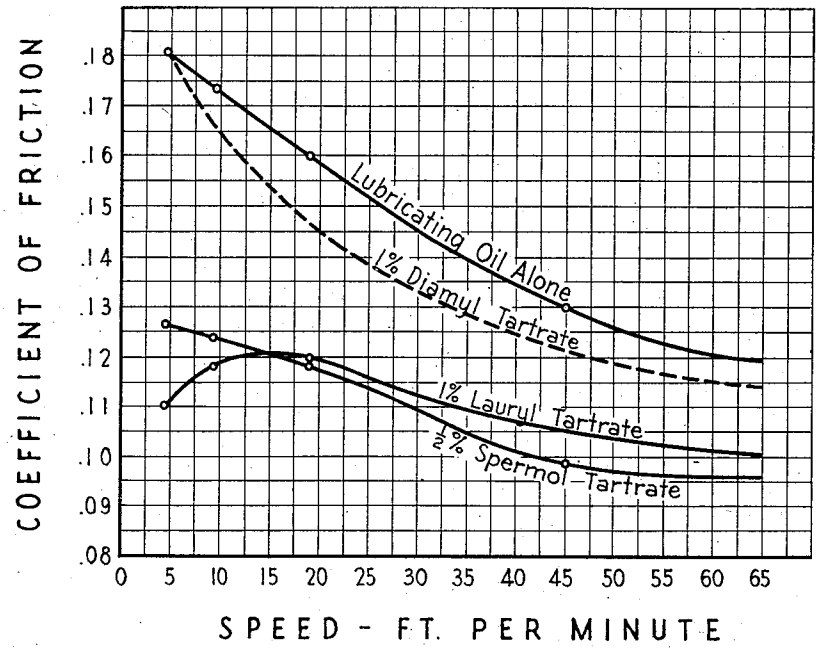
Feb. 27, 1945. B. B. FARRINGTON 2,370,299

COMPOUNDED LUBRICANT

Original Filed Dec. 3, 1937




KINETIC OILINESS TESTING MACHINE (PAT. NO. 2,020,565)

Surfaces:- Cast Iron on Cast Iron.
Temperature:- 275° F.
Loading:- 1500 lbs./sq. in.

INVENTOR

Bruce B. Farrington

by J. Adams

ATTORNEY

Patented Feb. 27, 1945 2,370,299

# UNITED STATES PATENT OFFICE

2,370,299

## COMPOUNDED LUBRICANT

Bruce B. Farrington, Berkeley, Calif., assignor to Standard Oil Company of California, San Francisco, Calif., a corporation of Delaware

Continuation of application Serial No. 177,878, December 3, 1937. This application February 26, 1941, Serial No. 380,708

37 Claims. (Cl. 252—56)

This invention relates to compounded lubricants. The present application is a continuation of my parent application Serial No. 177,878, filed December 3, 1937, on Composition of matter and process of lubrication.

A large number of addition agents have been proposed to improve the lubricating action of mineral oils by reducing the coefficient of friction between metal surfaces to a greater extent than is obtainable with mineral oils alone. The action of these addition agents is in general quite specific and for the most part unpredictable. An addition agent which is effective to reduce friction between one pair of metals at high speeds will often be found ineffective to reduce the friction between the same pair of metals at low speeds. In other words, the phenomenon of lubrication and reduction of friction is not yet well understood and developments in this field are largely empirical. It is therefore apparent that the actual conditions of operation encountered in any particular mechanism must be examined critically if the addition agent is to be truly beneficial.

The lubrication of reciprocating parts necessarily involves lubrication at low speeds since the reciprocating element decelerates to and accelerates from zero speed at each end of the stroke. Since reciprocating parts are common in all types of machinery, reduction of friction at low speeds approaching zero is of great importance as a lubricating problem. The necessity for adequate lubrication at low speeds is illustrated by the fact that the maximum wear of the cylinder walls of an internal combustion engine occurs at the upper limit of the piston ring travel where the rubbing speed is low and where ordinary lubricants fail to reduce friction or wear to the same extent as it is reduced in the remaining portion of the piston travel.

Material reduction of friction at low speeds is a severe requirement of compounded lubricating oils, particularly when the metal surfaces to be lubricated are cast iron on cast iron, steel on steel, or other pairs of ferrous metal surfaces. It has been observed that most oiliness agents which have been proposed by the prior art fail to materially benefit the action of mineral oils in reducing friction under these extreme conditions.

Accordingly, it is an object of this invention to provide a process for effectively reducing friction at extremely low rubbing speeds between ferrous metal frictional surfaces.

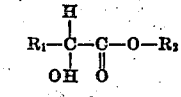
Another object of the invention is to provide a lubricating composition which is especially effective for reducing friction between ferrous metal frictional surfaces moving at low speeds relative to one another.

A further object of the invention is to provide a new composition of matter comprising esters of alcohols naturally occurring in sperm oil.

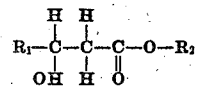
The drawing is a graphical representation of experimental results which show the discoveries embodied in this invention.

A certain class of compounds has been found to possess unpredictable and outstanding properties in that the compounds have the ability to materially reduce the coefficient of friction between metal surfaces at extremely low speeds as well as at higher speeds. These compounds are esters of a particular type and may be illustrated by the following examples:

*Alpha hydroxy esters*



*Beta hydroxy esters*



In these formulae $R_1$ may be hydrogen or an alkyl group; $R_2$ comprises a long carbon chain.

Examples of acids having either an alpha or beta or both alpha and beta hydroxyl groups are:

Tartaric acid, $(CHOH\ COOH)_2$
Tartronic acid, $CHOH\ (COOH)_2$
Lactic acid, $CH_3\ CHOH\ COOH$
Citric acid, $HOOC\ CH_2COH\ COOH\ CH_2\ COOH$
Mucic acid, $(CHOH)_4\ (COOH)_2$
Malic acid, $CHOH\ CH_2\ (COOH)_2$
Glycolic acid, $CH_2\ OH\ COOH$

An essential characteristic of the compounds of this invention is that the alcoholic portion of the ester must comprise a long carbon chain. The following are alcohols having a long carbon chain:

Decyl alcohol, $C_{10}H_{21}OH$
Dodecyl alcohol, $C_{12}H_{25}OH$
Tetradecyl alcohol, $C_{14}H_{29}OH$
Cetyl alcohol, $C_{16}H_{33}OH$
Octadecyl alcohol, $C_{18}H_{37}OH$
Ceryl alcohol, $C_{26}H_{53}OH$
Myricyl alcohol, $C_{30}H_{61}OH$
Lanolin alcohol, $C_{12}H_{25}OH$
Oleyl alcohol, $C_{18}H_{35}OH$

"Lorol," a material containing lauryl alcohol and sold by E. I. du Pont de Nemours, is a satisfactory source of long chain alcohols.

Esters of any of the above types of acids in combination with any of the above listed long chain alcohols are regarded as falling within the broad scope of this invention. For example, decyl tartrate, dodecyl tartrate, tetradecyl tartrate, cetyl tartrate, lauryl tartrate, octadecyl tartrate, ceryl tartrate, myricyl tartrate, oleyl tartrate and lanolin tartrate may be used. Similarly, decyl lactate, dodecyl lactate, tetradecyl lactate, cetyl lactate, lauryl lactate, octadecyl lactate, ceryl lactate, myricyl lactate, oleyl lactate and lanolin lactate are encompassed in the broad scope of the invention.

These esters are prepared from the respective acids and alcohols by the usual esterification reaction:

$$RCOOH+HOR \rightarrow RCOOR+H_2O$$

The reaction may be effected by heating the two constituents and vaporizing the water formed. Dehydration agents such as sulfuric acid may also be utilized to promote the reaction.

The invention also embodies one species of ester having definitely superior merit as compared with other members of the above described genus. This species is believed to be a new composition of matter which possesses utility for purposes other than a compounding ingredient in lubricating oils. The compound comprises the ester of an hydroxy acid, such as previously described, and the alcohols obtained from sperm oil.

Sperm oil comprises esters of several long chain alcohols and hydrolysis of the oil yields a mixture of these alcohols together with fatty acids. The acids and alcohols may be separated by converting the acids to soaps and separating the soaps and alcohols by distillation or extraction with solvents by processes well known in the art. The mixture of long chain alcohols so obtained is termed "spermol" in the present specification. The exact chemical formulae and relative proportions of the alcohol ingredients of "spermol" have not been ascertained, but it is said that sperm oil contains alcohols such as cetyl and octadecyl in minor proportions and an alcohol of the type of oleyl in larger proportions. It is to be noted that sperm oil is not the equivalent of "spermol," since the former is a naturally-occurring oil and the latter comprises the natural mixture of alcohols obtained by hydrolysis of the oil.

"Spermol" esters of hydroxy acids are especially effective for reducing friction between ferrous metal surfaces at low speeds.

In order to illustrate the effectiveness of the process and the compositions of this invention, a series of tests was run in a kinetic oiliness testing machine of the type disclosed in United States Patent No. 2,020,565, granted to Neely et al. November 12, 1935. The data from these tests are shown graphically in the drawing. Attention is directed to the fact that esters of shorter chain alcohols are not effective in reducing friction between cast iron surfaces at low speeds. This is illustrated by the curve showing the coefficient of friction at various speeds of an oil containing 1% diamyl tartrate.

Esters of "spermol" are decidedly superior to esters of various other long chain alcohols falling within the broader scope of the invention. This fact is illustrated by data showing .5% of "spermol" tartrate to be approximately as effective in reducing friction as 1% of lauryl tartrate. In other words, it takes approximately half as much addition agent to obtain the same reduction in friction when "spermol" esters are used as is required when esters of other long chain alcohols, exemplified by lauryl alcohol, are added.

Experiments indicate that "spermol" esters of alpha and beta hydroxy acids other than tartaric are effective addition agents for lubricating oils.

The proportions of the addition agent which may be incorporated in lubricating oils may vary over a considerable range. Measurable improvements are obtained with as little as 0.1% of the ester, but it is preferred to add from .5 to 1.5% by weight of the compound. Because the esters are expensive ingredients, it is generally not desirable to add more than about 2% to the lubricants, although as much as 10% or more may be permissible for various purposes.

The esters of this invention may be utilized in mineral lubricating oils of all types, and it should be understood that the term "lubricating oil" includes highly naphthenic lubricants such as are obtained from California crude oils or highly paraffinic lubricants obtained by solvent refining processes or from Pennsylvania type crudes. Likewise, the addition agent will be of utility in oils of widely different viscosities, ranging from light spindle oils through the usual range of viscosities utilized in ordinary internal combustion engines to the highly viscous oils manufactured for gears or heavy machinery.

The discoveries disclosed hereinabove are utilized in the process of this invention by lubricating ferrous metal surfaces, such as cast iron on cast iron, moving in frictional contact at low speeds relative to each other with a film of lubricating oil and adding an alpha or beta hydroxy ester of long chain alcohols to the lubricant in order to reduce the coefficient of friction.

This process is not merely a mechanical one but involves chemical or physico-chemical action, since the added esters are present in a proportion so small that they have no appreciable effect on the viscosity or mere mechanical action of the lubricant. The reduction of friction effected by the esters is probably due to their chemical action on the metal surfaces being lubricated, although the esters may also act on the base oil itself in some unknown chemical manner and thereby contribute to the improved lubricating action.

Specific embodiments of the invention have been described but this has been done by way of illustration only and with the intention that the scope of the invention should not be limited thereby. For example, the generic aspect of this invention includes highly thickened oils, such as castor machine oils containing aluminum naphthenate, or other known thickening agents. The invention also includes grease compositions containing soaps of the alkali and/or heavy metals within its generic scope. It will be apparent that numerous modifications and variations of the illustrated examples may be utilized in the practice of the invention which is of the scope of the following claims.

I claim:

1. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic type alcohol having from approximately ten to approximately thirty carbon atoms in the chain esterified with an hydroxy aliphatic acid having at least

one hydroxyl group not more than two carbon atoms removed from a carboxyl group of said acid, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

2. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic type alcohol having from approximately ten to approximately thirty carbon atoms in the chain esterified with an aliphatic acid having an hydroxyl group in an alpha position with respect to a carboxyl group thereof, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

3. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic type alcohol having from approximately ten to approximately thirty carbon atoms in the chain esterified with an alphatic acid having an hydroxyl group in a beta position with respect to a carboxyl group thereof, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

4. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of tartronic acid ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

5. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of a malic acid ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

6. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of a glycolic acid ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

7. A compounded lubricant comprising a hydrocarbon oil and from approximately 0.1% to approximately 10% by weight based on the oil of an organic ester comprising an aliphatic type alcohol having from approximately ten to approximately thirty carbon atoms in the chain esterified with an hydroxy aliphatic acid having at least one hydroxyl group not more than two carbon atoms removed from a carboxyl group of said acid.

8. A compounded lubricant comprising a hydrocarbon oil and from approximately 0.1% to approximately 10% by weight based on the oil of an organic ester comprising an aliphatic type alcohol having from approximately ten to approximately thirty carbon atoms in the chain esterified with an aliphatic acid having an hydroxyl group in an alpha position with respect to a carboxyl group thereof.

9. A compounded lubricant comprising a hydrocarbon oil and from approximately 0.1% to approximately 10% by weight based on the oil of an organic ester comprising an aliphatic type alcohol having from approximately ten to approximately thirty carbon atoms in the chain esterified with an aliphatic acid having an hydroxyl group in a beta position with respect to a carboxyl group thereof.

10. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising "spermol" esterified with an hydroxy aliphatic acid having at least one hydroxyl group not more than two carbon atoms removed from a carboxyl group of said acid, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

11. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising "spermol" esterified with an aliphatic acid having an hydroxyl group in an alpha position with respect to a carboxyl group thereof, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

12. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising "spermol" esterified with an aliphatic acid having an hydroxyl group in a beta position with respect to a carboxyl group thereof, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

13. A compounded lubricant comprising a hydrocarbon oil and from approximately 0.1% to approximately 10% by weight based on the oil of "spermol" tartronate.

14. A compounded lubricant comprising a hydrocarbon oil and from approximately 0.1% to approximately 10% by weight based on the oil of "spermol" malate.

15. A compounded lubricant comprising a hydrocarbon oil and from approximately 0.1% to approximately 10% by weight based on the oil of a "spermol" ester of glycolic acid.

16. A compounded lubricating oil comprising a petroleum lubricating oil and a small amount of a neutral ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain and an aliphatic acid containing not more than six carbon atoms and containing an hydroxyl substituent not more than two carbon atoms removed from a carboxyl group of the acid, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

17. A compounded lubricating oil comprising a petroleum lubricating oil and a small amount of a neutral ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain and an alpha hydroxy aliphatic acid containing not more than six carbon atoms, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

18. A compounded lubricating oil comprising a petroleum lubricating oil and a small amount of a neutral ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain and a beta hydroxy aliphatic acid containing not more than six carbon atoms, the proportion of said ester being sufficient to effectively decrease the coefficient of

friction between metal frictional surfaces at low rubbing speeds.

19. A compounded lubricating oil comprising a petroleum lubricating oil and a neutral ester of "spermol" and an aliphatic acid containing not more than six carbon atoms and containing an hydroxyl substituent not more than two carbon atoms removed from a carboxyl group of the acid, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

20. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group not more than two carbon atoms removed from a carboxyl group of the acid, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

21. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group in an alpha position with respect to at least one of the said carboxyl groups, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

22. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group in a beta position with respect to at least one of the said carboxyl groups, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

23. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic polycarboxylic polyhydroxy acid having at least one hydroxyl substituent not more than two carbon atoms removed from a carboxyl group of the acid, said acid being esterfied with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

24. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising a polyhydroxy aliphatic polycarboxylic acid having at least one hydroxyl group not more than two carbon atoms removed from a carboxyl group thereof, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

25. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group not more than two carbon atoms removed from a carboxyl group of the acid, said acid being esterified with "spermol," the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

26. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group in an alpha position with respect to at least one of the said carboxyl groups, said acid being esterified with "spermol," the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

27. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group in a beta position with respect to at least one of the said carboxyl groups, said acid being esterified with "spermol," the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

28. A compounded lubricant comprising a hydrocarbon lubricating oil and a small amount of an organic ester comprising an aliphatic polycarboxylic polyhydroxy acid having an hydroxyl substituent not more than two carbon atoms removed from a carboxyl group of the acid, said acid being esterified with "spermol," the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

29. A compounded lubricant comprising a hydrocarbon lubricating oil and from approximately 0.1% to approximately 10% by weight based on the oil of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group not more than two carbon atoms removed from a carboxyl group of the acid, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain.

30. A compounded lubricant comprising a hydrocarbon lubricating oil and from approximately 0.1% to approximately 10% by weight based on the oil of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group in an alpha position with respect to at least one of the said carboxyl groups, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain.

31. A compounded lubricant comprising a hydrocarbon lubricating oil and from approximately 0.1% to approximately 10% by weight based on the oil of an organic ester comprising an aliphatic polycarboxylic acid having an hydroxyl group in a beta position with respect to at least one of the said carboxyl groups, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain.

32. A compounded lubricant comprising a hydrocarbon lubricating oil and from approximately 0.1% to approximately 10% by weight based on the oil of an organic ester comprising an aliphatic polycarboxylic polyhydroxy acid having an hydroxyl substituent not more than two car-

bon atoms removed from a carboxyl group of the acid, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain.

33. A compounded lubricant comprising a hydrocarbon lubricating oil and from approximately 0.1% to approximately 10% by weight based on the oil of an organic ester comprising a polyhydroxy aliphatic polycarboxylic acid having at least one hydroxyl group not more than two carbon atoms removed from a carboxyl group thereof, said acid being esterified with an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain.

34. A compounded lubricating oil comprising a petroleum lubricating oil and a small amount of a neutral ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain and an aliphatic polycarboxylic acid containing not more than three carboxyl groups and not more than six carbon atoms and containing an hydroxyl substituent not more than two carbon atoms removed from a carboxyl group of the acid, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

35. A compounded lubricating oil comprising a petroleum lubricating oil and a small amount of a neutral ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain and an alpha hydroxy aliphatic polycarboxylic acid containing not more than three carboxyl groups and not more than six carbon atoms, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

36. A compounded lubricating oil comprising a petroleum lubricating oil and a small amount of a neutral ester of an aliphatic alcohol having from approximately ten to approximately thirty carbon atoms in the chain and a beta hydroxy aliphatic polycarboxylic acid containing not more than three carboxyl groups and not more than six carbon atoms, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

37. A compounded lubricating oil comprising a petroleum lubricating oil and a small amount of a neutral ester of "spermol" and an aliphatic polycarboxylic acid containing not more than three carboxyl groups and not more than six carbon atoms and containing an hydroxyl substituent not more than two carbon atoms removed from a carboxyl group of the acid, the proportion of said ester being sufficient to effectively decrease the coefficient of friction between metal frictional surfaces at low rubbing speeds.

BRUCE B. FARRINGTON.