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(21) International Application Number: PCT/CA92/00368 (22) International Filing Date: 27 August 1992 (27.08.92) (30) Priority data: 9118430.9 28 August 1991 (28.08.91) GB (71) Applicant (for all designated States except US): MORTILE INDUSTRIES LTD. [CA/CA]; 3411 McNicoll Avenue, Unit #11, Scarborough, Ontario M1V 2V6 (CA). (72) Inventors; and (75) Inventors/Applicants (for US only) : MORTIMER, Jacques [CA/CA]; 10873 Kennedy Road, Unionville, Ontario L3R 2L6 (CA). MORUZI, Paul [CA/CA]; 233 Arvin Avenue, Stoney Creek, Ontario L8E 2L9 (CA).		(74) Agent: SIM & McBURNEY; 330 University Avenue, Toronto, Ontario M5G 1R7 (CA). (81) Designated States: AT, AU, BG, BR, CA, CH, CS, DE, DK, ES, FI, GB, HU, JP, KP, KR, NL, NO, PL, RO, RU, SE, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, SE). Published <i>With international search report.</i>
(54) Title: COMPOSITE METAL (57) Abstract A process for compounding a polymer resin heavily loaded in excess of 65 % by weight with a metal powder to produce a compounded mixture of metal particles in the resin having a consistent specific gravity and suitable for extrusion, the process comprises: i) blending the polymer resin with the metal powder, the polymer resin being selected from the group consisting of thermoplastic resins, elastomer resins and mixtures thereof, the selected resin having a defined melt phase temperature range at which compounding is carried out, the metal powder being selected from metals having specific gravities in excess of 2.7 and are in a powder form having a particle size of less than 1 mm with greater than 50 % of the powder passing a 100 mesh screen, ii) continuing to blend the polymer resin and the metal powder by folding the resin and powder in a confined chamber of high shear mixer at an elevated controlled temperature in the range of the melt phase temperature, the folding of the polymer and resin continuing with high shear mixing of the resin in softened state until the particles of metal are wetted with the resin to form the compounded mixture, iii) removing the compounded mixture from the confined chamber of the mixer, and iv) pelletizing the compounded mixture.		

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COMPOSITE METALFIELD OF THE INVENTION

This invention relates to composite materials which
5 are formed by compounding plastic resins with metal
powders where the loading of the metal powders in the
plastic resin normally exceeds 65% by weight.

BACKGROUND OF THE INVENTION

Injection moulding of mixtures of fine metal powders
10 and plastic binders is known to combine strength with
durability of the metal as well as design versatility.
Injection moulded products are being substituted for
machined, dye-cast or investment cast metal products
which are particularly useful in the automobile, medical
15 instrument and fire arms field.

Metal injection moulding relies on the use of a
thermoplastic binder which is typically polyethylene,
polypropylene, methyl cellulose, acetate polymers,
Nylons® and the like which may be a mixed with waxes or
20 oils. The polymer is mixed with extremely fine, usually
10 to 25 micron metal powder which is passed through an
injection moulding machine. Usually the injection
moulded product has the thermoplastic removed by a
sintering process to produce a densified part. It is
25 generally accepted, however, in forming such parts that a
maximum of 65% metal fines can be incorporated in the
mixture for injection molding and that significant
problems are encountered during the rather lengthy
debinding process.

30 Although it is possible to press mold thermoplastic
materials loaded with metal powders and obtain metal
loadings in excess of 65% by weight, normally pressed
products are of little interest because of limited design
variation, lack of consistency and productivity and
35 product quality and consistency in metal powder
distribution throughout the product. This is
particularly critical when the parts are sintered to
remove the plastic material to provide a metal part. It

is generally understood that composites of plastic resin with metal powders can be injection moulded at metal contents of less than 60% to 65% by weight. Normally with the lower metal loadings the existing approaches in compounding materials provide a resin which may be injection moulded. The metal powder is adequately distributed and each powder granule is coated, that is, wetted over its entire surface by the polymer material. In the past, metal loadings in excess of 60% and more particularly in excess of 90% had been possible because during extrusion the presence of excessive amounts of metal powders cause binding of the extrusion screws. This is thought to be due to the metal powders welding the screw faces to the screw barrels. Once the heated composites cool and sets it is virtually impossible to dismantle the extruder and remove the composite. In view of these problems, composite parts are normally extruded with metal loadings less than 60%. There continues however to be a significant demand for metal powder injection in polymer resins. This is due to the significant cost associated with the tooling of complex parts and cost associated with die cast or investment cast materials. A specialty compound, such as manufactured by LNP Engineering and sold under the trade- marks THERMOCOMP PDX-4208 and THERMOCOMP PDX-5156, have metal loadings in the range of 83% to 85% bronze with or without molybdenum disulfide up to 3% and the remainder a polyamide-Nylon 11. Such materials are however suited for compression molding.

In the field of firearm ammunition it is also generally understood that lead bullets are a significant environmental hazard. Lead shot causes lead poisoning in animals particularly ducks. Soil around rifle ranges is significantly contaminated by lead. There is therefore a demand for a suitable substitute for lead shot which has a consistent specific gravity, preferably in excess of 5.

Other uses for sintered composites of plastic with metal powder include seal elements of the type described in U.S. patent 4,983,355. Organic binders, usually in the form of plastic and/or waxes are used with metal

5 powders and moulded into tap washers and the like. The polymer is then removed from the formed product by either solvent extraction or sintering at high temperature. In order to prepare the moulded composite product for use, a precise finish is applied by physical or chemical vapour

10 deposition of silicon carbide. In the electrical field composite plastic with metal loadings are useful. For example, a metallic modified plastic composite is disclosed in U.S. patent 3,708,387. The metal particles by way of processing technique are arranged in the

15 plastic composite so as to contact and provide electrical conductivity. This is achieved by heating the mixture of plastic particles having an average particle size of 20 to 1,000 microns and 5% to 8% by weight of conductive nickel particles having an average particle size of one-

20 tenth the size of the plastic particles in order to cause the plastic particles to flow and form a conductive plastic composition. U.S. patent 4,689,250 discloses a filler composition composed of metal particles which are individually coated with a cross-linked polymer layer.

25 Such coated metal particles may be processed into desired parts having electrical insulative properties with breakdown voltages in excess of 100 volts. The particles are normally coated with thermoset resin such as epoxy resins to achieve the high degree of cross-linking. Such

30 thermoset resins do not lend themselves readily to extrusion moulding. The metal powders commonly used in such composites may be obtained from a variety of powder manufacturers such as Alcan Powders and Pigments. Such powders include Inco® nickel powders types 255, 270, 287

35 and 287+, custom alloy powder such as nickelsilver, cupronickel, coppers, aluminum and silicon, bronze, stainless steel chromium, manganese, antimony, bismuth

and the like where such powders normally have a specific gravity in excess of 2.7.

In theory up to 98% by weight of the composition could be metal. However, this has not been attained due to processing restrictions. Normally above 88% by weight of metal in the mixture before injection moulding, the metal substrate cannot be properly "wetted" by the polymeric matrix resin. As a result, high void volumes are found in the product. Usual specific gravities of the compounded product before debinding is in the range of 4.8 grams per cm².

There are, however, many applications which demand a higher metal loading, either because of desired thermal, structural or electrical properties or because of higher specific gravities for specialty uses such as in munitions where specific gravities equal to or greater than 5.6 are desired.

SUMMARY OF THE INVENTION

According to an aspect of the invention, a process is provided for compounding a polymer resin heavily loaded in excess of 65% by weight with a metal powder to produce a compounded mixture of metal particles in the resin. The process provides a compounded composite which has a consistent specific gravity determined primarily by the selected metal powder, the process comprises:

- i) blending the polymer resin with the metal powder, the polymer resin being selected from the group consisting of thermoplastic resins, elastomer resins and mixtures thereof. The selected resin having a defined melt phase temperature range at which compounding is carried out. The metal powder being selected from metals having specific gravities in excess of 2.7 and are in a powder form having a particle size of less than 1 mm with greater than 50% of the powder passing a 100 mesh screen,
- ii) blending of the polymer resin and the metal powder is continued by folding the resin and powder in a

confined chamber of a high shear mixer at an elevated controlled temperature in the range of the melt phase temperature, the folding of the polymer and resin being continued with high shear mixing of the resin in softened state until the particles of metal are wetted with the resin to form the compounded mixture,

iii) the compounded mixture is removed from the confined chamber of the mixer, and

iv) the compounded mixture is pelletized.

According to another aspect of the invention, a composite of compounded polymer resin heavily loaded with metal powder has a specific gravity in excess of 4.9 and comprises in the range of 88% to 98% by weight of metal powder, the resin being selected from the group consisting of thermoplastic resins, elastomer resins and mixtures thereof. Preferably, the metal powder is selected from the group of powders consisting of aluminum, copper, lead, bismuth, bronze, steel, titanium, zinc, silver, gold, antimony, chromium, manganese and mixtures thereof. The polymer resin is preferably selected from the group consisting of polyolefins, polyacrylates, polytetraglycols, polyethylene teraphalate, polyamides injection mouldable rubbers and polyethylenevinyl acetates.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the mixing device in which the composite of this invention is prepared is shown in the drawings wherein:

Figure 1 is a perspective of the mixer;

Figure 2 is a section in side elevation of the embodiment of Figure 1;

Figure 3 is a perspective view of the high shear mixing blades of the mixer of Figure 1;

Figure 4 is a section through the mixer of Figure 2 showing high shear mixing of the composite within the confined space;

Figure 5 is a section through the mixer showing removal of the mixed composite from the mixer by way of a conveyor;

Figure 6 is a section through the mixer showing the
5 cooling of the mixer side walls;

Figure 7 is a perspective view of the pelletizing machine;

Figure 8 is an enlarged section through the extrusion screw of the pelletizer of Figure 7;

10 Figure 9 is a perspective view of a partially coated metal particle with the preferred polymer;

Figure 10 is a perspective of the metal particle completely wetted with the preferred polymer; and

Figure 11 is a graph plotting the increase in
15 specific gravity versus metal content in the polymer composite.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

By the process of this invention, a composite of plastic resin and metal powder is provided and which is
20 capable of having metal loadings up to 98% by weight. By virtue of the processing technique the composite is provided with a consistent specific gravity primarily predetermined by the selected metal powder. These advantages provide a significant advance in the metal
25 composite field. Such materials are, as already noted, particularly useful in the formation of sintered metal products, ammunition and the like due to the consistent specific gravity of the injection moulded product. With substantially higher metal loadings, the "green" product
30 does not shrink appreciably on sintering. It is also possible in accordance with this invention to form composites with a variety of plastic resins and a variety of metal powders. Hence, the composite can be customized to the particular use without jeopardizing the consistent
35 specific gravity and overall structural integrity of the product. Particularly in the munitions field the composites of this invention provide an alternative to

lead, even though lead has a substantially higher specific gravity in excess of 8. The composite of this invention can achieve specific gravities greater than 5 and even greater than 6. Since they are of a consistent
5 specific gravity from product to product the ammunition is fairly consistent and accurate from load to load.

As is appreciated, a variety of thermoplastic elastomer resins and mixtures thereof may be used in formulating the composite. Preferred resins of the noted
10 group include polyethylene, polypropylene and polyamides of the polyamide group. Nylon 6® and Nylon 11® are particularly preferred. Although it may be possible in some situations by virtue of compression moulding thermoset resins might be useful, however, they are not
15 normally preferred in the application of this invention. The metal powders may be of those already noted. However, the preferred powders are copper, bronze, steel and stainless steel. The powders may be of any granular shape and usually not flake in nature. Some metal flake
20 may be used in the composite to enhance electrical conducting of the composite. Preferred metal flake includes nickel or silver coated flake substrate.

Preferably the powders are spherical granules having a mean diameter of less than 10 microns and passing at
25 least 100 mesh screen and preferably 200 mesh screen. The finished composite may have specific gravities, as already noted, in excess of 5 and in the range of 5.4 to an excess of 6 and up to 6.5. Not only is the specific gravity determined by the chosen metal but also by the
30 percent by weight content of metal in the plastic resin. With the Nylons and copper in an excess of 90% loading, specific gravities in excess of 6 can be achieved. The consistency in specific gravity in the formed product is attributable to minimal void content in the composite
35 which is achieved by the process of this invention in providing for proper wetting of the metal powder before pelletizing.

Normally the plastic resins are in the pellet form and as such are loaded into the mixer and by friction heating and outside heating are brought to the necessary melt phase temperature range to effect wetting of the metal powder which is also introduced to the mixer either before, at the same time or after the introduction of the polymer resins. It is also appreciated that copolymers of various plastics may also be useful in the execution of this invention such as copolymers of polyolefins, polyacrylates, polyteraglycols, polyethylene teraphalates and ethylenevinyl acetates. By suitable selection of the particle size, its distribution and uniform spherical particle geometry one can provide for high packing of metal fractions with low void content in the composite primarily due to the excellent wetting by the process of this invention of the selected metal powder surfaces.

In addition to the normal uses for metal composites it is also appreciated that by virtue of the ability to extrude metal composites having such high metal loading in accordance with this invention that the composites are particularly useful in the replacement of stainless steel wraps for coaxle wire and cable and a variety of uses in electrical components. Due to the presence of the heavily metal loading in the composite it is possible to manufacture various computer systems which employ the composite as electromagnetic wave propagating shielding material. The composite of this invention exhibits excellent properties in attenuating electromagnetic waves as well be demonstrated in the following examples.

The process by which the composite of this invention is formed will be described with reference to the preferred style of mixer shown in the drawings. It is appreciated however that the principle of mixing as demonstrated with respect to the mixer of the drawings can be accomplished in other types of mixers which have corresponding high shear folding within a confined space.

The mixer is generally designated 10 in Figure 1. The mixer has a mainframe 12 with outwardly extending spaced apart 14 which support the mixing vessel 16. The mixing vessel has outwardly extending bearings 18 which
5 are correspondingly disposed in the support arms 14. The bearings 18 permit pivoting of the mixing vessel 16 in the direction of arrow 20 to permit discharge of product from the mixing vessel in the direction of arrows 22 for purposes to be discussed with respect to Figure 5. In
10 order to define a confined space within the mixing vessel 16 a mandrel 24 is lowered into the vessel in a manner to be discussed with respect to Figure 4. The mandrel 24 is secured to a ram 26 which is hydraulically driven to exert sufficient pressure on the material within the
15 vessel 16 to effect the high shear mixing thereof. The ram 26 is supported on the mainframe 12 by outwardly extending arm 28. Through the frame 12 is an opening 30 through which material to be mixed is introduced. The material flows along shoot 32 in the direction of arrow
20 34 and flows into the vessel 16. As already discussed, the material consists of the polymer resin and metal powder which may be introduced to the vessel 16 either together or separately. Once a sufficient amount of material is introduced to the vessel 16 the mandrel 24 is
25 lowered into the vessel 16.

With reference to Figure 2 the section through the mixing vessel 16 shows the longitudinally extending adjacent mixer rotors 36 and 38. The rotors rotate about shafts 40 and 42. The vessel 16 has opposing interior
30 side walls 44 and 46 which merge into rounded concave surfaces 48 and 50 which intersect at apex 52. The concave surfaces 48 and 50 are circular and spaced slightly from the locus of points defined by the rotation of the tips of rotors 36 and 38. This ensures that
35 material along the surfaces 48 and 50 is folded back into the main material within the vessel 16 during the mixing process.

As shown in Figure 3 the rotors 36 and 38 comprise lobes 54 and 56 with complex surfaces which mesh with one another when the respective rotors 36 and 38 rotate. The portion of the lobe 54 which is in close proximity to the corresponding portion of the other rotor is shown at 58. During counter rotation of the rotors portions 58 come within approximately 3 mm of each other to effect high shear mixing of the material within the confined space. The design of the rotors is such that the high shear mixing is accomplished by rotation of the rotors at different speeds. For example, rotor 38 may be rotated faster than rotor 36. Representative speeds are 24.5 rpm for rotor 36 and 30 rpm for rotor 38. This provides a rotor speed ratio of 1.22.

With reference to Figure 4, the mandrel 24 is lowered into the vessel 16 by extension of the ram 26 in the direction of arrow 60. The shape of the underside 62 of the plenum is such to conform with the concave portions 48 and 50 in regions 64 and 66 to ensure drawing of the materials around the concave surfaces 48 and 50 in the direction of arrows 68 and 70. The mandrel 24 is held in position to define the confined space 72 so that during mixing of the polymer resin with the metal powder there is a continued folding of the material onto itself with the effect of high shear between surfaces 58. By virtue of this high shear mixing where the mixing takes place in a confined space for an extended period of time at a temperature which is in the range of the melt phase temperature for the plastic resin, the wetting of the particles surface is assured. Essentially all of the particle surface is wetted, that is, coated with the polymeric material. With previous processes for compounding the composite a common problem was in achieving sufficient wetting of the particle surface.

As shown in Figure 9 a metal particle 74 with is spherical in shape is only partly coated by polymer resin 76. As will be discussed with respect to Figure 8,

partially coated metal particles that is only partially wetted particles can cause binding of the extrusion screw. However, by virtue of the process of this invention where the compounding takes place in a confined space over an extending period of time at high shear the spherical particles 74 are almost entirely, if not completely coated by the polymer resin 76.

Such total wetting of the particle quite surprisingly allows the extrusion of the composite without causing binding in the extrusion screw and also surprisingly ensures uniformity or consistency in the specific gravity of the produced product, even at very high metal loadings up to 98% by weight.

To achieve proper mixing within the confined space at the melt phase temperature range for the plastic, cooling and/or heating is provided in jacketed portions of the mixing vessel 16 and the mandrel 24 as shown in Figure 6. The mixing vessel 16 has heat exchange medium entering through conduits 78 and 80 to within heat exchange chambers 82 and 84. The heat exchange medium exits from the chambers through conduits 86 and 88. During the initial phase of mixing if frictional heat is not sufficient to heat the resin to the melt phase temperature, a hot exchange medium may be introduced to the vessel 16. Similarly, with the mandrel 24 heat exchange medium may be introduced through conduit 90 and passed through heat exchange cavity 92 and exit therefrom through conduit 94. Once the introduced material attains the melt phase temperature range, the temperature of the system is controlled by introducing cooling medium into both the vessel 16 and the mandrel 24. This ensures that the material does not overheat and cause degradation of the thermoplastic or elastomer resins during the compounding phase so that continued folding of the material with high shear mixing can be effected until the metal particles are substantially or fully wetted to facilitate subsequent processing. Without the cooling of

the vessel 16 and 24 it is understood that overheating of the thermoplastic resin can cause deterioration thereof and hence poor wetting of the metal particles so that subsequent processing with high metal loadings is prevented particularly with respect to extrusion as will be discussed in regards of Figure 8.

Normally, by trial and error with respect to a particular composite mix and with suitable temperature control, the completion of mixing is determined by period of mixing. Hence, after a predetermined period of time for mixing a particular composite mix the mandrel 24 is retracted as shown in Figure 5 and the vessel 16 rotated to the dump position 16a. During dumping of product 96 from the mixer vessel the rotors 36 and 38 continue to be rotated to ensure complete discharge of the composite from the mixing vessel 16. The compounded composite is dropped onto a conveyor system 98 which travels in the direction of arrow 100 to convey the material to a pelletizer system shown in Figure 7. The distance the material 96 is conveyed is usually of a short distance to avoid over cooling of the freshly mixed composite.

As shown in Figure 7 the composite 96 is discharged in the direction of arrow 102 from the conveyor 98 into a hopper 104 of the pelletizing machine generally designated 106. In accordance with standard pelletizing practice the composite 96 is introduced to the screw of the extrusion barrel 108. The composite material is extruded through circular die 110 to provide a cylinder which is schematically shown as being severed into pellets 112 by rotating knife 114. Preferably, the pitch of the extrusion screw is such that the extrusion barrel 108 is relatively short in the range of 2 to 3 feet to expedite thereby processing of the material in forming the pellets 112 which are subsequently cooled and packaged for transport.

As shown in Figure 8 the extrusion barrel 108 is in section. The barrel has an outer wall 116 with a

rotating screw 118 provided therein. The outer surface 120 of the screw is proximate the inside 122 of the barrel 116 as shown in the area 124. In accordance with this invention, the composite in the form of fully wetted particles advances in direction of arrow 126 through the screw towards the dye 110. The wetted particles ensure that in regions 124 along the barrel minimal portions of the metal particle are exposed to the barrel wall 122. This has been found to prevent "welding" of the screw outer edge 120 to the interior 122 of the barrel, preferably with heavily loaded composites. Virtually all of the metal particles are fully wetted, as shown in Figure 10. It has been found that with partially wetted particles, such as shown in Figure 9, the heat of extrusion and friction of the metal to metal surfaces where the metal particles therebetween can cause a fusion or welding and hence seizing of the extrusion barrel 108. This results in costly shut down and refitting of the system. In accordance with the processing techniques of this invention, such costly shut down times are now avoided.

Depending upon the selection of materials to form the composite it is appreciated that various processing additives may be included such as low density polyethylenes, silicon, carbon, zinc stearate and aluminum stearate. Other processing additives as well may be included as long as they do not effect the overall integrity of the prepared composite.

By virtue of the process in accordance with this invention significant increases in metal loading can be achieved. Normally with prior art processes extrudable composites included up to 60% by weight of metal. As shown in Figure 11. The specific gravity at this range is about 2.0. However, by increasing metal loadings up to 95% there is a steep significant rise in specific gravity to a level in excess of 6.0. Quite surprisingly, by a 50% increase in metal loadings there is a 200%

increase in specific gravity which was not thought possible because of the substantially linear relationship between % by weight metal to specific gravity, up to about 60%. Hence, the process of this invention provides
 5 a novel composite having significant specific gravities for metal loadings in the 88% to 98% range.

As shown in Table I and II Nylon copper composites are provided in accordance with the process of this invention having specific gravities in the range of 5.7.

10

TABLE I

Material	Nylon-11/Cu/92/NATL	Nylon-11/Cu/93/NATL
Tensile Strength (MPa)	34	44
15 Elongation (%)	1.7	1.7
Flexural Strength (MPa)	69	74
Flexural Modulus (MPa) (Secant)	3 640	3 800
20 Flexural Modulus (MPa) (Tangent)	7 570	9 500
Izod Impact (Notched J/m)	60	63
(Unnotched J/m)	120	147
Spec. Grav. (g/cu. cm)	5.76	5.77

25 In accordance with the following Table II various other composites involving copper powders with Nylon, Surlyn® and rubber are demonstrated with the noted physical properties, all of which have specific gravities in excess of 5.

TABLE II

TEST RESULTS - PROPERTIES: M-2013/X/NAT

[illegible]

For the copper loaded composites, significant metal conductivity or resistivity can be provided. To reduce conductivity and hence increase resistivity of the material, inert fillers may be included in the composite.

5 For example, it has been found that the use of calcium carbonate in the composite can render the composite non-conductive. Usually minimal amounts of calcium carbonate are required such as up to 5% by weight. The resistivity of the materials can range from 0.07 to 1.8 uohms per
10 square. Conductive materials may have resistance in the range of 0.07 to 0.15 uohms per square whereas higher resistant materials may have values ranging from 0.6 to 1.8 uohms per square.

The attenuation values for the material may also
15 vary considerably depending upon the composite make-up For the copper loaded materials shielding effectiveness in terms of attenuating electromagnetic waves propagation is greater than 60 dB. dB expresses the power ratio for the attenuation values of the materials. For example, a
20 power attenuation loss of 100:1 is equivalent to 20 dB. 60 dB is equivalent to a power loss attenuation of 1,000,000:1, hence, the heavily loaded metal composites of this invention are very useful in microwave propagation attenuation.

25 Although preferred embodiments of the invention are described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention or the scope of the appended claims.

CLAIMS:

1. A process for compounding a polymer resin heavily loaded in excess of 65% by weight with a metal powder to produce a compounded mixture of metal particles in said resin having a consistent specific gravity and suitable for extrusion, said process comprising:

i) blending said polymer resin with said metal powder, said polymer resin being selected from the group consisting of thermoplastic resins, elastomer resins and mixtures thereof, said selected resin having a defined melt phase temperature range at which compounding is carried out, said metal powder being selected from metals having specific gravities in excess of 2.7 and are in a powder form having a particle size of less than 1 mm with greater than 50% of said powder passing a 100 mesh screen,

ii) continuing to blend said polymer resin and said metal powder by folding said resin and powder in a confined chamber of high shear mixer at an elevated controlled temperature in the range of said melt phase temperature, said folding of said polymer and resin continuing with high shear mixing of said resin in softened state until said particles of metal are wetted with said resin to form said compounded mixture,

iii) removing said compounded mixture from said confined chamber of said mixer, and

iv) pelletizing said compounded mixture.

2. A process of claim 1 wherein said polymer resin is selected from the group consisting of polyolefins, polyacrylates, polytetraglycols, polyethylene terephthalate, polyamides injection mouldable and polyethylene vinyl acetates.

3. A process of claim 1 wherein said polymer resin is selected from the group consisting of polyethylene, polypropylene and polyamide.
- 5 4. A process of claim 3 wherein said polyamide is Nylon 6 or Nylon 11.
- 10 5. A process of claims 1, 2, 3 or 4 wherein said metal powder is selected from the group of powders of aluminum, copper, lead, bismuth, bronze, steel, titanium, zinc, silver, gold, antimony, chromium, manganese and mixtures thereof.
- 15 6. A process of claims 1, 2, 3 or 4 wherein said metal powder is selected from the group of powders consisting of copper, bronze, steel and stainless steel.
- 20 7. A process of claims 1, 2, 3 or 4 wherein said metal powder is copper, bronze or steel, said powder having spherical granules and having mean diameter of less than 10 microns.
- 25 8. A process according to any one of the preceding claims wherein said high shear mixer folds said resin and metal powder upon itself a sufficient number of times at said controlled temperature to effect said wetting of said particles.
- 30 9. A process of claim 8 wherein said folding is effected with counterrotating blades with a clearance of about 3 mm.
- 35 10. A composite of compounded polymer resin heavily loaded with metal powder, said composite having a specific gravity in excess of 4.9 and comprising in the range of 80% to 98% by weight of metal powder, said resin

being selected from the group consisting of thermoplastic resins, elastomer resins and mixtures thereof.

11. A composite of claim 10 wherein said metal powder is
5 selected from the group of powders consisting of
aluminum, copper, lead, bismuth, bronze, steel, titanium,
zinc, silver, gold, antimony, chromium, manganese and
mixtures thereof.
- 10 12. A composite of claim 10 wherein said polymer resin
is selected from the group consisting of polyolefins,
polyacrylates, polytetraglycols, polyethylene
terephthalate, polyamides injection mouldable rubbers and
polyethylenevinyl acetates.

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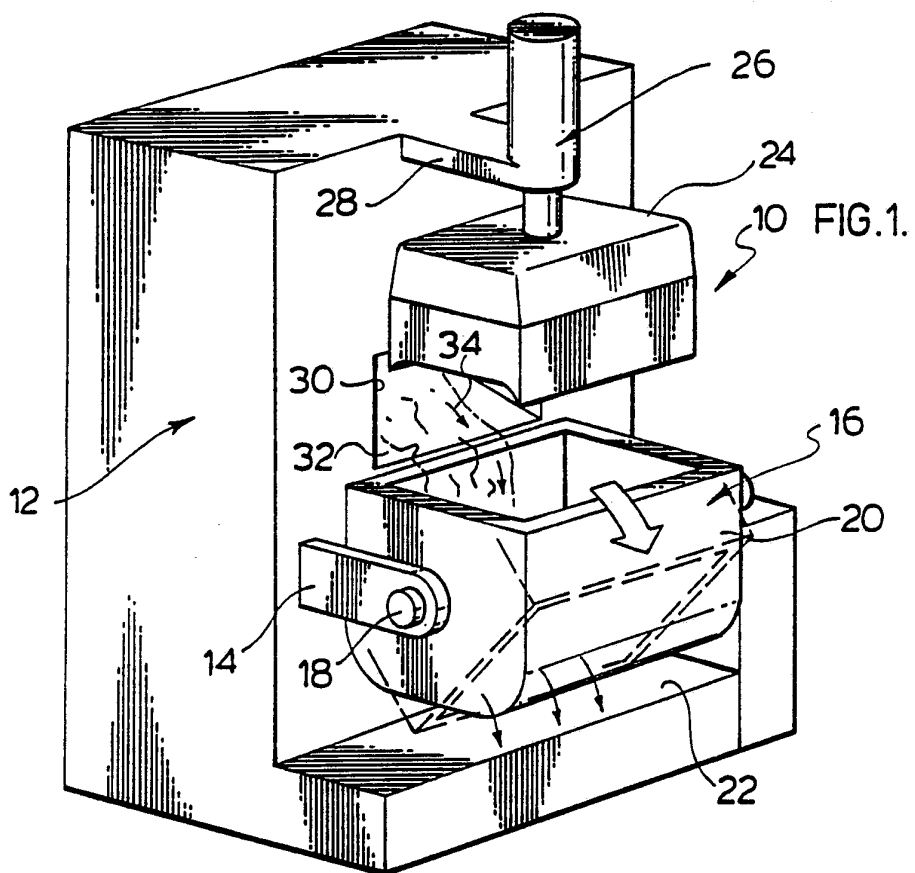
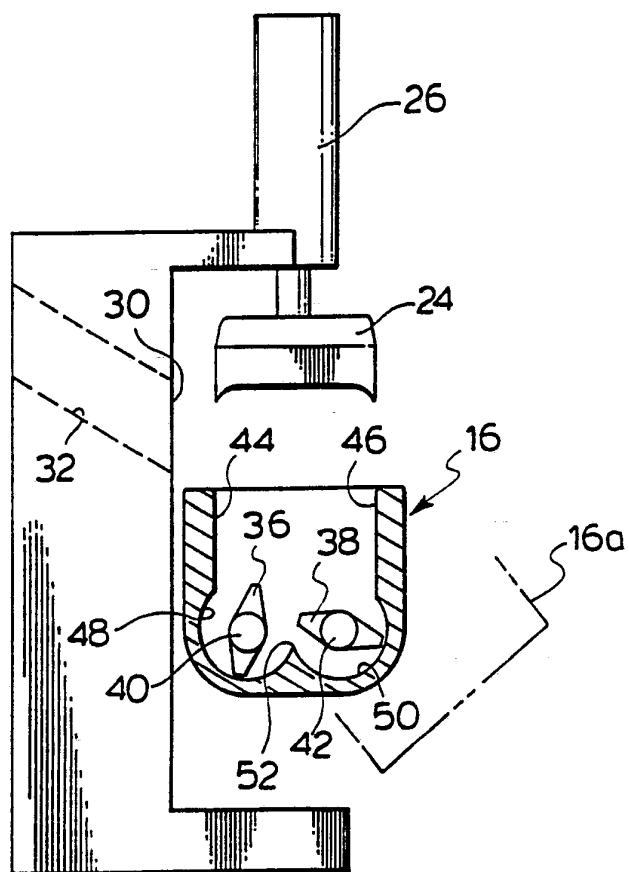


FIG. 2.



215

FIG. 3.

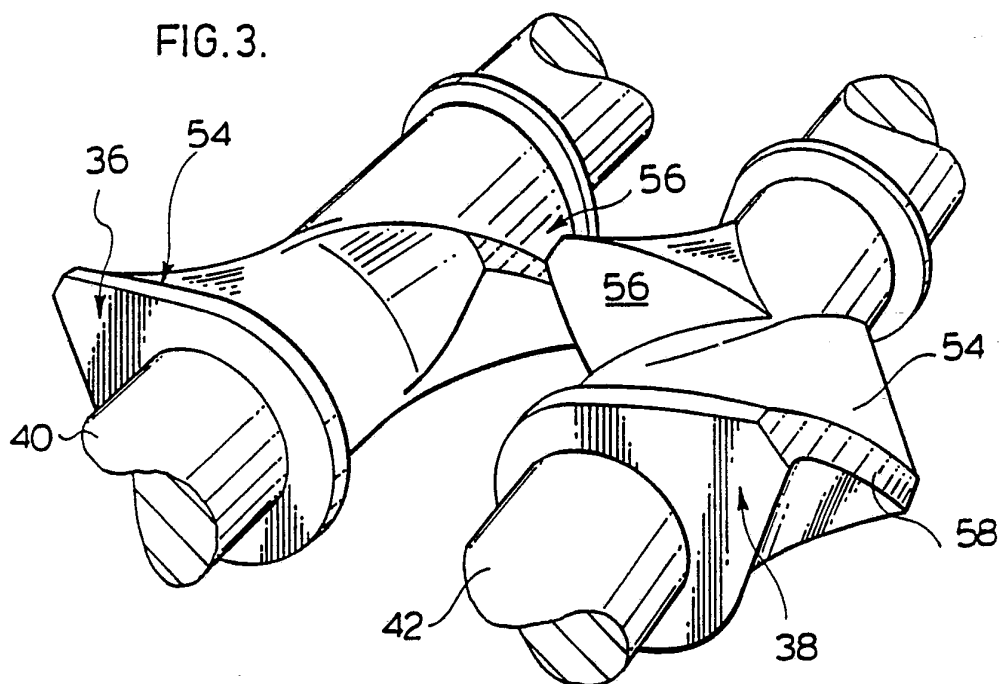
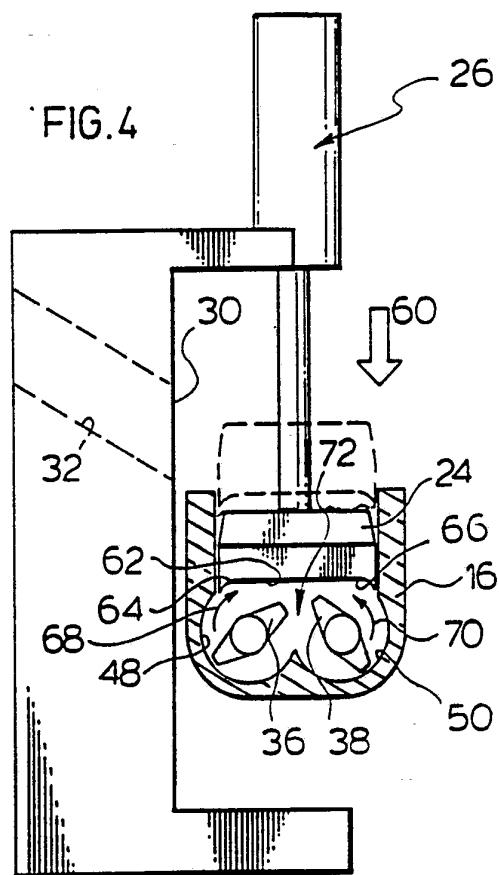
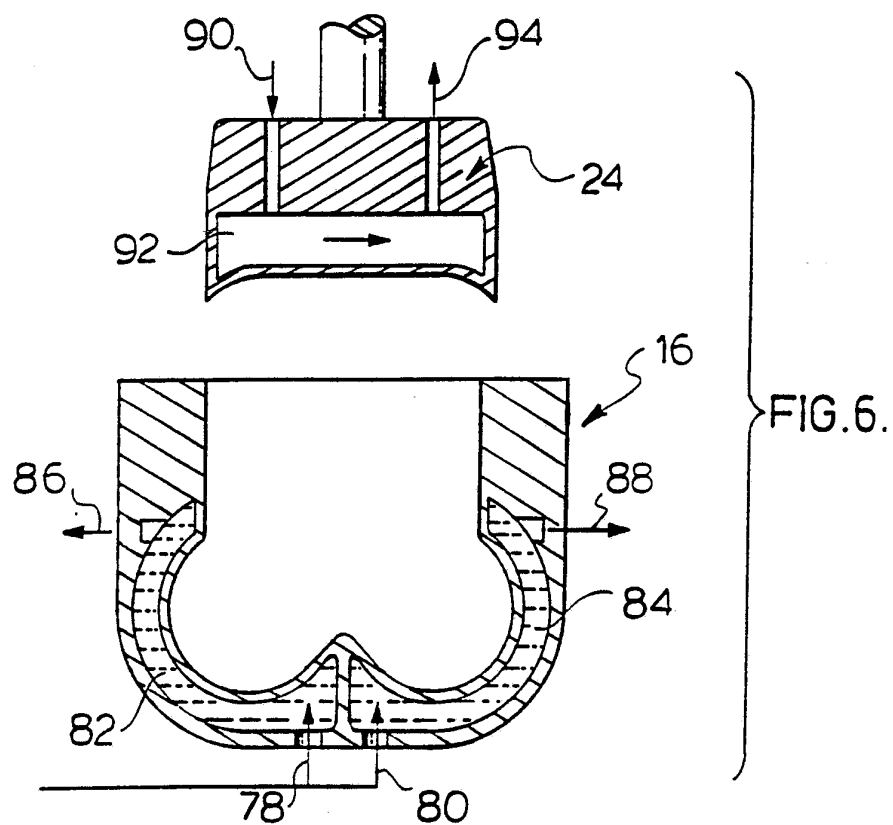
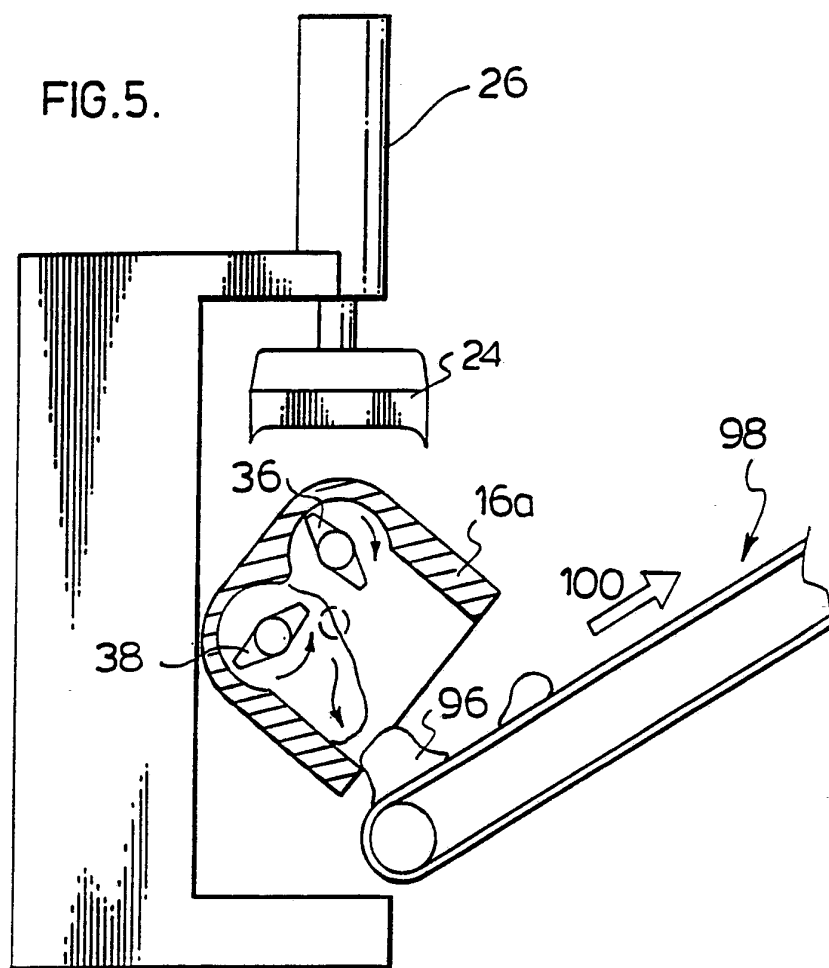


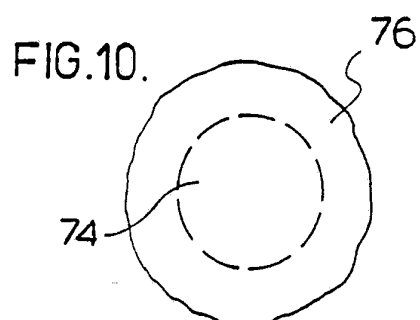
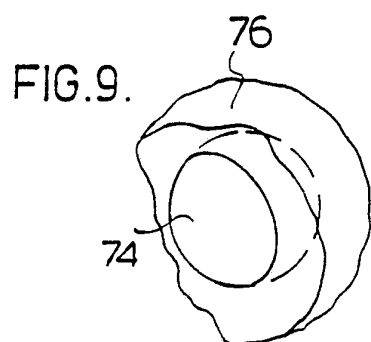
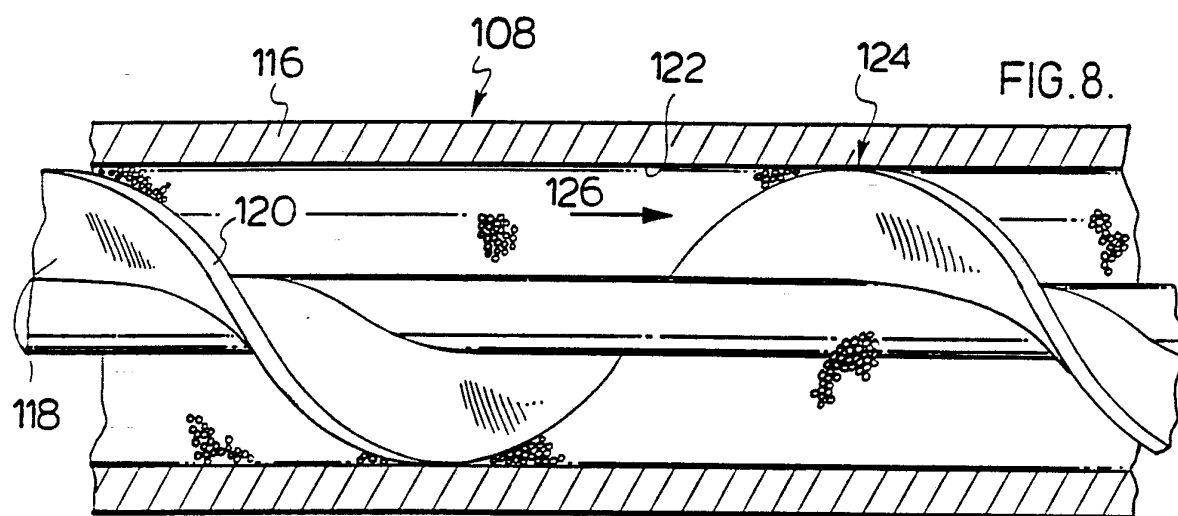
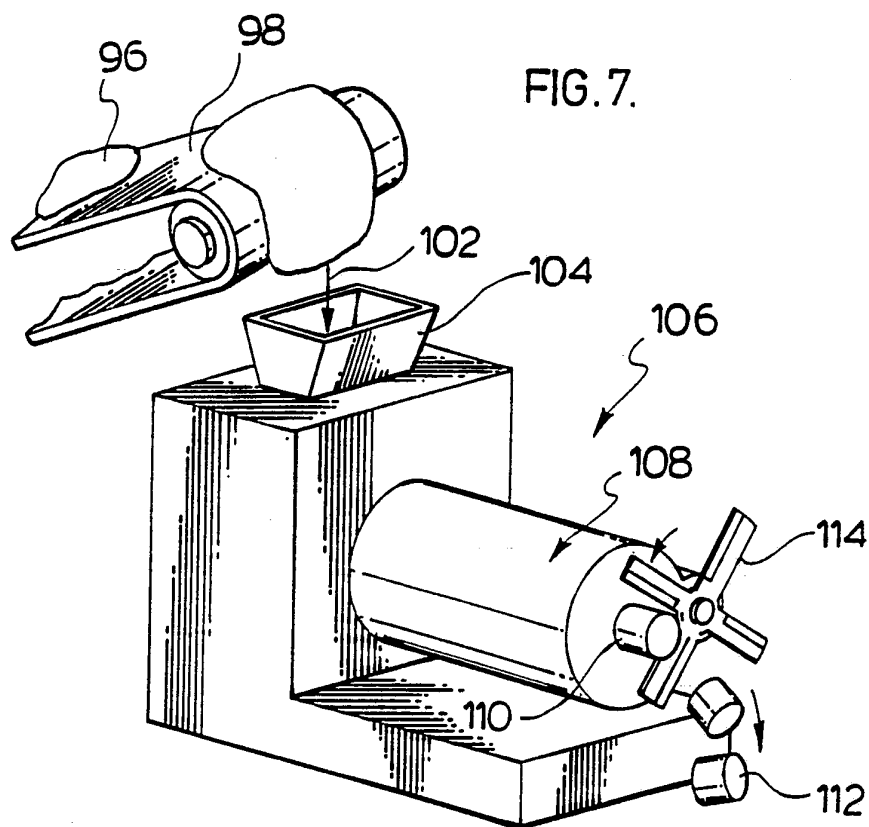
FIG. 4



SUBSTITUTE SHEET

FIG. 5.





SUBSTITUTE SHEET

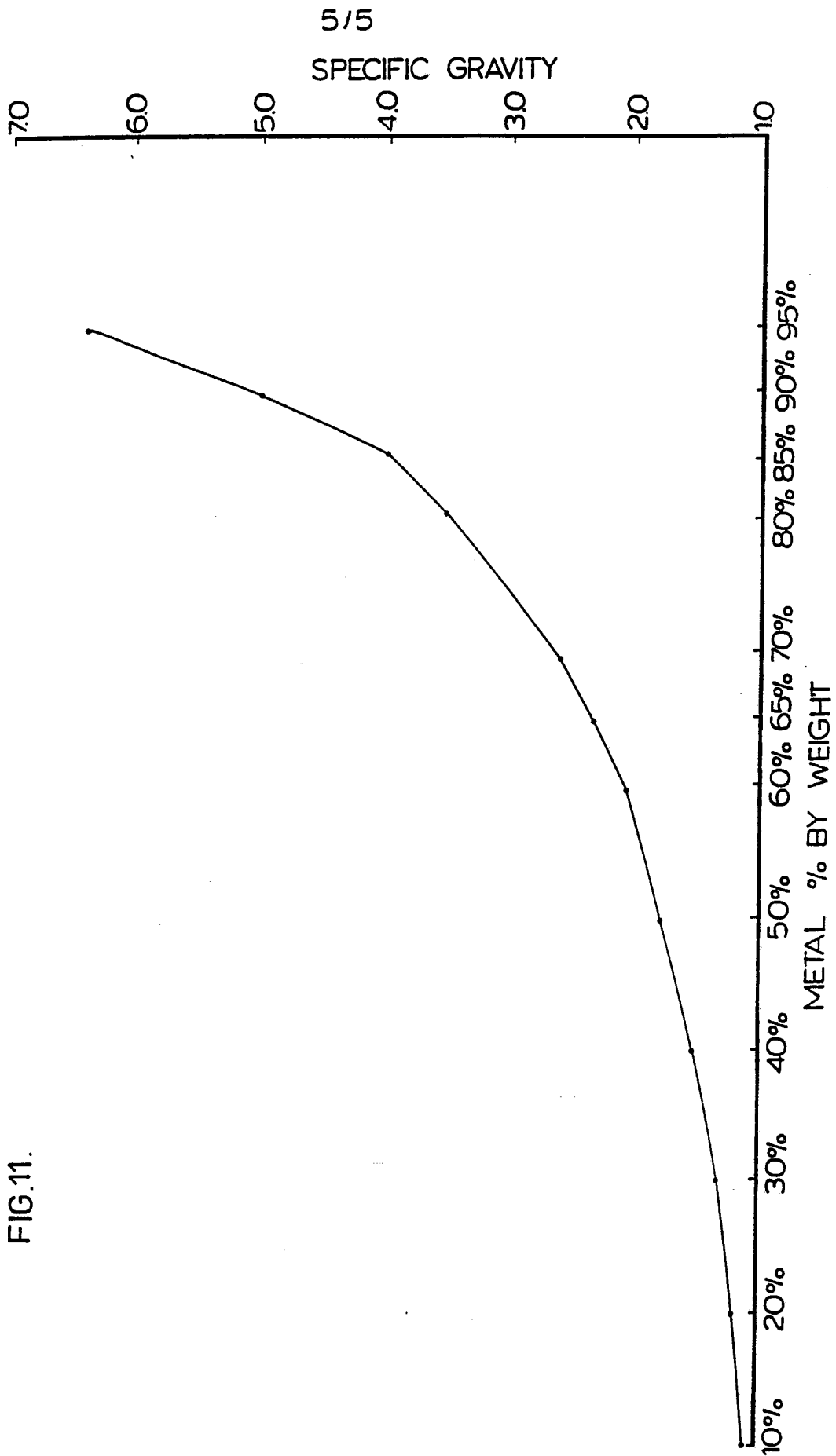
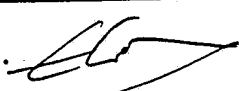


FIG.11.

INTERNATIONAL SEARCH REPORT

PCT/CA 92/00368

International Application No

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 C08J3/20;	C08K3/08;	B29B9/12; B29B9/06
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	C08J ; C08K ; C08L ; B29B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	GB,A,2 190 087 (KABUSHIKI KAISHA TOSHIBA) 11 November 1987 see page 2, line 51 - line 63; claims ---	1-8, 10-12
A	EP,A,0 372 758 (DU PONT CANADA INC.) 13 June 1990 see page 5, line 30 - line 42; claims; examples X,XV ---	1-12
X	DE,B,1 127 581 (ASSOCIATED LEAD MANUFACTURERS LIMITED) 12 April 1962 see claims; table -----	10-12
¹⁰ Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
27 NOVEMBER 1992		- 8. 12. 92
International Searching Authority		Signature of Authorized Officer
EUROPEAN PATENT OFFICE		DE LOS ARCOS Y E. 

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. CA 9200368
SA 63739**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 27/11/92

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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EP-A-0372758	13-06-90	CA-A- 2003879	25-05-90
		JP-A- 2223899	06-09-90
DE-B-1127581		FR-A- 1251998	
		GB-A- 868524	