Jan. 19, 1965 H. R. FEHLING ETAL 3,166,618

METHOD OF MAKING A NIB FOR A BALL POINT WRITING INSTRUMENT

Filed Sept. 27, 1960 4 Sheets-Sheet 1

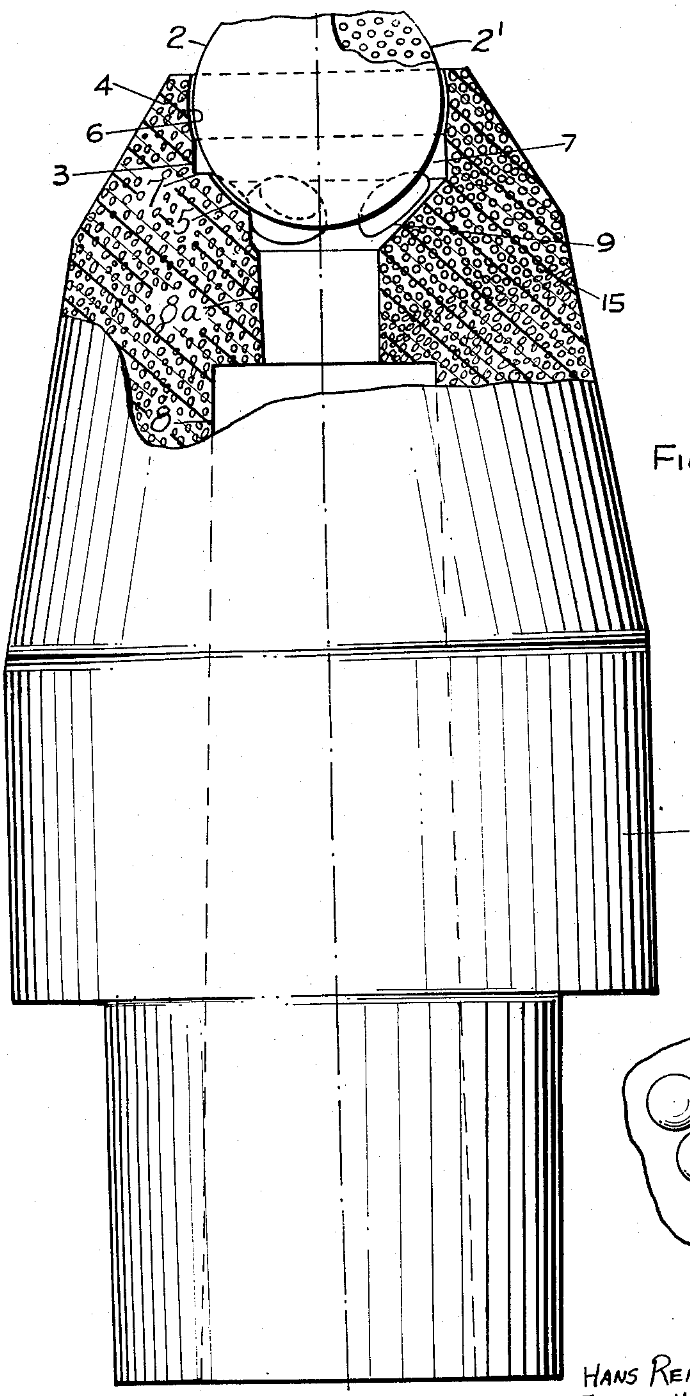

Fig. 1.

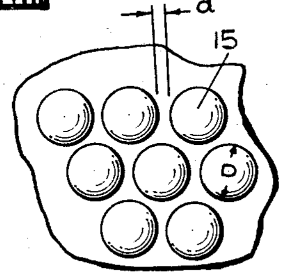

Fig. 2.

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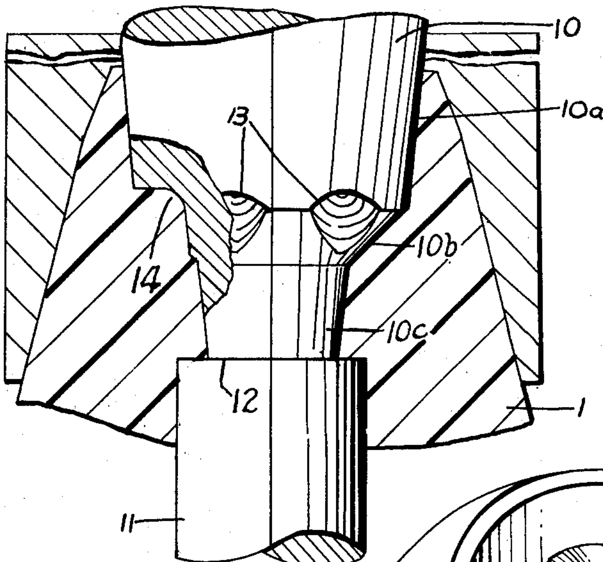

FIG. 3.

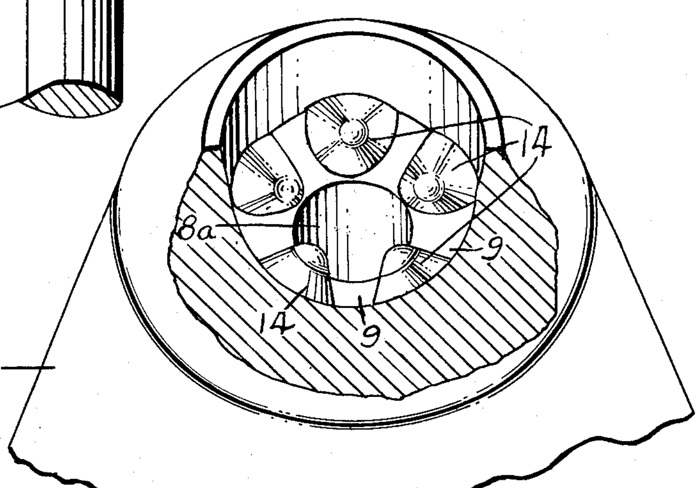

FIG. 4.

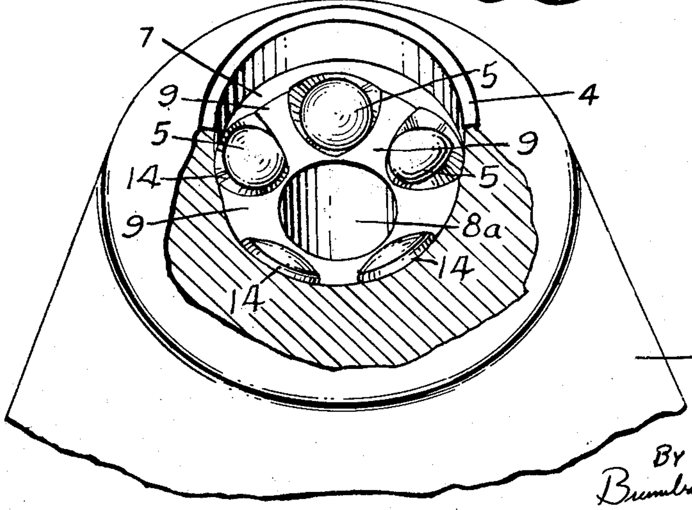

FIG 5.

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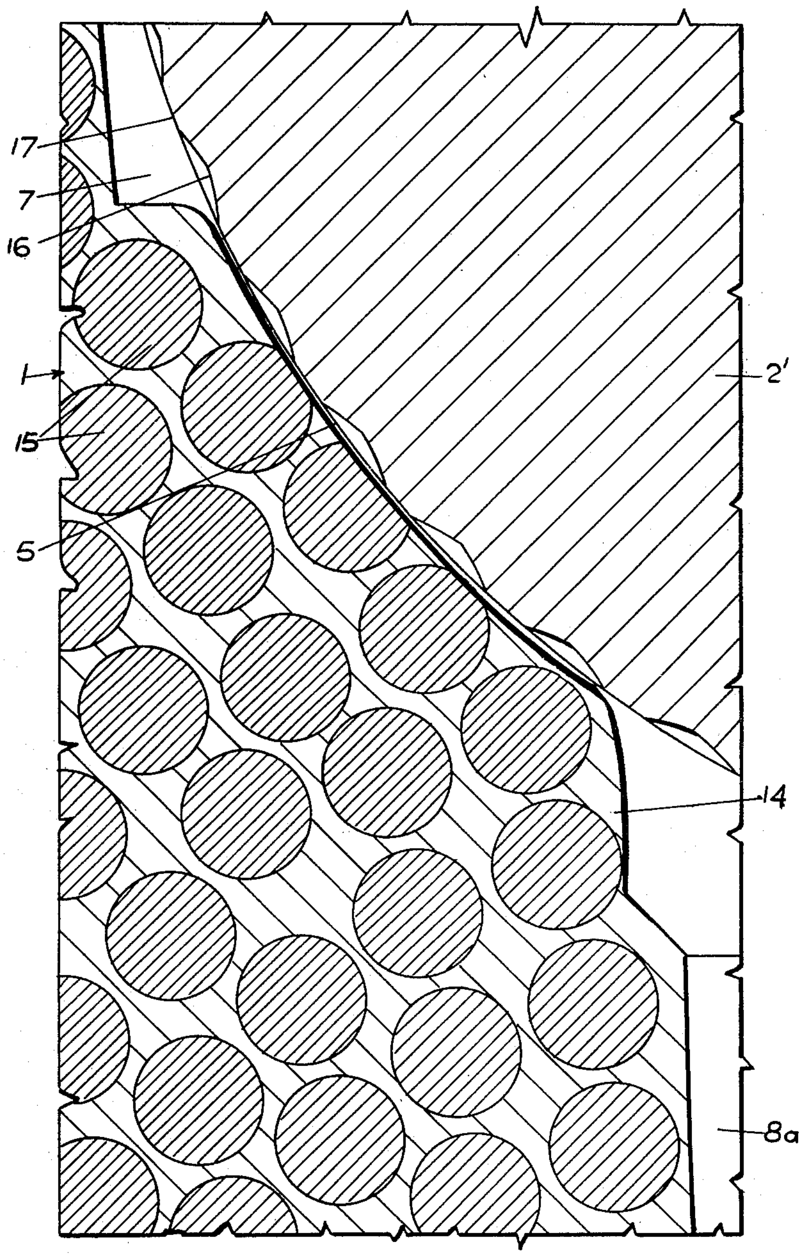

Fig. 6.

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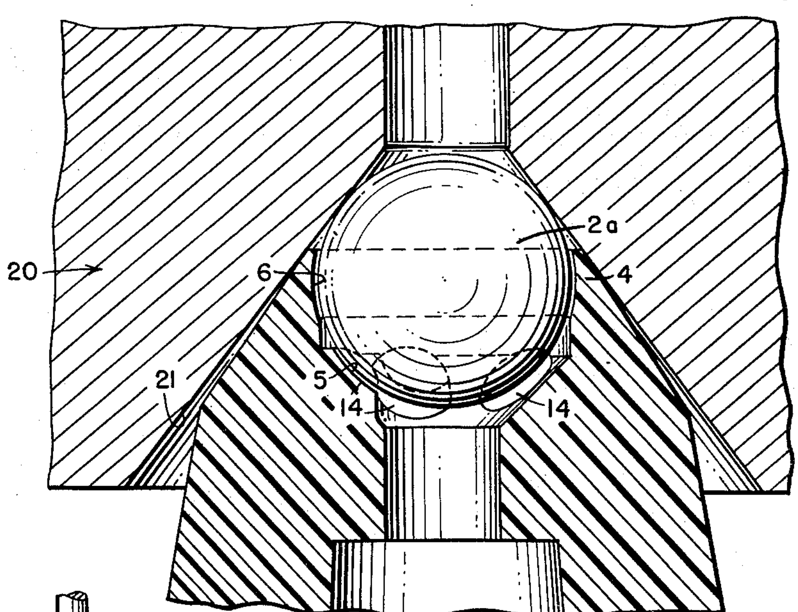

FIG. 7

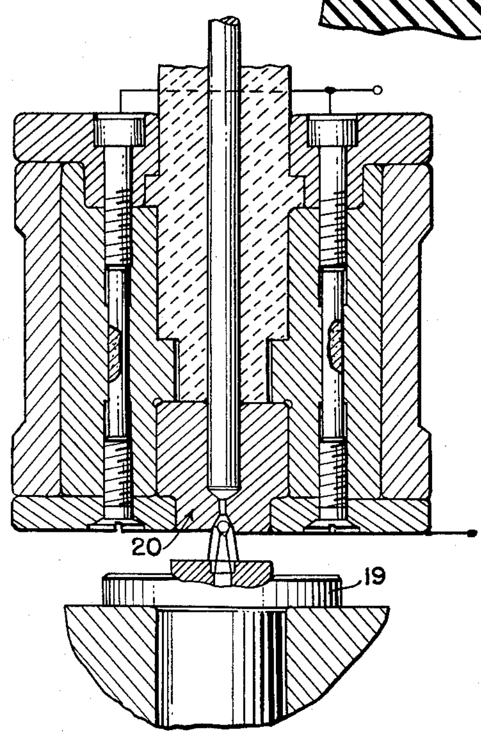

FIG. 8

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METHOD OF MAKING A NIB FOR A BALL POINT WRITING INSTRUMENT

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5 Claims. (Cl. 264—242)

This invention relates to writing extremities or nibs for ball point writing instruments and, more particularly, to new and improved methods for making nibs.

In most of the conventional ball tipped writing instruments the writing extremity or nib incorporates a socket or housing for a writing ball which latter partly protrudes from the socket or housing but is rotatably held therein, without substantial play, between an inturned lip and a base seat within the housing and is supplied with a writing substance (hereinafter referred to as ink) through a feed duct leading through the base seat to the ball, the arrangement and disposition of the parts being such that as the ball is rotated such as by being moved over and in contact with a writing surface such as a sheet of paper the ball carries a thin film of ink through the narrow gap formed between the ball and its housing which film is deposited on said surface as a writing trace. In general the bearing surfaces or seating surfaces provided in the housing for the ball are part-spherical and comprise a part-spherical lateral seating surrounding the ball in the region of the ball equator and a part-spherical base seat (which may be discontinuous, being divided by at least one ink channel leading outwards from the end of the feed duct). Typical designs of housing are shown in United States Patent No. 2,390,636.

Proposals have been made in the past to manufacture the nib of such a writing instrument from a thermoplastic material. Though this method is very attractive in view of its obvious suitability for mass production of an article at a low cost, all attempts so far have failed to produce a writing instrument with a satisfactory writing performance. It was not only found that the trace was generally poor but also that its quality changed during the use of the instrument.

We have found that these faults could not even be eliminated by precision molding of nibs having a suitable housing design in a tough material like a synthetic polyamide resin, and that the principal reason for the poor performance lies in the lack of rigidity of all suitable thermoplastic materials. Subsidiary reasons are dimensional instability and permeability to water vapour of such materials, as well as the difficulty of producing a nib in such materials which gives a writing trace heavy enough to be acceptable.

Lack of rigidity is a result of the low modulus of elasticity of thermoplastic materials (1×10^4 to 5×10^5 p.s.i.) compared with that of metals (1×10^7 to 3×10^7 p.s.i.) which are conventional materials for ball-point pen nibs. In many cases this low modulus is further reduced by absorption of moisture. Due to this lack of rigidity the socket or housing is slightly distorted under the writing pressure so that a sufficiently even handwriting trace cannot be produced under normal variations of writing angle and load.

Far from being of assistance, the resilient nature of such materials is their main defect for the present purpose. A good writing performance depends on the maintenance of a very small but substantially uniform radial clearance. As has been established, this object is defeated by any significant elastic movement of the base seat and and/or the distortion by bending of the lateral seat encircling the ball, when these seats and thereby the housing structure are subjected to fairly substantial and complex stresses. The compressive stresses on the average base seat for a 1 mm. ball range, for example, from 1,000 to 3,000 p.s.i.

Lack of dimensional stability also influences the gap or clearance between the housing and the writing ball, which in turn causes variations in the depth of trace. With most thermoplastic materials the dimensional instability is due to their hygroscopic nature, which results in swelling on absorption and shrinkage on loss of moisture.

Permeability to water vapour is very detrimental where moisture setting inks are used. Most modern ball-point pen inks are now based on organic solvents which have an affinity for water. If these modern moisture setting inks are contained in thermoplastic vessels exposed to normal temperate conditions, they absorb moisture through the walls of such vessels and suffer a decrease in viscosity which is most undesirable. Furthermore, the absorbed moisture may cause the precipitation of some constituents of the ink, and result in the blockage of the very narrow ink filled passages adjacent to the ball thus rendering the instrument useless.

Finally, it is difficult to produce a nib from plastic material which gives a writing trace of sufficient depth. In order to form the seatings and shape the rim of such a plastic nib to retain the ball, the nib usually has to be heated by some means and thus rendered into a plastic condition. In this plastic condition the housing is formed around the ball, or other spherical or part-spherical former, by the application of pressure. As the coefficient of thermal contraction of plastic materials is larger than that of metals, the housing, on cooling, shrinks tightly on to the ball. Even when it is possible to rotate the ball when writing with such an instrument, the writing trace is very faint.

In previous proposals it has been suggested that the slight grip exercised on the ball by the resilient rim of a plastic nib is an advantage, e.g. in order to avoid leakage when the pen is not in use and in order to achieve some kind of modulation in the depth of trace when varying load is applied to the pen during writing. We have found that such a grip is, on the contrary, most undesirable and that, for a satisfactory writing performance, it is necessary to effect accurate control of the gap or clearance between the ball and its housing in order to obtain the desired depth of trace together with complete freedom of rotation of the ball. The foregoing also applies when the nib is injection-molded around a spherical or part-spherical former.

One object of this invention is to overcome these difficulties, at least in part, and to devise means of producing a ball-point pen nib from a suitable thermoplastic material, such that the resulting writing instrument performs satisfactorily. As used hereinafter the term "nib" refers either to the "blank," or partially formed product of the molding operation, or to the completely formed writing tip, with or without the writing ball. With this object in view, the invention consists in a method of manufacturing a nib for a ball point pen by injection molding from an injection-moldable material consisting of a suitable thermoplastic material which is so loaded with a finely divided solid filler of suitable size and shape that the elasticity modulus in compression of the molded material is not less than 6×10^5 p.s.i. and preferably exceeds 8×10^5 p.s.i. By "injection-moldable" we mean that the loaded material is capable of being injection molded. The thermoplastic material is preferably a synthetic polyamide resin or similar wear resistant plastic having preferably an elasticity modulus in compression of not less than 1×10^5 p.s.i. such as polycarbonate or acetal resins.

The filler apart from additives, if any consists preferably of granular, preferably rounded or spherical solid particles and has preferably an elasticity modulus in compression of not less than 2×10^6 p.s.i. The injection-molded material contains preferably not less than 20 percent by volume of such granular filler. The filler material should be dimensionally stable and impermeable to water vapour. Apart from the filler the material may contain small quantities of additives, e.g., pigments and/or low friction substances like graphite or molybdenumdisulphite. Copper powder, in bead form, is a particularly satisfactory filler.

The invention provides the further step, in the manufacture of a ball point nib by the method above defined, of forming the part-spherical seating surfaces in the socket or housing subsequently to the molding operation by permanently deforming the material of the nib around a ball or ball-like member, inserted in the socket, under the application of pressure and of sufficient heat to render the material sufficiently plastic to conform to the surface of said member. Subsequent to the deformation of the material around the ball or ball-like member, the latter may be withdrawn and a writing ball of slightly smaller diameter may be inserted.

The invention also consists in providing a rigid injection-moldable material suitable for articles manufactured by injection molding and having an elasticity modulus in compression of not less than 6×10^5 p.s.i. consisting of a thermoplastic material loaded with preferably at least 20 percent by volume of a finely divided granular filler having an elasticity modulus in compression of not less than 2×10^6 p.s.i., and a melting point above the molding temperature. Preferably the thermoplastic material is a synthetic polyamide resin or similar wear resistant plastic, and the filler consists of substantially spherical particles. Polyhexamethylene-sebacamide is a particularly suitable material.

The invention further consists of a nib, for a ball point pen, at least the housing of which nib is manufactured by injection molding a mixture of a synthetic polyamide resin or similar wear resistant material as a matrix and a finely divided solid filler of suitable size and shape such that the elasticity modulus in compression of the molded material is not less than 6×10^5 p.s.i. and preferably exceeds 8×10^5 p.s.i.

In this specification all figures for the elasticity modulus of plastic materials refer to the latter in the completely dry state at a temperature of 20° C. This state can, for example, be attained by storing the material over calcium chloride for a sufficient time. The material as molded is not necessarily completely dry.

All metals commonly used in the manufacture of ball point pen nibs are sufficiently rigid to withstand any noticeable distortion under writing pressure. The elasticity modulus of brass and aluminum alloys is, for example, of the order of 1×10^7 p.s.i. On the other hand, all such metals are subject to significant wear due to the abrasive effect of dust and fibers picked up by the writing ball and entrained into the nib by its rotation.

Synthetic polyamide resins have considerable wear resistance and have in fact proved superior from this point of view to metals when used for the manufacture of ball point nibs. But the compression modulus of this class of materials is less than one tenth of that of metals.

Hence, a very considerable amount of stiffening is required though, surprisingly, it has been found to be unnecessary to increase the modulus beyond about 20 to 25×10^5 p.s.i., which is well below that of any metal suitable for nib manufacture. According to this invention this is achieved by filling the plastic material with a rigid filler. However, the thermoplastic material may easily lose its injection moldability if the concentration of solid filler is too high. Rigidity of the molded material can, therefore, only be increased at the expense of moldability, and vice versa.

We have found that the fractional volume occupied by the rigid filler in the filled material is not by any means the only factor deciding the ultimate rigidity of the filled material when molded. Particle shape and size distribution are very important, so that it is not generally possible to lay down hard and fast rules how to obtain good (and still less the best) results, in terms of a choice of values for the factors mentioned. We have, however, discovered that the control of both the lowest permissible fluidity to ensure injection moldability and the highest attainable rigidity obtainable with a given filler, the combination of which would obviously give the best possible result, can be obtained by the following method steps:

(1) Take a fine powder of a suitable rigid material and screen off all particles larger than approximately 0.002 in.

(2) Pour the dry powder into a suitable container and determine the maximum fractional volume occupied by the filler when packed in dry air, e.g., by shaking it down.

(3) Prepare a dense and uniform suspension of the filler in a suitable liquid, e.g. castor oil, such that the fractional volume of the filler is a little less than the maximum fractional volume in air as determined under (2).

(4) Test whether this suspension when uniform will flow in an even, though slow, stream without blockage when pressed out of a syringe with an orifice of, say, $\frac{1}{16}$ inch internal diameter.

(5) If the test under (4) is not satisfactory, diminish the fractional volume of the filler, still further e.g. by adding liquid, until the required minimum fluidity is achieved.

(6) Prepare a molding powder in which the mixture of thermoplastic material and filler is so adjusted that the fractional volume of the latter corresponds to the value determined under (5).

From this aspect the invention consists in a material suitable for injection molding consisting of a matrix of a suitable thermoplastic substance filled with a finely dispersed rigid filler, the fractional volume of said filler in said material being more than 10% and less, but preferably not substantially less, than the maximum fractional volume of said filler in air. In order to be suitable, the viscosity of the unfilled thermoplastic liquid substance in the molten condition should be as low as possible, as it is otherwise impossible to fill it to the extent desired without obtaining a mixture which can no longer be molded at a normal injection pressure. In this respect polyamides are particularly suitable as their viscosity is of the order of 1,000 to 2,000 poises at the temperature of molding. Other plastics like methylmethacrylate are not suitable for this reason as their viscosity in the unfilled state already approaches the present limit of moldability which is of the order of 100,000 to 150,000 poises.

The invention further consists in a nib for a ball point pen manufactured by injection molding from such a material with a matrix consisting of a wear resistant thermoplastic substance like a synthetic polyamide resin and a filler consisting of a powder of one or more ceramic and/or metallic materials with particles having a maximum linear dimension not exceeding 0.002 in. It should, however, be appreciated that this limit is nominal in the sense that no practical method of separation can ensure that a powder contains no particles above a certain size; nor is this essential for present purposes, as it is only necessary to ensure that the thinnest sections of a nib are uniformly filled with a homogeneous mixture of the material.

The wear resistance of a filled thermoplastic substance cannot be predicted without experiment. Polyamides have given the best results so far. When filled according to the examples given below, the wear resistance has been substantially higher than that of present brass or bronze nibs. On the other hand, cellulose acetate and acetate-butyrate plastics have been found unsatisfactory in this respect.

We have also found that best results can be obtained according to the method described when using a filler which due to its particle shape is least detrimental to the fluidity of the molten mixture in combination with a thermoplastic substance having a low viscosity at molding temperature, preferably less than 10,000 poises.

The best results have accordingly been obtained with rounded or spherical filler particles in a polyamide resin which of all the suitable thermoplastic substances at present available, has the highest fluidity in molten form. In this case, perfect moldability was retained up to 55% by volume of copper or glass beads, the limit being reached at 61% (see Example 4 below).

On the other hand, the addition of fine copper flakes of the type used in metallic paints or of mica powder was limited to approximately 10% by volume due to progressive deterioration of the moldability for higher concentrations. However, the relative increase in elasticity modulus per one percent addition of filler is also substantially higher than for a spherical filler.

For these reasons no hard and fast rule can be given about the suitability of a particular shape of filler without a test on the lines indicated above. But for roughly spherical particles the following table will afford general guidance:

Filler content, percent by volume	0	10	20	30	40	45	50	55	60
Relative increase in viscosity	1	1.5	2.5	5	9	12	17	24	>30
Relative increase in compression modulus:									
High adhesion	1	1.5	2.1	2.8	3.6	4.1	4.8	5.8	9
Low adhesion	1	1.3	1.6	1.9	2.3	2.5	2.8	3.1	----

The following are examples of suitable compositions for a filled plastic material for the manufacture of injection molded nibs according to the present invention.

EXAMPLE 1

Matrix.—Polyhexamethylene-sebacamide (B 100 Nylon of I.C.I. Ltd. corresponding to U.S. type 610).

Compression modulus, completely dry: 3.0×10^5 p.s.i.

Maximum size of chips, approx. 0.050″.

Fillers.—Copper powder, in bead form, manufactured by atomisation from pure electrolytic copper (manufacturer: Powder Metallurgy Ltd.); passed through U.S. Standard sieve 400 mesh; approx. range of particle size 0.0001″ to 0.0015″; maximum fractional volume in air=64%.

Injection-molded material. — Fractional volume of filler=45%.

Compression modulus, dry: 11×10^5 p.s.i.

EXAMPLE 2

Matrix.—B 100 Nylon as in Example 1.

Filler.—Glass powder, in bead form, manufactured from soft soda glass (manufacturer: Ballotini Manufacturing Co., Ltd., Barnsley, Yorks.); passed through U.S. Standard sieve 400 mesh; approx. range of particle size 0.0002″ to 0.0015″; maximum fractional volume in air=58%.

Injection-molded material. — Fractional volume of filler=51%.

Compression modulus, dry: 8.5×10^5 p.s.i.

EXAMPLE 3

Matrix.—B 100 Nylon as in Example 1.

Filler.—Mica powder, in flake form, manufactured from pure Muscovite mica (manufacturer: The Central Pulverizing Co., Ltd. London); designated 150/3 mica powder, 300 mesh; approx. range of particle size: 0.0001″ to 0.002″; maximum fractional volume in air=12%.

Injection-molded material. — Fractional volume of filler=11%.

Compression modulus, dry: 9×10^5 p.s.i.

EXAMPLE 4

Matrix.—B 100 Nylon as in Example 1.

Filler.—Copper beads (as in Example 1); particle size range: between .0015″ (400 mesh) and .002″ (270 mesh); maximum fractional volume in air=64%.

Injection-molded material. — Fractional volume of filler 61%.

Compression modulus, dry: 25 to 30×10^5 p.s.i.

EXAMPLE 5

Matrix.—B 100 Nylon as in Example 1.

Filler.—Copper beads (as in Example 1), but silver plated; particle size range .002″ to .003″.

Injection-molded material. — Fractional volume of filler 36%.

Compression modulus, dry: 10.5×10^5 p.s.i.

EXAMPLE 6

Matrix.—Polycarbonic acid ester of 4,4-dihydroxy-diphenyl-2,2 propane (Markrolon Grade S of Farbenfabriken Bayer, Leverkusen); compression modulus: 3.2×10^5 p.s.i.; maximum chip size: 16 mesh.

Filler.—Copper heads (as in Example 4).

Injection molded materials. — Fractional volume of filler: 39%.

Compression modulus, dry: 8.5×10^5 p.s.i.

We have also observed that copper spheres yield better results than glass spheres as fillers for a synthetic polyamide material. It appears that copper adheres to the latter after injection molding while glass and bronze powders are far inferior in this respect. The adhesion of silver approaches that of pure copper. Whether this is due to the chemical differences between these filler materials or to any differences in their surface structure could not be established. Though in both cases the plastic material shrinks on to the solid filler after solidification and cooling, it is plausible that any firm adhesion between the filler and the matrix will enhance the rigidity of the molded material, and vice-versa. It is obvious that adhesion is of less importance where the material is used in compression only which is very nearly the case in a plain bearing. The permeability to water vapour is strongly reduced and the dimensional stability increased by using heavily filled materials according to the invention. The permeability of the filled Nylon, according to the above examples was reduced to about one third of the value for the unfilled Nylon which was found to be sufficient for the use of this material in the field of ball point pens. No distortion of the nibs made of this material due to moisture absorption could be detected.

FIGURE 1 shows in section, and on a large scale, a writing extremity or nib, of the ball point type, suitable for manufacture by injecting molding, while

FIGURE 2 is a diagram, on a still larger scale, illustrating the dispersal of spherical particles within the plastic matrix;

FIGURE 3 illustrates the molding process and parts of the tools;

FIGURE 4 is a perspective view, partly broken away, illustrating the configuration of the socket as molded;

FIGURE 5 is a similar perspective view illustrating the configuration of the socket after the formation of the part-spherical seating surfaces;

FIGURE 6 is a greatly enlarged cross-sectional view through the base seat of a nib prepared according to the invention and fitted with a cratered ball.

FIGURE 7 is a schematic sectional view illustrating one step in the formation of a nib according to the invention; and FIGURE 8 is a schematic sectional view on a reduced scale illustrating a heated die for use in the step shown in FIGURE 7.

The general design of the nib **1** shown in FIG. 1 is of known form and therefore requires no detailed description. The writing ball 2 (usually 1 mm. diameter) is rotatably retained in a socket or housing 3, without substantial play, by an inturned lip 4 on the nib, the ball being positioned between this inturned lip and a base seat consisting of a plurality of circumferentially-spaced, part-spherical, seating surfaces 5; it is held laterally by a part-spherical lateral seat 6 which encircles it above and below the equatorial plane. The lateral seat 6 is spaced from the base seat by an annular cavity 7 which surrounds the ball; there is an ink feed duct 8, 8*a*, which leads to the submerged pole of the ball and ink channels 9 lead from this duct, between the base seating surfaces 5, to the cavity 7. The ball may be cratered ball as indicated at 2' and as hereinafter described.

The nib is produced by injection molding from the material herein specified but the inturned lip 4 and the part-spherical seating surfaces 5 and 6 are not produced in the molding process but are produced later (as is hereinafter described). In the molding process, two co-axial core pins 10 and 11 meeting at face 12 and each having the requisite taper or "draw" are employed. Pin 10 has a large-diameter upper part 10*a* which produces the substantially-cylindrical main portion of the socket, joined by a frusto-conical portion 10*b* to a stub 10*c* which produces part 8*a* of the feed duct 8. The frusto-conical portion 10*b* has a plurality (e.g. five) of circumferentially-spaced concave depressions 13 which may be formed by spark erosion. In the molding operation, these depressions 13 result in complementary mounds or pimples 14 on the interior of the socket, as illustrated in FIG. 4, with the channels 9 extending between them from the feed duct 8, 8*a*, to the substantially-cylindrical part of the housing. Nibs according to this design could be manufactured by injection molding the materials specified in the above examples, under the following working conditions:

Injection pressure	5–10,000 p.s.i.
Length of sprue	0.5" (12 mm.).
Diameter of sprue	0.065" (1.6 mm.).
Size of square gate	0.055" (1.4 mm.).
Injection temperature for materials based of B 100 Nylon	285° C.
Mold temperature for materials based on B 100 Nylon	150° C.

Comparatively large gates, as well as high injection and mold temperatures according to the above values have been found very desirable in order to achieve moldings of high quality.

The right hand part of FIG. 1 indicates how the particle size of the filler is limited by the configuration of the housing. For the design illustrated in FIG. 1 the preferred filler consists of spheres or substantially spherical beads 15 with a maximum diameter of 0.0015" (or approximately 0.040 mm.=40 microns). FIG. 2 illustrates the idealized arrangement of such spheres within the plastic matrix for a fractional volume of 50% and for rhombohedral packing, in which case $d=0.14D$.

The actual arrangement of the spherical particles in the solidified material can best be described as a uniform random distribution not differing in its essential characteristics from the idealized arrangement shown in FIG. 2. It will be appreciated how close this packing is, and why a very large increase in rigidity can be obtained without destroying the mobility of the mixture in the molten state. It will be equally clear that the dimensional stability and resistance to permeation by water vapour are greatly increased, if the filler consists of a ceramic material (e.g. glass) or a metal (e.g. copper).

In the present manufacture of ball point nibs the ball has to be retained in its housing by permanently deforming the housing walls round the ball such that they assume a spherical interior shape conforming to the ball. For metal nibs this is done by impact with a conical die (peining), by spinning or any similar method suitable for the accurate cold deformation of ductile metals.

In view of the large elastic strain which plastics can undergo such methods are usually unsuitable for nibs in which the plastic material forms the matrix because the deformation of the housing wall in the retaining operation does not stress the material beyond the elastic limit and is therefore not permanent. It is, therefore, necessary to lower the elastic limit of the material which is most conveniently done by heating it.

The best method of hot deformation of the housing walls to produce both the part-spherical base seat 5 and lateral seat 6 for the ball, illustrated in FIGS. 7 and 8, is the following:

An oversize ball of, say, 1.005 to 1.010 mm. is inserted into the open socket of the nib molding which is firmly positioned on a suitable anvil 19. This ball therefore rests on the mounds 14. A heated die 20 with a conical recess 21 is brought into contact with the ball and the lip portion of the nib molding while in longitudinal alignment with the axis of the die and of the nib housing. Axial loading is applied to the die over a short period which suffices to convert the sections of the nib housing in contact with the ball and the die into a plastic or semi-plastic state so that, the ball being pressed into the crests of the mounds 14 and the periphery of the housing being molded around the ball, the desired permanent formation of spherical seats 5 and 6 (and of the inturned lip 4) is achieved. It will be appreciated that if a steel ball is used as a former in this operation its high thermal conductivity materially assists to conduct the heat to where it is required for the process.

The following is a typical set of operating conditions:

Material	B 100 Nylon.
Loading	45% by volume of copper spheres.
Included angle of die	90 degrees.
Die temperature	200° C.
Load	6 lbs.
Duration of load	5 seconds.

After the nib has cooled to room temperature the oversize ball is pushed out of the housing, past the inturned lip 4, by a suitable needle passing through the feed channel at the rear of the ball. A smaller ball of, say, 1,000 mm. is replaced by pushing it past the lip into the housing.

This procedure is necessary as the plastic material shrinks tightly on the metal ball in cooling subsequent to the process of hot deformation. Hence, the replacement by a ball 10 microns smaller in dia. does not lead to the formation of a radial clearance of 5 microns but to a considerably smaller clearance depending on the stresses set up during the hot deformation and the physical properties of the material used. The correct oversize may easily be determined by experiment. It will be appreciated that it is very easy to obtain complete and accurate control over the depth of trace wanted by the simple device of varying the size of the ball replaced into the nib, or for preference varying the size of the ball used in hot deformation.

Certain plastics like the polycarbonate resin in Example 6, are capable of being permanently deformed without the application of heat. As in the case of metal nibs, the operation of peining does not jam the ball in its housing: due to the release of the elastic stresses set up during peining a radial clearance is formed between the ball and its seatings. As the elasticity modulus of the molded material is considerably lower than that of metals, this clearance is larger than in peined metal nibs. For this reason it may be desirable to replace the ball (or ball-like member) used in peining by a slightly larger ball.

Ball replacement as outlined, can only be practised with materials which, like synthetic polyamide resins, are not brittle and can undergo a high enough elastic strain in the cold state. Owing to the re-entrant configuration of the housing lip after the hot deformation, the lip has to undergo a transient elastic deformation to allow removal and substitution of the ball. The tensile strain which the material undergoes in this operation is approximately as follows:

Ball protrusion, percent of ball dia	36	34	32	30	28
Total tensile strain approx. percent	4	6	7.5	9	11.5

We have found that B 100 Nylon material loaded with copper or glass spheres up to 55 percent by volume is capable of withstanding this strain without fracture or significant permanent deformation. On the other hand, comparatively brittle thermoplastics like styrenes are unsuitable in this respect, so that the ball replacement method cannot be applied to them.

It will be appreciated that of all the thermoplastic materials at present available B 100 Nylon is the one best suited for the manufacture of nibs according to the present invention because it combines low melt viscosity, high wear resistance, dimensional stability and high elastic strain. We found that B 100 Nylon, due to its high dimensional stability was superior to the A 100 grade (polyhexamethylene adipamide) though the latter has a higher elasticity modulus. The only drawback of these polyamides, i.e., their relatively poor adhesion to many materials, is overcome by the choice of a metal like copper or silver, both of which are also excellent bearing metals in a nib for a ball point pen.

The best writing performance of nibs manufactured from this combination of materials was obtained by replacing the oversize ball used for deforming the lip by hot peining by a cratered ball as described in the copending United States application of Hans R. Fehling and Edward H. Harvey, Serial Number 29,608, filed May 17, 1960, and as illustrated in FIGURE 6 of this application. Preferably the difference in diameter between the oversize ball and the cratered ball should be 8–10 microns. The cratered ball should preferably have craters of 40 to 50 microns in diameter covering about 40% of the ball surface. Best results have been obtained by using, in such a nib, an ink having a viscosity between 50 and 100 poises at the normal temperature of writing.

The base-seat of a nib **1**, equipped with a cratered ball **2'**, is illustrated on a much-enlarged scale in FIGURE 6. It will be seen that the smooth surface **17** of the ball is pitted with a multiplicity of craters **16** of substantially uniform area dispersed over the whole of said surface. Therefore, in addition to the radial clearance or gap between the smooth spherical surface of the ball and the part-spherical seating surfaces (such as **5**) through which gap the ink is carried in shear by rotation of the ball, the craters **16** carry ink bodily from the housing to the writing surface irrespective of the size of the radial clearance. The craters are produced by spark-erosion in accordance with the said co-pending patent application. In a suitable example the ball is a polished stainless steel ball 1 mm. in diameter pitted with craters of about 40 microns in diameter and about 6 microns deep, the craters

occupying about 40% of the ball surface and being produced by sparking at 40 volts D.C. using a condenser of 0.1 microfarad capacitance and a charging resistance of 1180 ohms. The nib is injection molded from a mixture of of B 100 Nylon with 50% by volume of copper powder in bead form (as in Example 1).

Although the invention has been described herein with reference to specific embodiments, many modifications and variations therein will readily occur to those skilled in the art. Accordingly, all such variations and modifications are included within the intended scope of the invention as defined by the following claims.

We claim:

1. A method for making a nib for a ball point writing instrument comprising the steps of preparing a deformable plastic material loaded with at least ten percent by volume of a finely divided solid filler material so that the resultant mixture is capable of injection molding and has an elasticity modulus in compression of at least 6×10^5 p.s.i. when dry, and injecting the mixture into a mold to form a nib housing having a central ink duct, a ball-receiving socket communicating with the ink duct provided with a plurality of base seat mounds surrounding the ink duct and a rim portion adapted to be deformed to retain a ball in the socket.

2. A method according to claim 1 including the steps of removing at least the socket-forming part of the mold and inserting a die member having a spherical surface into the socket and applying sufficient pressure to permanently deform the base seat mounds to provide part-spherical base seating surfaces thereon for the ball.

3. A method according to claim 2 wherein the plastic material is a thermoplastic and including the step of applying heat to the socket through the die member simultaneously with the application of pressure.

4. A method according to claim 2 wherein the rim portion forming part of the mold is also removed and including the step of applying pressure to the exterior of the nib housing to deform the rim portion so as to form an internal part-spherical lateral seating surface for the ball.

5. A method according to claim 2 including the steps of withdrawing the die member and inserting into the socket a writing ball having a slightly smaller diameter than the spherical surface of the die member.

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