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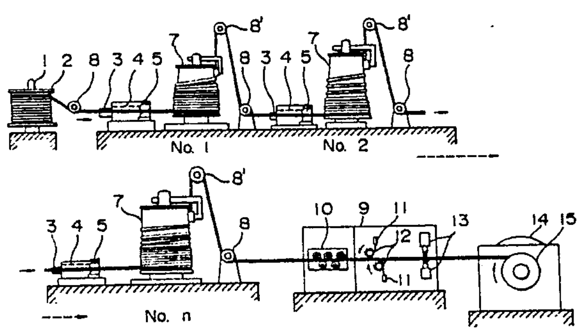
(54) **Lubricant composition and a method for manufacturing electrically conductive substances with the same.**

(57) A lubricant composition (4) for use in plastic working and wire drawing of non-ferrous material (2) or a composite substance (2) consisting of a core material cladded with non-ferrous material comprises as base oil a liquid high molecular compound having a viscosity of 0.0003 to 0.05 m^2/s (300 to 50,000 cSt) at 40 °C and an oiliness selected from a group consisting of animal and vegetable fats and oils and aliphatic dicarboxylic acids. The lubricant composition allows workability and safety of working to be greatly improved and the high velocity wire drawing to be performed.

FIG. 2



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LUBRICANT COMPOSITION AND A METHOD FOR MANUFACTURING ELECTRICALLY CONDUCTIVE SUBSTANCES WITH THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a lubricant composition for use in working electrically conductive substances such as power transmission cables, leads or wires used in electronic parts, coiling wires and the like, and a method for manufacturing such electrically conductive substances with the lubricant composition.

Description of Related Art

Linear metallic substances for use in power transmission cables, leads in electronic parts and the like, and in electrically conductive composite wires or cables (for convenience, referred to as composite wires hereinafter) consisting of a metallic core cladded with non-ferrous metals such as copper, aluminum and the like have been manufactured by producing linear metallic materials by any of known methods, for example, hot or warm extrusion, or hot rolling and reducing the diameter of the materials with a drawing bench having a die for working to produce linear substances having a desired diameter. In industry, electrically conductive wires of a given dimension have been manufactured by means of a continuous drawing equipment having a plurality of benches bearing dies disposed on line.

In the production of composite wires, the ratio in cross sectional area of the core to the cladding layer changes with the drawings of the wires, because the resistance to deformation of the core is different from that of the cladding. Therefore, the change of the ratio in cross-sectional area of the core to the cladding due to drawing is predetermined, thereby the thickness of the cladding layer relative to the core is determined, based on which the composite substances are made and then drawn to give composite wires having desired dimensions.

The working such as the drawing described above has been carried out generally with lubricants of liquid- and/or powder-types as lubricants for working.

When the drawing is conducted by means of the continuous drawing bench, the reduction of the diameter of wires is increased as the wires pass through from a drawing die to a next one. Therefore, the velocity of transferring a wire must be higher in the later drawing step through which the wire passes. At the final drawing step, the velocity may become as high as 250 to 400 *m*/min.

There is stringent requirement for the uniformity of surface properties and conductivity, particularly of the cladding thickness of the composite wires so as to have a constant conductivity over the whole length thereof. Concurrently, the surface is required to be in such a good surface condition as having no " galling " due to seizure between dies and materials upon the plastic working, nor " discoloration " due to deterioration of lubricants and the like.

The surface condition of composite wires is dependent upon the ratio in cross-sectional area of the core to the cladding layer, the configuration of drawing dies, the percentage reduction, particularly to a great extent upon the lubricants. Furthermore, there is a need for increasing the speed of working to produce composite wires at a higher productivity, and for the purpose, the quality of lubricants must be improved to a great extent.

Although a wide variety of lubricants have been employed in attempting to satisfy the aforementioned rquirements and needs, there is still no lubricant capable of satisfactorily attaining both the higher speed of working and the better surface condition.

Generally, a lubricant having a higher viscosity is more effective to prevent metal materials from contacting with one another and the wires from galling during drawing.

Liquid lubricants include formulations consisting of a basic oil selected from mineral oils, synthetic oils such as ester oils and the like, and mixtures thereof, with addition of any of various additives such as oiliness improving agents, for example, higher fatty acids and higher alcohols as described by T. SAKURAI in " PETROCHEMICAL ADDITIVES " (published by Saiwai Shobo, Japan, May 1973) and extreme-pressure lubricants of a phosphorus, chlorine or sulfur type.

Powder-type lubricants include metallic soaps such as calcium soap and sodium soap. The soap powder is forced into a space between a die and a wire under pressure and then the drawing is effected.

For drawing wires from steel material alone, there is a lubricant produced by incorporating metallic soap powder of 100 μm or less into polybutene [see, Japanese Patent KOKAI (Laid-Open) No. Sho 55-135198]. There are also lubricants for use in metal wire drawing produced by incorporating paraffin wax, chlorinated paraffine and phosphite ester or phosphate ester [see, Japanese Patent KOKAI (Laid-Open) No. Sho 62-153396] and those produced by dispersing fats and fatty oils or wax in water with a high molecular dispersant, surfactant and the like [see, Japanese Patent KOKAI (Laid-Open) No. Sho 55-147593]. Since the viscosity resistance of these lubricants is high, however, the temperature rises during drawing and as a result the viscosity of the lubricants is reduced to cause galling. In addition, owing to the increase of temperature, the mechanical strength of the wire materials themselves is reduced so that with the prior lubricants the drawing velocity is limited at maximum to about 100 to 150 m/min.

Moreover, the high viscosity lubricants as described above suffer from being reluctant and unmanageable in replenishing and the like, and when they are splashed around adhering to the surfaces of machinery and floor, their high viscosity may cause sticking of work clothings and shoes of operators on the splashed spots. In such case, there may be a risk that the operators fall down or be caught in the drawing machine to raise the problem of safty practice.

On the other hand, lubricants suitable for drawing steel wires are unsuitable for drawing non-ferrous metals, particularly soft metals such as copper or aluminum and apt to cause galling and surface cracking. The surface cracking occurs when the non-ferrous metal materials has a higher shearing strength than the frictional force between the materials and the die.

Moreover, since these lubricants have a higher content of metal soap, they have a disadvantage in that the surfaces of workpieces are discolored to diminish the commercial value thereof.

As lubricants for use in plastic working of aluminum, one may employ polybutene having a viscosity of 0.171 m^2/s (171,000 cSt)(40 °C) or more. As described above, however, the lubricants have a less tendency to cause seizing of materials and dies making it possible to draw wires even at a velocity of 200 m/min, though the higher viscosity lubricants raise difficulties in workability and safty as pointed out above.

As above, there have been many problems in wire drawing with conventional lubricants.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a lubricant composition which allows to prevent the surfaces of wires manufactured from seizing during plastic working with wire materials resulting in the production of wires having good surface properties.

It is another object of the present invention to provide a method for manufacturing electrically conductive linear substances such as power transmission cables, leads used in electronic parts, coiling wires and the like by effecting the plastic drawing of metal materials at a high speed with the aforementioned lubricant composition.

It is another object of the present invention to provide a method for manufacturing electrically conductive linear substances which do not cause any problem in improvement of working environment and safty by using the aforementioned lubricant composition.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a diagrammatical view of a system for manufacturing wires by drawing linear metal materials in a single stage,

FIGURE 2 is a diagrammatical view of a system for manufacturing wires by drawing linear metal materials in multiple stages,

FIGURE 3 is a diagrammatical cross-sectional view of a die part of a system for manufacturing wires by drawing linear metal materials,

FIGURE 4 is a plot of an variation of the temperature of the die as a function of the viscosity of the lubricant composition according to the present invention when the wire drawing is effected therewith,

FIGURE 5 is a diagrammatical cross-sectional view of an aluminum material prior to plastic working,

FIGURE 6 is a diagrammatical cross-sectional view of an aluminum part after plastic working, and

FIGURE 7 is a diagrammatical view showing three stages for producing a superconductive composite wires and tapes; (a) is a diagrammatical cross-sectional view of a composite substance produced by enclosing superconductive material 18 with a cladding pipe 17; (b) is a diagrammatical cross-sectional view of an elongated composite substance produced by swaging the substance as shown in (b); and (c) shows diagrammatically both a composite wire produced by drawing and a composite tape produced by rolling the swaged substance.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The above objects of the present invention can be achieved by the techniques as described under.

In the primary aspect of the present invention, there is provided a lubricant composition comprising a base oil such as liquid high molecular compounds having a viscosity of 0.0003 to 0.05 m^2/s (300 to 50,000 cSt) (at 40 °C) and an additive selected from a group consisting of animal and vegetable oils and aliphatic dicarboxylic acids.

In the second aspect of the present invention, there is provided a lubricant composition comprising a base oil such as polybutene, polymethacrylate, polyisobutylene, or ethylene-α-olefin copolymers and an oiliness agent.

In the third aspect of the present invention, there is provided a lubricant composition comprising 98 to 75 % by weight of a liquid high molecular compound having a viscosity of 0.0003 to 0.05 m^2/s (300 to 50.000 cSt) (at 40 °C) a base oil and 2 to 25 % by weight of an oiliness agent.

In the fourth aspect of the present invention, there is provided a method for manufacturing electrically conductive substances characterized by coating the surface of a non-ferrous metal material with a lubricant composition comprising a base oil of a liquid high molecular compound and an oiliness agent and plastically working the non-ferrous metal material with a die while forming a lubricant film on the surface of the material.

In the fifth aspect of the present invention, there is provided a method for manufacturing elongated electrically conductive composite substances characterized by providing an elongated composite substance consisting of a core material cladded with a non-ferrous metal material, coating the surface of the elongated composite substance with a lubricant composition comprising a base oil of a liquid high molecular compound and an oiliness agent and plastically working the substance with a die while forming a lubricant film on the surface of the non-ferrous metal cladding.

In the sixth aspect of the present invention, there is provided a method for manufacturing electrically superconductive composite substances characterized by providing a composite substance consisting of a superconductive core material cladded with a non-ferrous metal material, coating the surface of the substance with a lubricant composition comprising a base oil of a liquid high molecular compound and an oiliness agent and plastically working the substance with a die while forming a lubricant film on the surface of the non-ferrous metal cladding.

In the seventh aspect of the present invention, there is provided a method for manufacturing electrically conductive wires characterized by providing an elongated substance of non-ferrous material alone or an elongated composite substance of a core material cladded with a non-ferrous metal material, coating the surface of the substance with a lubricant composition comprising a base oil of a liquid high molecular compound and an oiliness agent, passing the substance through a wire drawing die to reduce the diameter thereof while forming a lubricant film on the surface of the substance with the heat generated during drawing to produce wires and twisting two or more of the resulting wires.

In the eighth aspect of the present invention, there is provided a method for manufacturing electrically conductive wires characterized by providing an elongated substance of non-ferrous material alone or an elongated composite substance of a core material cladded with a non-ferrous metal material, coating the surface of the substance with a lubricant composition comprising a base oil of a liquid high molecular compound and an oiliness agent, passing the substance through a wire drawing die to reduce the diameter thereof while a film produced by a reaction of the non-ferrous metal and the oiliness agent in the lubricant composition with the heat generated during drawing is being formed on the surface of the substance to produce wires and twisting two or more of the resulting wires.

In the ninth aspect of the present invention, there is provided a method for manufacturing electrically superconductive wires characterized by providing an elongated composite substance consisting of a superconductive core material cladded with a non-ferrous metal material, coating the surface of the substance with a lubricant composition comprising a base oil of a liquid high molecular compound and an oiliness agent, passing the substance through a wire drawing die to reduce the diameter thereof while forming a lubricant film on the surface of the substance with the heat generated during drawing to produce wires and twisting two or more of the resulting wires.

In the tenth aspect of the present invention, there is provided a method for manufacturing electrically superconductive wires characterized by providing an elongated composite substance consisting of a core material cladded with a non-ferrous metal material, coating the surface of the substance with a lubricant composition comprising a base oil of a liquid high molecular compound and an oiliness agent, passing the substance through a wire drawing die to reduce the diameter thereof while a film produced by the reaction of the non-ferrous metal and the oiliness agent in the lubricant composition with the heat generated during drawing is being formed on the surface of the substance to produce wires and twisting two or more of the resulting wires.

The method of the present invention will be illustrated under with reference to drawings.

Referring to FIGURE 2. continuous linear material 2 is unwound from supply 2, guided by first roller 8, passes via guide 3 of wire drawing machine No.1, coated on its surface with lubricant 4, pulled by storage dram 7 to be drawn to have the first reduced diameter with drawing die 5 and wound on the storage dram.

Then the resulting wire is guided by rollers 8′ and 8″ to wire drawing machine No.2 where it is drawn to have the second reduced diameter as described above. The thinner wire may further drawn sequentially by a desired number of wire drawing machines (the last one is designated as No.n) to have a desired diameter.

Then the wire is introduced into treating chamber 9, passed through straightening machine 10 where the strain is removed, thereafter the lubricant adhered on the surface of the wire is removed by rolling brush 12 with solvent 11 and then the wire is dried. The dried wire is wound on winding dram 15 of winding machine 14.

The lubricant comprises a base oil and an additive. As a common base oil, one may mention mineral oil. However, mineral oil has a viscosity index not higher than 100 and its viscosity is rapidly reduced with an increase of temperature. For the reason, adhesion force of mineral oil to the surface of wire materials is lowered rendering lubrication poor, so that galling and fracturing of the wires are apt to occur and smooth drawing is unattainable. Moreover, if the temperature of the drawing die is 120 °C or higher, the use of mineral oils as base oil leads to discoloration of the surface of the wires and is unsuitable for the high velocity drawing.

It has been found that as base oils, liquid high molecular compounds do not diminish the excellent lubricating properties of animal and vegetable fats and oils or aliphatic dicarboxylic acid as additives, have less tendency to lower the viscosity with an increase of the temperature and have excellent adherability and heat resistance. The present invention has been made on the basis of this finding.

Liquid high molecular compounds include, for example, polybutene, polymethacrylate, polyisobutylene, ethylene-α-olefin copolymers. In addition, polyphenol ether, fluorinated ester, polyether, and the like may be employed.

The liquid high molecular compounds are liquid polymers which can be produced by any of known methods, and their viscosity can be freely controlled by varying their molecular weight or selecting and incorporating those having different molecular weights.

The liquid high molecular compounds to be used as base oils should preferably have a viscosity of 300 to 50,000 cSt at 40 °C in view of the conditions of drawing, workability and manageability.

Additives (lubricity improving agents) to be incorporated into the base oils include animal and vegetable oils such as hardened castor oil, lard oil, linseed oil, soybean oil, hardened tallow, lanolin and the like.

Aliphatic dicarboxylic acids include those having 5 to 36 carbon atoms such as glutaric acid, adipic acid, pimelic acid, azelaic acid, sebacic acid, undecanoic acid, dodecanoic acid, tridecanoic acid, dimer acid and the like.

An amount of animal and vegetable fats and oils or aliphatic dicarboxylic acids to be incorporated into the base oil, liquid high molecular compound is 2 to 25 % by weight, preferably 5 to 20 % by weight. It an amount of animal and vegetable fats and oils or aliphatic dicarboxylic acids to be incorporated is less than 2 % by weight, the effect of improving lubricity is insufficient and galling is apt to occur during drawing. Although one may use a higher amount than 25 % by weight of the additives, any further improvement of antigalling will not be attained.

To the lubricants used in drawing according to the present invention, one may add an oiliness improving agent such as higher fatty acids, higher alcohol and the like, an extreme-pressure lubricant of phosphorus-, chlorine- or sulfur-type, or metal soap powder and the like, if necessary. Moreover, to the lubricants as described above may be added water so as to produce the lubricants of emulsion type. In this case, any of known emulsifiers may be added.

The present invention allows composite wires consisting of superconductive core material cladded with non-ferrous metal material such as copper, aluminum and the like to be drawn at a higher velocity.

Although the present invention has been explained primarily with respect to wire drawing, it can be applied to general plastic working of non-ferrous metal materials for forming parts therefrom.

The lubricants used in the present invention exhibit a lower reduction of viscosity with an increase of the temperature and are thermally stable and excellent in adhesion to the surface of metal material with formation of a good lubricant film (oil film) at the frictional interface upon plastic working. Particularly, the film produced by the reaction of the surface of non-ferrous metal material and the additive in the lubricant, i.e., animal and vegetable fats and oils or aliphatic dicarboxylic acid is formed on the surface subjected to plastic working resulting in prevention of galling and in facility of plastic working because the film has an excellent lubricating property.

It may be postulated that the film is a metal soap film produced by primarily the reaction of the surface of the non-ferrous metal material and the additive with frictional heat generated at the interface between the material and the die; see, T.SAKURAI, "LUBRICANT OIL ADDITIVES - STATE AND FUTURE", LUBLICATION, 15, No.6302-310, (1970).

The metal soap film is effectively formed locally at a part of the surface of the material in contact with the die to become a stiff film preventing the "galling" which occurs owing to direct contact of the metal material with the die. Therefore, smooth plastic working can be achieved. Such effect can be most remarkably attained in wire drawing with no galling occurring even in high velocity wire drawing.

The present invention will be illustrated practically with the following Examples.

Examples 1 to 11

To polyisobutylene having a viscosity of 0.00065 m^2/s (650 cSt)at 40 °C to be used as lubricant base oil, were added 10 % by weight of fats and oils or aliphatic dicarboxylic acid as shown in Table 1 which had been heated and molten to prepare lubricant oils. With these oils, composite linear substances consisting of steel core cladded with copper were subjected to wire drawing by means of the drawing machine as shown in FIGURE 1. FIGURE 3 shows a diagrammatical cross-sectional view of the die.

Composite linear substance 2 unwound from supply 1 was guided by guide 3, immersed in and coated with lubricant 4, drawn through drawing die 5 equipped with thermocouple 6 to reduce the diameter of the substance and wound on dram 7 disposed in the drawing machine.

Then the resulting wires were allowed to pass through straightening machine 10 where the strains were removed, and thereafter the lubricants adhered on the surfaces of the wires were removed by rotating brushes 12 while spraying trichlene solvent onto the surface. After removing the solvent by air blowing with blower 13, the wires were wounded on winding dram 15 disposed in winding machine 14.

The surfaces of the wires were observed with the naked eyes to determine the surface condition on the basis of appearance of galling and surface cracking. In addition, the temperature increase of the die [-(Temperature during drawing) - (Initial temperature)] was determined. The results are indicated in Table 1. The wire drawing was performed under the following condition:
substance for wire: steel core - copper cladding composite (Cu-steel linear substance)
Shape of die : conical shape die having the dimensions of:
reduction angle ; 2°
drawing diameter ; 2.89 *mm*
bearing length ; 2 *mm*
Reduction ratio : 20.4 % (wire drawing reduction from a diameter of 3.24 *mm* to that of 2.89 *mm*)
Drawing velocity : 110/min
Die temperature : room temperature, 12 °C.

Table 1

Example No.	Lubricant	Die temperature increase (°C)	Surface condition
1	PI + castor oil	129	◎
2	PI + lard	127	◎
3	PI + tallow	128	◎
4	PI + hardend tallow	121	◎
5	PI + lanolin	128	◎
6	PI + glutaric acid	125	◎ ~ ○
7	PI + pimelic acid	128	◎ ~ ○
8	PI + azelaic acid	125	◎ ~ ○
9	PI + undecanoic diacid	126	○
10	PI + tridecanoic acid	127	○
11	PI + dimer acid	126	○
Comparative Example No.			
1	mineral oil	147	Δ
2	polybutene	149	Δ
3	polymethacrylate	145	Δ
4	ethylene-α-olefin copolymer	146	Δ
5	polybutene + calcium soap powder	153	×
6	paraffin wax + chlorinated paraffin + dilauryl hydrogen phosphite	168	× (grayish brown)
7	mineral oil	165	galling fracture
PI : polyisobutylene (base oil)			
◎ : excellent, ○ : good, Δ : just before galling, × : galling			

Comparative Example 1 to 7

The lubricant used in each Comparative Example is shown in Table 2. The parenthesized number indicates the viscosity at 40 °C (m^2/s).

Table 2

Comparative Example No.	Lubricant
1	mineral oil (0.00083)
2	polybutene (0.001)
3	polymethacrylate (0.00073)
4	ethylene-α-olefin copolymer (0.001)
5	90 % by weight polybutene (0.00065) / 10 % by weight calcium soap powder having a grain size of 105 to 150 µm
6	20 % by weight paraffin wax(mp.58 °C) / 20 % by weight chlorinated paraffin (chlorine cont.:60%) / 60 % by weight dilauryl hydrogen phosphite
7	90 % by weight mineral oil(0.000085) /10 % by weight lanolin

Example 12

Using the same lubricants as in Examples 1 to 11, the composite linear substances consisting of a steel core cladded with aluminum were subjected to wire drawing by means of the drawing machine as shown in FIGURE 1. The surface conditions (with respect to galling and surface cracking) after drawing were observed with the naked eyes and the die temperature increase was determined. The results are shown in Table 3.

The analysis with the roundness measuring apparatus (available from KOSAKA Laboratory, Modle EC-4S) indicates that the surface roughness after wire drawing is about ± 2 µm in the circumferential direction.

The surface roughnesses of the wires of the Comparative Examples 2 (using polybutene) and 5 (using polybutene and calcium soap) analyzed in the same procedure are both about ± 4 µm.

Example 13~38

Lubricants consisting of base oils and fats and oils and aliphatic dicarboxylic acids as shown in Table 4 were melted under heat and using the melted lubricants at 15~17 °C, the aluminum-cladding steel composite substance was subjected to wire drawing with the same drawing machine as in Example 2. The die temperature increase and the surface condition were determined. The results are shown in Table 4.

Table 3

Example No.	Lubricant	Increase of Die temperature(°C)	Surface condition
1	PI + castor oil	131	◎
2	PI + lard	130	◎
3	PI + tallow	135	◎
4	PI + hardend tallow	130	◎
5	PI + lanolin	131	◎
6	PI + glutaric acid	136	○
7	PI + pimelic acid	137	○
8	PI + azelaic acid	139	○
9	PI + undecanoic diacid	137	○
10	PI + tridecanoic acid	129	○
11	PI + dimer acid	140	○
Comparative Example No.			
1	mineral oil	156	Δ
2	polybutene	159	Δ
3	polymethacrylate	157	Δ
4	ethylene-α-olefin copolymer	156	Δ
5	polybutene + calcium soap powder	163	×
6	paraffin wax + chlorinated paraffin + dilauryl hydrogen phosphite	171	× (grayish brown)
7	mineral oil	163	galling fracture

PI : polyisobutylene (base oil)

◎ : excellent, ○ : good, Δ : just before galling, × : galling

Table 4

Base Oil	Example No.	Additive					Increase of Die temperature	Surface condition
		astor oil	tallow	lanolin	glutaric acid	dimer acid		
polymeth-acrylate (0.00073)	13	1					149	△
	14	2					132	○
	15	5					128	○～◎
	16	15					129	◎
	17	20					128	◎
	18	25					126	◎
polyiso-butylene (0.00065)	19		1				151	×～△
	20		2				136	○
	21		5				130	◎
	22		20				125	◎
	23		25				126	◎
	24			1			150	△

Base Oil	Example No.	Additive: castor oil	Additive: tallow	Additive: lanolin	Additive: glutaric acid	Additive: dimer acid	Increase of Die temperature	Surface condition
polyiso-butylene (0.00065)	25			2			134	○
	26			5			126	◎
	27			20			124	◎
	28			25			126	◎
ethylene-α-olefin copolymer (0.031)	29				1		156	× ~ △
	30				2		137	○ ~ ◎
	31				5		134	◎
	32				20		129	◎
	33				25		131	◎
	34					1	156	× ~ △
	35					2	136	○
	36					5	137	◎
	37					20	134	◎
	38					25	134	◎

The parenthesized number indicates a viscosity at a temperature of 40 ℃ (m^2/s)

◎ : excellent, ○ : good, △ : just before galling, × : galling.

It can be seen from the results shown in Table 4 that if an amount of fats and oils or aliphatic dicarboxylic acids to be incorporated is lower than 2 % by weight, the die temperature rises rapidly and the surfaces of the wires become in the state just before galling. Even if it is higher than 20 % by weight, there is a tendency that further improvement of the surface properties is unattainable.

Example 39

Using the lubricant prepared by incorporating 10 % by weight of lanolin into polybutene having a viscosity of 0.0002 to 0.3 m^2/s (200 to 300,000 cSt at a temperature of 40 °C, the same aluminum-cladding steel composite substances as in Example 2 were subjected to wire drawing under a working reduction of 20 % with the drawing machine as shown in FIGURE 1. Variation of the die temperature was measured as a function of the viscosity of the base oil. The results are shown in FIGURE 4.

When the viscosity was not higher than 0.0003 m^2/s (300 cSt), the die temperature increased greatly. Moreover, when the drawing was temporarily stopped and then again started, there were cases where the wires fracture.

On the other hand, if the viscosity is above 0.035 m^2/s (35,000 cSt), the die temperature begins to rise and the carry-over of lubricant increases with the lubricant being apt to adhere to the single decked wire drawing machine, winding dram, floor and the like, that is, the workability, particularly, manageability of the lubricant during replenishment thereof being poor. The viscosity of lubricants should be up to about 50,000 cSt.

Example 40

Using the lubricant comprising 90 % by weight of ethylene-α-olefin copolymer having a viscosity of 0.031 m^2/s (31,000 cSt) at a temperature of 40 °C and 10 % by weight of lanolin, the aluminum-cladding steel composite substances having a diameter of 8.4 *mm* were subjected to wire drawing through eleven stages with the continuous multi-stage wire drawing machine as shown in FIGURE 2. The practical performance of the lubricant was evaluated. The results obtained by observing the surface properties of the wires after drawing, working condition and the ratio in cross-sectional area of the core to the cladding layer are indicated in Table 5.

As can be seen from the results shown in Table 5, remarkably good surface properties and smooth wire drawing could be achieved. The ratio in cross-sectional area of the core and the cladding was excellently in the range of 34.8 to 36.0 %. Moreover, the surfaces contaminated with the lubricant of the wires after the eleven stages was washed by rotating brush 12 with trichlene solvent 11 in treating chamber 9 as shown in FIGURE 2 and one washing step was sufficient to remove almost perfectly the lubricant adhered to the surface.

Table 5

Stage No.	Drawing diameter $mm\phi$ (Reduction)		Drawing velocity (m/min)	Surface condition	Drawing force(Kgf)	Ratio in Crossectional of Cladding to Core(%)
0	8.4		-	◎	-	36.0
1	8.1	(7.0)	45	◎	-	36.1
2	7.4	(16.5)	55	◎	-	35.2
3	6.8	(15.5)	65	◎	-	35.1
4	6.3	(14.2)	78	◎	-	35.1
5	5.7	(18.2)	93	◎	-	34.8
6	5.1	(19.9)	114	◎	-	34.8
7	4.38	(26.2)	135	◎	-	34.9
8	4.04	(14.9)	178	◎	-	34.8
9	3.65	(18.3)	220	◎	-	34.9
10	3.45	(10.7)	250	◎	-	34.8
*11	3.26	(10.7)	280	◎	250 ~ 260	34.8

* Adhered lubricant was removed with trichlene after the wire drawing having eleven stages.

Example 41

The aluminum-cladding steel wires (the individual wire has a diameter of 2.9 $mm\phi$) obtained in Example 40 were twisted under the conditions of a number of wires of 30 and a cross-sectional area of 200 mm^2 with the tandem high velocity twisting machine and the practical performance was evaluated. As a result, there could be obtained a normal twisted wires having no flaw on the surfaces thereof.

The use of the aforementioned lubricant upon twisting operation is more effective to give such twisted wires.

Examples 42 to 52 and Comparative Examples 8 to 14

A number of aluminum substances of A 2218 (O) (annealed from 400 °C to room temperature according to JIS-H4000) of a ring type having dimensions of 63 mm in outside diameter x 12 mm in inside diameter × 12 mm in thickness as shown in FIGURE 5 was coated on its surface with the lubricants having the same compositions as in Examples 1 to 11 and Comparative Examples 1 to 7 and were subjected to plastic working at a velocity of 40 pieces / min to produce 2000 parts having the configuration as shown in FIGURE 6. The surface conditions are indicated in Table 6. It can be seen from the table that workpieces worked in accordance with the present invention have no galling generated, but excellent surface conditions.

Table 6

Example No.	Lubricant	Surface condition
42	PI + castor oil	◎
43	PI + lard	◎
44	PI + tallow	◎
45	PI + hardend tallow	◎
46	PI + lanolin	◎
47	PI + glutaric acid	○～◎
48	PI + pimelic acid	○～◎
49	PI + azelaic acid	○～◎
50	PI + undecanoic diacid	○
51	PI + tridecanoic acid	○
52	PI + dimer acid	○～◎
Comparative Example No.		
8	mineral oil	×
9	polybutene	×～△
10	polymethacrylate	△
11	ethylene-α-olefin copolymer	△
12	polybutene + calcium soap powder	△
13	paraffin wax + chlorinated paraffin + dilauryl hydrogen phosphite	×～△
14	mineral oil	×～△

PI : polyisobutylene (base oil)

◎ : excellent, ○ : good, △ : just before galling, × : galling

Example 53

Y-Ba-Cu-O and Bi-Ca-Cu-O system superconductive substances in the form of pellet produced by an oxide-kneading process were introduced in a tube of oxygen-free copper C 1020 (JIS H 3300) and an aluminum tube A 1070 (JIS H 4080) having dimensions 8 *mm* in outside diameter × 0.6 *mm* in thickness. After the opposite ends are sealed, the tubes were subjected to swaging by using a lubricant composition comprising 90 % by weight of ethylene-α-olefin copolymer having a viscosity of 0.031 m^2/s (31000 cSt) at a temperature of 40 °C and 10 % by weight of lanolin to reduce the outside diameter to 6 *mm*. These substances were subjected to wire drawing at a drawing velocity of 110 / min through five stages with the same die as in Example 1 to produce superconductive wires having a diameter of 2.9 *mm*. The results are indicated in Table 7.

Table 7

No.	Superconductive composition	Cladding tube material	Increase of Die temperature (℃)	Surface condition
1	Y-Ba-Cu-O	oxygen free Cu tube C1020	105	○～◎
2	Bi-Sr-Ca-Cu-O		108	○～◎
3	Y-Ba-Cu-O	aluminum tube A 1070	104	○
4	Bi-Sr-Ca-Cu-O		106	○

◎ : excellent

○ : good

As clearly seen from Table 7, the surfaces of the wires after drawing are excellent without any galling generated and no cracks were formed inside the wires.

Example 54

The superconductive wires having a diameter of 2.9 *mm* obtained in Example 53, No.1 and No.3, were rolled repeatedly 5 to 8 times by using a lubricant composition comprising 90 % by weight of ethylene-α-olefin copolymer and 10 % by weight of lanolin to produce tapes having a thickness of 0.1 *mm*. The resulting tapes were remarkably good without any galling generated on their surfaces. No cracks were generated inside the tapes.

The method for plastic drawing in according to the present invention allows the plastic drawing to be effected generating no galling and the like and to provide high quality non-ferrous parts since the parts after working·have an excellent surface condition.

Furthermore, the lubricant composition according to the present invention has an excellent antigalling property and a high lublicity even during high velocity wire drawing. Therefore, it allows the high velocity wire drawing and the high velocity twisting to be smoothly effected and allows excellently the quality of wires and the productivity to be improved.

Moreover, the wire drawing method according to the present invention can provide sufficiently acceptable composite wires with respect to conductivity (the thickness of the cladding is constant).

The lubricant for use in wire drawing in accordance with the present invention is excellent in workability and safty of operation because of its low viscosity.

Claims

1 A lubricant composition comprising as base oil a liquid high molecular compound having a viscosity of 0.0003 to 0.05 m^2/s (300 to 50,000 cSt) (at 40 °C) and an additive selected from a group consisting of animal and vegetable fats and oils and aliphatic dicarboxylic acids.

2 A lubricant composition comprising a base oil selected from a group consisting of polybutene, polymethacrylate, polyisobutylene and ethylene-α-olefin copolymers and an oiliness agent.

3 A lubricant composition comprising as base oil 98 to 75 % by weight of a liquid high molecular compound having a viscosity of 0.0003 to 0.05 m^2/s (300 to 50,000 cSt) (at 40 °C) and 2 to 25 % by weight of an oiliness agent.

4 A method for manufacturing electrically conductive substances characterized by providing non-ferrous metal material (2), coating the surface of the non-ferrous metal material (2) with a lubricant composition (4) comprising as base oil a liquid high molecular compound and an oiliness agent and plastic-working the non-ferrous metal material (2) with a die (5) while forming a lubricant film on the surface of the material(2).

5 A method for manufacturing elongated electrically conductive composite substances characterized by providing an elongated composite substance (2) consisting of a core material cladded with a non-ferrous metal material, coating the surface of the elongated composite substance (2) with a lubricant composition (4) comprising as base oil a liquid high molecular compound and an oiliness agent and plastic-working the substance (2) with a die (5) while forming a lubricant film on the surface of the non-ferrous metal cladding.

6 A method for manufacturing superconductive composite substances characterized by providing a composite substance (2) consisting of a superconductive core material cladded with a non-ferrous metal material, coating the surface of the substance (2) with a lubricant composition comprising (4) as base oil a liquid high molecular compound and an oiliness agent and plastic-working the substance (2) with a die (5) while forming a lubricant film on the surface of the non-ferrous metal cladding.

7 A method for manufacturing electrically conductive wires characterized by providing an elongated substance (2) of non-ferrous material alone or an elongated composite substance (2) of a core material cladded with a non-ferrous metal material, coating the surface of the substance (2) with a lubricant composition (4) comprising as base oil a liquid high molecular compound and an oiliness agent, passing the substance (2) through a wire drawing die (5) to reduce the diameter thereof while forming a lubricant film on the surface of the substance (2) with the heat generated during drawing to produce wires and twisting two or more of the resulting wires.

8 A method for manufacturing electrically conductive wires characterized by providing an elongated substance (2) of non-ferrous material, coating the surface of the substance(2) with a lubricant composition (4) comprising as base oil a liquid high molecular compound and an oiliness agent, passing the substance (2) through a wire drawing die (5) to reduce the diameter thereof while a film produced by a reaction of the non-ferrous metal and the oiliness agent in the lubricant composition (4) with the heat generated during drawing is being formed on the surface of the substance (2) to produce wires and twisting two or more of the resulting wires.

9 A method for manufacturing electrically superconductive wires characterized by providing an elongated composite substance (2) consisting of a superconductive core material cladded with a non-ferrous metal material, coating the surface of the substance (2) with a lubricant composition(4) comprising as base oil a liquid high molecular compound and an oiliness agent, passing the substance (2) through a wire drawing die (5) to reduce the diameter thereof while forming a lubricant film on the surface of the substance (2) with the heat generated during drawing to produce wires and twisting two or more of the resulting wires.

10 A method for manufacturing electrically superconductive wires characterized by providing an elongated composite substance (2) consisting of a superconductive core material cladded with a non-ferrous metal material, coating the surface of the substance (2) with a lubricant composition (4) comprising as base oil a liquid high molecular compound and an oiliness agent, passing the substance (2) through a wire drawing die (5) to reduce the diameter thereof while a film produced by the reaction of the non-ferrous metal and the oiliness agent in the lubricant composition (4) with the heat generated during drawing is being formed on the surface of the substance (2) to produce wires and twisting two or more of the resulting wires.

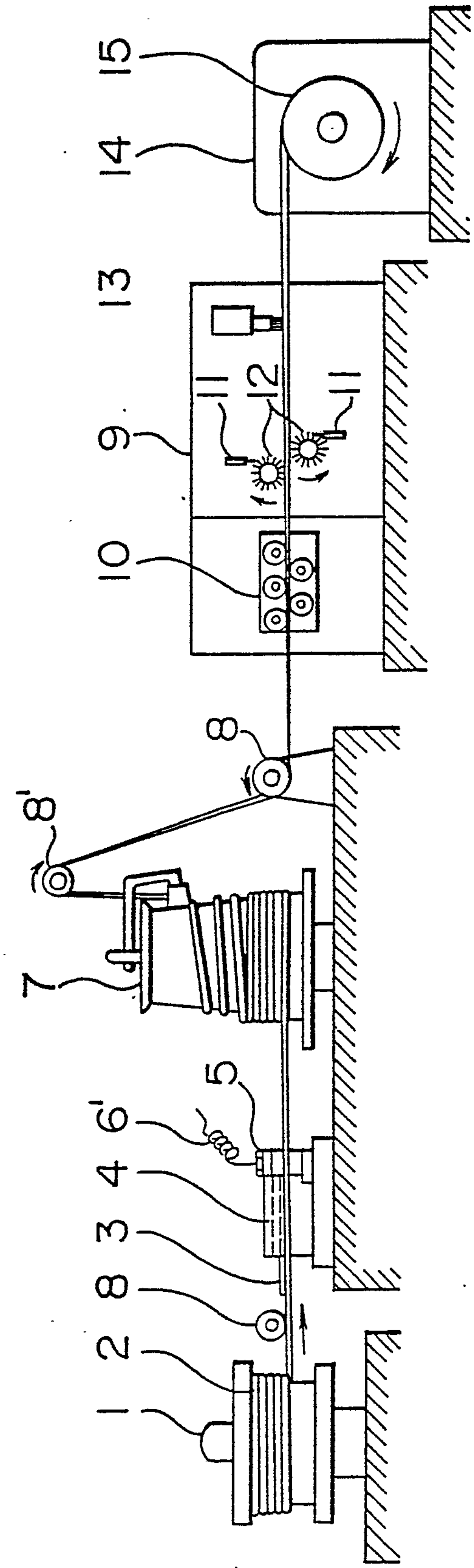

FIG. 1

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FIG. 2

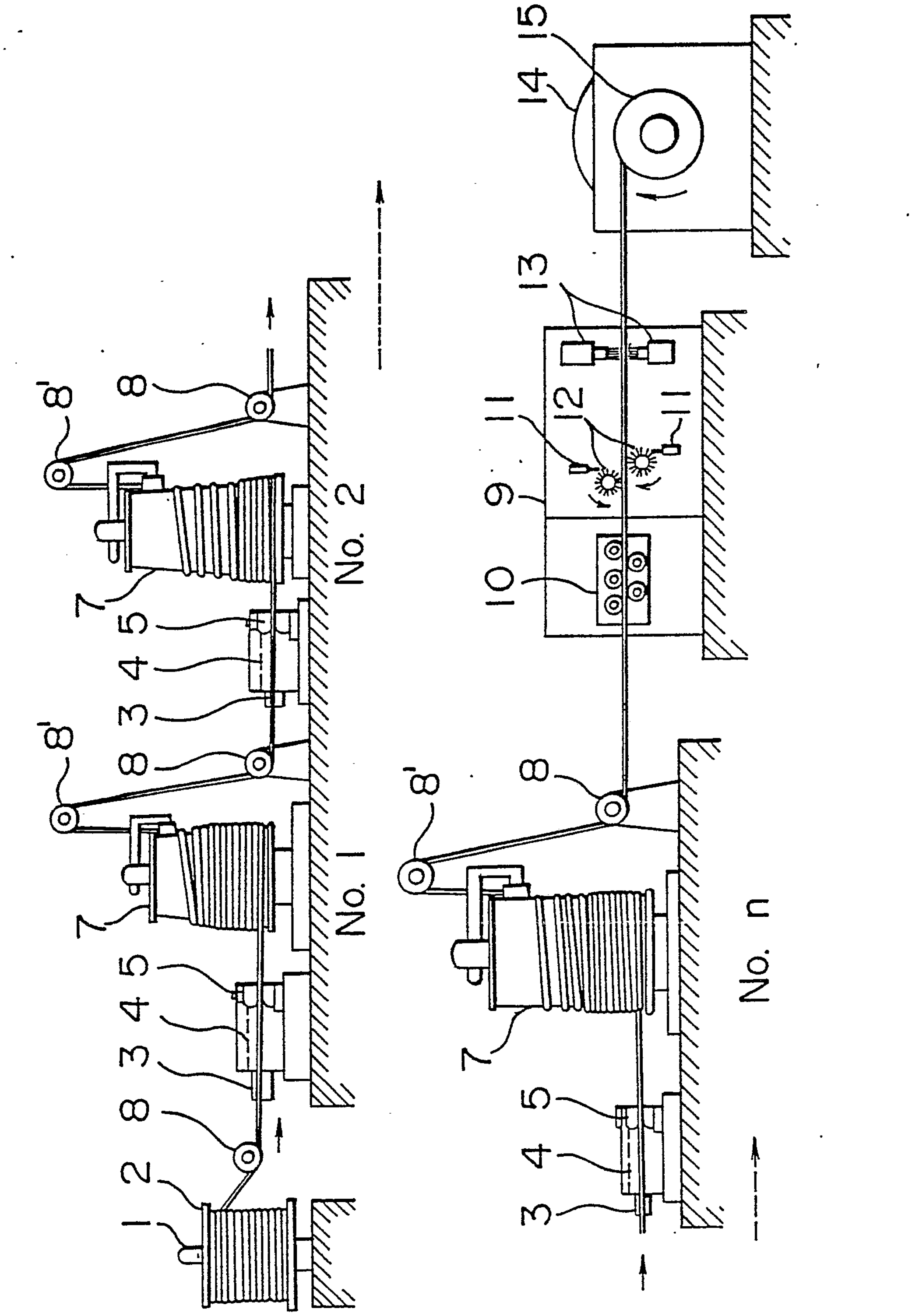

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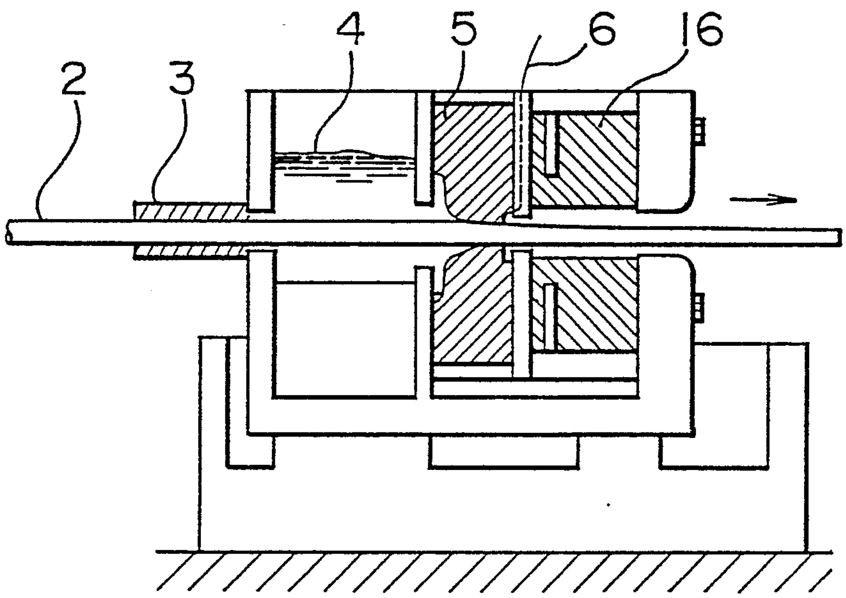
FIG. 3



F I G. 4

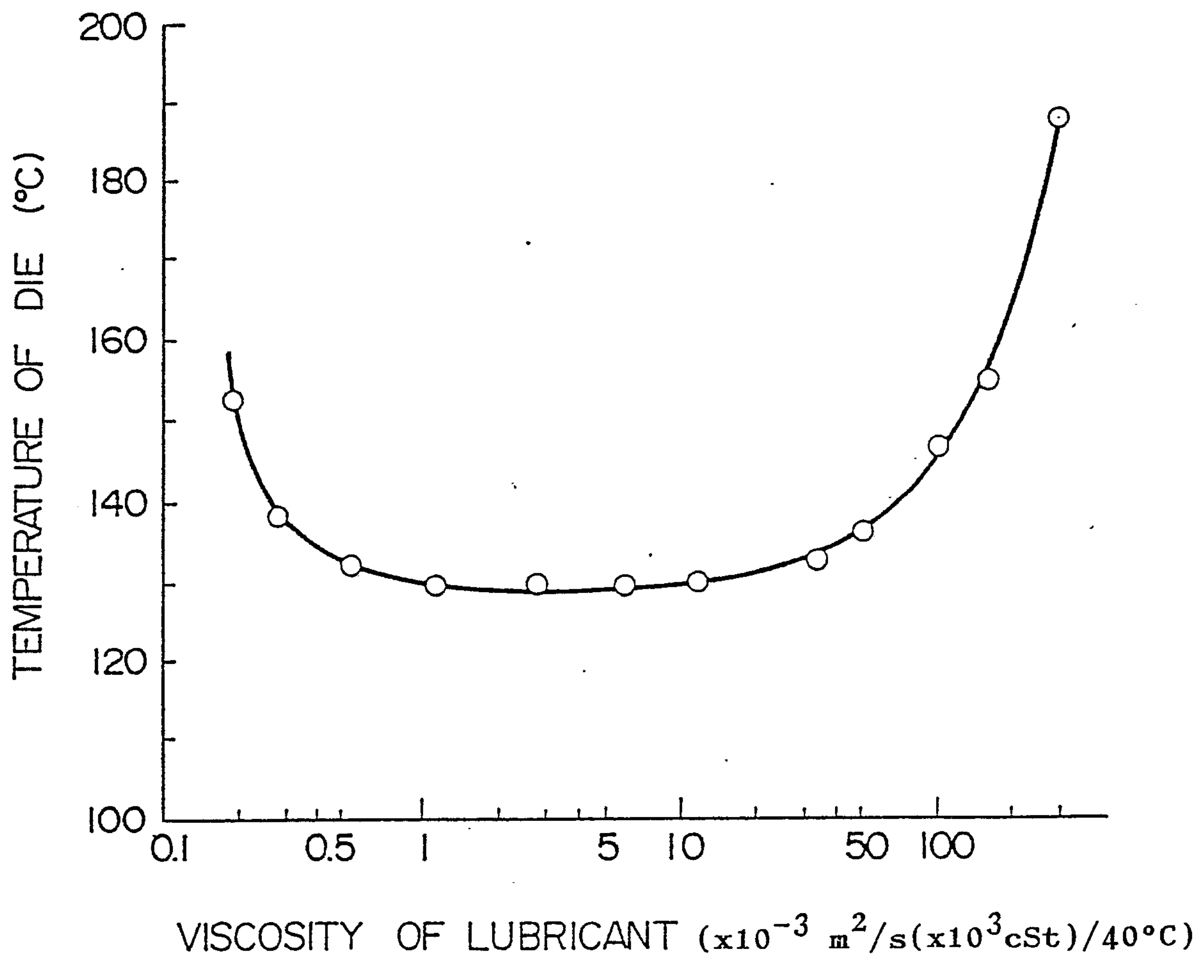

200
180
160
140
120
100
TEMPERATURE OF DIE (°C)
0.1
0.5
1
5
10
50
100
VISCOSITY OF LUBRICANT (x10⁻³ m²/s(x10³cSt)/40°C)

FIG. 5

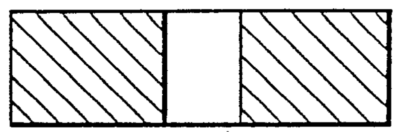


FIG. 6

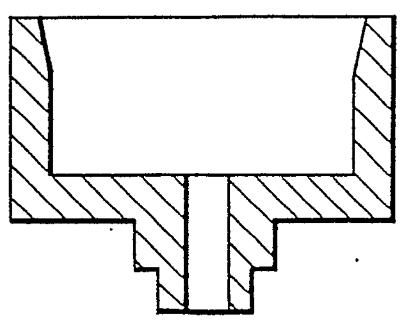
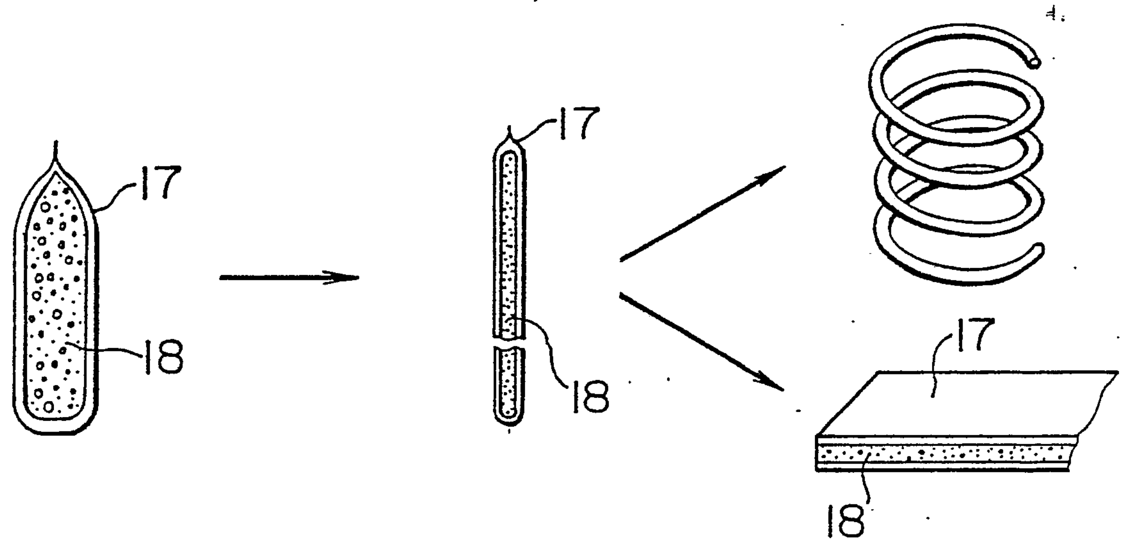


FIG. 7(a) FIG. 7(b) FIG. 7(c)



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EUROPEAN SEARCH REPORT

Application Number

EP 89 10 8389

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X Y	EP-A-0 242 040 (NIHON KOUSAKUYU CO. LTD) * Page 1, line 5 - page 3, line 4; page 7, line 13 - page 8, line 11; page 13, line 11 - page 14, line 30; page 24, table 11 * ---	1-3 4,7,8	C 10 M 169/04 // (C 10 M 169/04 C 10 M 107:04 C 10 M 107:08 C 10 M 107:28 C 10 M 129:34 C 10 M 129:42 C 10 M 159:08) C 10 N 20:02 C 10 N 30:06 C 10 N 40:24
Y	US-A-3 915 869 (T. KATONO) * Column 14, example 12; claim 1 * ---	4,7,8	
Y	WIRE AND WIRE PRODUCTS, vol. 27, no. 11, November 1952, pages 1180-1184; L. SALZ: "What are the differences in wire drawing lubricants?" * Page 1181, column 2, line 34 - column 3, line 3; page 1182, column 2, lines 17-34; page 1183, column 3, lines 9-31 * ---	4,7,8	
X	FR-A-1 426 791 (STANDARD OIL CO.) * Page 2, column 1, line 4 - column 2, line 2; page 2, column 2, example 3 * ---	1-3	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)**
X	DE-A-3 207 296 (SCHWEIZERISCHE ALUMINIUM AG) * Page 4, line 14 - page 5, line 2 * ---	1-3	C 10 M B 21 C
A	GB-A-1 507 823 (ARTHUR LEE & SONS LTD) * Page 1, lines 8-55; page 3, lines 24-29,66-110; page 4, lines 36-49 * ---	1-10	
A	US-A-3 250 103 (S.J. BEAUBIEN) * Column 1, lines 9-19,44-57; claims 1,2,12,13 * --- -/-	1-10	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	02-08-1989	HILGENGA K.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A	CHEMICAL ABSTRACTS, vol. 102, 21st January 1985, page 332, abstract no. 29906k, Columbus, Ohio, US; E. DAMBORAKOVA et al.: "Copper wire drawing and determination of antiabrasion properties of drawing emulsion lubricants", & ROPA UHLIE 1984, 26(8), 497-503 * Abstract *	4-10	
A	CHEMICAL ABSTRACTS, vol. 104, 3rd March 1986, page 291, abstract no. 73520v, Columbus, Ohio, US; & JP-A-60 149 752 (FURUKAWA ELECTRIC CO. LTD) 07-08-1985 * Abstract *	4-10	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

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THE HAGUE	02-08-1989	HILGENGA K.J.

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