United States Patent Office
3,288,715
Patented Nov. 29, 1966

3,288,715

FABRICATING ALUMINUM PRODUCTS WITH OLEFIN LUBRICANTS

Robert S. Owens, Latham, and Leon E. St. Pierre, Schenectady, N.Y., and Robert V. Klint, Newtown Square, Pa., assignors to General Electric Company, a corporation of New York

**No Drawing. Filed Oct. 24, 1963, Ser. No. 318,520
12 Claims. (Cl. 252—59)**

This invention is concerned with fabricating aluminum products. More particularly, the invention is concerned with improving techniques in fabricating aluminum products under frictional conditions by employing a certain class of olefins at the frictional interface between the fabricating member and the aluminum piece during the fabrication step.

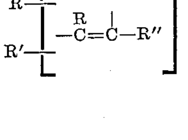
In the fabrication of aluminum products, for instance, aluminum sheets (including films, foils, etc.), aluminum wire, in the cutting, extrusion, pressing, stamping and forging of aluminum, etc., difficulty has often been encountered in lubricating the interface between the fabricating member and the aluminum undergoing fabrication or working. One difficulty has been in preventing the aluminum being fabricated from building up or accreting undesirably on the fabricating member in amounts which hinder the fabrication operation. Thus, in the cutting, extrusion or drawing of aluminum (involving the deformation of metal and heavy rubbing pressures between adjacent surfaces of tool and work materials), great care must be exercised in lubricating the frictional interface between the aluminum work piece and the fabricating member in order to insure minimum build-up of aluminum on the fabricating member while at the same time attaining a bright surface on the fabricated aluminum.

In the rolling of aluminum to reduce the size of the initial aluminum member from one thickness to a thinner thickness using, for example, chrome steel rolls, difficulty has frequently been encountered in preventing transfer of the aluminum onto the rolls because of the high rolling pressures used. In addition, commercially available lubricants for rolling aluminum have their limits as far as the degree of reduction which can be accomplished per pass of the aluminum through the reducing rolls.

Even in the drawing of aluminum wire or in the extrusion of aluminum bodies through metal dies, care must be exercised in the choice of the lubricant used between the frictional interface of the aluminum undergoing drawing or extrusion, and the dies in contact with said aluminum to prevent an undesirable build-up of the aluminum metal on the die. Also, many of the lubricants used for drawing or extrusion of aluminum have limits on the rate of drawing or extrusion of the aluminum.

Unexpectedly, we have discovered that a certain class of unsaturated organic compounds can be effectively used to prevent the accretion of aluminum during metal working operations, especially under conditions where the aluminum is undergoing plastic flow or plastic deformation. In addition these compounds are able, under equivalent conditions, to effect greater reduction in size of aluminum during rolling operation than the usual commercial lubricants employed for the purpose. The compositions which we have found useful for the above purpose (and which have no significant irritating or other physiological effects) are long chain olefins (also hereinafter identified as "olefins" or "olefinic compositions") of at least 10 carbon atoms having the general formula

(I)



$$\begin{matrix}\mathrm{R}- \\ \mathrm{R'}-\end{matrix}\left[-\overset{\mathrm{R}}{\mathrm{C}}=\overset{|}{\mathrm{C}}-\mathrm{R''}\right]$$

where R and R′ are members selected from the class consisting of hydrogen and fluorine, and additionally R′ is selected from the class consisting of the methyl, fluoromethyl, difluoromethyl and trifluoromethyl radicals, and R″ is a monovalent straight chain saturated aliphatic radical selected from the class consisting of linear alkyl radicals having at least 8 carbon atoms and linear fluoroalkyl radicals having at least 8 carbon atoms. Preferably, R″ does not exceed 35 carbon atoms, although longer chain radicals may be used.

It was unexpected and in no way could have been predicted that these long chain olefins would be effective in the fabrication of aluminum, since it had been found that under boundary lubrication conditions between two solid surfaces which constantly move relative to each other under high pressure conditions (such as in bearings where the same two surfaces constantly rotate against each other), these olefins were ineffective and in fact, although exhibiting a low coefficient of friction, nevertheless, caused high wear as though machining had occurred. The fact that such fabrication of aluminum could be carried out with these olefinic hydrocarbons was additionally unexpected because in an article by R. D. Guminski and J. Willis, entitled, "Development of Cold-Rolling Lubricants for Aluminum Alloys," in Journal of the Institute of Metals, 88, pages 481–492 (1960), the authors point out the undesirability of having unsaturated additives as lubricants in the cold-rolling of aluminum alloys.

It was therefore surprising to find that under conditions of working the aluminum where the fabricating member was in contact only once with the fresh surface of aluminum (after the aluminum oxide film had been broken through) as a result of the fabricating or working action of said member, the introduction of these long chain olefins at the frictional interface between the aluminum piece undergoing working and the fabricating member, resulted in a material reduction in the force necessary to accomplish the working of the aluminum (whether it was rolling, cutting, extruding, drawing, etc.); further, there was no evidence of accretion of aluminum to the fabricating member; and additionally, such olefins imparted to the worked aluminum a highly polished surface. It was also found that the use of these long chain olefins for the above purposes had the additional advantage that after fabrication of the aluminum, the long chain olefins could usually be readily volatilized from the aluminum surface under relatively mild conditions without any residual stain being detected. This constituted a marked improvement over usual compositions used in the fabrication of rolled aluminum sheet or foil because rather extensive processing is required to remove the lubricant from the aluminum after fabrication to avoid staining of the aluminum surface. Finally these lubricants eliminate much of the time devoted to cleaning, sharpening, and changing tools, and impart significantly longer tool life.

Included among the normal compounds (as contrasted to branched chain compounds) represented by Formula I are, for instance, decene-1, dodecene-1, tetradecene-1, α-methyl tetradecene-1, dodecene-2, tetradecene-2, pentadecene-1, hexadecene-1 (cetene), α-methyl hexadecene-1, octadecene-1, octadecene-2, 1-fluorotetradecene-1, 1,2-difluorotetradecene-1, 1-fluorohexadecene-1, trifluoro-hexadecene-1, 1,1,1,2-tetrafluorohexadecene-2, etc., as well as mixtures of such olefins obtained from the cracking of paraffin products or those olefins obtained from the Fischer-Tropsch process.

Because of the ease of preparation, ready availability of raw materials for synthesis and their suitability and outstanding properties as lubricants and as additives to other well known lubricants, we prefer to use as the olefinic material one which is a straight chain unsaturated aliphatic hydrocarbon having olefinic unsaturation in the 1- or 2-positions of a chain length of from 12 to 25 carbon atoms.

The aforesaid olefins can be used alone or as mixtures thereof, or they can be mixed with other diluents and extenders whose presence does not significantly affect the ability of the olefins to cause the improvement in fabrication of the aluminum. Thus, the olefins can be mixed with mineral oils of lubricating viscosity, diester compositions, etc. Where it is desired to use more viscous olefins or solid olefins in the above applications, it may be advantageous to dissolve the latter olefins in suitable solvents such as benzene, toluene, chlorinated hydrocarbons, kerosene, etc., to give fluid compositions which can be employed in the fabricating of the aluminum parts or objects. Aqueous emulsions of the olefinic compositions can also be used to advantage in the fabrication of aluminum. The solution and compounding of the solid olefinic compositions in other normally employed lubricating fluids, such as mineral (including hydrocarbon) oils and diester compositions, to make fluid mixtures of the olefins is included within the scope of our invention. Concentrations of olefins in the aforesaid solvents or other lubricating compositions ranging from about 10 to 95 percent, by weight, of the total weight of the solution or mixture are advantageously used. If desired, the olefins can be compounded into the form of greases where such greases can advantageously be applied to the surface of aluminum members which will be subsequently subjected to fabricating techniques.

Typical of the mineral or hydrocarbon oils with which the olefinic compositions may be mixed are those obtained from petroleum having viscosities of from 25 to 10,000 Saybolt Universal seconds (S.U.S.) and may be a single hydrocarbon or mixture of hydrocarbons. Typical of the diester lubricants are those disclosed in U.S. Patents 2,450,221, Ashburn et al.; 2,450,222, Ashburn et al.; and 2,977,301, Bergen et al.

For purposes of brevity, the term "aluminum" or "aluminum composition" is intended to include not only aluminum itself, but also compositions in which the aluminum is present in an amount equal to at least 50 percent of the total weight of the composition, as for instance, aluminum alloys, etc. Typical examples of the various aluminum compositions (including aluminum alloys) that can be lubricated by our lubricants are those disclosed on pages 851–853 and 865–958 of Metals Handbook, vol. 1, Properties and Selection of Metals, American Society for Metals, Novelty, Ohio, eighth edition (1961), for example, the high purity aluminum alloys which are greater than 99% aluminum, e.g., EC alloy, 1060 alloy, 1100 alloy, etc., alloys of aluminum with other metals, for example, copper, silicon, tin, zinc, etc., as are more fully described on pages 955–958 of the above reference.

The term "fabricating member" is intended to include metallic forming members used in the fabrication of aluminum products which have a hardness greater than aluminum. These include cutting tools, extrusion and drawing dies, milling rolls, stamping and forging equipment, etc. These fabricating members are generally made of ferrous materials such as iron, steel, chrome steel, etc. When employing cutting fabricating members, or dies for extrusion or drawing purposes, these fabricating members are usually of a harder material such as tungsten carbide.

The term "accretion" is intended to mean the build-up, whether temporary, permanent or continuing, of aluminum on the contacting surface of the fabricating member. For instance, in the cutting and rolling of aluminum, the fabricating member, when it first contacts the aluminum surface, breaks through the aluminum oxide film thereon (which is almost always present), and thereafter makes contact with the fresh aluminum surface. This fresh aluminum surface in turn comes into contact with the surface of the fabricating member and, unless a suitable lubricant is used, tends to accrete or weld to the contacting surface of the fabricating member. The build-up in amount or in time will depend upon the force exerted by the fabricating member and any liquid which is used at the frictional interface between the fabricating member and the aluminum work piece. Unless ths accretion or build-up is prevented, the fabricating member will then impart to the aluminum work piece (undergoing fabrication) surface defects such as lack of lustre, pitting, galling, and in some instances, seizing of the aluminum work piece.

The term "cold working" of aluminum or "cold rolling" is intended to mean that fabrication of aluminum which takes place at temperatures below 350° C. (see The Light Metals Industry, by Winifred Lewis, published by Temple Press, Ltd., Bowling Green Lane, London, England [1949], page 226). In rolling applications, particularly cold-rolling, the temperature of the rolls or the sheet or of the aluminum member undergoing fabrication should be below 350° C. and advantageously that temperature at which the olefinic composition will not volatilize or will be of maximum usefulness in the fabrication of the aluminum object.

In order that those skilled in the art may better understand how the present invention may be practiced, the following examples are given by way of illustration and not by way of limitation. Unless otherwise stated, all parts and percentages are by weight.

EXAMPLE 1

In the following example and in the succeeding examples, various olefinic hydrocarbons were used as cutting fluids in machining aluminum. In addition, a saturated hydrocarbon such as cetane was employed for comparison purposes as was a commercially available wax cutting composition which was used (as recommended by the manufacturer) in a mixture of one part, by weight, of the cutting wax to 10 parts of a spindle oil. The straight chain olefinic hydrocarbon compositions were used either as mixtures or as the individual olefinic hydrocarbon (hexadecene-1), as shown in Table I below; these mixtures were composed of α-olefinic hydrocarbons containing terminal $CH_2{=}CH—$ groups and the R of Formula I ranged in chain lengths such that the total carbon length of the olefinic compositions in the mixture was from 11 to 20 carbons. Thus, cutting fluid No. 1 was a mixture of olefinic hydrocarbons corresponding to Formula I in which there were present hydrocarbon compositions whose chain lengths ranged from 16 carbon atoms to 20 carbon atoms, in each instance the olefinic unsaturation being terminally located, e.g., hydrocarbons of formulas $C_{16}H_{31}$, $C_{17}H_{33}$, $C_{18}H_{35}$, $C_{19}H_{37}$, and $C_{20}H_{39}$.

Table I

Cutting fluid:	Composition, total carbon atoms
No. 1	C_{16}–C_{20} olefins.
No. 2	C_{11}–C_{15} olefins[1].
No. 3	C_{12}–C_{16} olefins.
No. 4	Hexadecene-1.
No. 5	Commercial cutting wax (1 part) dissolved in SAE–10 spindle oil (10 parts).

[1] Commercially available mixture of olefin.

The equipment used for carrying out these tests comprised an Axelson lathe, 14 inch swing, with a 20-horsepower variable speed drive. The cutting tool was a tungsten carbide cutting tool of 27.8 BHN. The aluminum used was 1100 aluminum (2S Al) 1⅞ inch diameter and 24 inches long. Each of the cutting fluids was evaluated in the manner in which cutting fluids are usually used by turning the aluminum bar at cutting speeds 10 and 57 feet per minute using a depth cut of 0.10 inch and a feed of 0.01 inch per revolution. A four channel Sanborn recorder measured the forces from the three-component lathe dynamometer. This measured values of tangential or cutting force in pounds (identified as F_T), longitudinal or feed force in pounds (identified as F_L) and radial force in pounds (identified as F_R). The feed force and radial force are the more prominent indicators of the ability of a cutting fluid to reduce friction on the face of the tool. Also included in the test results are the cutting of the aluminum dry (i.e., without any cutting fluid at all), and cetane alone as the cutting fluid. Under such conditions it was found that for each cutting speed, the cutting force in pounds (F_T) remained essentially the same for cutting fluids Nos. 1 to 5, although fluid No. 2 showed up about from 10–35% better than the others. The dry run (no lubricant) and that using cetane showed abnormally high forces required under the test conditions. The improvements in the use of the olefinic compositions for machining became quite evident when one measured the feeding force (F_L) and the radial force (F_R). The following Table II shows the feeding forces, and Table III shows the radial forces, both forces in pounds, of the various cutting fluids previously identified under the two cutting speeds.

Table II

FEEDING FORCE

	Cutting Speed, Feet/ Minute	Force in Pounds
Fluid No. 1	10	20
	57	18
Fluid No. 2	10	2
	57	5
Fluid No. 3	10	7
	57	18
Fluid No. 4	10	10
	57	20
Fluid No. 5	10	15
	57	90
Cetane	10	60
	57	110
Dry	10	100
	57	245

Table III

RADIAL FORCE

	Cutting Speed, Feet/ Minute	Force in Pounds
Fluid No. 1	10	10
	57	12
Fluid No. 2	10	1
	57	8
Fluid No. 3	10	16
	57	16
Fluid No. 4	10	10
	57	18
Fluid No. 5	10	14
	57	57
Dry	10	65
	57	135
Cetane	10	28
	57	58

EXAMPLE 2

In this example, the same type of aluminum, namely 1100 (2S) aluminum of 27.2 Brinell hardness, was subjected to cutting on the same type of equipment as was used in Example 1. The feed forces encountered as well as the surface profile of the machined aluminum (on a Talysurf surface analyzer) were determined, and the center line average (CLA) roughness was measured. These measurements were made after the aluminum was fed at 0.01 inch per revolution, the depth of the cut was 0.10 inch and the cutting speed was at 10 ft. per minute. Determined under these conditions was the aluminum in the dry state, and using cutting fluids composed essentially of cetane, cetene, and the aforementioned commercial cutting wax in spindle oil (same as in Example 1). The following Table IV shows the results of the feed force in pounds (F_L) and the roughness obtained in each instance with the smaller values of roughness being indicative of a more polished surface.

Table IV

Cutting Fluid	CLA Roughness in Micro-inches	Feed Force in Pounds
Cetene	45	17
Commercial cutting wax	59	55
Cetane	58	70
Dry	78	125

It will be noted that the CLA roughness of the aluminum machined with the cetene was materially lower than that obtained with the normal cutting fluid, specifically the commercial wax mixture.

EXAMPLE 3

When aluminum wire was drawn through a die immersed in a mixture of alpha olefins of the C_{11}–C_{15} chain lengths (see Table I above), it was found that the reduced drawn aluminum wire drew with less force being required and had a more polished surface (as contrasted to a dull finish) than wire drawn by means of conventional lubricants.

EXAMPLE 4

In this example aluminum sheet was passed between reducing rolls (driven by motors) in conventional manner by applying the mixture of alpha olefins of C_{11}–C_{15} chain length (see Table I) at the interface between the rolls and the aluminum. The initial aluminum sheet was about 0.085 inch in thickness. Normally using the best available commercial lubricant for rolling of aluminum, it was found that in order to go from about 0.85 inch to 0.025 inch in thickness, it was necessary to use the following schedule of four passes.

0.085″→0.057″
0.057″→0.043″
0.043″→0.032″
0.032″→0.025″

The reason it was necessary to make four passes was that available commercial lubricants would not allow the rolls to effect greater reduction per pass without rupture of the aluminum film or would harm the surface (because of pick up or accretion of the aluminum) thereby causing unattractive blemished surfaces. However, when the mixture of olefins described above was substituted for the commercial lubricant and otherwise employing the same rolling conditions, it was possible to reduce the 0.085 inch aluminum sheet to 0.025 inch in two passes in accordance with the schedule below without damaging the sheet, by closing the space between the rolls with no need for additional power than was previously used in the four passes.

0.085″→0.043″
0.043″→0.025″

This showed the advantageous lubricating qualities of the olefins. In addition to being able to reduce the aluminum in fewer passes, it was found that the finish of the aluminum using the mixture of olefins had a brighter appearance than that obtained with the conventional lubricant.

EXAMPLE 5

This example illustrates the effect of using other unsaturated organic compounds in place of the olefinic compounds of the present invention. More particularly, employing the equipment and type of aluminum described in Example 1, oleic acid (which has olefinic unsaturation in the middle of the molecule rather than the terminal unsaturation of the compounds used in the present invention); an unsaturated polyester, specifically a vegetable oil consisting essentially of glycerides of fatty acids in which, for the most part, the fatty acid residues were linoleic acid, oleic acid, and hexadecanoic acid (all of which are unsaturated acid residues), and small amounts of acid residues from palmitic acid, myristic, and stearic acids; as well as cetene, and mixtures of olefins of the C_{11}–C_{15}, C_{12}–C_{16}, and C_{16}–C_{20} carbon length chains, cetane and kerosene, were tested similarly as described in Example 1 at a cutting speed of 10 feet per minute, a feed speed of 0.01 inch per revolution, and 0.100 inch cut. The comparison of the effects of using each of the above fluids was based mainly on the type of chip which was obtained by the cutting tool. The ideal chip is one which is continuous in length without a built-up edge and is formed by continuous deformation of the metal ahead of the tool, without fracture, followed by smooth flow of the chip up the tool face. This type of chip is associated with low friction between the chip and the tool and is the most desirable type of chip from the point of view of finish, power consumption, and tool life. The formation of a chip breaking up into individual or small pieces shortly after the chip is formed is indicative of inadequate lubrication resulting in poor finish and excessive tool wear. As a result of carrying out the above tests, it was found that by using the cetene, C_{11}–C_{15}, C_{12}–C_{16}, and C_{16}–C_{20} fluids, long chips were obtained and the surface of the machined aluminum was smooth and highly polished. In contrast to this, the chips obtained with the other fluids, namely the vegetable oil, the cetane, kerosene and oleic acid, were short, broke into small pieces, and tended to bunch up; in addition, the surface of the machined aluminum was quite rough and in some instances (such as with the cetane) appeared to be chewed up from the cutting tool; concurrently, there was a tendency for build-up along the edges of the cut sample, resulting from accretion of the particles of aluminum, indicating high resistance to sliding of the chip up the tool face.

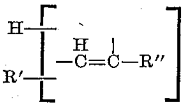
Further testing of various olefins encompassed within the scope of the invention for other purposes such as stamping, extrusion, etc., of aluminum members also resulted in easier processing and better finish than was obtained with other conventionally used fluids for the purpose.

It will of course be apparent to those skilled in the art that in addition to the fabrication of the aluminum recited in the aforesaid claims other kinds of aluminum and aluminum alloys can be used without departing from the scope of the invention. In addition many other types of olefins either alone or in combination with additives and extenders, examples of which have been given above, may be employed in place of those recited in the foregoing examples. The manner of fabrication, including the techniques and apparatus used for fabricating purposes, can be varied within wide limits.

Aluminum products made in accordance with the present invention can be used as electrical conductors, as foils and sheets for wrapping and packaging, as protective barriers, for instance, in construction of buildings, as decorative moldings for decorative purposes, etc.

What we claim as new and desire to secure by Letters Patent of the United States is:

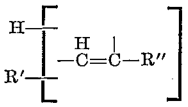
1. In the process for fabricating an aluminum body by contacting the latter with a fabricating member pursuant to a process of fabricating selected from the class consisting of cutting, rolling, drawing and extruding, the improvement which comprises supplying to an interface between the aforesaid fabricating member and the aluminum body a film consisting essentially of a monomeric olefin having the general formula



$$\begin{array}{l}\mathrm{H}-\\ \\ \mathrm{R'}-\end{array}\!\!\left[\begin{array}{l}\\ \overset{\mathrm{H}}{-\mathrm{C}}=\overset{|}{\mathrm{C}}-\mathrm{R''}\\ \\ \end{array}\right]$$

where R′ is a member selected from the class consisting of hydrogen and the methyl radical, and R″ is a monovalent alkyl radical having from 8 to 20 carbon atoms in which substantially all of the carbons of the alkyl radical are in a straight chain.

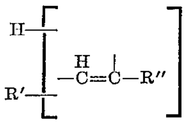
2. The process for rolling aluminum which comprises supplying to the interface between the milling rolls and the aluminum being rolled, a film consisting essentially of a monomeric olefin having the general formula



$$\begin{array}{l}\mathrm{H}-\\ \\ \mathrm{R'}-\end{array}\!\!\left[\begin{array}{l}\\ \overset{\mathrm{H}}{-\mathrm{C}}=\overset{|}{\mathrm{C}}-\mathrm{R''}\\ \\ \end{array}\right]$$

where R′ is selected from the class consisting of hydrogen and the methyl radical, and R″ is a monovalent alkyl radical having from 8 to 20 carbon atoms in which substantially all of the carbons of the alkyl radical are in a straight chain.

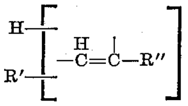
3. The process for cutting aluminum which comprises introducing between the contacting surface of the cutting tool and the aluminum work piece, a film consisting essentially of a monomeric olefin having the general formula



$$\begin{array}{l}\mathrm{H}-\\ \\ \mathrm{R'}-\end{array}\!\!\left[\begin{array}{l}\\ \overset{\mathrm{H}}{-\mathrm{C}}=\overset{|}{\mathrm{C}}-\mathrm{R''}\\ \\ \end{array}\right]$$

where R′ is selected from the class consisting of hydrogen and the methyl radical, and R″ is a monovalent alkyl radical having from 8 to 20 carbon atoms in which substantially all of the carbons of the alkyl radical are in a straight chain.

4. The process for drawing aluminum which comprises interposing between aluminum undergoing drawing and the die contacting the aluminum, a film consisting essentially of a monomeric olefin having the general formula



$$\begin{array}{l}\mathrm{H}-\\ \\ \mathrm{R'}-\end{array}\!\!\left[\begin{array}{l}\\ \overset{\mathrm{H}}{-\mathrm{C}}=\overset{|}{\mathrm{C}}-\mathrm{R''}\\ \\ \end{array}\right]$$

where R′ is selected from the class consisting of hydrogen and the methyl radical, and R″ is a monovalent alkyl radical having from 8 to 20 carbon atoms in which substantially all of the carbons of the alkyl radical are in a straight chain.

5. The process as in claim **1** in which the monomeric olefin is a mixture of linear straight chain olefinic hydrocarbons having carbon chain lengths of from C_{11} to C_{15}, substantially all of the carbons of the linear olefinic hydrocarbons being in a straight chain.

6. The process as in claim **1** in which the monomeric olefin is cetene.

7. The process as in claim **1** in which the olefinic composition is a mixture of linear olefinic hydrocarbons having carbon chain lengths of from C_{12} to C_{16}, substantially all of the carbons of the linear olefinic hydrocarbons being in a straight chain.

8. The process as in claim **1** in which the monomeric olefin is a mixture of linear straight chain olefinic hydrocarbons having carbon chain lengths of from C_{16} to C_{20}, substantially all of the carbons of the linear olefinic hydrocarbons being in a straight chain.

9. The process for rolling sheet aluminum to reduce the size of the latter which comprises applying at the frictional interface between the milling rolls and the aluminum sheet a lubricant consisting essentially of cetene, and thereafter subjecting the aluminum sheet to a rolling and reducing action while maintaining the cetene at the frictional interface.

10. The process for rolling sheet aluminum to reduce the size of the latter which comprises applying at the frictional interface between the milling rolls and the aluminum sheet a lubricant consisting essentially of a mixture of straight chain olefinic hydrocarbons having carbon chain lengths of from C_{11} to C_{15}, substantially all of the carbons of the olefinic hydrocarbons being in a straight chain, and thereafter subjecting the aluminum sheet to a rolling

and reducing action while maintaining the mixture of hydrocarbons at the frictional interface.

11. The process for cutting an aluminum work piece with a cutting tool which comprises interposing at the frictional interface between the cutting tool and the work piece a lubricant consisting essentially of cetene, and thereafter reducing the size of the aluminum work piece by means of the cutting tool while maintaining the cetene during such cutting action at the frictional interface.

12. The process for cutting an aluminum work piece with a cutting tool which comprises interposing at the frictional interface between the cutting tool and the work piece a lubricant consisting essentially of a mixture of linear straight chain olefinic hydrocarbons having carbon chain lengths of from C_{11} to C_{15}, substantially all of the carbons of the olefinic hydrocarbons being in a straight chain, and thereafter reducing the size of the aluminum work piece by means of the cutting tool while maintaining the aforesaid mixture of hydrocarbons during such cutting action at the frictional interface.

References Cited by the Examiner

UNITED STATES PATENTS

2,551,639	5/1951	Feasley et al.	252—58 X
3,167,511	1/1965	Crawford et al.	252—58 X
3,208,941	9/1965	Owens.	

FOREIGN PATENTS

878,431	6/1953	Germany.
696,960	9/1953	Great Britain.

DANIEL E. WYMAN, *Primary Examiner.*

P. E. KONOPKA, W. H. CANNON,
Assistant Examiners.