July 1, 1969 A. L. COEN 3,453,400

FIELD STRUCTURE FOR MAGNETIC LOUDSPEAKER AND METHODS OF MANUFACTURE

Filed Dec. 8, 1965 Sheet 1 of 2

Fig. 1

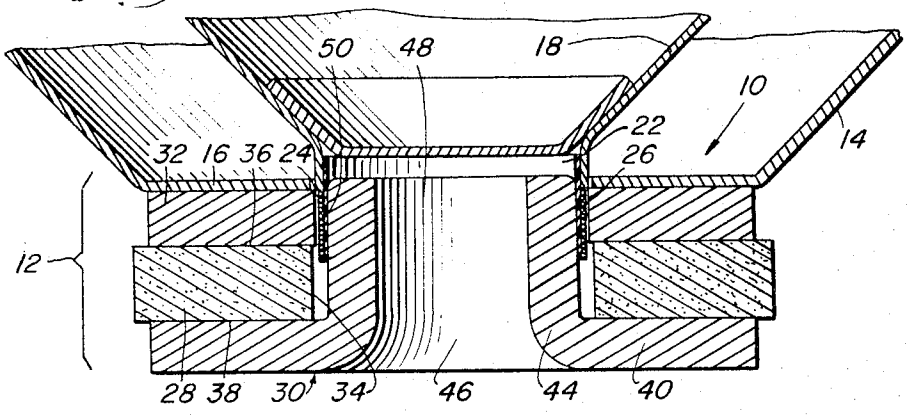


Fig. 2

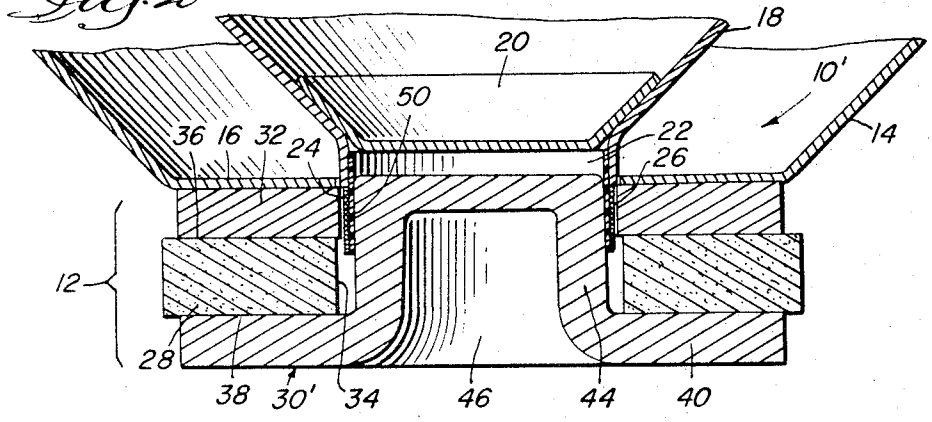


Fig. 3

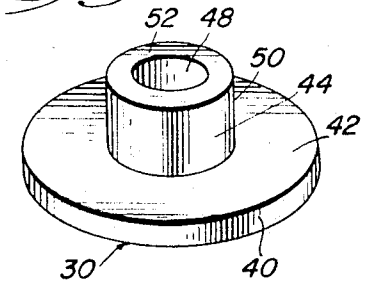
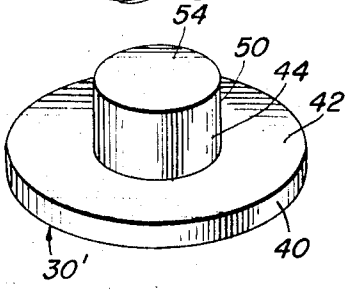


Fig. 4



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Filed Dec. 8, 1965 Sheet 2 of 2

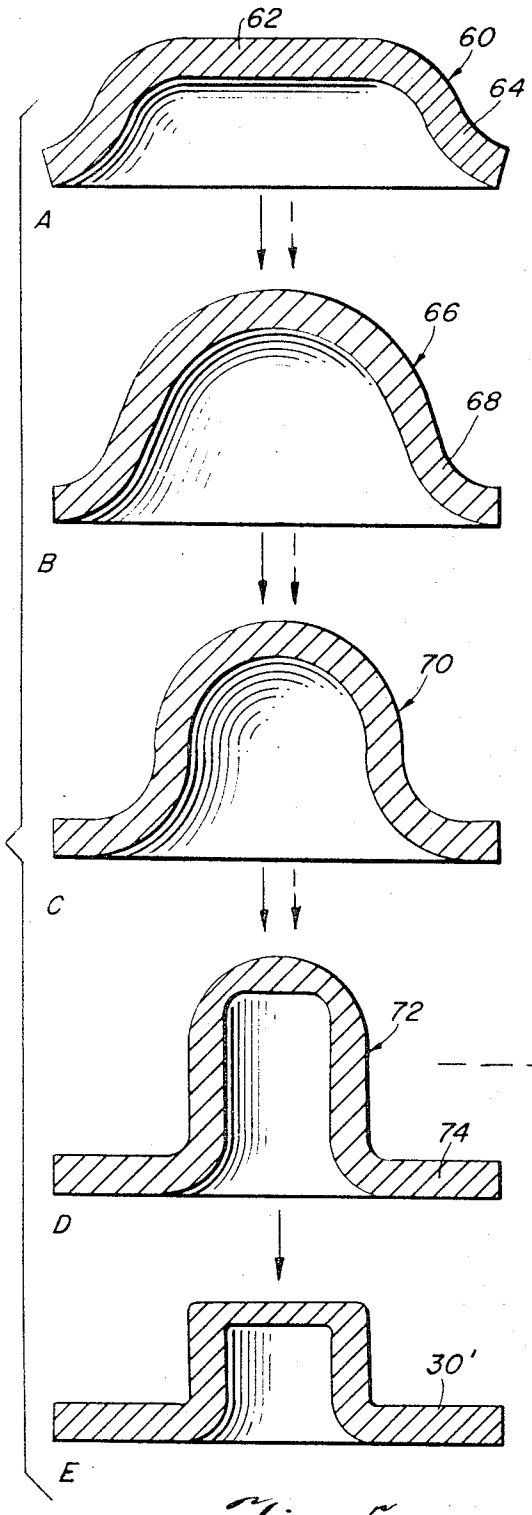


Fig. 5

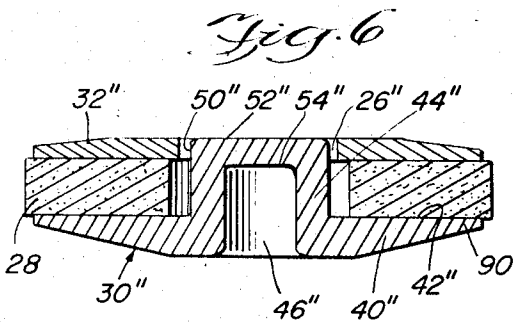
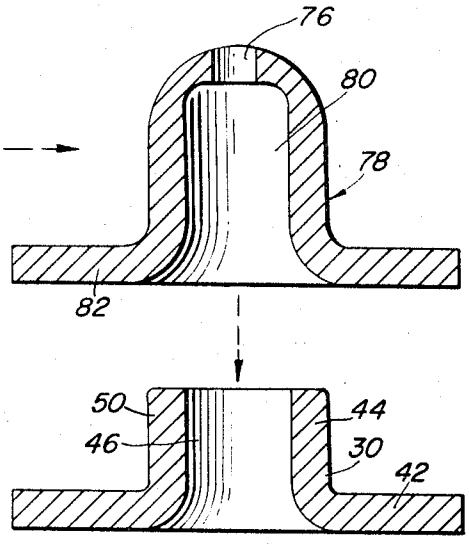


Fig. 6



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FIELD STRUCTURE FOR MAGNETIC LOUDSPEAKER AND METHODS OF MANUFACTURE

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Int. Cl. H04r 9/02, 11/06
U.S. Cl. 179—119 1 Claim

ABSTRACT OF THE DISCLOSURE

A motor for a loudspeaker having a combined base plate and post, a pole piece in the form of a washer surrounding the post and a ceramic magnet sandwiched between the base plate and pole piece. The combined base plate and post is comprised of a single piece of metal with the post being hollow and having an integral end cap formed thereon. The thickness of the annular wall of the post in a radial direction is substantially similar to that of the base plate.

This invention relates generally to audio reproducing devices and more particularly is concerned with improvements in a loudspeaker of the permanent magnet variety which utilizes a relatively flat annular magnet.

In the permanent magnet type of loudspeaker a strong magnetic field is established in an air gap in a magnetic circuit which includes a permanent magnet. The magnetic circuit usually includes a housing or "pot," as it is known in the trade, and a powerful permanent magnet, the combination in most cases being symmetrical about a single axis to provide uniform distribution of the flux. The magnet housing is rigidly secured to a metal basket which mounts a paper cone to which the voice coil is cemented. The voice coil is disposed at the apex of the cone and is cylindrical in configuration to enable it to extend into the cylindrical air gap between the pole pieces of the magnetic circuit.

A magnetic field of very high flux density is concentrated in the gap, being radial in most constructions, since the center pole piece is secured to the end of a cylindrical magnet and together therewith is mounted in the center of a cup-shaped steel housing. The top of the housing, that is, where the pole piece is disposed, is annular in configuration and its center hole is coaxial with the pole piece to form the gap. The wires of the voice coil are arranged annularly and normal to the principal lines of force of the magnetic field which are radial. The flow of A.C. signals through the wires of the voice coil causes the coil to move axially in accordance with the signal current by reason of electrical phenomena which are quite familiar, so that the cone attached to the coil will also move or vibrate in accordance with the signal.

The cone movement will cause sound waves to be generated which are audible, so that in effect the structure described is a transducer converting electrical energy into sound energy. The transducer described is of the reversible type, that is, sound waves which are directed against the cone will physically move the voice coil in the magnetic field and cause currents to be generated in the wires of the voice coil. These may be amplified, and treated in other manners as though the transducer were a microphone. The present state of the microphone art is highly sopisticated so that a transducer of the permanent magnet and cone type would not be acceptable for exacting requirements, hence the invention herein will be described particularly in connection with the use of the transducer as a loud speaker, although this is not intended as a limitation.

The technicalities of loud speaker operation are fairly well-known, and several structures of the type described above are illustrated and described in my U.S. Patents 3,133,162 and 3,176,086. Reference may be had to these patents for structural details of loud speakers of a variety in which the magnet is in the center of the magnetic circuit as a core, while the looping or return portions of the magnetic circuit are on the exterior of the magnet.

Recently loud speakers have been constructed in which the magnet is in effect on the outside of the circuit and the return portions are on the inside, still retaining the basic symmetrical and coaxial arrangement. Specifically, flat annular toroidal magnets have been manufactured, of hardened mixtures of magnetic particles and ceramics, these being referred to in the trade as ceramic magnets. Such magnets are available commercially from Indiana General Corporation of Valparaiso, Ind. and others.

Ceramic magnets, as they will be referred to hereinafter, are quite flat, compared to the cylindrical or core type of permanent magnet heretofore used in loudspeakers. When mounted in suitable metal field pieces, these ceramic magnets make up into "motors," as the assemblies are sometimes called, which have very small axial length. Thus the loud speaker itself has very short axial dimensions, enabling the manufacture of compact radios and television receivers.

A typical motor for a loudspeaker using a ceramic magnet as heretofore known utilized a structure requiring three metal pieces in addition to the magnet. There was a base plate in the form of an annular washer with a center perforation, having a cylindrical center post staked or force-fitted therein. The ceramic magnet, which is annular in configuration was arranged coaxial of the post, engaged against the top of the base plate. A flat washer was disposed overlying the magnet and having a central opening coaxial with the post but of a diameter larger than that of the post. The post extended axially at least to the plane of the outer face of the washer, usually slightly beyond, so that the air gap was formed as a cylindrical space between the post and the inner surface of the perforation in the washer.

Heretofore the base plate and washer were formed of cold rolled steel by any suitable method such as stamping or machining. Likewise the post was formed of cold rolled steel, usually as a screw-machined article. The assembly of the post and base plate required a separate operation, and the resulting assembly was of solid steel. The magnetic flux was required to pass through all of the steel members in its circuit, which included a joint where the post was inserted into the base plate. It is known that such joints will have higher reluctance than the metal members jointed. Likewise, the grain of the metal of the post and the metal of the base plate were not always arranged to provide maximum transmission of flux and uniformity of flux. There is always some fringing in magnetic fields, and a certain amount of this was expected from the prior ceramic magnet motors.

An important object of the invention is to provide a loudspeaker structure of the type to mount a substantially flat annular magnet in which the post and base plate of the magnetic circuit comprise an integral member formed of the same piece of steel and in which the post is hollow.

Still a further object of the invention is to provide a loudspeaker structure of the type to mount a flat annular magnet in which the post and base plate of the magnetic circuit comprise an integral member formed of a single piece of flat steel stock whereby the grain of the metal will be arranged in substantially the same configuration that is formed by the path of the magnetic flux through the post and base plate.

Still a further object of the invention is to provide a

loudspeaker structure of the character mentioned above in which the post and base plate of the magnetic circuit comprise an integral member formed of a single slug of steel stock extruded to the desired configuration to give good grain orientation for efficient flux transmission.

A further object of the invention is to provide a method of forming the post and base plate by the use of consecutive steps involving relatively simple reciprocatory movements of a punch press or of an extrusion press.

The invention as originally conceived contemplated primarily the construction of a loud speaker structure which was simpler to make, more economical, easier to assemble, which eliminated the need for machining the post, fitting it into the hole of the base plate, and generally providing these advantages while maintaining the necessary critical dimensions. It was discovered that the resulting combined post and base plate was superior in performance to the prior structures. It is believed that some of the reasons for this superior performance are that the joint is eliminated and the drawing of the flat stock or the extrusion of a slug of steel into a hollow piece integral with the base plate results in the grain of the steel being formed into lines which follow the magnetic path of the flux so that the permeability of the post is increased and concentrated at the outside thereof where it approaches the end washer. Whether or not these are the actual reasons or there may be more or others is of no concern, inasmuch as the invention is embodied in structure, and it is inherently intended to claim all benefits which flow from the structure, whether originally contemplated or not.

Accordingly, an important advantage of the invention is the provision of a loud speaker structure of the type which uses a flat annular magnet in which the performance of the structure is improved over prior loud speakers of this kind.

As will be described in detail, the preferred method of manufacturing the combined post and base plate is to form the same from a single member of flat metal stock using punch-press techniques, but the structure which results is capable of being made by other methods. One such method is machining, another molding and a third may be by cold-heading or extruding. At least the first two of these latter three methods are at the present time more expensive than the methods described herein and claimed, and not all of them may be commercially practical with present machinery. It is desired however to point out that regardless of how made, the structure of the invention results in advantages, at least some of which will result with the use of the structure although the method of manufacture of the invention may not be used in making that structure. Extruding will be described as another preferred method of the invention for certain advantages which obtain, as described hereinafter.

Other objects and advantages not specifically enumerated above will become apparent to those skilled in this art as a description of two preferred forms of the invention is set forth in detail, in connection with which the method of the invention will also be described. The drawings which accompany this specification illustrate both forms of the structure of the invention, and also illustrate in more or less diagrammatic form progressive steps used in carrying out the method.

In the said drawings, in which the same characters are used to indicate the same or equivalent elements or parts:

FIG. 1 is a fragmentary sectional view through a loudspeaker of the type which uses a flat annular magnet in which the motor assembly is constructed in accordance with the invention.

FIG. 2 is a view similar to that of FIG. 1 but in this instance a modified form of the invention is illustrated.

FIG. 3 is a perspective view of the post and base plate, or field piece of the loudspeaker of FIG. 1.

FIG. 4 is a perspective view of the post and base plate or field piece of the loudspeaker of FIG. 2.

FIG. 5 comprises a series of sectional views through metal members illustrating the progressive forming of the post and base plate of FIG. 3 in the series A through E, and the progressive forming of the post and base plate of FIG. 4 in the series A through D, followed by E' and F'.

FIG. 6 is a sectional view taken through an arrangement of parts illustrating a modified form of the invention, in which a further method of manufacture may be used to make the combined post and base plate.

The invention is characterized as to its structure by a combined post and base plate in which the two parts are an integral member, there being a hollow cylindrical space within the post so that the wall of the post is substantially the same thickness as the base plate. The end of the post which is remote from the base plate is either perforated or closed, while the end at the base plate is open. One method of the invention is characterized by the steps of forming the combined post and base plate through the use of a series of progressive punch press operations which may be carried out easily by practically any metal stamping shop. A second method of the invention is characterized by the use of extrusion techniques.

Referring now to the drawings, a loudspeaker is shown in sectional view at **10** in FIG. 1. Only the portion of the loud speaker needed to show the environment of the invention has been illustrated, and this is shown in its basic and most simplified form. There is a motor **12** which is secured to the bottom end of the metal basket **14** by some suitable means with which this invention is not concerned. For example, the motor may be cemented to the flange **16** by some adhesive (not indicated). Likewise the motor may be enclosed in some cap or housing which is not illustrated.

The speaker cone is designated **18** and at its apex beneath the dust cap **20** there is secured the cylindrical form **22** upon which the voice coil **24** is wound. The voice coil **24** is coaxial with and extends into an annular air gap **26** that is formed in the magnetic circuit of the motor **12**. The cone and cap are usually made of paper, as is the voice coil form.

The motor **12** is formed of three components, an annular flat permanent magnet **28**, a combined base plate and post **30** and an end washer **32**. For the purposes of the specification and claims which follow, the magnet **28** will be referred to as an annular magnet, the combined plate and post **30** will be referred to as the field piece, and the end washer **32** will be referred to as the pole piece. In the trade the member **30** might be referred to as a "pot" but this is not believed appropriate in this case.

The magnet **28** and pole piece **32** are not new, per se. The magnet **28** is a commercially available ceramic magnet having a central coaxial cylindrical passageway **34** and a pair of opposed parallel surfaces **36** and **38** at its top and bottom, respectively. (Relative directions relate only the to the arrangement of the structures in the drawings.) The pole piece **32** is a simple flat annular steel member which may be readily punched from flat stock, but which must have its center aperture carefully sized, since this forms the outer extent of the air gap **26**. The pole piece **32** is cemented to the surface **36** of the magnet **28**, coaxially therewith. The magnet may be in a plastic jacket (not shown) which is of no consequence to the invention.

The novelty of the invention is primarily in the construction and method of manufacture of the field piece **30**, this being shown independently of the speaker **10** in FIG. 3. The field piece **30** is comprised of an annular flat base plate **40** whose upper surface **42** must be perfectly flat in order to enable the intimate engagement of the lower surface **38** of the magnet **28** thereto. Integral with the base plate **40** and coaxially extending upward from the center thereof there is provided a post **44** of cylindrical formation having a wall thickness of approximately the same dimension as that of the base plate **40**. The center of the post **44** is hollow as shown at **46** and opens to the end at

48. Flux passing through the base plate **40** is concentrated in the walls of the post **44**, following the configuration thereof as the flux path, and such flux is concentrated at the upper end **50** of the post **44**. The post has at least its upper exterior end **50** accurately sized at least directly opposite the pole piece **32** to provide the inside extent of the air gap **26**, in cooperation with the aperture in the pole piece **32**.

The only other critical dimension of the field piece **30** is the height of the axial end surface **52** of the upper end **50** above the surface **42**. Surface **52** must not be too far beyond the sized portion of the post to allow for a rounded edge during manufacture extending above the pole piece.

The loudspeaker **10'** of FIG. 2 differs from the loudspeaker **10** of FIG. 1 in one respect only. In order to prevent the entrance of dust into the interior of the speaker, there is no opening **48** in the field piece **30'** of FIG. 2. Instead there is an end cap **54** and the height of this cap above the surface **42** is critical for the same reasons as the height of the end surface **52**. The loudspeaker structure of FIG. 1 gave excellent performance, with a decrease of flux-fringing over prior devices. The performance of the structure of FIG. 2 theoretically might be not as good because of the likelihood of increased fringing, but this is insignificant.

Although not shown, all assembly may be effected by the use of adhesives.

Referring now to FIG. 5 the illustrations there show the progressive steps in making the field pieces **30** and **30'**. The solid arrows indicate the progression of steps in making the field piece **30'** while the broken line arrows indicate the progression of steps in making the field piece **30**. Punch press techniques are used throughout, and reference generally may be had to my U.S. Patents 3,138,864 and 3,191,421 for the type of apparatus and category of dies suitable for carrying out the steps. Since die design and general techniques are capable of wide variation, no specific die designs need be illustrated. The shapes resulting from the various steps, together with the explanation and reference to my prior patents should be more than sufficient to teach the method of the invention.

The first four basic steps are the same for the making of both types of field pieces, and these steps result in the formations of FIGS. 5(A, B, C and D). In FIG. 5A, a strip of steel stock has been passed between upper and lower die members which, in a single stroke, have punched a circular disc of steel from the flat stock and have partially drawn the blank. This step is called blank and partially draw. The member is designated **60**, and it can be seen that a domed top is forming at **62** while the circumferential ends are starting to turn outward of the main portion, as shown at **64**. The technique is to have a rounded end punch engaging the bottom of the blank **60** and pushing it into an upper cavity whose diameter is substantially smaller than that of the blank but whose entrance is flared. A plunger above the blank on the inside of the upper cavity may eject the piece after the stroke, if necessary.

The second step is redraw and the resulting piece **66** is shown in FIG. 5B. This uses apparatus quite similar to that used to form the piece **60** but without the cutting portion, so that the piece is drawn deeper with the domed end of lesser diameter, while the outer lip becomes much more pronounced as shown at **68**. The central round end punch is of much smaller diameter than that used to make the first draw, so that the formation of the post **44** becomes more apparent.

The piece **70** of FIG. 5C and the piece **72** of FIG. 5D are further draws of the blank, with different dimensions of cavity and punch. In the piece **72**, however, the inside diameter of the cavity preferably has the eventually desired dimension of the end **50**. The outer lip **74** of the piece **72** is finished but for final sizing. The fourth step thus may be called draw and size.

If the field piece **30'** is to be made, from the fourth step described, the piece **72** goes into a sizing die set which coins or "spanks" the piece and at one blow establishes the three critical dimensions. The result is shown in FIG. 5E which is a sectonal view through the field piece **30'**.

If the field piece **30** is to be made, from the fourth step whose result is the piece **72**, the blank goes to a piercing die which forms the opening **76** in the dome end of the piece **78** of FIG. 5E'. This is done by means of an upper punch member and an apertured support within the hollow center **80**. Little or no distortion from the shape of the piece **72** will result from this step.

The next step is called swage, and the illustrated member in FIG. 5F' is designated **30** because the piece resulting from the swaging operation differs from the final form by very little. There is an intervening sizing step. In the swaging operation, an enlarging or swaging tool is piloted into the opening **76**, spreads it and forces the material to move into the wall **44** and opens up the hollow **46**. The resulting piece may have a slight flare at its upper end **50**, the bottom corners **82** may not be as square as desired and the base plate **42** may not be perfectly flat, but the overall shape is present. The hollow opens to both ends. The final sizing operation sizes the piece to establish the three critical dimensions. These are the diameter of the post, at least the upper circumferential end just inside axial end surface, the height of the end surface **52** above the surface **42** and the flatness of the surface **42**. The same dimensions of the field piece **30** are critical.

The steps which are taken in order to achieve the desired construction of the field pieces **30** and **30'** may be recapitulated. From a piece of flat stock the first step is to blank a disc and partially draw. The disc may be punched without drawing, if desired. Next follow several re-draws. These are done in different dies, but the entire operation may be carried out in a single machine with multiple punch heads and die sets, using transfer mechanisms.

After sufficiently drawn to form the general configuration of the post and base plate with a domed upper end, the piece is sized to make the field piece **30'** or it is pierced and swaged before sizing to make the field piece **30**.

The field piece of the invention may be made using extrusion techniques. In FIG. 6 there is illustrated an assembly of a field piece **30''** formed by extrusion, a ceramic annular magnet **28** and a pole piece **32''**. The latter piece may be made by any method. The base plate **40''** differs from the structures described thus far in that it is tapered to a relatively thin peripheral edge **90**. The pole piece **32''** has a correspondingly tapered configuration. The center post **44''** is hollow as shown at **46''** and capped at **54''**, providing an accurately sized upper end **50''** and accurately positioned upper surface **52''**. The post **44''** could be as easily made with a clear-through open passageway as in the field piece **30**. The tapered plate **40''** and pole piece **32''** provide a lighter weight assembly and somewhat improved magnetic characteristics.

In making the field piece **30''** by extrusion, or cold-heading as it is sometimes called, a round bar or billet of steel is used as the basic material, instead of plate or sheet as in the case of the methods described above. A short length or slug of known volume is cut from the bar by any suitable apparatus. If the resulting length is slightly deformed, as in the case of shearing as opposed to sawing or cutting, a preliminary step would be to shape the piece to a symmetrical cylinder in a suitable sizing die. Thereafter, the piece is annealed, phosphatized and placed in an enclosed extrusion die. The complete field piece **30''** is formed in one or more strokes.

The extrusion method requires equipment of quite substantial capacity in order to provide for easy flow of the steel. Accordingly, it is not as preferable as the methods using stamping techniques.

It is believed that the invention has been fully explained to enable an understanding thereof. Those in this art will appreciate that there are many variations capable of being made in the structure and method without departing from the spirit or scope of the invention as defined in the appended claim.

What it is desired to secure by Letters Patent of the United States is:

1. A motor for a loudspeaker which comprises, a field piece having a base plate and a hollow integral cylindrical post extending coaxially from the base plate, the post having an end axial surface spaced from the base plate and an end circumferential surface of predetermined outside diameter, said end axial surface being imperforate so that the hollow has a blind end, the post wall being of approximately the same thickness as the base plate at least adjacent said post, an annular magnetic coaxial with the post, an annular pole piece having an aperture coaxial with said post of predetermined inside diameter larger than the outside diameter, the magnet being sandwiched between the base plate and pole piece with the aperture adjacent the end circumferential surface whereby to form an air gap therewith.

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U.S. Cl. X.R.

29—607; 179—115.5