Sept. 24, 1940. F. B. DOWNING ET AL 2,215,956

LUBRICATION OF STEAM CYLINDERS

Filed Oct. 21, 1937

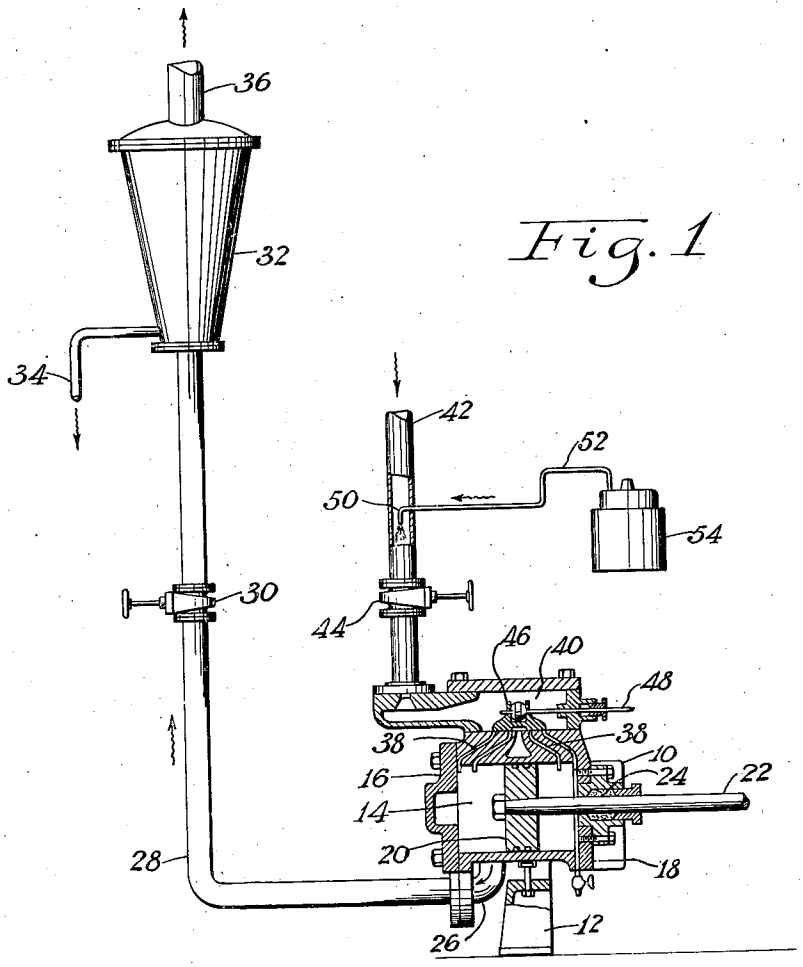


Fig. 1

Frederick B. Downing
Anthony F. Benning
Lawrence G. Benton
INVENTORS

BY
Edwin C. Woodhouse
ATTORNEY

Patented Sept. 24, 1940 2,215,956

UNITED STATES PATENT OFFICE

2,215,956

LUBRICATION OF STEAM CYLINDERS

Frederick B. Downing, Carneys Point, Anthony F. Benning, Penns Grove, N. J., and Lawrence G. Benton, Wilmington, Del., assignors to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

Application October 21, 1937, Serial No. 170,212

16 Claims. (Cl. 252—53)

This invention relates to lubrication and particularly to the lubrication of steam cylinders employing superheated steam.

The lubrication of steam cylinders employing superheated steam has heretofore required the use of mineral oils which had been compounded with various materials of the fatty oil type. A representative lubricant generally employed heretofore in steam cylinders was prepared by compounding 5% of lard oil with 95% of a reduced cylinder oil of the following characteristics:

API gravity		25–26°
Flash point	°F.	545–550
Fire point	°F.	610–620
Pour point	°F.	30
SUV_{210}	sec.	145–150

Such compounded oils have, however, very poor demulsibility characteristics, which is particularly undesirable in oils for this purpose. The lard oil decreases the separation of the oil from the condensed steam which results (1) in loss of oil and (2) in the appearance of oil in the boilers where it increases foaming and priming. If the oil is not compounded with lard oil or the like, its separation from the condensate is improved but the oil does not satisfactorily lubricate the cylinder walls, which results in overheating and scoring of the bearing surfaces.

It is an object of the present invention to improve the lubrication of steam cylinders operating with superheated steam. Another object is to provide a material which, when added to lubricating oil to be used in steam cylinders operated with superheated steam, will improve the lubrication of the steam cylinders without changing other desirable properties of the oil. A further object is to provide an improved lubricant for lubricating steam cylinders operating with superheated steam. Still further objects are to provide new compositions of matter and to advance the art. Still other objects will appear hereinafter.

The above and other objects may be accomplished in accordance with our invention which comprises incorporating in mineral oils, to be employed in the lubrication of steam cylinders operating with superheated steam, a small amount of a neutral aromatic ester of an acid of phosphorus. The addition of such esters to the lubricating oil improves the lubricating properties of the oil, causes it to adhere to the bearing surfaces more tenaciously in a thin film with decreased tendency to form drops, causes less carbonization of the oil and increases the separation of the oil from the exhaust steam.

In order to more clearly illustrate our invention, the problems involved and the method by which such problems have been solved, reference is made to the accompanying drawing. In Figure 1 of this drawing is disclosed a steam cylinder of conventional type with parts in section to more clearly illustrate the structure.

The numeral 10 indicates the cylinder, generally, supported on a base 12, which cylinder comprises cylindrical walls 14 and end members 16 and 18. A piston of conventional type is shown at 20 on the end of a piston rod 22 operating through the end 18, containing suitable metallic packing 24. The exhaust steam passes out of the cylinder at 26 through conduit 28 controlled by valve 30 to a conventional type of oil separator 32. The separated oil and condensed steam passes out through conduit 34 and the remainder of the steam passes out at the top through conduit 36 to the condensers, not shown.

The superheated steam enters the cylinder through conduits 38 from chamber 40. The steam enters chamber 40 through conduit 42 controlled by valve 44. The flow of steam into the cylinder is controlled by slide valve 46 operated by the valve rod 48. The lubricant is introduced into the steam passing through conduit 42 at the point indicated at 50. The lubricant is supplied through conduit 52 from a suitable reservoir 54.

From the above description of the drawing, it will be apparent that the lubricant enters the superheated steam and passes with the steam into the cylinder where it lubricates the cylinder walls and the piston. The excess lubricant passes out of the cylinder and into the oil separator. With the lubricants heretofore employed for this purpose, large amounts where necessarily required to properly lubricate the cylinder. Excess oil gathered on the walls of the cylinder and on the ends of the piston in the form of drops and was eventually carried to the oil separator. Such oil did not separate readily from the steam and a relatively large proportion of it was carried to the boiler where it was objectionable.

In the practice of our invention, the petroleum oil to be used may be any of those generally found to be suitable for relatively high temperature use and can be of a naphthenic type, but is preferably of a paraffinic type. Generally, it is desirable to use an oil of relatively high viscosity, that is, one having a Saybolt viscosity above 100 seconds at 210° F. The oil should be reasonably free from acids and should contain substantially no saponi-

flable oil, such as the animal and vegetable fats and oils. A suitable petroleum oil to be used as a base for the lubricants of our invention is preferably a steam-refined cylinder oil having the following characteristics:

API gravity		25–26°
Flash point	°F.	545–550
Fire point	°F.	610–620
Pour point	°F.	30
SUV_{210}	sec.	145–150

This oil should be compounded with a minor proportion of a neutral aromatic ester of an acid of phosphorus. It will generally be found satisfactory to use from about 1 to about 10% of such ester based on the oil. We preferably employ about 2%. By the term "an acid of phosphorus", we intend to include the various phosphoric, phosphorous, thiophosphoric and thiophosphorous acids. The preferred compound is tricresyl phosphate, prepared from a mixture of cresols. Other suitable esters are tri-phenyl phosphate, tri-naphthyl phosphate, tri-nitrophenyl phosphate, tri-hexoxyphenyl phosphate, mixed tri-tertiary-amylphenyl phosphate, tri-decahydronaphthyl phosphate, tri-tetrahydronaphthyl phosphate, tricresylmonothio phosphate, tri-phenyl monothio phosphate, tri-naphthyl monothio phosphate, tri-nitrophenyl monothio phosphate, tri-hexoxyphenyl monothio phosphate, mixed tri-tertiaryamylphenyl monothio phosphate, tri-decahydronaphthyl monothio phosphate, tri-tetrahydronaphthyl monothio phosphate, tri-cresyl trithio phosphate, tri-phenyl trithio phosphate, tri-naphthyl trithio phosphate, tri-nitrophenyl trithio phosphate, tri-hexoxyphenyl trithio phosphate, mixed tri-tertiaryamylphenyl trithio phosphate, tri-decahydronaphthyl trithio phosphate, tritetrahydronaphthyl trithio phosphate, tri-phenyl phosphite, tri-cresyl phosphite, tri-naphthyl phosphite, tri-nitrophenyl phosphite, tri-hexoxyphenyl phosphite, mixed tri-tertiaryamylphenyl phosphite, tri-decahydronaphthyl phosphite, tri-tetrahydronaphthyl phosphite, tricresyl thio phosphite, tri-phenyl thio phosphite, tri-naphthyl thio phosphite, tri-nitrophenyl thio phosphite, tri-hexoxyphenyl thio phosphite, mixed tri-tertiary-amylphenyl thio phosphite, tri-decahydronaphthyl thio phosphite, tri-tetrahydronaphthyl thio phosphite, tricresyl-trithio phosphite, tri-phenyl trithio phosphite, tri-naphthyl trithio phosphite, tri-nitrophenyl trithio phosphite, tri-hexoxyphenyl trithio phosphite, mixed tri-tertiaryamylphenyl trithio phosphite, tri-decahydronaphthyl trithio phosphite, tri-tetrahydronaphthyl trithio phosphite.

In order to more clearly illustrate our invention and the preferred modes of carrying the same into effect, the following example is given:

Example

Two practically identical reciprocating type steam engines of the type shown in the drawing were operated at an average speed of 120 R. P. M. with superheated steam at a steam pressure of about 175 pounds gage and at a steam temperature of about 480° F. One (A) was lubricated with a steam-refined cylinder oil having the characteristics hereinbefore described, compounded with 5% lard oil. The other engine (B) was lubricated with the same oil, but in which the lard oil had been replaced by 1% of technical tricresyl phosphate. In engine A, it was necessary to employ about four pints of oil per 24 hours to obtain effective lubrication. In engine B, it was possible to obtain good lubrication employing only about three pints of oil per 24 hours, this being a reduction of about 25% in the amount of oil necessary and previously used. Even with this reduction in the amount of oil feed, the cylinders had a high degree of polish and practically no excess oil was present, only a small amount, on the order of about 15–20 drops, adhering to the bottom of the piston ring. There was a much better oil film remaining on the cylinder of engine B and there was less carbonization of the oil in engine B to deleteriously affect the metal packing.

The exhaust steam leaving the oil separator from each of these two engines was condensed and examined for oil entrained therein. The condensate from engine A contained 33.7 parts per million of oil, while the condensate from engine B contained only 25.7 parts per million of oil. This was a reduction of at least 25% in the oil passing to the boiler, materially reducing the tendency for foaming, priming and other objectionable effects due to oil in the boiler water.

Similar advantageous results were obtained when operating with a steam pressure of about 450 pounds gage and a temperature of about 716° F.

While we have disclosed the preferred embodiments of our invention and the preferred modes of carrying the same into effect, it will be readily apparent to those skilled in the art that many variations and modifications may be made therein, particularly in the esters employed, without departing from the spirit of our invention. Accordingly, the scope of our invention is to be limited solely by the appended claims construed as broadly as is permissible in view of the prior art.

We claim:

1. The method of lubricating steam cylinders employing superheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral aromatic ester of an acid phosphorus, said lubricant being substantially free of saponifiable oils.

2. The method of lubricating steam cylinders employing superheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral aryl ester of an acid of phosphorus, said lubricant being substantially free of saponifiable oils.

3. The method of lubricating steam cylinders employing superheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral cresyl ester of an acid of phosphorus, said lubricant being substantially free of saponifiable oils.

4. The method of lubricating steam cylinders employing supherheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral aromatic ester of phosphoric acid, said lubricant being substantially free of saponifiable oils.

5. The method of lubricating steam cylinders employing superheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral aryl ester of phosphoric acid, said lubricant being substantially free of saponifiable oils.

6. The method of lubricating steam cylinders employing superheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a tri-cresyl phosphate, said lubricant being substantially free of saponifiable oils.

7. The method of lubricating steam cylinders employing superheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral phosphate ester of mixed cresols, said lubricant being substantially free of saponifiable oils.

8. The method of lubricating steam cylinders employing superheated steam which comprises introducing into the steam line passing to the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral aromatic ester of an acid of phosphorus, said lubricant being substantially free of saponifiable oils.

9. The method of lubricating steam cylinders employing superheated steam which comprises introducing into the steam line passing to the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral aryl ester of an acid of phosphorus, said lubricant being substantially free of saponifiable oils.

10. The method of lubricating steam cylinders employing superheated steam which comprises introducing into the steam line passing to the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral cresyl ester of an acid of phosphorus, said lubricant being substantially free of saponifiable oils.

11. The method of lubricating steam cylinders employing superheated steam which comprises introducing into the steam line passing to the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral aromatic ester of phosphoric acid, said lubricant being substantially free of saponifiable oils.

12. The method of lubricating steam cylinders employing superheated steam which comprises introducing into the steam line passing to the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral aryl ester of phosphoric acid, said lubricant being substantially free of saponifiable oils.

13. The method of lubricating steam cylinders employing superheated steam which comprises introducing into the steam line passing to the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a tri-cresyl phosphate, said lubricant being substantially free of saponifiable oils.

14. The method of lubricating steam cylinders employing superheated steam which comprises introducing into the steam line passing to the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of a neutral phosphate ester of mixed cresols, said lubricant being substantially free of saponifiable oils.

15. The method of lubricating steam cylinders employing superheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of tri-tertiaryamylphenyl phosphate, said lubricant being substantially free of saponifiable oils.

16. The method of lubricating steam cylinders employing superheated steam which comprises applying to the walls of the cylinder a lubricant comprising a mineral oil having incorporated therein a small proportion of tri-phenyl phosphate, said lubricant being substantially free of saponifiable oils.

FREDERICK B. DOWNING.
ANTHONY F. BENNING.
LAWRENCE G. BENTON.