

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO ELECTROMAGNETIC INSTRUMENTS

(71) We, UMEDA ELECTRONICS ENTERPRISES LABORATORY INCORPORATED, a Japanese corporate body, of 2/33, 2-chome Uehara, Shibuya-ku, Tokyo 151, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to moving-coil type electromagnetic instruments (commonly and hereinafter called "meters") and more particularly to a sub-assembly (hereinafter called a "framework assembly") of small-sized electromagnetic meters, comprising a frame of synthetic-resin (hereinafter called "plastics") material carrying the moving coil and holding a circular magnet.

It is an object of the invention to provide such framework assembly which can be efficiently and accurately assembled by virtue of improved assembly techniques in quantity production in the factory, while achieving a high dimensional stability.

In such a framework assembly, a circular magnet is forcibly press-fitted by an external force into a central cavity of the frame, which is preferably formed from a high molecular resin, having properties of stress resistance and resilient strength, so that the magnet may be correctly centered and cramped (i.e. clamped) by the resulting deformation of the frame and the restoring force of the same, in other words cramped by restorable resilient force from transient strain of the frame.

More specifically, to this end, the frame cramping the magnet and carrying the moving coil is non-forcibly inserted into, and tightened from its external side at symmetric peripheral surfaces by, a cylindrical yoke formed to have a suitable inner diameter such that the force exerted by the cylindrical yoke is added to the cramping restoring force of the frame, so that the magnet will be securely held and, at

the same time, in such a manner that the yoke forms a magnetic field air gap concentric with the magnet.

Another technique for holding a circular magnet in a plastics frame is known. In this case, two small holes are formed on the surface of the magnet, while the frame for surrounding the magnet is provided with a gap of a size suitable to allow smooth insertion of the magnet, as well as small holes at suitable portions thereof, for a thermoplastic processing. In assembling, after placing the frame with its holes in alignment with the small holes of the magnet, so as to correctly center and fix the magnet, the adjacent portion of the frame is heated to allow the resin of the heated portion to project into the small holes of the magnet, thereby to fix the latter.

The present inventor has proposed in US Patent No. 3,348,303 an arrangement in which the meter frame is formed of metallic material and the circular magnet is placed within said frame and held by restoring force of the surrounding yoke; however said metallic frame is formed with high accuracy and has not sufficient flexibility.

In contrast to the foregoing, turning again to the present invention, the resilient restoring force of the cylindric shaped yoke, which is applied from the outside to the frame, is used to compensate for the incomplete restoring of the frame to its original form and insufficient magnet cramping force exerted by the frame, which are likely to occur after the press-fitting of the circular magnet into the plastics frame through a deformation of the latter.

The yoke need not always be cylindrical and seamless. Thus, the yoke may have a partially cut-away circular form having a stretching portion. In such a case, the circular yoke, concentric with the frame, is stretched by external force for insertion of the plastics frame in its spread-out inner diameter and is then released to resume the concentric circular form, thereby to attain

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similar mechanical and electromagnetic purposes.

5 Taking suitability for mass-production and maintenance of moulding precision (dimensional stability) as essential requisites, the raw material of the high molecular plastics frame, which constitutes one of the major parts of the framework assembly in accordance with the invention, is selected from thermoplastic resins, particular importance being attached to qualities of resistance to physical breakage, such as compressive and tensile strength, and to impact strength, hardness, flexural strength, elasticity and so forth. Also, negligibly small coefficient of thermal expansion, high thermal stability and thermal transition point are important factors. The dielectric strength and the antichemical strength are not stressed here because these features are common to all thermoplastic resins.

25 As examples of thermoplastic resins which fulfil these requirements, one may cite poly-carbonic acid ester obtained through a high polymerization of phosgene and Bisphenol A, nylon 6, nylon 6-6 and polysulfonate resin. These various resins have different resistance to chemical strength, however, and it is essential that the kind of bonding agent and its solvent are selected so as to prevent cracking and swelling of the resin by diffusion of solvent which erodes the resin. Also, the bonding agent should have an unartificial hardenability; thus it should be selected from a stabilized level, taking the above stated considerations into account.

40 The invention may be more fully understood from the following description of several embodiments taken in conjunction with the accompanying drawings, in which:

45 Fig. 1 is an elevational view of an example of a rectangular seamless plastics frame which constitutes part of a framework assembly of a meter in accordance with the invention.

50 Fig. 2 is a top plan view of the frame as shown in Fig. 1.

55 Fig. 3 shows the frame after the insertion of a magnet along with a moving coil, this constituting a frame sub-assembly, Fig. 4A, 4B and 4C show the restoring of the frame to its original form, after a deformation of the same for press-fitting the magnet into the frame.

60 Fig. 5 shows a general view of a circular cylindrical yoke.

Fig. 6 shows the yoke as shown in Fig. 5 with its circular form slightly deformed, to a predetermined extent into an ellipse by mechanical pressure, to allow insertion of the frame sub-assembly,

65 Fig. 7 is a plan view of a meter unit in

which the cylindrical yoke is incorporated in the framework assembly for tightening the said frame sub-assembly and for providing a concentric magnetic field.

Fig. 8 is a side elevational view of the meter unit with a part of the yoke removed.

Fig. 9 shows an example of the relation between the yoke and the magnet having pole shoes for forming an uniform magnetic field.

Fig. 10 shows an arrangement in which compensation pieces for locally increasing the diameter of the magnet are located in the air gap between the end of the pole shoes, the surface of the compensation piece engaging the holding groove of the frame, so as to reduce the stress of deformation of the plastics frame as compared with the arrangement shown in Fig. 9.

Fig. 11 shows a modified form of frame, in front elevation, in which the frame has a partial opening.

Fig. 12 is a side elevational view of a meter unit embodying the invention having a framework assembly incorporating a plastics frame having a partial opening.

Fig. 13 is a top plan view of the meter unit as shown in Fig. 12;

Figure 14 shows a perspective view of a circular yoke having a cut-away portion accommodating a small rotatable cam,

Fig. 15 shows the circular yoke of Fig. 14 with its inner diameter increased by enlarging the cut-away portion by cam action.

Hereinafter, the invention will be described in more detail, with reference to the accompanying drawings in which various small parts, jigs and tools, which are self-explanatory, have been omitted for simplicity of explanation and clarity of the drawings.

Referring first to Fig. 1 showing a side elevation of an example of embodiment of a seamless plastics frame 1 which is a principal element of the framework assembly of small-sized electromagnetic meter in accordance with the invention, the central upper portion 2 and the lower portion 3 for supporting a moving coil corresponding to these portions which are to be threaded to permit screwing adjustment of screw bearings for support of the moving coil and other attachments such as shown in the drawings.

The left and right side portions 4, 5 shown by broken lines are provided with arcuate grooves arranged in symmetry, for closely holding the outer diameter of a circular magnet 8. The end edges 4', 5' of these arcuate grooves form an opening smaller by a predetermined dimension than the outer diameter of the circular magnet 8. The projections 4'', 5'' formed at the left and

right sides are intended for correctly locating the circular magnet 8 when the latter is inserted. The vertical posts of the frame 1 further have symmetrical arcuate surfaces 6 and 7 in the outside respectively which are adapted to be embraced and tightened by the resilient restoring force of a cylindrical yoke and to locate the yoke concentrically with the magnet, as described later herein.

Referring now to Fig. 2 showing the top plan of the plastics frame 1 shown in Fig. 1, the arcuate grooves 4, 5 shown by broken lines accurately receive and center the outer diameter of the circular magnet 8 which is shown by a chain line. In this example, adapter portions 9, 10 are unitarily formed if needed.

Referring to Fig. 3 showing an example of a step in the process of assembling the device in accordance with the invention, a moving coil 11 receives predetermined spacers within the coil bobbin, while the magnet 8 is cramped by the spacers. In press-fitting the circular magnet 8, a mechanical force is exerted on the arcuate grooves 4, 5 (referred to as cramping grooves, hereinafter), with the magnet held in the above stated condition.

In the arrangement shown in Fig. 3, magnetic torque generating sections of the moving coil are fitted, as a preliminary operation, to be pivotably movable on both sides of the frame, after insertion of magnet 8 as described above.

The spacers are elements of a small handy jig (not shown) which are adapted to provide equal air gaps between the upper section of the bobbin of the moving coil and the upper surface of the magnet, and between the lower section of the bobbin and the lower surface of the magnet, thereby to ensure constant relative positions between the upper and lower pivot ends and the inner surfaces of the frame, so that press-fitting of the magnet into the frame can be done safely, and they also make it possible to set the direction of the magnetic field of the anisotropic magnet by jig operation.

Referring now to Fig. 4A, in press-fitting the circular magnet 8 into the cramping grooves 4, 5, the original dimension of the end opening gap d_1 between the edges 4', 5' of the cramping grooves is smaller than the outer diameter D of the magnet 8 by $D-d_1$. As movement P_1 is imparted in the direction of arrow 12, the dimension d_1 of the gap between the end edges 4', 5' is spreaded forcibly to d_2 , as will be seen from Fig. 4B. Immediately after the frame has been deformed to make the gap d_2 equal to D , the magnet 8 is press-fitted into the space between both cramping grooves 4, 5, as shown in Fig. 4C, so as to be held stationary by these grooves.

During this insertion step, the outer periphery of the magnet 8 expands forcibly the gap between the end edges of the cramping grooves and frictionally slides on the surface of these edges. Therefore, it is of some help to apply a very small amount of bonding material solvent, which also acts as a lubricant, to these end edges, conveniently by means of a pen point or a small brush. Points to note in regard to the solvent of the bonding material have been stated already.

In Fig. 4C, the concentric annular zone around the magnet, designated g , is a magnetic field gap defined by two arcuate surfaces 6, 7 adapted to fit the inner diameter Y of a concentric circular yoke.

The aforementioned moving coil has been omitted from Figs. 4A to 4C, for the sake of clarity.

Fig. 5 is perspective view of a seamless cylindrical form of circular yoke 15 having an inner diameter Y_0 . This particular form of circular yoke is not essential: the yoke may be a press-formed member having a break in its wall and a cut-out portion, for spreading the inner diameter of the yoke by means of a cam, as shown for example in Figs. 14 and 15, so that a particular structural condition can be created as described later.

Fig. 6 shows an example of an external force, exerted by a vice, applied to a concentric yoke consisting of a seamless cylindrical body. The vice is provided with a fixture V_f and a movable member V_m . The inner contact surface adapted to impart a pressure to the yoke 15 is curved at a curvature suitable for making a circle into an ellipse.

A limited pressure P_2 is exerted on the inserted yoke 15, in the direction of the arrow. As the pressure P_2 is exerted, the diameter Y_0 of the yoke 15 is reduced to Y_0-y , in the direction in which the pressure is exerted, and is increased to Y_0+x , in the direction normal to the pressure, so as to produce the predetermined major axis of an ellipse of sufficient size to prevent forcible insertion of the frame into the yoke when it is inserted by an operative's fingers. The diameter Y_0 is such as to enable the yoke to tighten securely onto the external transverse dimension of the frame, owing to the restoring force inherent in the work-hardened resilient strength of the yoke, acting as hereinafter described.

After insertion of the frame 1, in which the magnet 8 with movement 11 has already been placed, into the yoke the length of whose major axis Y_0+x has been kept to the minimum necessary to permit this insertion the vice immediately releases the yoke 15, so that the yoke 15 then presses onto the aforementioned arcuate surfaces 6, 7, owing

to its inherent restoring force, with a desired pressure on the outer side of these symmetrical surfaces. Insufficient centering accuracy of the magnet cramping section of the frame which has been deformed and insufficient accuracy attributable to incomplete restoring of the frame, and all other factors which would transiently affect the correct centering and holding of the magnet by the frame, are corrected by the tight gripping force of the yoke, so as to achieve a magnetic field having a uniform and concentric gap g as shown in Fig. 4C.

In safely carrying out the insertion by imparting a deformation to the cylindrical yoke with an external force, there must be a practical limit to the length of the major axis of the ellipse; otherwise, a residual strain would be caused in the material and deteriorate the restoration to the original true circular form of the yoke. Thus, for obtaining a good restoration precision of the plastics frame, which has been deformed from the normal dimension or substantially from the normal dimension, i.e. in correcting and restoring with cramping the frame for insertion into the yoke, it is not permissible to mechanically deform the yoke beyond an upper limit of ellipse, nor to further forcibly pressfit the frame by the use of fingers. For this reason, the framework assembly in accordance with the invention necessitates a yoke shaping means which fulfills these requirements.

The partially cut-away cylindrical yoke, which is not in the form of a closed loop, can have an allowance of deformation larger by 30% or more at the effective inner diameter than that of the closed seamless cylindrical shaped yoke.

To explain in more detail, referring to Fig. 14 and Fig. 15 showing the perspective views of the yoke 35, this yoke 35 has been made from a steel plate by press-forming, and has an elasticity due to work-hardening. The cut-away portion 36 is provided with an opening 38 adapted for engagement with a cam 37 (of a jig) shown by a chain line.

The yoke has an original inner diameter of Y_o . The cam 37 is inserted with the orientation denoted by arrow 39 in Fig. 14.

As the cam is rotated in the direction of arrow 40 in Fig. 15, it acts to enlarge the opening 38 to increase the circumferential length of the yoke, thereby to expand the inner diameter of the same to $Y_o + \alpha$. It will be understood that the allowable expansion of the inner diameter of the yoke can be increased, whereas the stress due to the deformation is decreased, in the partially cut-away cylindrical yoke, as compared with the closed seamless yoke having no cut-away portion. Consequently, it becomes possible to standardize the mounting process, which would hardly be possible in

the case of the vice operation with the closed seamless yoke.

Fig. 7 shows a top plan view of a device in accordance with the invention after execution of the mounting operations which have been described above. A moving coil supporting screw bearing 13, illustrated at the center of Fig. 7, supports the upper pivot of the moving coil 11. The stability of the centering of the pivot axis is governed by the precision and holding force of the plastics frame and the stress resistance of the frame.

Fig. 8 shows a side elevation of the embodiment shown in Fig. 7. It will be seen that the moving coil supporting screw bearing 14 at the lower center supports the lower pivot of the moving coil 11. In this figure, the concentric circular yoke 15 has been partially cut-away to show the arrangement of the magnet 8 and the moving coil 11.

In order to obtain an uniform distribution of the magnetic field intensity, pole shoes may be provided in conformity with the polarity direction of the magnet. In contrast to the foregoing embodiment, the cramping grooves may be made to engage the magnet in the following manner.

Referring to Fig. 9, the breadth D' of projection of the pole shoes 16, 16' is slightly larger than the sum $D+t$ of the diameter D of the magnet and thickness t of the pole shoe. Therefore, the edge 5' of the cramping groove 5 is positioned at the depth of either one of the two gaps between the pole shoes, e.g. to the depth of the right-hand side end of the pole shoe 16' in the illustrated example, and, subsequently, the gap at the left-hand side of the magnet is inserted, so that the arcuate surface portions of the magnet appearing at the two gaps between the ends of the pole shoes 16, 16' may form the engagement portions which cooperate with the two arcuate surfaces of the cramping grooves of the plastics frame.

The expansion deformation of $D+t$ produces considerable elastic stress during subsequent restoration of the rectangular seamless frame. Thus the end clearance gap d_1 is transiently increased by d when, immediately after the insertion, the magnet comes to assume the position shown by line 17. In this embodiment, it is necessary to suitably increase the axial longitudinal length of the plastics frame, so as to achieve the desired elastic restoring effect.

When pressure is applied to the frame in the longitudinal direction of the same, the plastics frame as a whole is necessarily deformed so as to enlarge the gap of the magnet cramping section. Thus, when such a shape of magnet is press-fitted, it is possible to apply only a slight external force to the frame on the jig in the longitudinal

direction, so as to prevent occurrence of excessive stress in the material of the frame, thereby to minimize the strain attributable to the local stress, so that the material of the plastics frame may have only the original elasticity, i.e. the restoring force inherent in the shape and the material. The application of pressure in the longitudinal direction may be used, in all the embodiments of the invention herein described, for facilitating the demounting of the movement with magnet from the frame, as occasion demands, provided that the plastics material of the frame is such as to allow the repeated elastic deformation for mounting and demounting thereof.

In the embodiment shown in Fig. 10, the stress factors are decreased as compared with the foregoing embodiments. In the gaps between the pole shoes 18, 18' of the circular magnet there are positioned compensation pieces 19, 19' of non-magnetic material which are fixed to the magnet to serve as the engaging portions for engagement with the cramping grooves 4, 5 on the symmetric portion having inner diameter D2. In this embodiment, as compared with the method of fitting as described above and shown in Fig. 9, since the dimension E is greater than D', the magnet is press-fitted into the plastics frame by an external force in such orientation as to make the projection breadth D' confront the gap d3 between the cramping groove edges, i.e. in the same orientation as in the case of the example shown in Fig. 4, so that the cramping arcuate grooves 4, 5 may cramp the engaging portions of the magnet, the diameter of which has been locally increased to D2 by the compensation pieces 19, 19'. Thus the transient strain of the frame at press fitting of the magnet is reduced.

When the end portions of the pole shoes project, the bonding agent should be applied only to the portions of the compensation piece between the pole shoes ends, so as to avoid contamination by the bonding agent. However, it is not always necessary to apply the bonding agent in two symmetrically opposite locations.

In the foregoing embodiments, a seamless plastics frame is used as the element of the framework assembly of the electromagnetic meter in accordance with the invention.

The stress attributable to support loading of the movement and the reset-spring's damping force etc. is negligibly small. In addition, the external pressure applied during the mounting of the meter unit to a housing base is conveniently absorbed by the cylindrical yoke, so that no strain is caused in the plastics frame. Thus, taking into account that the maintenance of

precision of the frame against the deformation for the press-fitting of the magnet and the restoring, as well as the tightening force of the cylindrical yoke, is essential, the seamless frame consisting of plastics body is expected to satisfy the requirements of the frame against the residual stress, if any, and the restoring torque after the press-fitting of the magnet, through distributing the internal stress and through keeping the counterbalance of the molded shape and thickness.

As distinct from the above, a partly open plastics frame has been subjected to a test employing a constant temperature bath of -15°C to 60°C , in which no anomalous deviation of the center axis of the plastics frame has been observed. Thus, provided that the physical properties and plastics formation are compatible, the reliability of the holding precision is reduced to the sole problem of stability of the center axis for supporting the center of the movement. Therefore, the partly open frame may be employed as the principal element of the assembly having the requisites of the invention.

Both the closed and the partly open types of frame can be processed in the same way, as described above, up to the completion of the meter unit. However, in case of the partly open plastics frame, the deformation during the press-fitting of the magnet does not affect the open portions of the frame which are illustrated at the upper portion of Figs. 11 and 12 of the drawings. Thus, it is ensured that the whole of the opened portion is freed from the stress-strain attributable to the deformation, in good contrast to the case of the seamless plastics frame. Further, it is an advantage of the partially open frame that it has no weld line of the plastics body, which is likely to occur in the molding of the closed loop of the seamless frame. Since the frame in the device of the invention is subjected to an extremely large stress when deformed to allow the press-fitting of the magnet, the welding line, if it is formed, may be the cause of breakage of the frame. In order to prevent the occurrence of the welding line, an extremely severe control of molding condition is required, and the unsatisfactory molded goods are wasted. From this point of view, the latter type of frame, i.e. the partly open frame, is expected to ensure a better yield of usable parts.

Fig. 11 is an elevational view of an embodiment incorporating a partly open plastics frame 21. The upper and lower bearing portions 22, 23 are positioned on the extension of the neutral line 24, while cramping grooves 25, 26 are positioned symmetrically, for press-fitting therebetween the circular magnet 27. The

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outer surfaces 28, 29 constitute arcuate surface to which the inner surface of the cylindrical yoke 30 is to be pressed. Projections 31, 32 are intended for locating and defining the portions at which the frame is tightened by the cylindrical yoke and to locate correctly the frame on a housing base of a meter unit.

In this embodiment, adapters as shown in Fig. 2, 9 and 10 are omitted. Numeral 33 as shown at the right-hand side lower portion of the Figure is an injection gate for pouring the molten resin material, provided on the plastics die-tooling. The molten resin poured from this gate flows through the mold in respective directions by pressure feeding, and the parts made of the flowing material never meet one another, so that no welding line is formed.

To explain in more detail of this embodiment, the section taken along the line X—X' of Fig. 11 is identical to that of the Fig. 3, and the cycle of deformation of the frame 21 during the press-fitting of the magnet 27, at lower ends of the magnet cramping grooves 25, 26, is identical to that shown in Fig. 4A to 4C. However, in this embodiment, the portion of the frame above the lower end of the magnet as viewed in the Figure is allowed to move freely at the time of press-fitting the magnet, and no stress is caused in this especially in the upper central axis holding portion.

In assembling the device, plastics frame, in which the magnet and moving coil have already been mounted, is inserted into the cylindrical yoke which has been deformed by a predetermined external force to create a longer diameter (or major axis) of the ellipse, in the manner shown in Fig. 6.

Then, immediately after the insertion, the yoke is released from the external pressure, so that the yoke comes to press the arcuate surfaces 28, 29 and its restoring force adds reinforcement to the frame.

Thus, the cylindrical yoke functions as a part of the framework assembly, cooperating with the centrally disposed magnet cramping frame, irrespective of whether the frame is the closed seamless one or the partially open one. When the frame has a suitable restoring accuracy, the yoke embraces the frame with optimum cramping force. If the frame exhibits incomplete restoring characteristics, the restoring force of the yoke is exerted to grip and correct the centering with accuracy of the frame when the yoke embraces the frame with tightening force. At the same time, as in the case of the foregoing embodiment, a magnetic field-gap concentric with the circular magnet is formed.

Fig. 12 is a side elevational view of a meter unit assembled in accordance with

this embodiment. Minor parts are omitted for the sake of clarity of the drawing. The pivot of the moving coil 34 is supported on the extension of the arrow line 24 which represents the center line. In spite of the hysteresis of the deformation by the external force and the tightening load exerted by the yoke, no visible deviation of the center of the frame is caused by the remaining stress.

This Figure shows the state of cooperation of cramping groove 25 and a part of the circular magnet 27, as well as the relative position of the moving coil 34, omitting a part of the yoke 30. Fig. 13 shows a top plan view of the meter unit as shown in Fig. 12. It will be seen that the circular magnet 27 is pressed and held by arcuate cramping grooves 25, 26 of the frame 21, while the cylindrical yoke 30 presses and holds the frame 21 at the arcuate surfaces 28, 29 of the frame which are located in symmetry and just outside of the cramping arcuate grooves 25, 26. As will be seen from the drawing, the boss of pointer 34' may be attached such that the direction of the pointer coincides with the direction in which the coiling of the movement is set, this embodiment having the pointer direction perpendicular to the direction of the coil winding.

The framework assembly, providing for the creation of the magnetic field in a small-sized electromagnetic meter, having the above described construction greatly contributes to economy in cost. Conventionally, in the production of such meters, half-finished magnetic field formations having a frame combination unit made entirely of metal, which requires a high temperature process of hard soldering to secure the magnet, have been brought in from outside suppliers. However, the invention can employ assembly line techniques without large capital expense, so that the production of the meter may be carried out by using the improved construction.

As described hereinabove, the improved framework assembly of electromagnetic meter of the invention is mainly directed to the manufacture of such articles which are in common demand, by taking the value analysis for meter instruments, but should not be limited to such. It will be apparent that various modifications may be made in the form, construction and arrangement of the parts hereinbefore described without departing from the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:—

1. A framework assembly for rotatably supporting a moving coil of an electromagnetic instrument, comprising in structural combination:

outer surfaces 28, 29 constitute arcuate surface to which the inner surface of the cylindrical yoke 30 is to be pressed. Projections 31, 32 are intended for locating and defining the portions at which the frame is tightened by the cylindrical yoke and to locate correctly the frame on a housing base of a meter unit.

In this embodiment, adapters as shown in Fig. 2, 9 and 10 are omitted. Numeral 33 as shown at the right-hand side lower portion of the Figure is an injection gate for pouring the molten resin material, provided on the plastics die-tooling. The molten resin poured from this gate flows through the mold in respective directions by pressure feeding, and the parts made of the flowing material never meet one another, so that no welding line is formed.

To explain in more detail of this embodiment, the section taken along the line X—X' of Fig. 11 is identical to that of the Fig. 3, and the cycle of deformation of the frame 21 during the press-fitting of the magnet 27, at lower ends of the magnet cramping grooves 25, 26, is identical to that shown in Fig. 4A to 4C. However, in this embodiment, the portion of the frame above the lower end of the magnet as viewed in the Figure is allowed to move freely at the time of press-fitting the magnet, and no stress is caused in this especially in the upper central axis holding portion.

In assembling the device, plastics frame, in which the magnet and moving coil have already been mounted, is inserted into the cylindrical yoke which has been deformed by a predetermined external force to create a longer diameter (or major axis) of the ellipse, in the manner shown in Fig. 6.

Then, immediately after the insertion, the yoke is released from the external pressure, so that the yoke comes to press the arcuate surfaces 28, 29 and its restoring force adds reinforcement to the frame.

Thus, the cylindrical yoke functions as a part of the framework assembly, cooperating with the centrally disposed magnet cramping frame, irrespective of whether the frame is the closed seamless one or the partially open one. When the frame has a suitable restoring accuracy, the yoke embraces the frame with optimum cramping force. If the frame exhibits incomplete restoring characteristics, the restoring force of the yoke is exerted to grip and correct the centering with accuracy of the frame when the yoke embraces the frame with tightening force. At the same time, as in the case of the foregoing embodiment, a magnetic field gap concentric with the circular magnet is formed.

Fig. 12 is a side elevational view of a meter unit assembled in accordance with

this embodiment. Minor parts are omitted for the sake of clarity of the drawing. The pivot of the moving coil 34 is supported on the extension of the arrow line 24 which represents the center line. In spite of the hysteresis of the deformation by the external force and the tightening load exerted by the yoke, no visible deviation of the center of the frame is caused by the remaining stress.

This Figure shows the state of cooperation of cramping groove 25 and a part of the circular magnet 27, as well as the relative position of the moving coil 34, omitting a part of the yoke 30. Fig. 13 shows a top plan view of the meter unit as shown in Fig. 12. It will be seen that the circular magnet 27 is pressed and held by arcuate cramping grooves 25, 26 of the frame 21, while the cylindrical yoke 30 presses and holds the frame 21 at the arcuate surfaces 28, 29 of the frame which are located in symmetry and just outside of the cramping arcuate grooves 25, 26. As will be seen from the drawing, the boss of pointer 34' may be attached such that the direction of the pointer coincides with the direction in which the coiling of the movement is set, this embodiment having the pointer direction perpendicular to the direction of the coil winding.

The framework assembly, providing for the creation of the magnetic field in a small-sized electromagnetic meter, having the above described construction greatly contributes to economy in cost. Conventionally, in the production of such meters, half-finished magnetic field formations having a frame combination unit made entirely of metal, which requires a high temperature process of hard soldering to secure the magnet, have been brought in from outside suppliers. However, the invention can employ assembly line techniques without large capital expense, so that the production of the meter may be carried out by using the improved construction.

As described hereinabove, the improved framework assembly of electromagnetic meter of the invention is mainly directed to the manufacture of such articles which are in common demand, by taking the value analysis for meter instruments, but should not be limited to such. It will be apparent that various modifications may be made in the form, construction and arrangement of the parts hereinbefore described without departing from the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:—

1. A framework assembly for rotatably supporting a moving coil of an electromagnetic instrument, comprising in structural combination:

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a main element consisting of a unitary plastics frame which is formed of high molecular resin material having the properties of stress resistance and resilient strength, a circular cylindrical magnet and a tightening member consisting of a circular cylindrical magnetic yoke;

said plastics frame comprising a pair of vertical posts providing lengthwise symmetrically disposed inner arcuate grooves, the grooves having end edges which define opening gaps therebetween, which are dimensionally less than the distance between the inner arcuate cramping surfaces of the grooves, the magnet being centrally disposed in the frame and press fitted into close engagement between the inner cramping surfaces of the grooves, the frame having symmetrical external surfaces of predetermined peripheral diameter having an axial length which cooperates with an axial length of the circular cylindrical magnetic yoke, the frame with the magnet and a moving coil mounted within it being securely tightened by said yoke, the yoke providing a resilient restoring force owing to its own work hardened property after removal of an external deforming force, the arrangement being such that the structural arrangement provides a magnetic field gap concentric with the magnet.

2. A framework assembly according to claim 1, wherein the circular cylindrical magnet is pressed into position by external force directed to the opening gap, the gap being enlarged owing to frictional sliding of the oversized outer surface of the magnet, the magnet being then cramped by the cramping surfaces owing to the resilient restoring force from transient strain of the frame.

3. A framework assembly according to claim 1, wherein the frame having mounted therein the magnet and supporting a moving coil is non-forcibly inserted into the major diameter of an elliptical space formed by application of a necessary minimum external force in a diametral direction to the cylindrical yoke, said force being then released from the yoke to secure tightening of the frame with the centrally disposed magnet.

4. A framework assembly according to any one of claims 1, 2 and 3, wherein the main element is moulded to have a closed seamless construction.

5. A framework assembly according to any one of claims 1, 2 and 3, wherein the main element is moulded to have an open portion.

6. A framework assembly according to claim 3, wherein the tightening member consisting of the circular cylindrical yoke is formed in seamless manner and is deformable during assembly by use of a vice jig.

7. A framework assembly according to claim 3, wherein the tightening member consisting of the circular cylindrical yoke is formed with a break portion in its periphery by means of which during assembly the circumferential length is stretched by engagement of a cam within a cut-away portion at the break portion.

8. A framework assembly according to any one of claims 1 to 7, wherein symmetrically arranged compensation pieces are provided between end portions of two pole shoes of the magnet to reduce the transient strain of the frame at press fitting of the magnet, these compensation pieces being formed from non-magnetic material fixed to the magnet between said portions and being closely engaged by the inner cramping section of the frame.

9. In or for an electromagnetic instrument, a framework assembly substantially as herein described with reference to the accompanying drawings.

10. A method of forming a framework assembly for an electromagnetic instrument, substantially as herein described with reference to the accompanying drawings.

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