

United States Patent

Kuceski

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[45] July 11, 1972

[54] AQUEOUS LUBRICANT

- [72] Inventor: **Vincent P. Kuceski**, Chicago Heights, Ill.
[73] Assignee: **The C. P. Hall Company of Illinois**,
Chicago, Ill.
[22] Filed: **Aug. 17, 1970**
[21] Appl. No.: **64,454**

Related U.S. Application Data

- [62] Division of Ser. No. 791,259, Jan. 15, 1969, abandoned.
[52] U.S. Cl.252/49.3, 252/49.8, 252/49.5
[51] Int. Cl.C10m 1/46
[58] Field of Search252/49.3, 49.5, 49.8

[56] References Cited

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- 2,241,531 5/1941 Wiezevich252/49.8

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- 739,998 8/1966 Canada252/49.3

Primary Examiner—Daniel E. Wyman
Assistant Examiner—W. Cannon
Attorney—Gordon C. Mack

[57] ABSTRACT

Metals, when rolled or otherwise compressed, are lubricated by an aqueous solution of an organic, polar, surface-acting composition having a negative heat of solution which is a phosphate or phosphite of an alcohol ether which is soluble in the water at a lower temperature but insoluble in the water at the temperature to which the aqueous solution is heated during compression of the metal. This aqueous lubricant eliminates the fire hazard involved in the use of the present non-aqueous lubricants.

5 Claims, 2 Drawing Figures

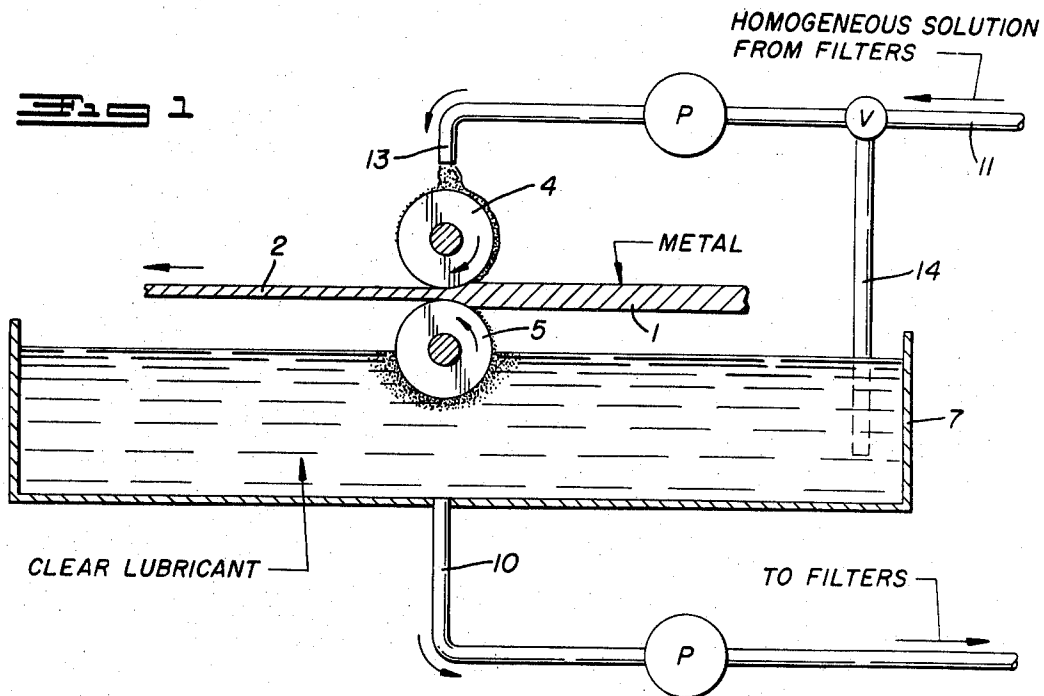
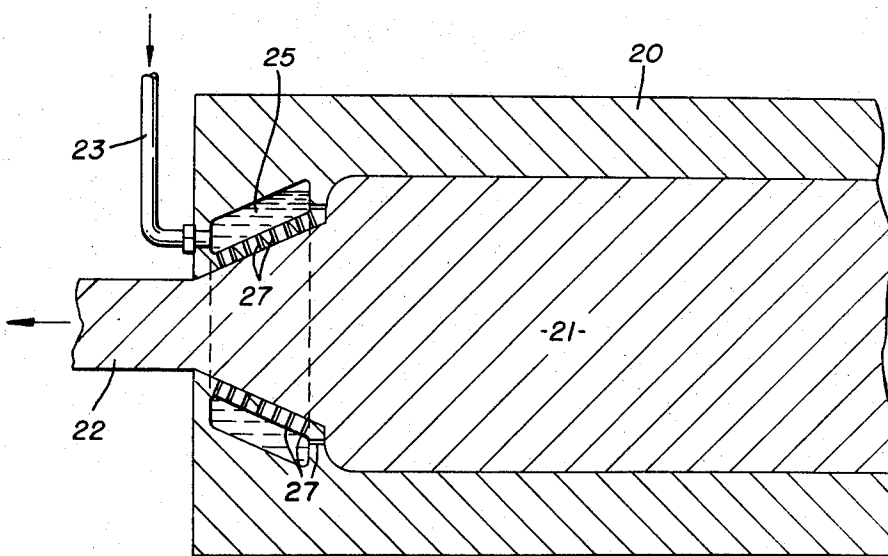


Fig. 2

INVENTOR
VINCENT P. KUCESKI

BY

John C. Luak
ATTORNEY

AQUEOUS LUBRICANT

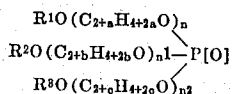
This application is a division of my application Ser. No. 791,259 filed Jan. 15, 1969, now abandoned.

This invention relates to the use of an aqueous lubricant on metals, including aluminum and magnesium, etc. during size reduction, as in rolling, extrusion or other compression. The aqueous lubricant is to replace the oil-based lubricants presently employed, and because of the large amount of water present the aqueous lubricant is preferred because it eliminates the fire hazard which is present when highly heated metal and an oil are brought into contact with one another. By eliminating the fire hazard, size reduction operations can be carried out at faster speeds at which the metal is heated to a higher temperature at which the danger of fire would be increased if an oil lubricant were used.

The solute of the aqueous lubricant used in carrying out the invention is an organic, polar, surface-acting composition which has a negative heat of solution and is more soluble in water at a lower temperature at which it is supplied to the rolling or extrusion system, and is less soluble at a higher temperature to which it is heated during the rolling or extrusion so that it separates from solution as a solid or liquid and serves as a lubricant.

The lubricant is a phosphate or phosphite of an alcohol which has a negative heat of solution and is soluble in water at a lower temperature and separates at the higher temperature to which it is heated during the operation.

Phosphates and phosphites of alcohol ethers having the following formula may be used:



In the formula the phosphite is the formula without the oxygen atom [O], whereas if [O] is attached to the phosphorus (P) the phosphate is represented.

R¹, R² and R³ are each an alkyl, cycloalkyl, aryl, aralkyl or alkaryl radical of one to 18 carbon atoms, and they may be the same or different; a, b and c are each 0, 1 or 2; and n, n¹ and n² are each 1, 2 or 3.

In the phosphates and phosphites the phosphorus atom and phosphorus oxide atom contribute to water solubility and this effect is equivalent to three ether groups. Thus the general formula for the ratio of carbon atoms to the number of ether groups is:

$$\frac{\text{The number of carbons in } \text{R}^1 + \text{R}^2 + \text{R}^3 + a + b + c}{\text{The number of carbons in } n + n^1 + n^2 + 3} = \text{substantially } 0.5 \text{ to } 2.5 \text{ and preferably } 0.8 \text{ to } 2.0$$

at a concentration of phosphate or phosphite which is 5 to 10 percent in water.

Representative triethoxy) include:

Tri(hexoxy triethoxy) phosphate and phosphite

Tri(pentylethoxy) phosphate and phosphite

Tri(hexoxy-diethoxy) phosphate and phosphite

Oleyldecaethoxy, di-methyl cellosolve phosphate and phosphite

The concentrations of the phosphates and phosphites having negative solubility, as they are used in aqueous solutions may vary from a few tenths of one per cent up to 25 or 50 percent or more, usually 1 to 20 percent, depending upon the nature of the compound and the temperatures to which the aqueous solution is subjected in the treatment of different metals. In most instances, the amount dissolved in the aqueous phase will depend on the viscosity and lubricity obtained. Generally, a clear solution which is easily pumped is required so that the solution may be filtered to remove suspended particles. Such filtration is generally essential for the production of a metal product with a bright unmarred finish.

The temperatures of solution and separation of the lubricant will vary, depending upon the metal being treated and the method of treatment. Usually the lubricant should be soluble at about room temperature. The temperature of rolling will depend upon the metal, etc. In rolling, the aqueous lubricant may be sprayed on upper and lower rolls, or the lower roll may be immersed in a bath of the lubricant. In extrusion the lubricant is added in any desired manner.

The invention is further described in connection with the accompanying drawings which are largely schematic.

FIG. 1 is a vertical section through equipment for a rolling operation; and

FIG. 2 is a vertical section through equipment used in extrusion.

FIG. 1 is illustrative of the application of the invention to one method of rolling a metal; namely, the cold-rolling of aluminum. It will be noted that the thickness of the metal 1 is reduced to that shown at 2 as the metal is passed between the rolls 4 and 5.

The tank 7 contains a clear, aqueous solution of lubricant which is continuously or periodically drawn off through the pipe 10 and filtered and returned through the pipe 11, usually some going to the spray head 13 and the balance being returned through the pipe 14 to the tank. If the filtering operation is carried out only periodically at long intervals, some of the clear lubricant from the tank 7 can be pumped directly to the spray 13 through pipe 14 for spraying the upper roll 4 while the lower roll 5 is rotated while partially submerged in the lubricant contained in the tank. As the aluminum or other metal is reduced from the thickness 1 to the thickness 2, a great deal of heat is given off and the rolls 4 and 5 become heated. The temperature of the bath may be controlled manually or automatically within a few degrees below the precipitation temperature to prevent overheating which would precipitate the lubricant. Water or lubricant may be added as required to maintain the desired concentration.

In starting up the operation the liquid sprayed on to the roller 4 and the entire liquid within the tank is clear. As the rolls 4 and 5 heat up, these rolls become hot enough to cause separation of the lubricant from the water solution either as a separate liquid phase or in particulate form. The drawing illustrates how, after the rolls 4 and 5 have been heated up, the liquid is converted to particulate form on the roll 4 due to its heat, and the heat of the roll 5 tends to cause separation of the solute adjacent the roll 5 as it is rotated in it. Thus the lubricant is supplied as a clear aqueous solution at a lower temperature and as heat is generated by the rolling operation and the rolls 4 and 5 become more and more heated the lubricant separates more rapidly after contact with the heated roll 4, and the lubricant surrounding the roll 5 separates and the separated phase adheres to the roll as it continues to rotate and carry the separated lubricant to the interface between the roll and the metal being treated. It is here that the lubricant which separates at a higher temperature performs its useful function. For example, in rolling aluminum, the separation may start at any temperature between 30° and 95° C.

The solute which separates on the roll 4 as the spray becomes heated and the solute which separates on the roll 5 as it becomes heated adhere to the rolls and are carried to the interface where they serve to lubricate the surface between the roll and the metal, thereby forming a smooth surface on the metal as well as cooling it while it is being compressed. The advantages of this method of producing a lubricant are not immediately apparent.

Heretofore, lubricants used in extruding or rolling metals when used with water, have been in a necessarily very stable finely divided or nearly colloidal emulsion form. The manufacture of a finely divided emulsion has been difficult and it has also been difficult to maintain the emulsion over different conditions of operating temperatures and speeds. In order to be a good lubricant, the lubricant must be brought out and made available to the metal surface. The better lubricants were made as emulsions which were deliberately made unsta-

ble so that the lubricant would separate out as a distinct phase. However, such unstable emulsions are difficult to handle and frequently are so heterogeneous that they do not give a uniform coating of lubricant at all times.

This invention overcomes the above difficulties by providing a homogeneous solution containing a controlled amount of lubricant which lubricant is freed at the point and at the time most needed for lubricity. Upon cooling, the lubricant re-enters solution and maintains a uniform concentration of the bath. As the lubricant is separated from the aqueous phase by the increase in temperature, some, or nearly all, of the water is evaporated, which further concentrates the lubricant. This evaporation of the water leaves behind a uniform film of lubricant on the rolls 4 and 5 which is transferred to the metal. Although evaporation also occurs in the usual emulsion system, the remaining lubricant film is spotty and, therefore, does not yield a smooth and continuous deposit on the roll or on the metal as does the lubricant of this invention.

In the practice of this invention the cold-rolling system, when it is first started, will not contain heat in the rolls 4 or 5, or in the metal 2. Therefore, the rolls should be heated up by some means, either electrically or by steam, in order to bring the rolls to a temperature high enough to separate the lubricant from the aqueous phase. However, it may not be necessary to pre-heat the roll if enough lubricant solution is sprayed on the rolls while they are operating. After a number of operations are performed in the rolling of the metal, the heat generated by the compression of the metal will maintain sufficient heat in the rolls to separate the lubricant satisfactorily.

Instead of rolling the metal, it may be extruded. FIG. 2 is a stylized representation of an extruder 20 with a die opening through which metal 21, after reducing its cross section, is extruded at 22. The lubricant is supplied in any suitable manner. It is indicated as being fed from a source through pipe 23 into a jacket 25 from which it is supplied through small conduits 27 to the metal as it is being compressed. The lubricant may be supplied along the metal in the extruder before being compressed, to be carried forward on the surface of the metal to the point where it is compressed, instead of applying it to the metal as it is compressed.

The solutes which may be used in preparing the lubricant solutions may be compounds well known in the literature, or they may be new compounds which have properties desired in the aqueous lubricant. A mixture of compounds having different properties may be employed to give the desired solubility and lubricity at required temperatures.

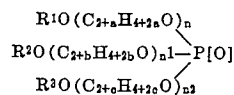
In rolling a metal such as aluminum, for example, the ingot is usually passed through one set of rolls in one direction and then, after narrowing the bite of the rolls, it is passed between the same rolls in the opposite direction, and this is repeated to gradually reduce the thickness of the sheet—usually without much widening of the sheet. Eventually it is often transferred to other rolls for the final rolling operation or operations. As the thinning process proceeds the temperature of the sheet increases. In operations where an oil lubricant has been employed the speed of the operation has to be reduced to prevent the metal from becoming so hot as to ignite the oil. An advantage of the use of an aqueous lubricant is that the danger of

ignition is eliminated and the speed of the operation can be increased because the water is a better coolant and the evaporation of water operates to keep the rolls and the treating bath cool. If the speed of the operation is too fast using the conventional nonaqueous lubricants, eventually the bath temperature becomes very high and there is an economic loss of volatile hydrocarbon and ester-type of lubricant medium. The rolls also become too hot, and the rolled sheet is neither as smooth nor bright as desired. The advantage of using the aqueous system is that the speed of the rolling operation can be increased four or five fold because the heat is easily carried off or controlled both by the evaporation of the water and by the high heat capacity of water. The amount of water evaporated may be considerable, but this is infinitesimally small in comparison to the losses that would be effective if an equal quantity of non-aqueous lubricant were evaporated.

In the practice of this invention, from 1 to 20 percent or more of the compound, and preferably 5 to 10 percent, having a negative heat of solution is dissolved in water to form a clear, homogeneous solution.

I claim:

1. The method of metal working which comprises compressing the metal while its surface is lubricated with an aqueous solution of 1 to 20 percent of a phosphate or phosphite of an alcohol ether of the formula



where O is attached to P if a phosphate but no such O is present in a phosphite; R^1 , R^2 and R^3 is each an alkyl, cycloalkyl, aryl, aralkyl or alkaryl radical of one to 18 carbon atoms; a , b and c are each 0, 1 or 2; each n is 1, 2 or 3 and a 5 to 10 percent solution of the lubricant is used in which the following ratio is true:

$$\frac{\text{The number of carbon atoms in } R^1 + R^2 + R^3 + a + b + c}{\text{The number of carbons in } n + n^1 + n^2 + 3} = \text{substantially } 0.5 \text{ to } 2.5$$

whereby the solution is heated by heat generated by compression of the metal, thereby separating lubricant from the solution and depositing it on the surface of the metal being compressed.

2. The method of claim 1 in which the lubricant is a phosphite.

3. The method of claim 1 in which the lubricant is a phosphate.

4. The method of claim 2 in which the metal article is a metal sheet.

5. The method of claim 2 in which the metal is lubricated as it is rolled, and the separation temperature of the aqueous lubricant is between substantially 30° and 95° C.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

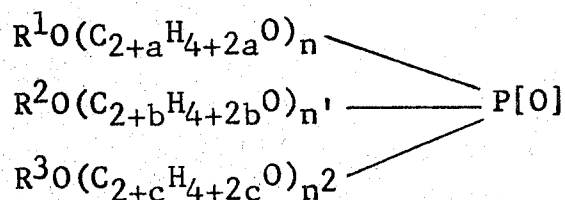
Patent No. 3,676,345 Dated July 11, 1972

Inventor(s) Vincent P. Kucski

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Correct the name of assignee from "The C. P. Hall Company of Illinois" to -- The C. P. Hall Company --

Correct the formula in lines 32-34 of column 1 and lines 26-30 of column 4, to read as follows:



Column 1, line 58 should read: -- Representative compounds include: --

Signed and sealed this 28th day of November 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents