem, however, involves the insertion of the relatively small size stationary pole piece within the tube. In a typical example, the tube is a brass cylinder which is 2" long, with an inside diameter of 0.279", and closed at one end. The stationary pole piece, which is a steel disc 0.275" in diameter and 0.062" thick, must be inserted precisely in the open end of the tube, and then be moved 2" to the closed end of the tube, where it is subsequently staked in place by an automatic staking tool. Since there is only 0.004" clearance between the disc and inside of the tube, the feeding and positioning mechanism must be extremely accurate to avoid a blockage of the disc at the open end of the tube or jamming during its 2" of travel from the open to the closed end of the tube.

The required accuracy can be obtained with clamping or collapsible collet-type fixtures, or by the widely used suction or vacuum mechanisms. These mechanisms, however, are relatively complex and costly, particularly the vacuum type, which requires pumps and involves relatively high maintenance costs. Electromagnet mechanisms are undesirable because they require a power source and present a space problem with parts as small as 0.275" in diameter. A permanent magnet mechanism would be ideally suited for this application, except that conventional permanent magnet feed and positioning means lacks the required accuracy of repetitive positioning for small parts. With very small parts, the flux spread of the conventional permanent magnet tends to move the part out of position due to random variations in the grain structure, dimensions, and inherent magnetic field of the parts. Large parts hold their position on a permanent magnet due to inertia and fraction, but small parts are displaced by the above noted random variations, and this displacement would exceed the required tolerance.

Accordingly, one object of this invention is to provide a permanent magnet feed and positioning means which has a high degree of repetitive positioning accuracy with very small parts.

Another object of this invention is to provide a permanent magnet feed and positioning means which minimize position displacements caused by random variations in the grain structure, dimensions, and inherent magnetic field of the parts.

A further object of this invention is to provide magnetic means for feeding and accurately positioning close tolerance parts in automatic assembly mechanisms.

An additional object of this invention is to provide an improved mechanism for automatically inserting the stationary pole piece into a hydraulic-magnetic time delay tube.

Other objects and advantages of the invention will become apparent to those skilled in the art from the following description of several specific embodiments thereof, as illustrated in the attached drawings, in which:

FIG. 1 is a schematic representation of a prior art permanent magnet mechanism for automatically inserting ferromagnetic discs into short, open-ended tubes;

FIG. 2A is an elevation section of a prior art magnetic stylus showing the lines of force produced thereby;

FIG. 2B is a plan section of the prior art magnetic stylus of FIG. 2A;

FIG. 3A is an elevation section of a magnetic stylus of this invention showing the lines of force generated thereby;

FIG. 3B is a plan section of the magnetic stylus of FIG. 3A;

FIG. 4A is an elevation section of a prior art magnetic stylus holding a small ferromagnetic disc;

FIG. 4B is an elevation section of the magnetic stylus of this invention holding a small ferromagnetic disc;

FIG. 5 is a schematic representation of a novel mechanism for inserting spherical pole pieces into hydraulic-magnetic time delay tubes;

FIG. 6A is an elevation section of the magnetic stylus of FIG. 5 with a spherical pole piece near the edge thereof;

FIG. 6B shows the spherical pole piece of FIG. 6A being attracted into position by the magnetic stylus;

FIG. 6C shows the spherical pole piece of FIG. 6B in its final position on the magnetic stylus;

FIG. 7A shows another magnetic stylus of this invention with a pole piece near the edge thereof;

FIG. 7B shows the pole piece of FIG. 7A being attracted into position by the magnetic stylus;

FIG. 7C shows the pole piece of FIG. 7B in its final position on the magnetic stylus; and

FIG. 8 shows another magnetic stylus of this invention with a central air channel for disengaging the part held thereby with a jet of compressed air.

Referring to FIG. 1, the prior art permanent magnet mechanism for feeding and inserting ferromagnetic discs into short, open-ended tubes contains a movable stylus **10** which is fitted at one end with a high flux density permanent magnet insert **12**. Stylus **10** is made of a non-magnetic material, and is slidably mounted in a guide member **14** for movement into and out of an open ended tube **16** positioned below stylus **10** by a movable support **18**, which can be an indexed assembly line or an indexed turntable. The movable support **18** holds a plurality of open ended tubes which may be indexed to position the tubes one at a time under stylus **10**, to receive the ferromagnetic disc. In this particular mechanism, the tubes are aligned in exact position under stylus **10** by a funnel-shaped locator **20**, which is moved down over the tube after it has been indexed into the approximate position by the movable support **18**.

A ferromagnetic disc **22** is shown attached to the stylus **10** by means of the magnetic attraction of permanent magnet **12**. The discs are fed into position on permanent magnet **12** by an automatic feed mechanism comprising a feed tube **24**, which receives a continuous supply of the discs from a feed hopper, and a slide member **26**, which is slidable in a guide member **28** and moves the discs one at a time under permanent magnet **12**. After a disc has been positioned on stylus **10**, slide member **26** retracts to receive another disc, and stylus **10** moves downwardly to insert disc **22** into tube **16** as indicated by the dashed lines in FIG. 1. At the end of the insertion stroke, disc **22** is staked into place in the bottom of tube **16** by staking members **30** and **32**, which are operated automatically by means not shown. After the disc **22** has been staked in place, stylus **10** is withdrawn from the tube to its initial position, and locator **20** is also withdrawn from the tube. An empty tube is then indexed into position under stylus **10**, and the cycle repeated.

Many different control means are known in the art for automatically sequencing an assembly mechanism in accordance with the foregoing sequence of operation; therefore, the details of the control means are omitted from this patent application for the sake of clarity.

Although the above described prior art mechanism works satisfactorily with large, loose tolerance parts, it lacks the required accuracy of repetitive positioning for small, close tolerance parts. It cannot, therefore, be used to insert 0.275" x 0.062" discs into 0.279" x 2" during the assembly of small, hydraulic-magnetic time delay tubes. The reason for this lack of repetitive positioning lies in the magnet rather than in the feed mechanism.

After the discs are positioned on the stylus, they come under the influence of the magnetic field of magnet **12**, as shown in FIGS. 2A, 2B and 4A. Since the discs are quite small, the flux spread of magnet **12** tends to move the discs out of position due to random variations in the grain structure, dimensions, and inherent magnetic field of the part. As shown in FIG. 4A, there is a strong component of magnetic force acting in the transverse direction on disc **22**, particularly at the periphery thereof, and the disc is too light to generate enough friction and inertia to resist movement. Therefore, after being accurately positioned on the magnet **12** by the slide mechanism, the disc is displaced by the flux spread of the magnet.

In accordance with the invention, however, this displacement is minimized by providing a novel magnetic insert with a short circuited magnet which minimizes the flux spread. As shown in FIGS. 3A and 3B, this invention utilizes two permanent magnets **34** and **36** which are positioned side by side with the north pole of one magnet adjacent the south pole of the other magnet. Since lines of flux travel by the lowest reluctance path from a north pole to a south pole, this produces a magnetic short circuit and holds most of the lines of flux close to the magnet. Furthermore, the magnetic short circuit minimizes the peripheral magnetic field and virtually eliminates the flux spread which caused displacement of the disc in the prior art mechanism. As shown in FIG. 4B, the magnet as used in this invention produces almost no transverse force on the disc **22**, and therefore does not cause any displacement due to random variations in the disc. Accordingly, the magnet as used in this invention allows the feed mechanism of FIG. 1 to be used to insert a 0.275" x 0.062" disc into a 0.279" x 2" tube.

The magnet as used in the invention is not limited to inserting discs in tubes. In some hydraulic-magnetic time delay tubes, a spherical stationary pole piece is used, and the invention can handle spherical parts as well as disc shaped parts.

FIG. 5 shows a mechanism for inserting 0.275" diameter spheres into a 0.279" x 2" tube. In this embodiment of the invention, spheres are released from a tube **40** by a feed lever **42**, which releases the spheres one at a time and allows them to roll to the edge of magnets **34'** and **36'**. FIGS. 6A, 6B and 6C show how the spheres are attracted into position on the magnets, which have a spherical depression formed in the face thereof mechanically to guide sphere **38** into exact position. The depression in the magnets is, of course, centered on the stylus **10**, and preferably has a slightly smaller radius of curvature than the sphere so that the positioning action will be governed by contact between the sphere and the periphery of the depression. This minimizes displacement due to variations in the diameter or curvature of the spheres.

The embodiment of FIG. 5 also differs from the embodiment of FIG. 1 in that the parts are disengaged from the stylus by a larger magnetic field rather than by being staked in place. Movable support member **18'** is fitted with a large permanent magnet **44** which is positioned under tube **16**. When sphere **38** is inserted in tube **16**, the magnetic field of magnet **44**, being stronger than the magnetic field of magnets **34'** and **36'**, holds the sphere in the tube when the stylus is withdrawn.

The magnet as used in this invention can also be used with other parts such as magnetic shaped washers, as illustrated in FIGS. 7A, 7B and 7C. In this example, the magnets **34''** and **36''** are shaped to form a truncated cone which serves mechanically to guide the washer into exact position by engaging the central opening in the washer.

FIG. 8 shows another variation of the invention in which a central air channel **48** is formed in stylus **10** and magnets **34** and **36** to disengage the part by means of a jet of compressed air. In the example shown, a disc **22** is being removed after having been inserted into a tube **16**. The air jet disengagement could, of course, also be utilized in the embodiment of FIG. 6 if desired, in place of permanent magnet **44**.

From the foregoing description it will be apparent that this invention provides improved magnetic means for feeding and accurately positioning close tolerance parts in automatic assembly mechanisms. And it should be understood that this invention is by no means limited to the specific embodiments disclosed herein, since many modifications can be made in the disclosed structure without departing from the basic teaching of the invention. For example, although permanent magnets are used in the disclosed embodiments, the short-circuiting principle is equally applicable to electro-magnets and can be used to minimize position displacement in electromagnetic devices if desired. Also, many different forms and shapes of magnets could be employed to match particular parts. These and many other modifications of the disclosed structure will be apparent to those skilled in the art, and this invention includes all modifications falling within the scope of the following claims.

What is claimed is:

1. In an apparatus for inserting a magnetic pole piece into a non-magnetic tube, the improvement comprising;

a longitudinal transport member having a free end for insertion into said non-magnetic tube located axially relative to the longitudinal axis of said member, said transport member being movably mounted to travel forward and return to its home position along its longitudinal axis, a pair of magnets adjacent each other at the free end, the south and north poles of a face of one magnet being adjacently opposed to the north and south poles respectively of a face of the other magnet, the opposed faces of said magnets being disposed along the axis of said longitudinal member, means located near the free end of said transport member for delivering a magnetic pole piece to said free end, and means at the free end of said transport member for mechanically centering and guiding said pole piece into its correct position when it it delivered to said free end so that said pole piece can be inserted easily into the non-magnetic tube by said transport member.

2. The apparatus of claim 1 wherein an air channel is provided passing axially through said magnets, whereby compressed air may be applied to said channel to deposit said pole piece when it is inserted into said non-magnetic piece.

3. The apparatus of claim 1 wherein a third magnet is provided located adjacent the bottom of said non-magnetic tube, said magnet being stronger than the magnets at the free end of the transport member so that when the pole piece is inserted into the tube, said magnet is able to remove the pole piece from the free end of said transport member.

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