

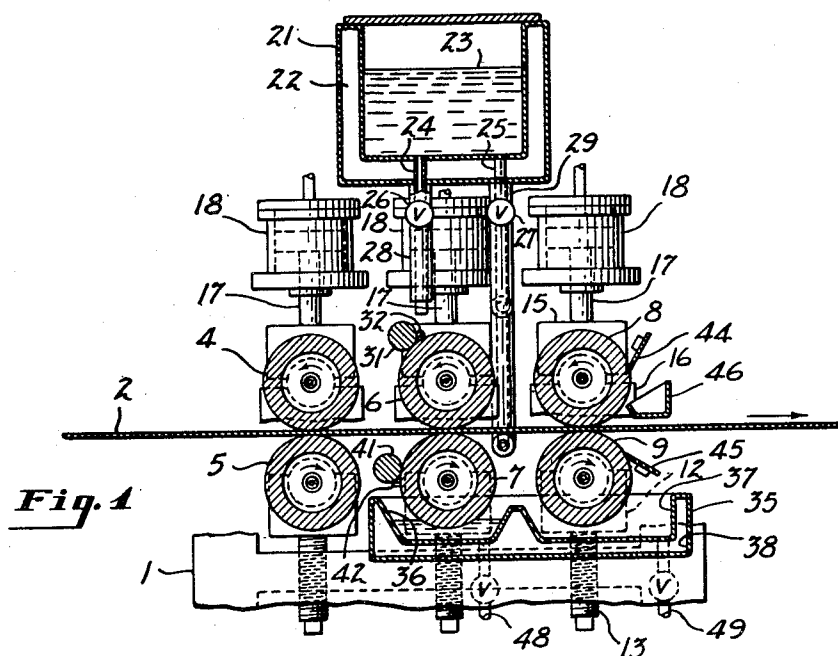
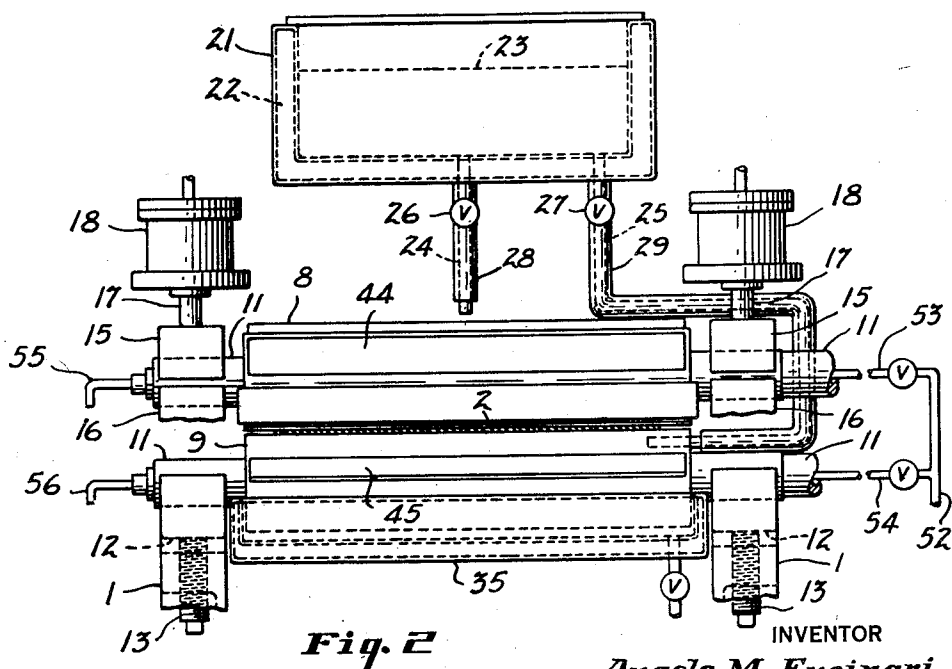
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METHOD AND APPARATUS FOR APPLYING LUBRICANTS TO SHEET METAL

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METHOD AND APPARATUS FOR APPLYING LUBRICANTS TO SHEET METAL

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This invention relates to dry film type drawing lubricants and methods and apparatus for applying the compositions to sheet metal prior to forming articles therefrom.

Sheet metal of relatively heavy gauge is subjected to deep drawing operations under extremely high die pressures in a number of manufacturing fields where practically flawless final stampings of intricate shapes are desired. A serious problem in such deep drawing of heavy gauge sheet metal has been to provide proper lubrication between the metal and the dies. Failure to do so results in many difficulties, such as tearing or excessive thinning out of the metal, excessive die wear, and the build-up of lubricant in the dies to a degree sufficient to seriously impair the accuracy of the work. Solution of the lubrication problem requires the provision of a satisfactory lubricant and a practical method or system for applying the lubricant at some stage prior to the actual stamping operation.

In many cases, it would be desirable to be able to apply drawing lubricants to sheet metal of all gauges well in advance of the metal drawing operations and to store the coated sheets for subsequent use as needed. However, this has required an impractically high degree of care in handling the coated sheets, and the aging characteristics of the coatings have generally not adapted them for storage. Much progress has been made in devising a number of lubricants that give excellent service under a variety of conditions. However, relatively little progress has been made in methods and apparatus for applying the lubricants. Spraying, dipping, and brushing techniques are commonly employed but have a number of draw-backs, such as: (1) excessive time, manpower, and/or plant floor space requirements, (2) the necessity for drying the applied lubricant film and protecting the film during temporary storage or transit to the press, (3) lack of accurate control of the thickness of the applied lubricant film and (4) the necessity for removing rust-proofing mill oil from the sheet metal before applying the drawing lubricant.

Efforts have been made to apply drawing lubricants by means of rollers, but such efforts have had very limited success in eliminating the above-mentioned draw-backs of other systems. At least, no roller type application systems have yet gone into general commercial use to the best of my knowledge.

The principal objects of the invention are to provide a process and apparatus for quickly applying a uniform, dry, lubricant film of the proper thickness to sheet metal with reduced manpower and plant floor space requirements; to eliminate the delays and floor space formerly required for drying the applied film; to eliminate the necessity for cleaning mill oil from the metal sheets before applying the drawing lubricant; to provide an improved drawing lubricant adapted to be applied by such a process and apparatus; to provide a drawing lubricant which will produce a hard, durable, non-tacky film capable of withstanding subsequent stacking, storage, and handling of the coated sheets before they are stamped; and to provide a drawing lubricant which satisfies the foregoing objec-

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tives and which is also efficient as a high pressure drawing lubricant, economical to produce, and easy to clean from the stamped product prior to the application of final protective coatings.

The foregoing objects are accomplished by applying to both sides of a sheet of metal, preferably by means of rollers, thin films of a melted, normally solid lubricant. The lubricant, as applied, and the application rollers as well, are maintained about 10 Fahrenheit degrees or so above the melting point of the lubricant, but the sheet being coated is enough cooler to chill the applied films almost instantaneously to a solid condition. The applied and solidified films, while still soft enough to flow under pressure, are then contacted by finishing rollers which thin the films to the desired final thickness and force them into more intimate contact with the metal sheet and into the microscopic pores in the surfaces of the sheet. The temperature of the finishing rollers is controlled to further chill the lubricant films to a degree such that they are in a hard, non-tacky condition as the coated sheets leave the machine, whereby the sheets may be immediately stacked and thereafter handled without damage to the films.

The apparatus employed for carrying out the foregoing process preferably includes a series of three closely spaced and aligned sets of substantially identical, power driven, cylindrical, steel rolls, whereby a flat sheet may be passed successively between the pairs of rolls comprising the three sets. The two rolls in each set are suitably mounted for opposite rotation within an adjustable spacing to accommodate metal sheets of various thicknesses. Suitable means are provided for adjusting the pressure exerted by the rolls on a metal sheet passing therebetween. Also, means are provided for maintaining the surface of each roller at a desired temperature.

The first set of rolls squeezes off from the sheets excessive quantities of mill oil that may be present and smooths out any major flaws in the surfaces of the sheets, while establishing the temperature of the sheets somewhat above normal room temperature if required because of a low initial temperature of the sheets as fed to the machine. The rolls of the second set have the melted lubricant spread on their outer surfaces in any desired manner, and they apply the lubricant to both sides of the sheets while exerting sufficient pressure thereon to control to some degree the thickness of the applied films. The rolls of the third set perform the above-described finishing functions.

A lubricant capable of behaving as desired during the coating operations and having the desired final properties preferably comprises a vegetable or mineral oil serving essentially as a vehicle for other ingredients that give the composition the desired lubricity and general physical characteristics. The other essential ingredients include a water-insoluble metal soap of a fatty acid, a cellulose ether, and a waxy lubricating component that is normally solid but plastic under pressure. Also, in most cases, a high-melting point coupler or mutual solvent, such as an amide of a higher fatty acid, is included to render the cellulose ether more compatible with the oil vehicle and to facilitate washing the lubricant from the metal after the drawing operation has been performed. The proportions of the ingredients are adjusted according to their relative melting points, viscosities, and other characteristics, mentioned hereinafter, to produce a normally solid, relatively hard and non-tacky, homogeneous mixture having a melting point substantially above the highest atmospheric temperatures likely to be encountered.

While particular emphasis has been placed above on the suitability of the invention for coating heavy gauge sheet metal to be severely deformed under high pres-

tures, the advantages of the invention are also realized in large part in the coating of light gauge metal for any kind of drawing operations.

The foregoing and other objects, advantages, and characteristic features of this invention will be more fully understood from the following detailed disclosure, and from the accompanying drawing illustrating the essential features of a preferred machine for applying the lubricant compositions. In the drawings—

Figure 1 is a fragmentary and somewhat diagrammatic longitudinal section of a machine for applying the lubricant compositions; and

Fig. 2 is an elevation of the machine of Fig. 1, looking at the left end thereof as viewed in Fig. 1.

The process of the present invention, depending upon the conditions of previous storage of the metal sheets to be processed and the melting point of the lubricant to be applied, may or may not require preliminary heating or cooling of the sheets to bring them to a coating temperature in the preferred range of about 70° to 125° F. The coating temperature of the sheet should be substantially below the melting point of the lubricant for chilling the lubricant as it is applied, preferably at least 50 Fahrenheit degrees below the lubricant melting point, and this melting point should be appreciably higher than any temperature likely to be encountered during subsequent storage of the coated sheets. A lubricant melting point above 125° F. is desired for nearly all applications, and a melting point above 175° F. is preferred.

The sheets to be processed are also preferably given a preliminary rolling operation between pressure rolls to remove surface flaws in the sheets and to squeeze excess mill oil from the sheets. By employing rolls for this purpose that are maintained at the proper temperature, they may also serve to warm or chill the metal sheets through such small temperature changes as may be required. Thus, the sheets are preferably preliminarily conditioned in this manner, the temperature thereof being thereby adjusted to whatever extent may be required.

The normally solid lubricant, while at a temperature 5 to 10 Fahrenheit degrees or so above its melting point, is then spread uniformly over both surfaces of the conditioned sheet. This may be done in any desired manner, but most conveniently by passing the conditioned sheet from the conditioning rolls directly between a pair of coating rolls maintained at substantially the temperature of the melted lubricant and supplied with continuously renewed layers thereof for transfer directly to both sides of the sheets. As so applied, the lubricant films are preferably spread to an initial thickness of 1 to 2 mils, somewhat in excess of the desired final film thickness. This may readily be done by suitable adjustment of the pressure of a pair of coating rolls employed for this purpose, and the lower initial coating temperatures of the sheets serves to chill and solidify the films practically instantaneously.

When employing a lubricant having the proper plasticity, the solidified film may then be rolled to a final thickness of less than 1 mil, preferably from about 0.2 to 0.5 mil, and chilled to a hard consistency by passing the coated sheets from the application rolls directly between a similar pair of pressure rolls maintained at a suitable temperature while exerting sufficient pressure to reduce the film thickness and force it into the microscopic pores in the metal surfaces, without picking up or peeling the films from the sheets. This finishing roll temperature will vary with the characteristics of the lubricant employed, but will be well below the melting point of the lubricant and generally well above the initial coating temperature of the sheets. Using lubricant compositions of the character hereinafter described, the finishing roll temperature should be 25 to 75 Fahrenheit degrees below the melting point of the lubricant.

With a preferred melting point between 175° and 205° F., the finishing temperature will be from about 125° F. to about 185° F. and generally between about 140° and 150° F.

When a properly formulated lubricant composition is employed, the coated sheets will leave the finishing rolls with hard, non-tacky films thereon which require no further drying. The coated sheets may be immediately handled and stacked and may be stored before being drawn for periods that depend upon the composition of the lubricant.

From the foregoing, it will be appreciated that a suitable drawing lubricant for the purposes of the invention should have the following general physical characteristics:

1. It should be a relatively hard and non-tacky material at temperatures up to at least 100° F. and preferably up to about 140° or 150° F.
2. It should be mobile under substantial pressure over a wide range of temperatures below its melting point, for instance down to room temperature.
3. It should have a melting point above at least 125° F. and preferably between about 160° and 200° F.
4. It should preferably be a free-flowing viscous liquid at close to its melting point, preferably within 10 to 25° F. of its melting point, or even closer.
5. It should have a high degree of lubricity and a high film strength under pressure.
6. It should be compatible with substantial amounts of mill oil present on sheets to be coated.
7. It should be stable with age when exposed in the form of thin films.

Compositions suitable for use in accordance with the invention on steel plates ranging up to ½ inch or more in thickness preferably are mixtures of the following principal components in approximately the amounts designated:

- 30% to 50% mineral, vegetable, or animal oil vehicle having a viscosity from about 100 to about 10,000 S. U. V. at 100° F.
- 5% to 25% normally solid fatty acid metal soap soluble in the oil component
- 2% to 15% cellulose ether dispersible in the mixture
- 8% to 30% normally solid fat, fatty acid, microcrystalline wax, or the like
- (5% to 18% normally solid fatty acid amide as a dispersing or coupling agent, if necessary to disperse the particular cellulose ether employed in the particular oil vehicle employed.)

In mixtures of this character, the mineral, vegetable, or animal oil serves as a vehicle and plasticizer for the solid components of the mixtures. It also renders the mixtures more compatible with mill oils commonly present on metal sheets to be coated with lubricant, thus making preliminary removal of the mill oil unnecessary. While the viscosity of the oil vehicle may be as low as 100 S. U. V. at 100° F., employment of a low viscosity oil vehicle requires the employment of higher viscosity additives or greater quantities of additives to achieve a suitable final viscosity for application as a thin film with coating rollers set at about 30 to 60 pounds pressure per inch of roller length. The indicated upper limit on viscosity of the oil vehicle (i. e. 10,000 S. U. V. at 100° F.) is based on practical considerations and is not a precise limit. It represents the highest viscosity of commercially available refined mineral oils. For greatest ease of application by rollers, the final viscosity of the lubricant mixture in the melted condition in which it is preferably applied to the metal should be about 100 to 300 S. U. V. at the application temperature. The viscosities of all of the individual ingredients may vary considerably, as hereinafter noted, and are balanced rela-

tive to one another so as to produce a mixture having a convenient application viscosity at 10° F. or so above its melting point and having a suitable hardness and degree of plasticity at temperatures below its melting point. Thus the viscosities of individual components of the mixture, including that of the oil vehicles, are not in the least critical and are mentioned herein merely as practical preferences for convenience in formulation.

As noted, vegetable or animal oils may be used in place of mineral oils, in which case the cellulose ether is more easily dispersed in the mixture and the fatty acid amide may be dispensed with except for the cleaning off problem noted below. If used, the fatty acid amide permits cellulose ethers of somewhat lower oil solubility to be dispersed without difficulty. However, from the standpoint of cost, the mineral oils are preferred over the vegetable and animal oils.

The normally solid metal soap of a fatty acid is employed to improve adherence of the composition to the metal and to reduce the tackiness of the applied film. It may also serve as an ingredient for increasing or controlling the viscosity of the composition for the purposes mentioned above. Aluminum stearate is a preferred soap. Other metals, such as the alkaline earth metals, zinc, lead, etc., may be combined with stearic acid to form the soap, or other acids having from 16 to 20 or more carbon atoms may be used in place of the stearic acid in combination with either aluminum or any of the other metals, so long as the resulting soap is normally solid and soluble in the oil vehicle.

The principal function of the water-insoluble cellulose ether is to increase the hardness and melting point of the mixture, to increase the viscosity of the mixture above its melting point, and to reduce the tackiness that otherwise tends to result from bleeding of the oil component out of the solids of the applied film. Care should be used not to employ excessive amounts of cellulose ethers, however, because they tend to increase the build-up of the lubricant in the drawing dies. Methyl cellulose and other water-soluble cellulose ethers are not as useful for the purposes of the invention as the normally water-insoluble ethyl cellulose because the former are less oil-soluble. Higher aliphatic radicals than ethyl may be used in the cellulose ether molecules, but they also tend to make the cellulose ether more difficult to disperse in oil and are preferably avoided for this reason, though they may be used more easily with a vegetable or animal oil vehicle. The preferred viscosity of the cellulose ether is about 20 centipoises. Higher viscosities up to 100 centipoises or so may be used, but this also decreases oil solubility and requires somewhat more coupling agent. If the oil vehicle is a vegetable or animal oil instead of a mineral oil, ethyl cellulose is amply soluble in the amounts used without the necessity for employing a coupling agent.

The normally solid fat, fatty acid, microcrystalline wax, or the like constitutes the primary lubricating ingredient of the composition. The particular one of these types or classes of lubricant ingredients employed will depend on a number of factors, for they differ considerably in certain properties as will be explained.

Since a hard film is desired, one of the principal considerations is that the lubricating ingredient be solid (i. e. self-sustaining but plastic under pressure) over the ordinary range of atmospheric temperatures. This rules out of consideration many, though not all, of the unsaturated fats and fatty acids per se. In general, any of the normally solid fats, fatty acids, or mixtures thereof can be employed when the metal to which the lubricant is to be applied is to be drawn soon afterward, i. e. without a long storage period during which the lubricant film may deteriorate from age and atmospheric influences. Such deterioration results in large part from the natural tendency of fats and fatty oils, when held

below their melting points, to crystallize progressively with time. When they have crystallized to a substantial degree, they become unsatisfactory drawing lubricants because they tend to build up on the drawing dies, destroying their accuracy and causing excessive die wear.

When ability to withstand storage periods of more than a relatively few hours is important, substantially non-crystalline or microcrystalline substances have been found to be eminently satisfactory as the essential lubricating component of drawing compositions contemplated by the present invention. Examples of such substances are the normally solid eutectic mixtures of saturated fatty acids, which are uniquely amorphous or non-crystalline in character. As a result of their apparent non-crystalline character, they retain their waxy and slippery or grease-like properties indefinitely. Whereas individual fatty acids and non-eutectic fatty acid mixtures are soft, eutectic fatty acid mixtures are relatively tough and hard, and contribute greatly to the kind of film-forming properties preferred for use in accordance with the invention.

According to the literature, only a relatively few of the many possible binary and tertiary eutectic mixtures of fatty acids have been investigated in the laboratory. Many are liquids at temperatures too low to be useful for the purposes of this invention. However, a substantial number are suitable, though only a very few are presently available commercially. A preferred fatty acid eutectic mixture that is presently available from Armour and Co. of Chicago, Illinois, is sold under the name "Neo-Fat 1-54." This is a hard, waxy mixture of palmitic acid (67%), stearic acid (29%), and oleic acid (4%), and has a melting point of about 150° F. The oleic acid is probably present as an impurity, since it is most difficult to remove it completely from stearic acid, and the mixture should be viewed as being essentially a binary eutectic mixture of palmitic and stearic acids.

Examples of suitable lubricating agents of the microcrystalline class are the so-called microcrystalline waxes obtained from petroleum. These waxes constitute the higher boiling end of the paraffin wax cut in conventional petroleum fractionation processes, and vary slightly in properties according to the particular limits employed in separating the petroleum fractions. These waxes are also commonly known as petrolatum. While the microcrystalline waxes produce excellent formulations for most purposes, they are inferior to the eutectic fatty acid mixtures as regards the ease with which the lubricant film may be removed from metal after the drawing operation, and they require use of hydrocarbon solvents or the like for effective cleaning.

The fatty acid amides are employed to aid in incorporating the cellulose ether into an oil vehicle in which its solubility may be limited. Depending on the particular oil vehicle and cellulose ether employed, more or less fatty acid amide may be required for this purpose. The normally solid amides of fatty acids are preferred over the many other compounds having comparable coupling properties because such amides may be employed without unduly reducing the hardness of the composition or its viscosity above its melting point. Of the normally solid fatty acid amides, those melting in the range of about 175° to 250° F. are preferred. The amides of saturated fatty acids having 16 to 18 carbon atoms are hard wax-like compounds melting around 200° to 220° F. and are ideally suited for the present invention, such as those sold as "Armide HT" by Armour and Co., Chicago, Illinois, which melt at about 208° F. However, insofar as the present invention is concerned, the fatty acid radicals of the amides may be either saturated or unsaturated.

While the broad range of ingredients given in the above tabulation may be considered to represent approximate practical limits for achieving the objects of this invention, practically all needs in drawing sheet metal may be met with optimum results and minimum

cost and formulation problems by formulations within the following preferred range:

- 35% to 45% mineral oil of 5000 S. U. V. at 100° F.
- 20% to 25% aluminum stearate
- 5% to 10% water-insoluble ethylcellulose, 20 to 100 centipoises
- 8% to 24% eutectic mixture of palmitic and stearic acids (such as Neo-Fat 1-54 manufactured by Armour and Co.)
- 8% to 15% amide of fatty acids having 16 to 18 carbon atoms and melting about 200° to 220° F. (such as Armid HT manufactured by Armour and Co., Chicago, Illinois).

Example 1

A specific composition illustrative of those embraced by the preferred ranges of ingredients mentioned above is as follows:

- 40% mineral oil of 5000 S. U. V. at 100° F.
- 23% aluminum stearate
- 8% ethyl cellulose of 20 centipoises
- 16% "Neo-Fat 1-54"
- 13% "Armid HT"

This composition is especially suitable for heavy duty drawing of relatively heavy steel plates up to about ½ inch thick. The composition melts at about 180° F. and has a viscosity of 200 S. U. V. at the preferred application temperature of 210° F. When this particular composition is to be applied at this temperature, the sheet metal is preferably at a temperature of about 90° to 95° F. as it is fed to the coating rolls. The optimum metal temperature will vary somewhat with its thickness and may require some preliminary heating of the metal in winter and cooling in summer depending on the storage conditions. As hereinafter described in more detail, the temperature of the sheet metal may be established at approximately the desired initial temperature by passing it between a set of pressure rolls that are either heated or cooled as may be required.

When the lubricant composition of this example, in liquid form at 210° F., is spread as a thin layer on heavy steel plate at a temperature around 90° to 95° F., the lubricant is almost instantaneously chilled to a solid but plastic condition and can be immediately rolled to any desired final film thickness by means of a set of finishing pressure rollers, which are preferably maintained at a temperature around 140° to 160° F. to prevent sticking of the coating to the finishing rolls and peeling it from the coated sheet. The final film thickness should be around 0.3 to 0.5 mil. The lubricant film thus formed is hard and non-tacky as it comes from the finishing rolls, and the coated sheets may be immediately handled and stacked without additional cooling or drying and without injury to the lubricant film. Even after months of storage under any atmospheric temperatures likely to be encountered, there is no apparent deterioration of the film, and it provides excellent service as a heavy duty drawing lubricant both as regards the avoidance of lubricant build-up on the dies and efficiency in performing its lubricating function.

Example 2

A somewhat lower melting lubricant composition suitable for the purposes of the present invention is as follows:

- 45% mineral oil of 5000 S. U. V. at 100° F.
- 24% aluminum stearate
- 8% ethyl cellulose of 20 centipoises
- 8% "Neo-Fat 1-54"
- 15% "Armid HT"

The ideal working temperature of this lubricant for roll application is about 180° F. The applied film is

softer and more mobile at room temperature than the film obtained with the composition of Example 1.

Example 3

- 5 A harder and less mobile film than is obtained with the composition of either Example 1 or Example 2 may be produced with the following composition:

- 37% mineral oil of 5000 S. U. V. at 100° F.
- 23% aluminum stearate
- 10% ethyl cellulose
- 15% "Neo-Fat 1-54"
- 15% "Armid HT"

- 15 The ideal roll application temperature of this composition is about 190° F.

- 20 Turning now to the apparatus shown in the drawing for applying lubricants in accordance with the invention, it will be observed that the apparatus includes sets of pressure rollers that are generally similar to those employed for a variety of purposes in different industrial arts. To the extent that the structure of the machine may follow well-known design principles, many of the details of the machine have been omitted for simplicity.

- 25 A suitable machine may comprise a frame 1 on which three sets of rollers may be mounted in horizontal alignment for passing a sheet of metal 2 along a horizontal path successively between the pairs of rollers of the three sets. The three sets of rollers may include a first pair 4 and 5 for squeezing excess mill oil from the surface of a metal sheet and smoothing out any major surface flaws in the sheet; a second pair of rollers 6 and 7 respectively horizontally aligned with the first pair of rollers 4 and 5 for applying lubricant to the sheet; and a third pair of rollers 8 and 9 respectively horizontally aligned with the first pair of rollers 4 and 5 and the second pair of rollers 6 and 7 for reducing the thickness of the lubricant film and forcing the lubricant into the pores in the surface of the metal sheet 2. Each of these pairs of rollers may be similarly mounted on the frame 1 in a well-known manner, and only the mounting of one pair of rollers need be briefly described.

- 45 Considering the pair of rollers 8 and 9, each roller is mounted on a hollow shaft 11 of reduced diameter with respect to the diameter of the roller, the shaft projecting axially in both directions beyond the ends of the roller. Each projecting end of the hollow shaft 11 is mounted for rotation in a bearing carried by the frame 1. The bearing for the lower roller 9 need only surround the lower half of the circumference of the shaft 11 and may comprise a suitable bearing block 12 mounted on the frame 1 for vertical adjusting movement by means of an adjusting screw 13.

- 50 The upper roller 8 is preferably mounted at each end by a pair of bearings that substantially completely surround the circumference of the shaft 11. Each of these bearings may comprise a pair of upper and lower bearing blocks 15 and 16 mounted on the frame 1 for vertical movement in response to the movement of a vertical shaft 17. The shaft 17 may be connected to the upper bearing block 16 and to a piston in a pressure cylinder 18 adapted to receive fluid under pressure for forcing the bearings at opposite ends of the upper roller 8 downwardly toward the bearings at opposite ends of the lower roller 9 with a controlled pressure. The adjusting screws 13 permit the elevation of the lower rollers 5, 7, and 9 in the three sets to be fixed at the desired level for accommodating sheets 2 of various thicknesses, and the upper rollers 4, 6, and 8 may be forced downwardly with selected different degrees of force by the application of fluid pressure to the pistons in the cylinders 18. This roller mounting arrangement is sufficiently common to various types of rolling machines to require no detailed disclosure and may be constructed in a variety of well-known ways.

- 75 The lubricant to be applied to the metal sheet 2 is stored in a container 21 that may be mounted in any

desired manner on the frame 1 above the three sets of rollers. The container 21 is constructed in a suitable manner for controlling the temperature of its contents, as by providing a hollow space 22 in the bottom and side walls of the container through which a heat exchange fluid may be circulated. According to the preferred forms of the invention, for most drawing lubricant applications, the drawing lubricant 23 stored in the container is one that melts in the range of 175° to 205° F. and is applied at a temperature around 5° to 10° F. above its melting point. When employing such a lubricant, it is not necessary to maintain its temperature in the container 21 above the boiling point of water, and water may constitute and is preferably used as the heat exchange medium in the space 22. Other heat exchange fluids or other heating methods may, of course, be employed if desired.

Suitable conduits are provided in communication with the interior of the container 21 for feeding the liquid lubricant 23 to both the upper and lower application rollers 6 and 7. As shown, a pair of separate conduits 24 and 25 may be employed for this purpose, each of the conduits having a suitable, manually adjustable valve 26 or 27 associated therewith for controlling the rate of feed of the lubricant. Each of the conduits 24 and 25 is also preferably provided with insulated coverings 28 and 29 to prevent cooling and solidification of the lubricant in the conduits, and the bodies of the valves 26 and 27 are preferably located close to or within the container 21 so that substantially all of the lubricant in the conduits 24 and 25 will drain downwardly therefrom when the valves are closed during periods of idleness.

The upper lubricant applying roller 6 is engaged by a doctor roller 31 that is parallel to and axially coextensive with the roller 6 and is suitably mounted for free rotation. The conduit 24 leading from the container 21 terminates directly above the converging surfaces of the oppositely rotating rollers 6 and 31 for feeding the lubricant 23 thereto at a controlled rate for maintaining a small quantity 32 of the lubricant between these converging surfaces over the full axial lengths thereof. The pressure of the doctor roller 31 against the lubricant applying roller 6 is made adjustable in any well-known manner to control the thickness of the film of lubricant on the downwardly moving surface of the application roller 6.

Another container 35 having two separate compartments 36 and 37 is mounted below the sets of rollers with the lower application roller 7 extending into the compartment 36 and the lower finishing roller 9 extending into the compartment 37. This container 35 is also preferably provided with a suitable space 38 through which a heat exchange fluid may be circulated for maintaining the lubricant in this container above its melting point and at the desired lubricant applying temperature. The conduit 25 leading from the upper container 21 terminates at a suitable point above the compartment 36 of the lower container 35 for feeding lubricant 23 thereto at a controlled rate for maintaining a lubricant level therein above the bottom of the lower application roller 7. This application roller rotates in the direction shown by the arrow applied thereto in Fig. 1 and picks up a continuous film of lubricant from the compartment 36.

A second doctor roller 41, similar to the doctor roller 31 described above, is mounted for pressure engagement with the lower application roller 7 for reducing the thickness of the film of lubricant picked up by the application roller 7 from the compartment 36. The pressure of the doctor roller 41 against the application roller 7 causes excess lubricant picked up by the latter to build up between the converging surface of the two rollers to a small extent, as indicated at 42, and any excess flows back down into the compartment 36.

The mechanism for mounting and controlling the pressure exerted by the doctor rollers 31 and 41 may be any of the types well-known in the art and has been

omitted for simplicity, since it forms no part of the present invention. The two finishing rollers 8 and 9, which apply pressure to the coated metal sheet 2 as it leaves the lubricant applying rollers 6 and 7, may tend to pick up small quantities of the lubricant which must be removed from the roller surfaces. For this purpose, a pair of scrapers 44 and 45 are respectively mounted on the frame 1 for engaging the finishing rollers over their entire length, as shown in Figs. 1 and 2. The scraper 44 associated with the upper finishing roller 8 removes any adherent solidified lubricant and causes it to drop into a receptacle 46 disposed below the scraper 44 and extending the full length of the scraper. The scraper 45 associated with the lower finishing roller 9 is located so that solidified lubricant removed from the lower finishing roller slides over this scraper and drops into the compartment 37 of the lower container 35, where it is remelted by the heat from the heat exchange fluid circulated through the space 38 in the walls of this container. The receptacle 46 may also be heated if desired so that lubricant received thereby may be remelted continuously and drawn off, or the receptacle 46 may merely be mounted for easy detachment so that its contents may be emptied from time to time. The latter procedure is generally satisfactory, since only a relatively small amount of lubricant will adhere to the finishing rollers and require removal by the scrapers. Both compartments 36 and 37 of the lower container 35 are preferably provided with valved conduits 48 and 49 for draining the compartments when the machine is to be shut down or when the accumulation of lubricant in the compartment 37 rises to a level approaching the lower finishing roller 9, which is not intended to pick up any lubricant.

As noted above in describing the method steps of the present invention, it is desirable to establish the sheet 2 at a suitable coating temperature by controlling the temperature of the first set of rollers 4 and 5. Similarly, it is desirable to maintain the temperature of the application rollers 6 and 7 at substantially the desired coating temperature of the liquefied lubricant 23 and to maintain the temperature of the finishing rollers 8 and 9 substantially below the melting point of the lubricant 23 for chilling the lubricant film. This may be most easily accomplished by passing streams of a suitable heat exchange fluid, maintained at a suitable temperature, continuously through both of the first pair of rollers 4 and 5, additional streams of heat exchange fluid maintained at a substantially higher temperature continuously through both of the lubricant applying rollers 6 and 7, and two other streams of heat exchange fluid maintained at an intermediate temperature continuously through both of the finishing rollers 8 and 9. Since all three of these heat exchange fluid temperatures are preferably below the boiling point of water, water will generally be the most convenient heat exchange fluid. If desired, it may be supplied from a single reservoir and pumped therefrom through 3 branching conduits containing thermostatically controlled heating elements of any desired type for providing 3 separate streams of fluid at the 3 different temperatures required. The 3 streams may then be conducted respectively into the rollers of the 3 sets. Any other desired arrangement for providing supplies of heat exchange fluid at the 3 different temperatures required may be employed. Each stream may be introduced into the upper and lower rollers of the set for which it is intended through a single conduit 52 which branches into a pair of valved conduits 53 and 54 respectively leading into the upper and lower rollers of that set through the hollow roller shafts 11 at one end thereof. Fluid discharge conduits 55 and 56 may project from the opposite end thereof. Inside of each individual roller the heat exchange fluid may simply be contained by the rollers themselves so that the fluid is directly in contact with the interior surfaces of the rollers.

In placing the machine in operation, the 3 sets of rollers

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are established at their desired temperature in the manner described above, they are appropriately adjusted to exert the desired pressures on sheets of the particular thickness to be processed, and a supply of lubricant in the upper container 21 is heated to the desired application temperature. When the lubricant has reached the application temperature, the valve 27 may be opened to supply a quantity of the liquefied lubricant to the compartment 36 of the lower container 35 until the lower lubricant applying roller 7 is partially immersed therein. Both valves 26 and 27 may then be set at the proper openings for continuously feeding liquid lubricant to the upper and lower application rollers 6 and 7 respectively. At the same time, power is applied through any suitable mechanism to rotate all 6 of the rollers at the same speed in the directions indicated by the arrows in Fig. 1.

Each sheet 2 to be coated with lubricant is then merely passed directly between the rollers of each of the 3 sets in succession. The first pair of rollers 4 and 5 perform the desired smoothing operation and establish the temperature of the sheet while squeezing excess mill oil from both surfaces thereof. The second pair of rollers 6 and 7 apply the lubricant to both sides of the sheet as relatively thin films that are chilled sufficiently by the sheet 2 itself to become solidified, while still remaining plastic in character. The third set of rollers 8 and 9 further chill the applied films while squeezing them down to the desired final thickness so that the films on both sides of the sheet emerging from the machine are hard, non-tacky, and uniform.

From the foregoing disclosure, it will be apparent to those skilled in the art that many variations of the invention may be made as regards the particular lubricant composition employed and the particular method and apparatus for applying the lubricants, while still employing the principles on which the invention is based. It will also be appreciated that, by the selection of proper lubricant ingredients and proportions, temperatures, roller pressures, etc., in accordance with those principles, the invention is admirably suited for accomplishing all of the advantages and new results mentioned in a simple and easily controlled manner. Accordingly, the invention is not to be construed as limited to the particular details of the invention disclosed herein for illustrative purposes except as required by the true spirit and scope of the appended claims.

Having described my invention, I claim:

1. A process for preparing a sheet of metal for subsequent drawing, comprising applying to the sheet a film of a lubricating composition having a melting point substantially above the initial temperature of the sheet, the temperature of the lubricating composition as applied being above its melting point, and applying pressure to said film by means of a rolling surface maintained at a finishing temperature between said melting point and said initial temperature of the sheet for reducing the thickness of the film and forcing it into more intimate contact with the sheet while chilling the film to accelerate setting to a non-tacky condition.

2. A process for preparing a sheet of metal for subsequent drawing, comprising applying to the sheet a film of a lubricating composition having a melting point above 125° F., the temperature of the lubricating composition as applied being above its melting point and the coating temperature of the sheet as said composition is applied being substantially below the melting point of the composition, and applying pressure to said film by means of a rolling surface maintained at a finishing temperature between said melting point and said coating temperature of the sheet for reducing the thickness of the film and forcing it into more intimate contact with the sheet while chilling the film to accelerate setting to a non-tacky condition.

3. A process for preparing a sheet of metal for subsequent drawing, comprising applying to the sheet a film

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of a normally solid and non-tacky lubricating composition having a melting point above 175° F., the temperature of the lubricating composition as applied being above its melting point and the coating temperature of the sheet as said composition is applied being substantially below the melting point of the composition, and applying pressure to said film by means of a rolling surface maintained at a finishing temperature between said melting point and said coating temperature of the sheet for reducing the thickness of the film and forcing it into more intimate contact with the sheet while chilling the film to accelerate setting to a non-tacky condition.

4. A process for preparing a sheet of metal for subsequent drawing, comprising applying to the sheet a film of a normally solid and non-tacky lubricating composition having a melting point above 175° F., the temperature of the lubricating composition as applied being above its melting point and the coating temperature of the sheet as said composition is applied being at least 50 Fahrenheit degrees lower than the melting point of the composition, and applying pressure to said film by means of a rolling surface maintained at a finishing temperature between said melting point and said coating temperature of the sheet for reducing the thickness of the film and forcing it into more intimate contact with the sheet while chilling the film to a non-tacky condition.

5. A process for preparing a sheet of metal for subsequent drawing, comprising establishing the temperature of the sheet at a coating temperature in the range of about 70° F. to about 125° F., applying to the sheet a film of a normally solid and non-tacky lubricating composition having a melting point above said coating temperature of the sheet, the temperature of the lubricating composition as applied being above its melting point, and applying pressure to said film by means of a rolling surface maintained at a finishing temperature between said melting point and said coating temperature of the sheet for reducing the film to a thickness between about 0.2 mil and 1 mil and forcing the composition into more intimate contact with the sheet while chilling the film to accelerate setting to a non-tacky condition.

6. A process for preparing a sheet of metal for subsequent drawing, comprising establishing the temperature of the sheet at a coating temperature in the range of about 70° to about 125° F., applying to the sheet while it is at said coating temperature a film of a normally solid and non-tacky lubricating composition having a melting point of at least 175° F., the temperature of the lubricating composition as applied being above its melting point, and applying pressure to said film by means of a rolling surface maintained at a finishing temperature between said melting point and said coating temperature of the sheet for reducing the film to a thickness between about 0.2 mil and 1 mil and for forcing the composition into more intimate contact with the sheet while chilling the film to accelerate setting to a hard, non-tacky condition, said finishing temperature being one at which said lubricating composition is solid but will flow under the pressure applied thereto by said rolling surface without sticking to said rolling surface sufficiently to peel the film from the sheet.

7. A process for preparing a sheet of metal for subsequent drawing, comprising establishing the temperature of the sheet at a coating temperature in the range of about 70° to about 125° F., rolling onto the sheet while it is at said coating temperature a film of a normally solid and non-tacky lubricating composition having a melting point of at least 175° F. while applying pressure to said film, said pressure being selected to produce an initial film thickness in the range from 1 to 2 mils, the temperature of the lubricating composition as applied being above its melting point, and applying pressure to said film by means of a rolling surface maintained at a finishing temperature between said melting point and said coating temperature of the sheet for reducing the

film to a final thickness between about 0.2 mil and 0.5 mil and forcing the composition into more intimate contact with the sheet while chilling the film to accelerate setting to its normal non-tacky condition, said finishing temperature being one at which said lubricating composition is solid but will flow under the pressure applied thereto by said rolling surface without sticking to said rolling surface sufficiently to peel the film from the sheet.

8. A machine for applying a drawing lubricant to sheet metal comprising a pair of substantially parallel, cylindrical, coating rolls mounted for opposite rotation with their cylindrical surfaces spaced for applying a drawing lubricant to opposite surfaces of a metal sheet passing therebetween, means for spreading said drawing lubricant on said coating rolls, a pair of substantially parallel, cylindrical finishing rolls mounted for opposite rotation with their cylindrical surfaces spaced for receiving a coated sheet therebetween from said coating rolls, means for forcing said coating rolls together with an adjustable pressure, means for forcing said finishing rolls together with an adjustable pressure, and means for maintaining said coating rolls and finishing rolls at different predetermined temperatures, said last mentioned means including means for passing a stream of heat exchange fluid at one temperature through said coating rolls and for introducing a stream of heat exchange fluid at a different temperature through said finishing rolls.

9. A machine for applying a drawing lubricant to sheet metal comprising a first pair of substantially parallel, cylindrical, coating rolls mounted for opposite rotation with their cylindrical surfaces spaced for applying a drawing lubricant to opposite surfaces of a metal sheet, means for spreading said drawing lubricant on said coating rolls, a pair of substantially parallel, cylindrical finishing rolls mounted for opposite rotation with their cylindrical surfaces spaced for receiving a coated sheet therebetween from said coating rolls, the cylindrical surfaces of said finishing rolls being spaced for engaging opposite surfaces of said coated sheet, means for forcing said coating rolls together with an adjustable pressure, means for forcing said finishing rolls together with an adjustable pressure, means for maintaining said coating rolls at a predetermined temperature, and means for maintaining said finishing rolls at a predetermined temperature substantially below the temperature of said coating rolls, said means for maintaining the predetermined temperature of said coating rolls including means for passing a stream of heat exchange fluid at one temperature through said coating rolls, and said means for maintaining the predetermined lower temperature of said finishing rolls including means for passing a stream of heat exchange fluid at another temperature through said finishing rolls.

10. A machine for applying a drawing lubricant to

sheet metal comprising a pair of substantially parallel, cylindrical, pressure rolls mounted for opposite rotation with their cylindrical surfaces spaced for receiving a metal sheet therebetween, a pair of substantially parallel, cylindrical coating rolls mounted for opposite rotation with their cylindrical surfaces spaced for receiving a coated sheet therebetween from said pressure rolls and applying a drawing lubricant to opposite surfaces thereof, a pair of doctor rolls respectively mounted for applying said drawing lubricant to said coating rolls, a pair of substantially parallel, cylindrical finishing rolls mounted for opposite rotation with their cylindrical surfaces spaced for receiving a coated sheet therebetween from said coating rolls, means for forcing said pressure rolls together, for forcing said coating rolls together, and for forcing said finishing rolls together with adjustable pressures, and means for maintaining said pressure rolls, said coating rolls, and said finishing rolls at different predetermined temperatures.

11. A machine for applying a drawing lubricant to sheet metal comprising a first pair of substantially parallel, cylindrical, pressure rolls mounted for opposite rotation with their cylindrical surfaces spaced for receiving a metal sheet therebetween, a pair of substantially parallel, cylindrical, coating rolls mounted for opposite rotation with their cylindrical surfaces spaced for receiving a coated sheet therebetween from said pressure rolls and applying a drawing lubricant to opposite surfaces thereof, a pair of doctor rolls respectively mounted for applying said drawing lubricant to said coating rolls, a pair of substantially parallel, cylindrical, finishing rolls mounted for opposite rotation with their cylindrical surfaces spaced for receiving a coated sheet therebetween from said coating rolls, means for forcing said pressure rolls together, for forcing said coating rolls together, and for forcing said finishing rolls together with adjustable pressures, means for maintaining said pressure rolls at a first predetermined temperature, means for maintaining said coating rolls at a second predetermined temperature, and means for maintaining said finishing rolls at a third predetermined temperature substantially below the temperature of said coating rolls.

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