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METHOD AND COMPOSITION FOR ETCHING
TITANIUM

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This invention relates to the shaping of metal parts and
more particularly to the method of shaping metal parts
by chemical dissolution techniques.

In recent years it has increasingly become more ap-
parent that conventional methods of machining parts,
particularly aircraft parts, have become inadequate for
obtaining present day needs. Various methods of fabri-
cating aircraft parts, for example, have been employed
in the past to obtain high strength, exceedingly light weight
articles. However, conventional methods still do not
permit the manufacture of parts having the most desir-
able strength-to-weight ratios. This limitation in con-
ventional manufacturing techniques is particularly im-
portant where a conventional, relatively heavy material
must be used in aircraft or rocket parts. When making
turbine or compressor wheels of a jet engine, for exam-
ple, the web portion of the wheel can be quite thin. Con-
ventional manufacturing methods cannot be used under
commercial production conditions to satisfactorily form
the webbing to the most desirable thinness.

Moreover, in the manufacture of metal parts, frequently
the parts must be machined after being formed by casting,
forging or the like. When the part is machined a burr
ordinarily results at the edge of the surface which is
machined. The presence of a burr on a finished part is
ordinarily objectionable and must be removed. Con-
ventionally burr removal is accomplished by an abrasive
blast, tumbling, shot peening, etc. However, conventional
methods are quite costly and time consuming.

By utilizing chemical dissolution technique parts made
of titanium or aluminum have been manufactured so as
to have optimum strength-to-weight ratios. These tech-
niques, used in conjunction with conventional machining
operations, permit the formation of satisfactory, exceed-
ingly thin formed metal sections economically under
production conditions. Moreover, the use of chemical
dissolution techniques further provides an economical
means whereby burrs on machined parts can be removed.

It is universally recognized that the surface finish of a
part which is subjected to physical and thermal stresses
should be exceptionally smooth. It is accepted that ex-
tremely smooth surface finishes are not only desirable but,
in most instances, necessary to obtain the optimum re-
sistance to fatigue and corrosion. Titanium and titanium
alloys have been chemically machined by acid dissolution
in which there is a simultaneous hydrogen generation.
The hydrogen generated is believed to be absorbed in the
titanium metal, which action seriously impairs the fatigue
resistance of the metal through hydrogen embrittlement.
Moreover, a solution may be available which will dis-
solve titanium, for example, but in so doing will produce
the smooth surface finish required. In making a part
utilizing chemical dissolution techniques the primary prob-
lem is not to merely obtain metal removal but to obtain
it in a controlled manner. Moreover, in some instances,

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it is even a problem to obtain a solution which will dis-
solve a given metal at a satisfactory rate.

The satisfactory dissolving of a given alloy requires a
highly specific solution which will dissolve the metal and
simultaneously either give rise to a smoother surface
finish, or at least maintain the existing surface finish of
the part. It has been found that, in general, solutions
which will dissolve an alloy will simultaneously produce
a rough, etched, striated or pitted surface. The solution-
ing of a given metal must, therefore, be done under con-
trolled conditions, in a specific manner, with a particular
type of solution to obtain the surface finish which is
desired. By means of this invention titanium or a titani-
um base alloy, which is of extreme importance in the
manufacture of aircrafts and missiles, can be satisfactorily
machined by chemical dissolution techniques.

It has now been found that titanium or a titanium base
alloy containing at least about 85% titanium can now
be satisfactorily machined by chemical dissolution in an
aqueous bath containing potassium permanganate and
hydrofluoric acid. In this bath metal is removed from
titanium base alloys at a rapid rate without any deleteri-
ous surface effects.

For example, the results obtained with the titanium
base alloy, commonly referred to as 110 AT, are espe-
cially satisfactory when treated in accordance with our
invention. The alloy 110 AT has a general composition
which is as follows:

	Percent
Aluminum	5
Tin	2.5
Titanium	Balance

By means of this invention parts made of titanium base
alloys, such as 110 AT, can be chemically readily ma-
chined to exceptionally thin sections having an excep-
tionally smooth surface finish. This invention further
provides the method of chemically deburring parts formed
of such alloys in a satisfactory economical manner. Now
titanium base metals can be satisfactorily machined under
commercial production conditions by chemical dissolu-
tion techniques.

In order to form a metal part by means of chemical
dissolution techniques, the part is initially cast or pre-
machined to desired measurements prior to the chemical
dissolution treatment. It is generally desirable to form
the part slightly oversize when no masking is employed
so that in the chemical dissolution treatment the part is
reduced to finish dimensions. It is preferred to form
the part to as close to final desired specifications as is
practical by conventional techniques since metal removal
by chemical dissolution is somewhat more time consum-
ing. The performed part can then be placed on a suit-
able support means where it is cleaned.

Although various methods of cleaning may be em-
ployed, highly satisfactory results have been found to be
obtainable when the part is initially degreased in a tri-
chloroethylene vapor at a temperature of approximately
180° F. However, one of the many commercially avail-
able di-phase cleaners which are stable emulsions of an
organic cleaner and an alkali cleaner, can be used.

After degreasing, the part is dried and then subsequent-
ly immersed in an alkaline solution and electrically
cleaned. A solution containing soda ash 35%, trisodium
phosphate 55% and caustic soda 10%, all proportions

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by weight, can be used. In general, it is desirable to include a wetting agent, such as sodium resinate, in the bath in quantities up to 5%, by weight.

The part is subjected to an anodic potential of about six volts for approximately one minute and subsequently rinsed with water. The duration of the anodic cleaning is variable, depending upon the size, configuration, etc. of the part and upon the freshness of the cleaner. The effectiveness of the cleaner decreases in use so that more extended periods of anodic cleaning may be required for a part in a cleaning solution that has been used a number of times.

After rinsing the part free of any of the cleaning solution that may adhere to its surface, it is dried. The part is then ready to be chemically machined. The part is preferably positioned in the machining solution in such a manner as to avoid non-uniform dissolution of the surfaces. Gas generated during the dissolution of the metal part can accumulate in recesses or horizontal areas of the part so as to interfere with uniform chemical dissolution of the entire surface. When chemical machining an article having a planar configuration, such as a panel, it is desirable to support the panel in the machining solution in a vertical attitude.

On the other hand, articles of a more complicated configuration containing complex contours and recesses may not be suitably maintained in any position which will entirely inhibit collection of the generated gases and formation of gas pockets. For these and other types of articles it may be desirable to chemically machine the parts in a plurality of steps in which portions of the part are masked from the solution. For example, the top of such an article can be chemically machined while its lower surface is masked with a suitable stop-off material. When sufficient metal removal of the upper surface is obtained, the part is removed from the solution, rinsed, and the stop-off removed to expose the protected surface. The machined surface is then masked and the part reimmersed for completion of the chemical machining of the part. Of course, to complete the machining, the part is inverted so that the masked surface is on the bottom of the part.

Titanium base metals, such as pure titanium and titanium base alloys containing at least 85%, by weight, titanium, particularly titanium base alloys formed of, by weight, about 1% to 10% aluminum, about 1% to 5% tin and about 85% to 98% titanium can be chemically machined in an aqueous solution which is made up approximately as follows:

Potassium permanganate	grams	25 to 75
Concentrated hydrofluoric acid (52% to 55%)	milliliters	30 to 90
Water	do	1500

The chemical machining of a titanium base alloy containing aluminum, tin and at least about 85% titanium, by weight, can be satisfactorily solution machined in a bath solution of the above composition. However, in some instances, a titanium base metal containing at least 85%, by weight, titanium and particularly those metals containing higher amounts of titanium, can be satisfactorily solution machined when the concentrated hydrofluoric acid (52% to 55%) in the bath is as low as about 25 milliliters and as high as approximately 150 milliliters.

More specifically, we have found that a highly satisfactory surface leveling effect is produced when a part composed of 110 AT titanium alloy is immersed in a suitable bath solution at a temperature of about 150° F. We have found highly satisfactory results to be available when dissolving 110 AT in a solution which is formed as follows:

Potassium permanganate	grams	50
Concentrated hydrofluoric acid (52% to 55%)	milliliters	60
Water	do	1500

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Although optimum results with the above solutions are obtained when the metal removal is accomplished at a bath temperature of approximately 150° F., it has been found that highly satisfactory results are obtained employing bath temperatures of approximately 100° F. to 200° F. At these bath temperatures not only is original surface smoothness retained but a highly desirable surface leveling is additionally effected.

If stopping-off of the part to be machined is required, generally any maskant can be used which is insoluble in the bath solutions described above. However, stop-off materials such as a phenolic base lacquer or a polyvinyl base lacquer can be used. Of course, when employing phenolic base lacquers the masked part is subjected to a temperature of approximately 350° F. for several minutes to bake the lacquer. The usual time for air drying of polyvinyl base lacquers can be reduced by heating for several minutes at temperatures up to approximately 250° F.

After the stop-off has been applied, the part is again cleaned to remove any fingerprints or any adhesive from some of the stop-off materials which might have been used. Generally, fingerprints can be removed by wiping the surface of the part with a suitable solvent. One such solvent which can be used with a phenolic base lacquer is methyl ethyl ketone. When using a polyvinyl base lacquer, however, a more satisfactory solvent would be methyl alcohol or some other solvent which does not dissolve the base lacquer as does methyl ethyl ketone. In some instances it may be additionally desirable to wipe the surface with a second solvent which is more particularly suited to the removal of the adhesive which is used in applying the maskant. After cleaning, the part is then ready for immersion in the chemical machining solution.

In the manufacture of high strength, corrosion-resistant parts, especially those employed as aircraft components, it is recognized that surface smoothness is exceedingly important in forming an improved part. It is believed that, with increases in surface smoothness, the fatigue life of a part is not only increased but that its corrosion resistance is also materially increased. Our invention provides a means whereby such surface smoothness can be readily obtained on an alloy of a specific composition. The rate of chemical dissolution between the grains, grain boundaries, inclusions, etc. of a metal are not generally equal. A highly specific solution used under specific conditions must be employed in order to obtain a uniform rate of dissolution of the various phases of the metal composition. Our invention provides for rapid metal removal without deleterious surface activity.

Although this invention has been described in connection with certain specific examples thereof, no limitation is intended thereby except as defined in the appended claims.

We claim:

1. An aqueous bath solution for the chemical machining of a titanium base metal, said bath solution consisting essentially of, in addition to water, about 50 grams potassium permanganate and about 60 milliliters of concentrated hydrofluoric acid, respectively, for each 1500 milliliters of water in the solution.

2. A method of chemically machining a metal part which comprises applying an aqueous solution consisting essentially of, in addition to water, about 50 grams potassium permanganate and about 60 milliliters concentrated hydrofluoric acid, respectively, for each 1500 milliliters of water in the solution to a surface of a part made of a titanium base metal to chemically remove metal from said surface to form a predetermined configuration.

3. The method of chemically machining a metal part which comprises immersing a part made of a titanium base alloy having at least about 85%, by weight, titanium in an aqueous solution consisting essentially of, in addition to water, about 50 grams potassium permanganate and 60 milliliters of concentrated hydrofluoric acid, respec-

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tively, for each 1500 milliliters of water in the solution, said solution being at a temperature of approximately 100° F. to 200° F., and maintaining said part immersed in said solution for a sufficient duration to dissolve metal from a surface of the part to form a predetermined configuration.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,082,137

March 19, 1963

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It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 39, for "technique" read -- techniques --;
line 60, after "will" insert -- not --.

Signed and sealed this 1st day of October 1963.

(SEAL)

Attest:

ERNEST W. SWIDER

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