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LUBRICANT COMPOSITION COMPOSED OF HIGH-TITRE SOAP, BORAX, AND AN INORGANIC COMPOUND

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This invention relates to the lubrication of worked metallic surfaces in the processing of metals in contradistinction to that encountered in a fixed machine or engine. The difference does not lie in the nature of the friction encountered but in the dimensional variations which exist in the case of worked metals but which do not exist in a machine. Any machine or engine is designed and built to perform its function with a definite and as nearly as possible constant clearance between the moving surfaces and thus encounters only a uniform sliding friction. On the other hand, in metal processing such as machining, drawing, and forming of metals the only fixed dimensions are those of the cutting tool or the forming dies that are set up for the specific operation. Thus the clearance between the tools and the metal being processed are a resultant between the pressure and force applied to the work and the counter and resisting forces offered by the work. Thus the high points between the tool and the work are subjected to a tremendous thrusting friction which will cause actual metal to metal contact and with it a welding and scoring of the surfaces.

An object of the invention is to control by a novel means of lubrication the dimensional variation which is a necessary incident to metal working but practically does not exist in functional machinery.

In the present process we utilize a planned succession of endothermic reactions initiated by the frictional heat or mechanical equivalent thereof (e.g. pressure) that not only cool the frictional surfaces by absorbing heat but which produce nascent fluid lubricants at points of extreme heat and pressure. The preferred procedure uses both fusible organic and fusible inorganic materials to produce such succession of reactions.

Bowden and Ridler (Proceedings Royal Society 1936, Series A No. 883, page 154) made a classical and incontrovertible study of the sliding friction of metals in which the contacting metals were a part of an accurate thermocouple. It was convincingly demonstrated in this study that in dry sliding friction, the junction point between the two metals reaches and maintains the melting point of the lower melting metal. This fact is as startling as the recent proof by the application of the electron microscope which showed that the amorphous Beilby layer actually existed on polished metals, which meant that it was possible to cause a metal to melt

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and flow by buffing it with a cloth buffing wheel on a polishing lathe.

When iron is alloyed with other elements specific to the purpose, the hardness is thereby increased, but the melting point of the alloy is usually lowered. Thus when a steel is alloyed for hardening and used as a tool in metal processing, high melting point has been sacrificed for the hardness attained. Therefore, when some failure in lubrication allows a sliding frictional contact between the hardened tool and the processed metal, the tool rather than the work will usually be softened and scored or otherwise damaged. The effectiveness of chromium plated or tungsten carbide tools and dies is due not only to their inherent hardness, but to their high melting point, well above that of a steel being processed.

When a steel cup, for example, is pickled to remove the annealing scale, the surface is etched and dully crystalline. When this rough surfaced cup is drawn in a press to a 25 to 40% elongation, the rough surface is flowed to a highly reflective surface which, at points of maximum contact and pressure, could be described as mirror-like. Likewise, when the mill scale is removed from rod by acid, the surface is dull and etched. When etched quarter inch rod, however, is drawn to 0.0095 in twenty successive drafts the surface of the fine wire has a brightness of highly buffed amorphous metal.

These mirror-like drawn surfaces give a different electron diffraction pattern than the oriented etched surface, indicating amorphous metal. Thus in drawing metal we form, as we do in buffing, a Bielby layer at points of extreme pressure and friction. This, as pointed out above, means that the metal has melted and flowed at these mirror-like contact areas.

The action described above can be more readily understood by converting the foot pounds utilized in the drawing operation into the mechanical equivalent of heat. For example, in drawing a .75 millimeter steel shell casing in a 180 ton press which travels eight inches in the draw, the mechanical heat equivalent is equal to over 38,000 calories which, if there were no heat radiation, would be sufficient to melt over a pound and a half of steel.

From literature on the subject of metal working and experience in that field it appears that two fundamental requirement factors operate or would operate conjointly to effect ideal or perfect lubrication when a metal is formed or drawn. One of these factors is adequate cool-

ing, and the other is the prevention of actual direct physical contact between the metal and the tool or die at any point. "Contact" as used herein indicates the apparent but not actual relationship between the metal and working element in a successful method of lubrication. By preventing actual contact between the tool or die and the work we prevent the dry sliding friction that would cause the lower melting metal to melt and flow in the manner revealed by Bowden and Ridler.

Since the melting point of high carbon steel is below that of the lower carbon steels it processes, it is important to protect it from harm. It is therefore readily understood how it becomes necessary to remove frictional heat and to prevent any metal to metal contact which would cause scoring of the tool or welding of the processed metal thereto. Similarly, when chromium plated or tungsten carbide tools are used, the lower melting steel must be protected.

It is a further purpose of this invention, in the case of alloy steel processing tools, to protect the tool against such a temperature rise as would approach the softening or welding point of the relatively lower melting tool steel, or in the case of chromium plated or tungsten carbide steel, the melting of the lower melting steel being processed. Inasmuch as such a temperature is far above the carbonization point of normally fluid lubricating materials commonly spoken of as oil, we utilize inorganic compounds to achieve the essential cooling and lubrication of the sliding surfaces at the elevated temperatures existing when combustible organic lubricants are ordinarily no longer capable of functioning; but, in addition, we utilize properties of the inorganic materials to increase the thermal stability of the preferred organic lubricants used.

A specific object of the invention is to provide an improved method of treating metals preparatory to the cold drawing or forming thereof in order to insure both stepwise cooling and stepwise lubrication of the metal. That object is accomplished, for example, by coating the surface of the metal to be worked with a composition, the ingredients of which will act progressively and successively both as coolants and as lubricants when the coating is subjected to the extreme pressures incident to drawing or forming operations and temperatures approaching the melting point of the worked metal or, in the case of a non-metallic tool or die, the point at which such working element might be damaged by working that particular metal.

A correlative object is to prepare the stock so that it may be drawn or formed more efficiently and with increased tool or die life.

A specific object, in connection with wet drawing or wet metal processing, is to afford stepwise lubrication at high temperature contact points, where the aqueous solvent is evaporated and ineffective to prevent seizure, so that a mixture of fusible organic and inorganic lubricants that are identical in lubricating action to a pre-deposited coating will come into action.

In one modification of the present method we achieve cooling and lubrication by coating the surface to be drawn or formed not only with a low melting point fusible, polar, organic lubricant but with certain inorganic glass forming materials, such as hydrated alkali metal salts which will melt stepwise under frictional heat, and will then boil in their water of crystallization or hydration and thereby act successively or progressively as coolants after which, when the water of crystallization or hydration has been removed, the residue, upon sufficient rise in temperature, becomes a fluid glass and a hydraulic lubricant. Characteristic hydrated alkali metal salts, along with their primary melting points and their boiling points are as follows (centigrade scale):

	Melting Point	Boiling Point
	Degrees	*Degrees*
Sodium carbonate (Na_2CO_3—$10H_2O$)	32.5	33.5
Sodium metasilicate (Na_2SiO_3—$9H_2O$)	40.48	100
Sodium phosphate (Na_3PO_4—$12\ H_2O$)	73.3	100
Sodium tetraborate (Na_2B_4—$10H_2O$)	75	200

The large and valuable heat absorbing capacity of the hydrated alkali metal salts listed above can best be understood by comparison of their latent heats with those of other common substances used for cooling or lubricating metal surfaces. The latent heat of a body represents the quantity of heat necessary to change one gram of the body from a solid to a liquid or from a liquid to a vapor.

The heat of fusion expressed in gram calories per gram of the common bearing metals is about 6 for lead, about 14 for tin, while disodium phosphate ($Na_2HPO_4 12H_2O$) has a latent heat of fusion of about 67 gram calories per gram or ten times that of lead. Added to this is the unexcelled latent heat of vaporization of water which is about 500 gram calories per gram and which is present as water of crystallization in our preferred glass forming hydrated alkali metal salts. As a comparison the ethylene glycol used in liquid cooled engines has a latent heat of vaporization of about 190 gram calories per gram, and lubricating oils about 90 gram calories per gram.

Thus each of the hydrated alkali metal salts identified above has a heat capacity far exceeding that of a bearing metal in heat of fusion as well as the unexcelled latent heat of water in the water of hydration or crystallization. The hydrated alkali metal salts become highly efficient tool-protective coolants in preventing the occurrence of extreme frictional heat such as would result from actual sliding contact between the metal and tool.

In addition, the polar organic compounds which operate as primary or introductory lubricants, as already mentioned, are preferably hydrated colloids which likewise liberate water in melting.

The steam generated when the glass forming alkali metal salts give up their water of crystallization or hydration and when the hydrated colloid (e. g. soap) melts, is an important contributing factor to the operation of the process. The steam generated and entrapped in the closely confined frictional areas between the metal and the die would be at a high temperature and pressure and would undoubtedly have a cushioning effect upon the moving surfaces. Such an effect might be compared to the cushioning of steam from a damp cloth under a tailor's iron. Or it could be noted that, in hand glass blowing, the luted face of the steel mold is first wet with water so that the glass will be cushioned by steam to prevent it from actually touching the mold as the red hot ware is rotated therein.

In the wet drawing of wire the cushioning effect of steam generated by frictional heat contributes to the success of the process. The high

latent heat of vaporization of water is utilized in this invention to an even greater degree by the application of an aqueous solution of fusible organic and inorganic lubricants selected for stepwise action in the case of wet drawing, grinding or wet machining operations.

While cooling is of great importance in the drawing or forming of metals, it is, of course, to be understood that successful cold working of metals can only be accomplished by proper lubrication. The function of lubrication is well expressed in the following quotation from an excellent text, by Dr. Jevons, "The Metallurgy of Deep Drawing and Pressing," Chapman & Hall, 1941:

"Since the primary function of a lubricant is to reduce the coefficient of friction between two surfaces, it follows that the quality of slipperiness is equalled in importance only by that of film strength, or ability to maintain this slipperiness under severe conditions of temperature and pressure. Slipperiness may be defined as ability to reduce the coefficient of friction between sliding surfaces after the breakdown, or in the entire absence of a viscous film. This definition applies also to the 'filler' type of lubricant.

"In the rather special lubricants which have been developed specifically for deep drawing operations, some distinction needs to be made between the property of true 'oiliness' and the wider attribute here termed 'slipperiness.' 'Oiliness' is attained by the addition to the lubricant of a suitable oily substance, either free or in a combined state; slipperiness is attained by the addition of solids ranging from graphite, a substance held by some to possess truly oily characteristics, to substances such as chalk, which although not oily in the accepted sense of the word, yet produces a measure of apparent 'slipperiness' in drawing lubricants containing them."

In the prior metal drawing, some of the "fillers" or "solids," mentioned in the above quotation, apparently performed their function by absorbing the fluid lubricant used therewith. Other solids, for example, mica and graphite, have a natural lubricating quality and in some forms may also absorb oil. The various oxides, chalk or clay, used in prior practice, act as would a sponge, due to well known interfacial phenomena to absorb the oil. After the absorption of lubricant fluid, those fillers functioned as would, theoretically, a solid drop of oil somehow fastened in place against the "contacting" walls. In each case the essential lubrication at extremely high pressures could be considered to be mechanical in nature in the prevention of contact between the sliding surfaces since those temperatures would ordinarily be upwardly beyond the carbonization points of the oils used. In the present invention we utilize with naturally "slippery" substances a type of filler which will melt and flow under the frictional heat of the forming operation. Since commercially practicable organic lubricants are destroyed by heat, we utilize glass forming substances as additional lubricants or previously formed glass particles suitably small.

It is of significance that the commercially used fillers in pigmented drawing compounds such as lime, clay, mica, calcium, or magnesium carbonate and titanium dioxide are infusible. When these materials are used in drawing, minute particles of them can be found embedded in the drawn work, resulting in an undesirable dull surface that is very difficult to clean. We provide coolants such as water and low melting inorganic

compounds before the organic lubrication is endangered. The inorganic materials act as fillers during the life of the organic lubricant and a series of mineral fluid lubricants after the organic lubricant has been burned off or is otherwise destroyed or rendered ineffective.

As well known in the ceramic arts, glasses consist of certain basic oxides such as K, Na, Pb, Ca etc. combined with acid oxides such as those of silicon, boron, or phosphorus. The compounds are melted down commercially to form a fluid which when solidified we recognize as glass.

We utilize the frictional heat generated by nearly actual sliding contact between the metal and tool, which actual sliding contact is initially prevented by interposition of an organic lubricant, to form both cooling and lubricating fluids at temperatures beginning approximately at the breakdown temperatures of commonly used organic lubricants.

An important feature of the process is the fact that we combine with the inorganic fluid-glass-forming materials, as a binder and vehicle for said materials and also as a primary introductory lubricant, a fusible film-forming organic material which is preferably a polar compound capable of forming an efficient lubricating film at a temperature below the fusion point of the inorganic materials used and which may be below the melting point of said organic material. We are aware that polar compounds are commonly used as lubricants in the metal working arts.

The polar compounds are so used because due to their surface activity they cannot be as readily displaced from position on the metal to be worked as can non-polar compounds of similar nature sometimes used as lubricants. The polar compounds such as soaps, fatty acids, wetting agents or waxes fall into an active chemical group that form an absorption complex with the metal and thereby an anchored layer on the surface of the metal. In the ordinary use of such polar compounds, the extreme frictional heat and pressure convert the organic materials into a black insoluble substance commonly referred to in internal combustion engines as "varnish." The preferred glass forming ingredients of the composition by which the present process is carried out protect the hydrated colloids (polar compounds) in a manner to inhibit the deterioration thereof, and avoid the formation of such black insoluble deposits.

We have noted particularly that when boric acid or borax are used in the composition the hydrated colloids remain on the worked metal as an amber colored soluble substance which remains slippery to the touch and has no appearance of having been carbonized or polymerized and is readily removed in H_2O. A further explanation for the protective action of the glass forming ingredients, particularly when these comprise hydrated glass forming salts, is that since said inorganic materials melt and then boil in the liberated water, there is sufficient cooling effect on the organic material so that the latter does not reach carbonizing or polymerizing temperatures during working of the metal. Probably the reason for the conversion of soaps into the black insoluble varnish-like substance is that the sodium hydroxide formed by hydrolysis of the soap causes the polymerization of the unsaturates formed by the thermal cracking of the soap. If the composition contains, for example, borax, it is probable that such polymerization is

prevented by the presence in the composition of borax in an amount in excess of the chemical equivalent of the sodium hydroxide which the borax would take up to form sodium metaborate, viz:

$$2\ NaOH + Na_2B_4O_7 \rightarrow 4NaBO_2 + H_2O$$

Such a mixture of sodium metaborate with excess sodium tetraborate would buffer around pH 9 and eliminate the high pH polymerization of the unsaturates and ketonic bodies formed by cracking.

Additionally, the preferred organic compound provides a plastic binder and vehicle for the inorganic components which, without such binder, can be scraped off as powder. Scraping off of the present coating as with a knife results in producing pliable ribbons of the coating material.

In addition to plasticizing and binding of the inorganic glass forming materials or glass, the soap or equivalent organic lubricant performs another valuable function. Using for illustration die drawing of wire, metal coated with inorganic glass forming materials containing no soap or equivalent readily fusible organic lubricant is not slippery to the touch, so that when it enters the die and before frictional heat brings into play the cooling and lubricating properties of the inorganic materials, the coating would seize and drag at the die throat and tend to be removed. In the presence of soap, however, the coating is safely lubricated through the die throat.

The importance of using in the process fusible inorganic materials of different melting and flowing points, all above that of the binder or vehicle material but below the melting or welding point of the tool or the seizure point of the metal worked on thereby, is largely that these materials act as coolants when they take up their heat of fusion, whereas in the case of infusible materials such as graphite, chalk, lime, etc., these materials, which are not actually lubricants but mainly act as barriers between the metal and tool, sometimes tend to increase the die wear. That is never true of hydrated glass forming salts, for example, which actually decrease temperature, primarily by liberating water and secondarily taking up heat to melt and produce lubrication fluids of unusually high film strength.

As an example:

The following composition suitable for cold wire drawing and other cold formed processes involves a series of primary and secondary melting points in its ingredients as indicated:

	Primary Melting Point	Secondary Melting Point (Anhydrous)
	°C.	°C
High titre soap (e. g. sodium tallow soap), 15%	[1] 177	205
Boric acid H_3BO_3, 20%	185	577
Borax (sodium tetraborate), 40%	75	741
Potassium carbonate, 25%		891

[1] Softens.

The particular high titre soap mentioned above ordinarily decomposes at 340° C. and carbonizes at 375° C.

As substitutions for part of the borax we may use up to 10% disodium phosphate which primarily melts at 34.6° C. or sodium metasilicate up to 10% (primary melting point 47° C.). In the event of using either of such substitute ingredients, the borax content of the formula would be reduced proportionately, for example, up to 10%.

The above composition may, for example, be dissolved in water using from four ounces to saturation of the composition in one gallon of water. For wire drawing the wire is dipped in the solution while the latter is heated somewhere near the boiling point or at boiling temperature and the solvent is then suitably evaporated from the wire, leaving a deposited coating of the organic and inorganic materials of the composition thereon.

For wet process drawing, grinding or machining and for use primarily as a coolant in such process, we may use from one quarter ounce up to four ounces of composition per gallon of water.

Where the metal working takes place under conditions of high relative humidity, less hygroscopic alkali salts may be advantageously substituted in place of the more hygroscopic salts. While the soap acts as a wetting agent and other suitable wetting agents may be added, excess moisture is a hindrance to the process because it tends to cause premature flow of the coating compositions and failure of the glass forming materials properly to reach the working region. In the case of wire drawing, for example, the materials must be fairly dry when introduced into the die aperture for otherwise the coating may be partially sloughed off by the excess moisture. Water of crystallization or hydration (in case of hydrates) is not liberated until the endothermic reactions thereof earlier described take place and the reactions occur stepwise both in point of time and linear position in the working direction because, as apparent in wire drawing, the frictional heat increases as a particular point on the work progresses through the reducing portions of the die. Under humid weather conditions it is desirable to heat the coated work above the boiling point of water in an oven, a flash baker or by means of infra red light to expel any moisture picked up by the somewhat hygroscopic sodium salts and other hygroscopic materials which may be used.

In addition to grading the ingredients according to melting points, hygroscopic action, etc., the ingredients are balanced in respect to acidity and alkalinity so that the aqueous solution thereof, ordinarily used in order to apply the composition to the metal to be worked will be substantially neutral with the object of protecting human skin from deleterious effects of high acidity and alkalinity.

As an instance of the efficiency of the present process, finishing dies for drawing stainless steel wire containing chromium, nickel and titanium and formerly producing a maximum of twenty-five pounds of wire, by the use of the present composition, were able to produce from 180 to 250 pounds. We might mention that we produced with the present process a 30% increase in die life in the drawing of steel shell casings where a copper coating had previously been used in order to protect the dies. Additionally, it was found impossible to draw 0.20 to 0.30 carbon steel such as currently used for shells unless copper or lead coatings were used. With the present process and with no coatings of strategic materials perfectly formed pieces were produced.

Further to explain the operation of the process, it will be seen that by the incorporation of sodium tetraborate (borax) with high titre soap we have a naturally slippery composition, the borax of which melts at 75° C., gives up its water of crys-

tallization at 200° C. and intumesces at that temperature to form an impalpable powder. The powder so formed after intumescence could be considered analogous to a solid filler in known types of lubricant; but said powder has, in addition, an important physical property. At 741° C. the intumesced borax becomes fluid and thereby serves to lubricate the metal being worked. Similarly, the higher secondary melting point glass forming substances, following dehydration and intumescence, become fluid lubricants at respective increased temperatures and those added ingredients and the proportions thereof are selected so as to fill in any gaps that may occur, that is to bridge over from one temperature range to another.

Thus the invention enables selective use of a large variety of materials not previously believed useful as lubricants in metal forming processes. For example, we can utilize not only the lower melting glass forming alkalis, but a frit which will melt at higher temperatures still below the melting point of the forming tool work. On carburized tool steel, which in case hardening acquires about a 0.9 or less carbon with a welding or seizure point (red hot) considerably below 1000° C. and a melting point of 1420° C., we may utilize in the composition or possibly all by itself with appropriate introductory lubricant such as high titre soap, a frit which melts at an appropriate temperature sufficiently lower than 1000° C. to lubricate the work at nearly the maximum safely withstandable temperature.

It has been the custom in the glass or enameling industry to describe the component that forms the glass in terms of the ratio of the alkali base to that of the glass forming oxide. As an example of a frit which melts at 890° C. which is below the melting point of carburized steel we may use:

	Percent
K_2O	5.5
CaO	12.7
Fe_2O_3	3.6
Al_2O_3	5.5
SiO_2	64.5
B_2O_3	8.2

Another example of a working formula is:

	Percent
Borax	25
Boric acid	12½
Infusorial earth or clay	40
Litharge	12½
Soap	10

The formula just given may be used to form a frit by frictional heat in situ of the composition 0.5 PbO, 0.5 Na_2O–2.0 SiO_2 and 1.0 B_2O_3 with a melting point of 580–600° C. We may use a concentration of two to four pounds per gallon and a temperature near boiling to form a slurry for coating the work.

In the working of metals illustrated, for example, by cold drawing of wire or steel shell casings, there are a number of variables which affect metal working processes in respectively different ways. The speed at which the wire is drawn regardless of the amount of reduction in the die inherently creates different temperatures at the working region. The amount of reduction and size of the stock create additional variable factors in each of the dies and these variables are multiplied when the drawing speed variable is taken into consideration. It should be mentioned that size of the wire affects the problem of lubrication mainly because in the case of a small wire there is less opportunity for heat dissipation along the wire away from the working surfaces of the die than in the case of large wire.

A further and important variable is introduced by the fact that a smooth die (unscored or not built up by welding of particles of drawn stock) requires much less lubrication than one which is worn or scored or built up. For example, in the case of building up by welded-on metal certain portions of the die present separated points of contact with the work which tend to bite through any lubricant film regardless of its strength and in such cases a much greater cooling and lubricating effect is necessary in order to secure proper drawing.

Additional variables result from dies having different throat angles since the more gradual the reduction is, the greater is the opportunity for heat to become dissipated, particularly by the die metal as well as by the metal being worked. In addition, of course, there are other variables arising from the heat conductivity of different metals to be drawn and the composition of the dies. A diamond die for instance will not conduct heat as rapidly as an alloy steel die. Copper wire will conduct heat away from the working region very rapidly, carbon steel wire less rapidly, and stainless steel wire still less rapidly.

Accordingly, it is important, since one supplying a drawing compound for a particular class of work would not ordinarily be apprised of all the variable factors which might appply, to make the process as nearly universally applicable as possible at least to certain classes of work. Therefore we provide a sufficient range both of primary and secondary lubricatingly effective points (initial melting and subsequent glass forming points) so that if, for example, drawing or forming speed is actually greater than specified by the customer or user, or the material to be worked on is different from that for which the user purchased the materials, or some other or unexpected variable is introduced, satisfactory results will nevertheless be obtained.

Illustrating further by reference to multiple die wire drawing, it will be apparent from the formula heretofore given that the first ingredient (e. g. soap) will necessarily function as a lubricant at the first die and in case of high speed or considerable reduction by that die a considerable portion of that ingredient will be removed or chemically changed so that there will be less of that ingredient capable of operation at the second or third die. The soap all by itself is a very good drawing lubricant and none of the other ingredients might be called upon to do any work in the first die, particularly since the speed at which the wire passes through the first die is much slower than in the case of the second die and still slower as compared to the operation of the third die and so on due to the elongation of the wire. The second-mentioned material in the formula which is an inorganic glass forming material but yielding a relatively low melting point glass may be called upon to do its principal work in the second die where because of the greater speed, the heat generated by forming pressure and friction may render a large part of the soap partially ineffective upon subjection to the working pressure of that die, yet be insufficient to more than cause primary fluidity of the third or fourth ingredient (as by melting thereof and releasing some or all of the water of crystallization or hydration). Accordingly, it is neces-

sary, in order fully to take advantage of the present composition, to provide a sufficient range of lubricant film forming temperatures so that any instantaneous condition which could normally be expected will be met.

The following table illustrates one manner of arranging known glass forming materials for enabling ready selection of a formula for different work. Proportions are arrived at in the manner already indicated:

	Primary Melting Point	H_2O lost (or decomposes "d")	Parts H_2O Lost	Secondary M. P. (Glass forming point)
	°C.	°C.		°C.
Sodium silicate:				
Meta	47	100	6	1,088
Na_2O-$2SiO_2$				874
Sodium phosphate:				
Monobasic				
$NaH_2PO_4.2H_2O$	60	200(d)	4	988
Disod. phosphate				
$Na_2HPO_4.12H_2O$	34.6	100	12	1,340
Trisod. phos	[1] 73.4	100(d)	12	1,340
Borax:				
Sod. tetraborate				
$Na_2B_4O_7$-$10H_2O$	75	200		741
Sod. metaborate	57		2	966
Boric acid:				
Ortho H_3BO_3	185	300	1½	577
Meta HBO_2	200			577
Pyro $H_2B_4O_7$				577
Sodium carbonate: $Na_2Co_3.H_2O$	100			851
Potassium carbonate: K_2CO_3	[2]			891
Potassium borate:				
Meta	[2]			947
$K_2B_2O_4$				950
Sodium aluminate: $NaAlO_2$	[2]			1,650

[1] Losses $2H_2O$. [2] Anhydrous.

We recognize that certain partially dehydrated alkali metal salts have been used prior hereto as alternatives in the hot drawing of tungsten wire. Said salts were fused on the wire before the wire entered the die, and were then conducted to the die aperture by the hot wire. Solid substances, or at least finely divided graphite, were proposed as additives in said process. When used as a fused bath, such salts as mentioned would have lost all of their water of crystallization plus part of their chemically combined H_2O or hydration and therefore no advantage was taken of the latent heat of fusion and the cooling effect on the metal and tool surfaces which occurs when the primary melting point has been reached and the water of crystallization given up in accordance with the present composition as described above, and no advantage was taken of the cushioning effect of entrapped steam. Additionally, relatively infusible materials such as graphite or, for further examples of known "barrier" materials: lime and mica, cannot possibly act as a plastic binder and vehicle for the alkali metal salts as will for example high titre soap as preferably employed in the present process or method of lubricating metals during cold working thereof.

We are also aware that certain alkaline orthophosphates have been previously proposed for use in aqueous solution for wet process wire drawing and also deposited as a dry coating on wire prior to drawing through dies. These have the disadvantage of marked hygroscopicity.

Furthermore, we are aware of the prior employment of certain alkaline materials some of which are glass forming materials as peptizers in connection with aqueous suspensions of water insoluble, high melting point, argillaceous materials for operation in cold drawing as barrier materials as hereinbefore explained. Such prior employment of glass forming materials with barrier particles is not operative to supply between the metal surfaces of the material worked upon and the tool fluid glass to prevent metal-to-metal contact, nor is any stepwise succession of operations produced thereby. Instead the alkaline materials used for peptizing purposes combine actively with the argillaceous particles to form high melting point ceramic bodies of complex sodium aluminum or sodium magnesium silicate at the surface temperatures which occur during cold working of metal. Glaze films would be formed on those ceramic bodies during fluxing at relatively high temperatures if attained but the argillaceous materials themselves prevent any and all lubricating flow of the glass between the metal surfaces.

The upper limit of 1000° C. for the melting point of the glass forming materials in accordance herewith and in conjunction with the lower melting constituents is seen to distinguish sharply from prior usages of insoluble barrier particles or abrasive particles which melt considerably above 1000° C. and which, as pointed out by Bowden and Ridler, cited above, develop very high junction temperatures, altogether in contrast to the present melting and cooling constituents.

This application is a division of our application Serial No. 497,117, filed August 2, 1943, now matured into U. S. Patent No. 2,469,473, issued May 10, 1949.

By the term "consisting essentially of" as employed in the annexed claims we mean to denote that the active lubricating ingredients thereof consist of the material claimed. This term is not to be construed that no other materials can be present. That is to say conventional and well-known compounds and compositions which are conventionally used in minor amounts in metal working lubricants may be present in our composition.

Other modes of applying the principle of the invention may be employed, change being made as regards the detail described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

We therefore particularly point out and distinctly claim as our invention:

1. A water soluble lubricating composition for use in the formation of metal articles consisting essentially of at least about 15% of an organic lubricating material selected from the group consisting of a water soluble high titre soap and a mixture of water soluble high titre soap and organic water soluble aliphatic, polyhydric alcohol having less than four hydroxy groups, and at

least two lubricating, water liberating hydrated, glass forming, water soluble inorganic materials selected from the group consisting of metal phosphates, metal carbonates, metal silicates, metal borates and boric acid, one of said inorganic materials being borax and present in an amount at least about 40% of the total composition and greater than the amount of any other inorganic material present in the composition, the amount of the total inorganic material being greater than the amount of the organic lubricating material, the melting point of the organic lubricating material being less than that of any of the inorganic materials, and the inorganic materials each having a melting point below 1000° C. and each having a melting point different from each other each inorganic material being present in an amount sufficient to provide and maintain lubrication throughout a material range of temperature different from each other, and the organic material being present in an amount sufficient to provide and maintain initial lubrication up to a temperature at which the inorganic material of lowest melting point becomes operative, whereby the composition will provide progressive and stepwise lubrication of the metal during the forming operation.

2. A composition in accordance with claim 1 wherein the organic lubricating material is high titre soap and is present in an amount of at least about 15%.

3. A water-soluble lubricating composition for use in the formation of metal articles consisting essentially of 15% high titre soap, 20% boric acid, 40% borax, and 25% potassium carbonate.

4. A lubricating composition in accordance with claim 3 wherein the high titre soap is tallow soap.

5. A composition in accordance with claim 3 in which an alkali metal salt selected from the group consisting of alkaline earth metal silicates and alkaline earth metal phosphates is substituted for a portion of the borax up to an amount of about 10%.

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