

[72] Inventors **Ivor W. Mills**
Media;
Glenn R. Dimeler, West Chester; John J.
Melchiorre, Wallingford, all of, Pa.
 [21] Appl. No. **850,779**
 [22] Filed **Aug. 18, 1969**
 [45] Patented **June 22, 1971**
 [73] Assignee **Sun Oil Company, Philadelphia, Pa.**

701,131 1/1965 Canada 174/25

Primary Examiner—Lewis H. Myers
Assistant Examiner—A. T. Grimley
Attorneys—George L. Church, Donald R. Johnson, Wilmer E.
 McCorquodale, Jr. and Barry A. Bisson

[54] **ELECTRICAL CONDUIT CONTAINING
 HYDROREFINED OIL**
12 Claims, 3 Drawing Figs.

[52] U.S. Cl. 174/25,
 208/14
 [51] Int. Cl. H01b 9/06
 [50] Field of Search 174/25, 25
 C, 26, 120.11, 17.1; 208/14; 252/50, 59

[56] **References Cited**

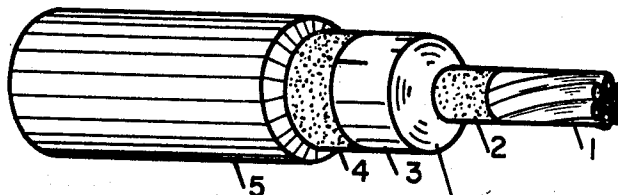
UNITED STATES PATENTS

3,163,705 12/1964 Feick, III, et al. 174/25
 3,406,111 10/1968 Wynkoop et al. 208/14
 1,757,010 7/1929 Fair 174/120

FOREIGN PATENTS

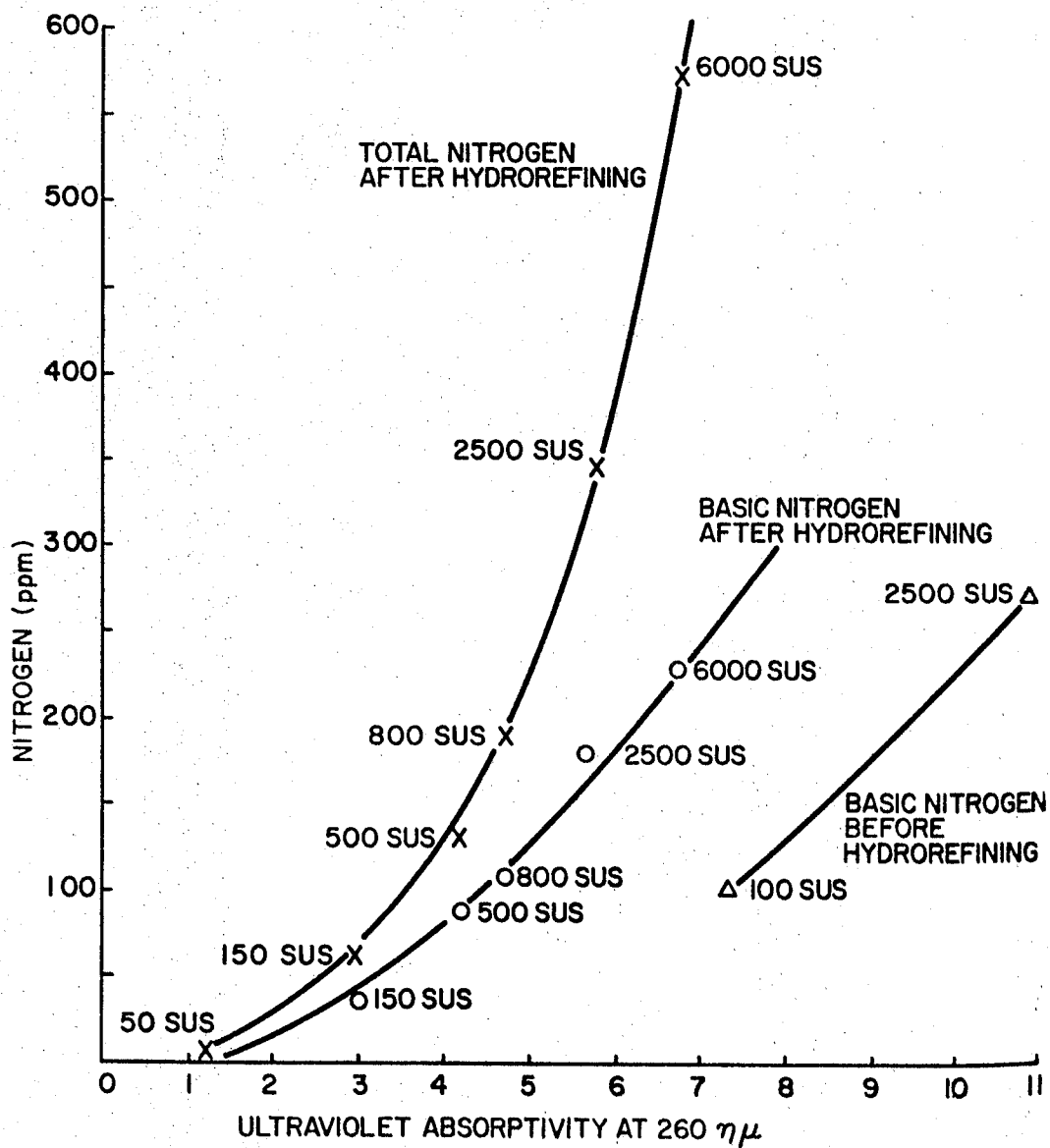
896,065 5/1962 Great Britain 174/25

ABSTRACT: An oil impregnated electrical conduit comprises a conductive metal, a cellulosic insulator, and a hydrorefined insulation oil, wherein the hydrorefined oil has a viscosity in the range of 100—12,000 SUS at 100° F., contains 10—65 weight percent aromatics (by gel analysis) and less than 10 p.p.m. of basic nitrogen (preferably less than 5 p.p.m. and typically less than 2 p.p.m.). Typically, such an oil can contain more than 10 p.p.m. of total nitrogen (e.g., 15—600 p.p.m.) depending on the viscosity of the oil. Preferably, the hydrorefined oil is naphthenic or aromatic (by VGC classification). A preferred conduit is an oil-filled electrical cable wherein the cellulosic insulator is paper and is wrapped around the conductive metal. A preferred paper is capacitor grade Kraft paper of relatively high density and can be creped or microcreped. The cellulosic insulator can also comprise chemically treated cellulose such as cyanoethylated cellulose or acetylated cellulose.



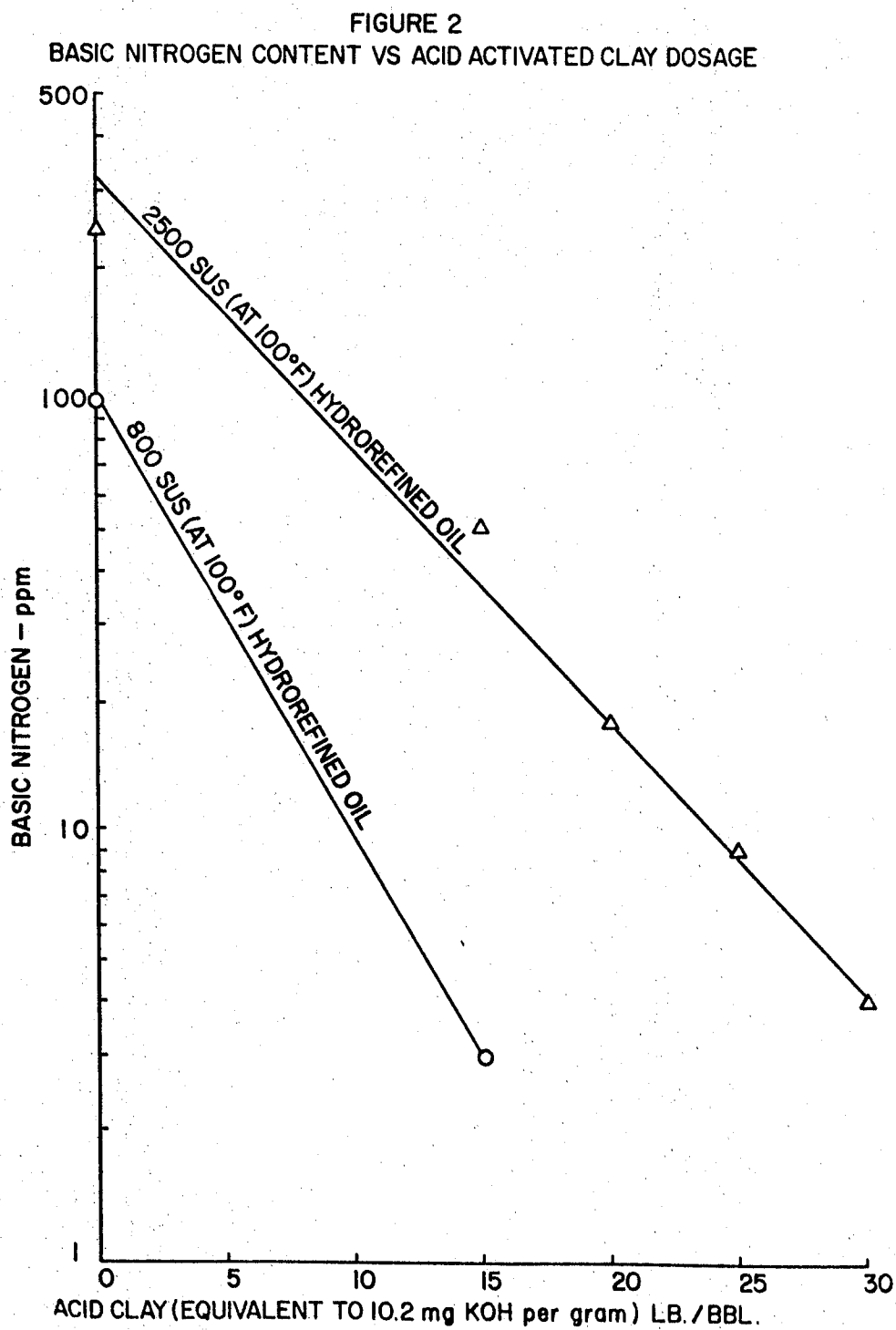
**HYDROREFINED OIL CONTAINING LESS
 THAN 10 PPM OF BASIC NITROGEN**

FIGURE 1
TOTAL NITROGEN AND BASIC NITROGEN VS ULTRAVIOLET ABSORPTIVITY
FOR NAPHTHENIC OILS OF DIFFERING VISCOSITY (AT 100°F)



INVENTOR

Ernest M. Brown
ATTORNEY



INVENTOR

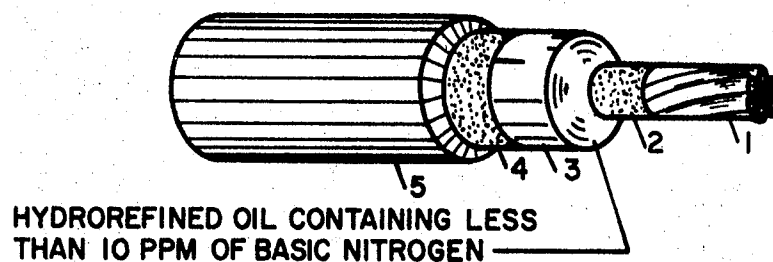
Berry A. Simon
ATTORNEY

PATENTED JUN 22 1971

3,586,752

SHEET 3 OF 3

FIGURE 3



INVENTORS
IVOR W. MILLS
GLENN R. DIMELER
JOHN J. MELCHIORE

BY *Barry A. Bisson*
ATTORNEY

ELECTRICAL CONDUIT CONTAINING HYDROREFINED OIL

CROSS REFERENCES TO RELATED APPLICATIONS

The present application is copending with the following listed applications, all of which are assigned to the Sun Oil Company, to whom the present application is also assigned:

Serial No.	Filing date	Title
622,398.....	3-13-67	"Clay Treatment of Hydrorefined Oils"—Ivor W. Mills, Glenn R. Dimeler.
652,026.....	7-10-67	"Process for Producing Cable Oils by Sequential Refining Steps"—Ivor W. Mills, Glenn R. Dimeler.
636,493.....	5-5-67	"Process for Preparing an Aromatic Oil and Non-Discoloring Rubber Composition Containing Said Oil"—Ivor W. Mills, Glenn R. Dimeler, Merritt C. Kirk, Jr.
730,909.....	5-22-68	"Hydrorefined Transformer Oil and Process of Manufacture"—Ivor W. Mills, Glenn R. Dimeler.
812,516.....	2-19-69	"Catalytic Hydrofinishing of Petroleum Distillates in the Lubricating Oil Boiling Range"—Ivor W. Mills, Glenn R. Dimeler, Merritt C. Kirk, Jr., Albert T. Olenzak.
850,717.....	(2)	"Hydrorefined Lube Oil and Process of Manufacture"—Ivor W. Mills, Glenn R. Dimeler.
850,778.....	(3)	"Process for Preparing High Viscosity Hydrorefined Cable Oil"—Ivor W. Mills, Glenn R. Dimeler, William A. Atkinson, Jr., James P. Hoffman.
850,716.....	(3)	"Blended Hydrocarbon Oil and Process of Manufacture"—Ivor W. Mills, Glenn R. Dimeler.

¹ Patent No. 3,460,358, issued August 19, 1969.

² Patent No. 3,502,567, issued March 24, 1970.

³ Filed of even date with present application.

The disclosures of all the above-referred to applications are hereby incorporated herein by reference, particularly as to disclosure therein directed to hydrorefined oils in the lube viscosity range, to uses of such oils, and to the production of such oils.

All of the above-referred to copending applications contain disclosure relating to conditions which can be used to produce severely hydrorefined petroleum distillate in the lubricating oil viscosity range.

BACKGROUND OF THE INVENTION

In copending application Ser. No. 622,398, filed Mar. 13, 1967 and titled "Clay Treatment of Hydrorefined Cable Oils," a process is claimed for producing an improved cable oil having an ASTM D-1934 aged dissipation factor (ADF) below 0.010 in the absence of added oxidation inhibitors, from a hydrogenated naphthenic oil having a viscosity in the range of 500—2000 SUS at 100° F., an ultraviolet absorbency (UVA) less than 8 at 260 millimicrons and having an ADF greater than 0.015, comprising contacting said oil at a temperature in the range of 100—400° F. with an adsorbent comprising an acid-activated adsorbent clay in an amount per barrel of oil such that from 10—90 grams of KOH would be required to neutralize the acidity of the acid-activated adsorbent clay. Also claimed is a naphthenic electrical oil having a viscosity in the range of 500—2000 SUS at 100° F., having an ADF less than 0.010 in the absence of added oxidation inhibitors, and which requires at least 75 hours at PFVO test conditions to reach a 6 percent power factor. It was further disclosed that, in the case of the high viscosity cable oils (4000—6000 SUS at 100° F.), a relatively inexpensive fuller's earth bleaching clay was preferred as the adsorbent for such a hydrorefined oil and that the dosage of clay was not particularly critical insofar as the ADF of the resulting cable oil was concerned.

Also disclosed were hydrogenation conditions and catalysts which could be used to severely hydrorefine distillate oils in the lubricating oil viscosity range (35 and higher SUS at 100° F.). It was further disclosed that such severe hydrogenation should be conducted so that the 260 UVA of the feed to the hydrogenation step be reduced at least 40 percent.

Further disclosed in said application, by example, was that the degree of nitrogen removal caused by the severe hydrorefining can vary according to the viscosity of the charge oil (an oil having a viscosity of 107 SUS and containing 170

p.p.m. N produced an oil containing 47 p.p.m. N; whereas, an oil having a viscosity of 2901 SUS and containing 467 p.p.m. of N produced, under the same hydrogenation conditions, an oil containing 313 p.p.m. of N).

BRIEF SUMMARY OF THE INVENTION

It has been discovered that, in hydrorefined lubes having viscosities of 100 SUS or higher at 100° F. (whether paraffins, naphthenic or aromatic), the total nitrogen content is not a reliable indicator of the stability of the oil under all conditions of use (as with refrigeration oils, textile oils, electrical oils, transmission fluids, etc.), but that the "basic" nitrogen content of the hydrogenated oil is an important indicator of how the oil (or blends containing the oil) will respond under severe conditions of use.

Although the hydrorefined cable oils disclosed in the above-referred to applications, Ser. Nos. 622,398 and 652,026, are satisfactory as an insulating medium in most types of electrical conduit, it has been found that, in oil-impregnated electrical conduits (such as cables) which contain a cellulosic insulator, the basic nitrogen content of the hydrorefined oil must be less than 10 p.p.m. (preferably less than 5 p.p.m.) in order that the resulting conduit can have a long life under service conditions. The basic nitrogen content of the hydrorefined insulating oil is especially critical when the cellulosic insulator comprises a Kraft paper or board or a chemically modified Kraft paper or board.

A novel hydrorefined oil if improved stability under severe conditions of use has a viscosity in the range of 100—12,000 SUS at 100° F., contains 10—44 percent gel aromatics and less than 10 p.p.m. (preferably less than 5 p.p.m., more preferably less than 2 p.p.m.) of basic nitrogen. Typically, such an oil can contain more than 10 p.p.m. of total nitrogen (e.g., 15—600 p.p.m.) depending on the viscosity of the oil. Preferably, the hydrorefined oil is naphthenic or aromatic (by VGC classification). The basic nitrogen in such severely hydrorefined lube oils (typically 15—400 p.p.m.) can be reduced to less than 10 p.p.m. by a process comprising contacting the hydrorefined oil with an acidic adsorbent (such as an adsorbent comprising an acid-activated clay), preferably at 50—150° F., or by contacting the hydrorefined oil with sufficient quantities of a mineral acid (e.g., 90—120° percent H₂SO₄) followed by a basic wash to neutralize the oil and remove impurities (as by the procedures referred to in the commonly assigned copending application Ser. No. 657,438 of Schneider and Stuart entitled "Rubber Containing Acid-Treated Oils And Its Preparation," the disclosure of which is hereby incorporated herein). More preferably, the contacting is at a temperature in the range of 50—100° F. (e.g., 70° F.). The oil which has been acid contacted and neutralized can be further finished (as may be desired for an electrical oil) by adsorbent contacting, as with a fuller's earth bleaching clay (attapulgit), activated carbon, alumina, or a crystalline aluminosilicate zeolite (e.g., Linde 5A, or 13X molecular sieves), an acid-activated clay or combinations of two or more such adsorbents (e.g., see U.S. Pat. No. 3,369,993). A preferred adsorbent combination is an admixture of attapulgit and acid-activated clay.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, FIG. 1 is a plot of the 260 UVA versus the nitrogen content (total or basic) of hydrorefined naphthenic oils of various viscosities. The hydrorefining of each charge oil was at 650° F., 0.5 LHSV (of the fresh feed), 1200 p.s.i.g. of 75 percent hydrogen (at the reactor inlet) with sulfided NiMo oxides on alumina as the catalyst. Also plotted is the basic nitrogen content of the charge stock (in the 100—2500 SUS viscosity range) before hydrorefining.

FIG. 2 is a plot of the pounds of acid-activated clay (equivalent to 10.2 mg. KOH per gram) required per barrel of

hydrorefined oil to reduce the basic nitrogen to a given p.p.m. level in two of the severely hydrorefined naphthenic distillates from which the data plotted in FIG. 1 was obtained. The basic nitrogen is on a logarithmic scale, indicating that at lower concentrations it becomes increasingly more difficult to remove basic nitrogen with a single contacting step.

FIG. 3 shows a cable, in fragmentary perspective view, having a central stranded conductor 1 surrounded throughout its entire length by a semiconducting layer 2 of carbon black paper. Both the conductor 1 and the semiconducting layer 2 surrounding it are covered by a substantially continuous concentric insulating layer 3 which is composed of many layers of helically wrapped paper tape saturated with a hydrorefined oil having a viscosity in the range of 100—12,000 SUS at 100° F. and containing 10—65 weight percent aromatics and less than 10 p.p.m. of basic nitrogen. The insulating layer 3 is shielded in turn, by an outer semiconducting layer 4 of carbon black paper and a protective lead sheath 5.

FURTHER DESCRIPTION OF THE INVENTION

Petroleum fractions (e.g., distillates, extracts, raffinates, reformer bottoms, cycle oil fractions, etc.) in the lubricating oil viscosity range (35—14,000 SUS at 100° F.) can be severely hydrorefined (e.g., at 600° F., 1200 p.s.i.g. of 80 percent hydrogen, 0.3 LHSV, presulfided Ni—Mo oxide catalyst) to produce a hydrogenated oil having a lighter ASTM color, a lower (by at least 40 percent) ultraviolet absorptivity at 260 millimicrons and containing appreciably less total nitrogen (and, if desired, lower gel aromatics) than was in the charge to the hydrorefining stage.

With some charges, such as paraffinic distillates, dewaxing and/or deasphalting can be advantageous prior to hydrorefining. Preferably, to insure longer catalyst life and to reduce hydrogen consumption, when the petroleum fraction is derived from a stock containing naphthenic acids, such acids should be removed (or substantially reduced) prior to hydrorefining as by the processes disclosed in the following U.S. Pat. Nos. 1,603,174; 2,770,580; 2,795,532; 2,966,456; and 3,080,312.

In case of light lubes (e.g., having a viscosity in the range of 35—65 SUS at 100° F.), such as the transformer oils, the total nitrogen remaining in the oil after a single stage of severe hydrogenation can frequently be less than 10 p.p.m. (typically, less than 5 p.p.m.). Hydrorefining can also be conducted (in a single stage or in multiple stages) so as to obtain a hydrorefined (or hydroaromatized) oil with such low nitrogen and an increased gel aromatic content (as disclosed in the aforementioned application, Ser. No. 636,636,493).

therefore, in light lubes and, particularly, in transformer oils severe hydrogenation in a single stage is normally sufficient to reduce the basic nitrogen to less than 5 p.p.m. Generally, basic nitrogen is not a problem in such severely hydrorefined light lubes. Similarly, when the charge to a severe hydrorefining stage consists essentially of a paraffinic distillate in the lubricating oil boiling range, severe hydrogenation in a single stage is usually sufficient to effectively reduce both total and basic nitrogen to less than 10 p.p.m.

However, as is illustrated in FIG. 1 in the drawings attached hereto, when the charge stock is naphthenic or aromatic distillate (including a raffinate or extract product from solvent extraction of a naphthenic distillate), having a viscosity greater than about 100 SUS, severe hydrogenation in a single stage, as to an ultraviolet absorptivity at 260 millimicrons (i.e., 260 UVA) in the range of 3 for a 150 SUS oil, cannot economically be used to reduce the basic nitrogen content below about 10 p.p.m., nor the total nitrogen content below about 20 p.p.m. As can be seen from FIG. 1, both the total and the basic nitrogen contents of such hydrorefined oils typically are greater as the viscosity of the oil increases. This is probably due to less efficient utilization of the hydrogen caused by the

hindering effect of the larger oil molecules on hydrogen diffusion.

Also shown, in FIG. 2 is the dramatic degree to which such basic nitrogen can be removed from such a hydrorefined oil by means of an acidic adsorbent, particularly, acid-activated adsorbent clay.

For many uses (as in dark colored rubber vulcanizates or in electrical cables where the oil is not in contact with Kraft paper) such severely hydrorefined oils exhibit satisfactory performance even at total nitrogen levels in the range of 30—900 p.p.m. (about 50 percent of the total nitrogen being "basic" nitrogen). For certain end uses (such as in textile spinning oils, light colored oil-rubber vulcanizate, cables where the oil is in contact with Kraft paper, and in refrigerator oils subjected to high operating temperatures) a much more satisfactory performance is obtained with a novel hydrorefined oil which has a viscosity in the range of 100—12,000 SUS at 100° F., contains 5—50 percent (typically 10—44 percent) of gel aromatics, and contains less than 10 p.p.m. of basic nitrogen (preferably, less than 5 p.p.m. and more preferred less than 2 p.p.m.).

The phrase "total nitrogen" refers to the nitrogen content of an oil as determined by such methods as that of P. Gouverneur, *Anal. Chim. Acta*, 26 (1962) 212 or, more preferred, the modified Gouverneur method described by Smith, A. J. et al. in *Anal. Chim. Acta*, 40 (1968) 341—343.

The phrase "basic nitrogen" refers to those nitrogen compounds present in crudes, petroleum distillates and residues which have a basic ionization constant, K_b , greater than 10^{-12} . A preferred analytic method determining the content of such basic nitrogen compounds in hydrorefined oils in the lube oil viscosity range, involves dissolving a sample of the oil in an appropriate solvent and potentiometrically titrating the solution with perchloric acid and acetic acid. In the case of light-colored oils, the solvent can be glacial acetic acid and par-naphthol-benzene can be used as a colorimetric indicator as an alternative to the potentiometric procedure. Dark samples and heavier oils are dissolved in chlorobenzene-acetic acid solvent and titrated potentiometrically (utilizing a pH meter or its equivalent and a glass-calomel electrode system).

For the potentiometric titration, the procedure is to place a 20-gram sample of the oil in a 250 ml. tall-form titration beaker and add about 100 milliliters of a mixture of equal quantities of glacial acetic acid and chlorobenzene. The sample is then titrated potentiometrically, at room temperature, while being stirred continually by a magnetic stirrer, with 0.01 N perchloric acid in glacial acetic acid to which has been added about 20 ml. of acetic anhydride for each liter of glacial acetic acid (in order to insure the removal of any water that might be present). The weight percent basic nitrogen is calculated as follows:

$$\text{PPM Basic N} = \frac{(V_1 - V_2)(N)(0.014)}{W} \times 10^6$$

Where:

V_1 = ml. titrant for sample

V_2 = ml. titrant for blank

N = normality of perchloric acid

W = sample weight (grams)

This potentiometric titration can be used to determine the basic nitrogen content of a hydrorefined oil in the range of 1 to at least 2000 p.p.m. and, in the range of 1—10 p.p.m. is at least accurate to within 1 p.p.m. when corrections are made for interferences by hydroxides, some oxides, carbonates, naphthenates, and similar bases (if these are present in the sample).

The phrases "severe hydrorefining" or "hydrogenation" refer to processes conducted in the presence of a hydrogenation catalyst at from about 500—775° F., with hydrogen of 50—100 percent purity, and from 800—3000 p.s.i. of hydrogen at the reactor inlet (at total pressures from 800—6000 p.s.i.g.) at a fresh feed liquid hourly space velocity (LHSV) of from 0.1—8.0 (usually below 2.0), preferably conducted either in

vapor phase or trickle phase. Such hydrogenation or severe hydrotreating is to be distinguished from hydrocracking in that the production of "overhead" (i.e., hydrocarbons boiling below 485° F.) is less than 25 percent by volume per pass through the reactor (and, typically, less than 10 percent). Product recycle, for example, as in U.S. Pat. No. 2,900,433 can be used to increase severity. Recycle liquid hourly space velocity can vary from 0 to 20; however, we prefer to operate at total liquid throughputs that obtain at greater than 25 percent of flooding velocity and more preferably at from 40—98 percent of flooding velocity.

Preferably, the temperature is below that at which substantial cracking occurs, that is, no more than 20 weight percent (preferably less than 10 percent) of the feed stock is converted to material boiling below 300° F. in a single pass through the reactor. Although the maximum hydrogenation temperature which will not produce substantial cracking is somewhat dependent upon the space velocity, the type of catalyst and the pressure, generally it is below 750° F. but can be as high as 785° F. To allow a margin or safety, we prefer to operate below 700° F. (except when it is desired to obtain a hydrogenated oil containing more gel aromatics than are in the charge). At total pressures below about 2000 p.s.i. we prefer a temperature below about 660° F., since above that temperature the degradation of oil viscosity can become larger.

Typical of such severe hydrotreating methods, when conducted within the aforementioned processing conditions, are those of U.S. Pat. Nos. 2,968,614; 2,993,855; 3,102,963; 3,114,710; 3,144,404; and 3,278,420; and those of the previously referred to compending applications, Ser. Nos. 622,398; 652,026; 636,493; 730,999 and 812,516. The terms "severely hydrotreated oil" or "hydrogenated oil" include the products, within the lubricating oil boiling range, of such severe hydrotreating or hydrogenation. One characteristic of a severely hydrotreated or hydrogenated oil is that the ratio of monocyclic aromatics to polycyclic aromatics is significantly greater than in hydrotreated oils or conventional distillate oils.

Where the desired hydrotreated oil is to be of the naphthenic class, a preferred charge to the hydrogenation reactor can be obtained by vacuum distillation of naphthenic crude oils (as in U.S. Pat. No. 3,184,396), especially those naphthenic crude oils wherein the 1500—3000 SUS (at 100° F.) distillate fractions have viscosity-gravity constants from 0.84 to 0.92. Preferably, such a charge stock should be substantially free of naphthenic acids prior to the hydrotreating. Usually materials boiling below about 600° F. (including residual H_2S , NH_3 , etc.) are removed from the hydrotreated oils, as by atmospheric distillation (and the viscosity can also be adjusted by choice of distillation end point) prior to clay contacting (if the oils are to be clay finished).

The viscosity of the base oil, or of the final hydrotreated oil, can be adjusted by the addition of other oils of higher or lower viscosity and which are within the lube oil boiling range. For example, a preferred cable oil having a viscosity of 100° F. in the range of 500—2000 SUS can be obtained by blending hydrogenated oil having a viscosity from 300—600 SUS with hydrogenated oil having a viscosity from 1500—3000 SUS and then contacting the resulting blend of hydrogenated oils with sufficient acidic adsorbent or mineral acid to reduce the basic nitrogen content of the oil to below 10 p.p.m.

FURTHER DESCRIPTION OF THE DRAWINGS

FIG. 1 herein illustrates the typical contents of total nitrogen and basic nitrogen for severely hydrotreated naphthenic oils in the viscosity range from 50 to over 6000 SUS. The curves can be extended (either by mathematical means or by use of a French curve), to obtain typical nitrogen contents of oils as high as 12,000 SUS at 100° F.

In FIG. 1, two curves have been drawn to illustrate the relationship between the total and basic nitrogen content of severely hydrotreated oils of a number of viscosity ranges. The

nitrogen content has been plotted against the 260 UVA, since the 260 UVA indicates the degree to which the oils have been hydrogenated. Also illustrated in a third curve is the basic nitrogen content of the charge oils before hydrotreating.

For example, in FIG. 2, a 2500 SUS naphthenic distillate (which was substantially free from naphthenic acid) was hydrotreated at 650° F., 0.5 LHSV at 1200 p.s.i.g. of 80 percent hydrogen (at the reactor inlet). The 2500 SUS oil contained about 270 p.p.m. of basic nitrogen before the hydrotreating. The hydrotreated oil contained about 180 p.p.m. of nitrogen (and about 350 p.p.m. total nitrogen). The UVA of the 2500 SUS distillate before hydrotreating was about 10.8 and, the hydrotreated oil had a 260 UVA of about 5.6, indicating a severe hydrogenation for such a relatively highly viscous distillate.

FIG. 2 of the drawings illustrates the degree to which the basic nitrogen in a hydrotreated oil can be reduced by contacting the oil with an acid clay. In the figure, the acid clay used had an acidity equivalent to 10.2 mg. KOH per gram. In FIG. 2, the basic nitrogen is plotted on a logarithmic scale, indicating that as the lower levels of nitrogen content are approached, it becomes progressively more difficult to remove basic nitrogen with the acid clay adsorbent. The two curves in FIG. 2 illustrate that as the viscosity of the hydrotreated oil increases, greater amounts of acid clay are necessary to reduce the basic nitrogen content to less than 10 p.p.m. (and or more preferably to less than 5 p.p.m.). With the more highly viscous, hydrotreated oils, it becomes more economical to utilize a mineral acid, and to dilute the oil with a nonreactive, less viscous, lower boiling solvent (such as iso-octane or gas oil). Such contacting with a mineral acid can be by the processes shown in the previously referred to compending applications, Ser. No. 622,398 and Ser. No. 652, 026. Other preferred processes for removing basic nitrogen from such oils can be found in the compending application of Scheider and Stuart, Ser. No. 657,438.

ILLUSTRATIVE EXAMPLES

Example I

A 2500 SUS naphthenic distillate (which was substantially free from naphthenic acid) was hydrotreated at 650° F., 0.5 LHSV at 1200 p.s.i.g. of 80 percent hydrogen (at the reactor inlet). The 2500 SUS oil contained about 270 p.p.m. of basic nitrogen before the hydrotreating. The hydrotreated oil contained about 180 p.p.m. of nitrogen and about 350 p.p.m. total nitrogen. The UVA of the 2500 SUS distillate before hydrotreating was about 10.8 and, the hydrotreated oil has a 260 UVA of about 5.6, indicating a severe hydrogenation for such a relatively highly viscous distillate. The appropriate values for the charge and hydrogenated oil produced from this charge are plotted in FIG. 1.

Example II

FIG. 2 of the drawings illustrates the degree to which the basic nitrogen in a hydrotreated oil can be reduced by contacting the oil with various amounts of an acid-activated clay. The upper curve in FIG. 2 shows the nitrogen levels which were obtained by such contact of the 2500 SUS hydrotreated oil of Example I. In the figure, the acid clay used had an acidity equivalent to 10.2 mg. KOH per gram. In FIG. 2, the basic nitrogen is plotted on a logarithmic scale, indicating that as the lower levels of nitrogen content are approached, it becomes progressively more difficult to remove basic nitrogen with the acid clay adsorbent. The two curves in FIG. 2 illustrate that as the viscosity of the hydrotreated oil increases, greater amounts of acid clay are necessary to reduce the basic nitrogen content to less than 10 p.p.m. (and or more preferably to less than 5 p.p.m.). With the more highly viscous, hydrotreated oils it becomes more economical to utilize a mineral acid, and to dilute the oil with a nonreactive, less viscous, lower boiling solvent (such as iso-octane or gas oil).

Such contacting with a mineral acid can be by the processes shown in the previously referred to copending applications, Ser. No. 622,398 or Ser. No. 652,026. Other preferred processes for removing basic nitrogen from such oils are those shown in the copending application of Schneider and Stuart, Ser. No. 657,438. Cables containing Kraft paper and the oils containing less than 5 p.p.m. of basic nitrogen show good performance under service conditions.

Example III

A residuum was obtained from the distillation of a naphthenic crude (VGC of 0.89) by the caustic distillation process described in U.S. Pat. No. 3,184,396. This residuum was distilled under a lower pressure than that used in the first distillation and a 35 volume percent overhead fraction (viscosity 13,000 SUS at 100° F. and 200 SUS at 210° F.) was recovered. This overhead will be referred to hereinafter as "heavy distillate from heavy residuum" or by the abbreviation "HDFHR." The HDFHR was hydrorefined, in the presence of a sulfided Ni-Mo oxide catalyst, at a temperature of about 605° F., 1140 p.s.i.g. total pressure (about 75 percent H₂ at reactor inlet), at a 7 to 1 volume ratio of recycle to charge and with a reactor gas bleed of 18,000 scfh. The hydrogenated product (95 volume percent yield) had a viscosity at 100° F. of 8850 SUS and 170 SUS at 210° F. This hydrogenated oil had an initial ASTM color of 2.0 and remained stable in color if stored at a temperature below 130° F. when contacted with 10 lb./bbl. of H₂SO₄, washed and neutralized and finished with 10 lb./bbl. of attapulgite. The final oil had an initial power factor (100° C.) of 0.0006 and an aged (with Cu) 100° C. power factor of 0.012.

Table I herein reports the additional improvement in electrical properties which can be obtained when the "HDFHR" is treated with an acid such as H₂SO₄, washed and neutralized prior to the hydrogenation step. Also shown is the additional improvement which can be obtained by a final contacting with acid-activating clay.

Example IV

Table II herein illustrates the criticality (for proper cable performance) of the basic nitrogen content of hydrogenated cable oils which are incorporated with cables containing cellulosic insulation (e.g., electrical grade Kraft paper). The low power factor reported for Kraft paper impregnated by Oil D indicates that an oil-impregnated electrical conduit comprising a conductive metal, a cellulosic insulator and Oil D would have satisfactory performance under use conditions.

TABLE I.—8,800 SUS (AT 100° F.) CABLE OILS MADE FROM HEAVY DISTILLATE FROM HEAVY RESIDUUM (HD-FHR)

Step further treatment of "HDFHR"	Basic nitrogen, p.p.m.	ASTM dissipation factor	
		Initial at 100° C.	Aged, 4 days Cu, 115° C.
1st—10 lb./bbl. H ₂ SO ₄	<1	0.0002	0.0160
2nd—Hydrogenation			
3rd—10 lb./bbl. acid-activated clay			
1st—25 lb./bbl. H ₂ SO ₄	23	0.0002	0.0160
2nd—Hydrogenation			
1st—25 lb./bbl. H ₂ SO ₄			
2nd—Hydrogenation	<1	0.0001	0.0002
3rd—10 lb./bbl. acid-activated clay			
1st—10 lb./bbl. H ₂ SO ₄			
2nd—Hydrogenation	8	0.0002	0.0021
1st—10 lb./bbl. H ₂ SO ₄			
2nd—Hydrogenation			
3rd—10 lb./bbl. acid-activated clay	<1	0.0002	0.0021
Commercial polybutene (2,500 SUS at 100° F.)			

¹ Maximum.

TABLE II.—ELECTRICAL CABLES CONTAINING PAPER AND HYDROGENATED CABLE OILS

	Oil A	Oil B	Oil C	Oil D
Viscosity, SUS/210° F. (ASTM D2161)	100	100	130	125
Dissipation Factor at 100° C.: Initial (ASTM D924)	0.0002	0.0002	<0.0001	<0.0001
Aged, With Cu, 4 days, (ASTM D924), 115° C. (D1934B)	0.0121	0.0138	0.0183	0.0066
Total nitrogen, p.p.m.	429	430	268	16
Basic nitrogen, p.p.m.	251	250	45	3
Power factor at 120° C., 50 to 100 volts per mil, of kraft paper impregnated with oil, percent.	7	7	0.7	0.3

NOTE: Oil A=45% 6,000 SUS Hydrogenated naphthenic distillate + 55% 2400 SUS hydrogenated naphthenic distillate. Oil B=90% Oil A plus 10% 6,000 SUS "raw" naphthenic distillate. Oil C=6,000 SUS hydrogenated naphthenic distillate plus 15 lb./bbl. acid clay plus 15 lb./bbl. attapulgite. Oil D=6,000 hydrogenated naphthenic distillate SUS plus 10 lb./bbl. 99% H₂SO₄ plus 15 lb./bbl. attapulgite.

The invention we claim is:

1. In an oil-impregnated electrical cable comprising a conductive metal, a cellulosic insulator, and a hydrorefined electrical insulation oil, the improvement wherein said hydrorefined oil has a viscosity in the range of 100—12,000 SUS at 100° F. and contains 10—65 weight percent aromatics and less than 10 p.p.m. of basic nitrogen.
2. An electric cable according to claim 1 wherein said cellulosic insulator is a paper and is wrapped around said conductive metal.
3. An oil-filled electrical cable according to claim 2 wherein said paper is a pure wood pulp Kraft paper with no sizing, coloring, or chemical additives and wherein said hydrorefined oil contains less than 5 p.p.m. of basic nitrogen.
4. An oil-filled electrical cable according to claim 2 wherein said paper is capacitor grade Kraft paper of a relatively high density.
5. An oil-filled electrical cable according to claim 4 and wherein said hydrorefined oil contains less than 5 p.p.m. of basic nitrogen.
6. An oil-filled electrical cable according to claim 5 and wherein said hydrorefined oil contains less than 2 p.p.m. of basic nitrogen.
7. An oil-filled electrical cable according to claim 1 and wherein said cellulosic insulator is a Kraft tissue.
8. An oil-filled electrical cable according to claim 1 and wherein said cellulosic insulator is creped or microcreped.
9. An oil-filled electrical cable according to claim 1 and wherein said cellulosic insulator is creped or microcreped.
10. An oil-filled electrical cable according to claim 1 and wherein said cellulosic insulator comprises cyanoethylated cellulose.
11. An oil-filled electrical cable according to claim 10 wherein said cellulosic insulator comprises acetylated cellulose.
12. An oil-filled electrical cable according to claim 1 and wherein said cellulosic insulator has been thermally upgraded by the incorporation of a nitrogen-containing compound, said nitrogen-containing compound being chemically bonded to the cellulose and serving to protect the fibers against degradation.