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Di Benedetto et al.

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[54] **METHOD OF FORMING RIFLING IN A GUN BARREL BY CHEMICAL MILLING**

[75] Inventors: **Josepe D. Di Benedetto**, Moline, Ill.; **Walter M. Kisner**, Davenport, Iowa

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

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[52] **U.S. Cl.** **156/16**, 156/19, 156/345

[51] **Int. Cl.** **C23g 3/04**

[58] **Field of Search** 156/16, 6, 19, 25, 156/345

[56] **References Cited**

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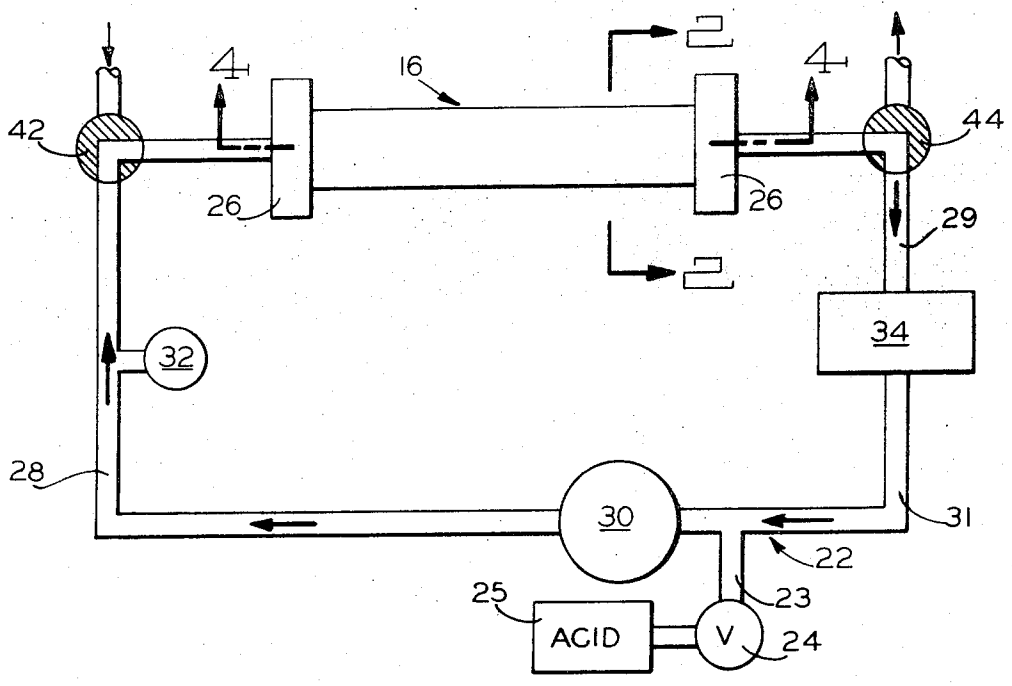
Primary Examiner—Jacob H. Steinberg

Attprmeu—Harry M. Saragovitz, Edward J. Kelly et al.

[57] **ABSTRACT**

A method of forming rifling, including that of a gain twist configuration, by the chemical milling process in the bore of a barrel which may include a liner of a refractory material. A template rod made of an acid resistant material which is radially compressible and which has a diameter slightly greater than that of the bore is pressed thereinto so that liquid tight contact is made between the surfaces of the rod and bore. A plurality of spiral channels and uninterrupted areas are formed in the rod to image the desired rifling configuration. A closed circulatory system delivers fluid acid to one end of the channels, and the rifling grooves formed thereby, and after passing therethrough returns the acid to the pump for recirculation. A pressure gage between the pump and barrel may be used in lieu of an elapsed time for chemical reaction to indicate when the rifling grooves are formed to the desired depth.

4 Claims, 4 Drawing Figures



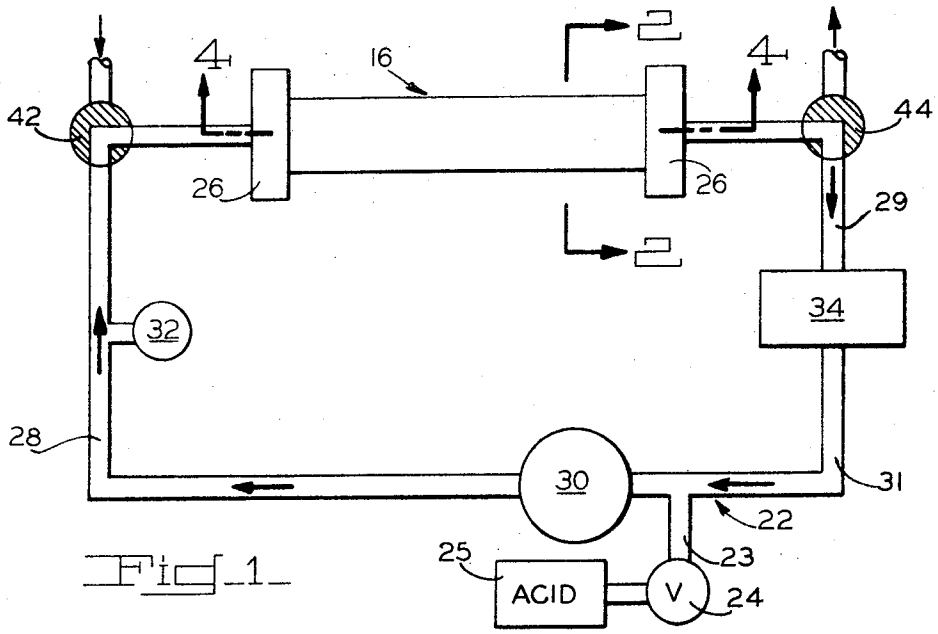


Fig. 1

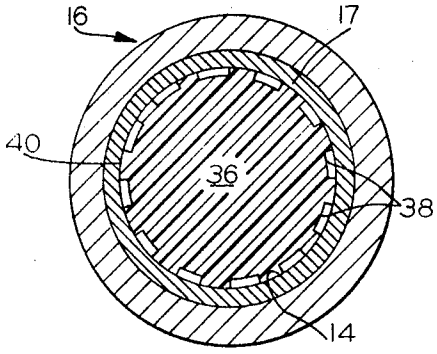


Fig. 2

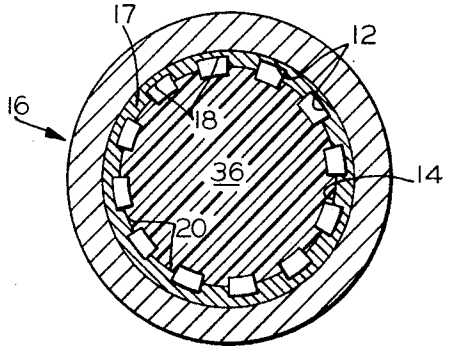


Fig. 3

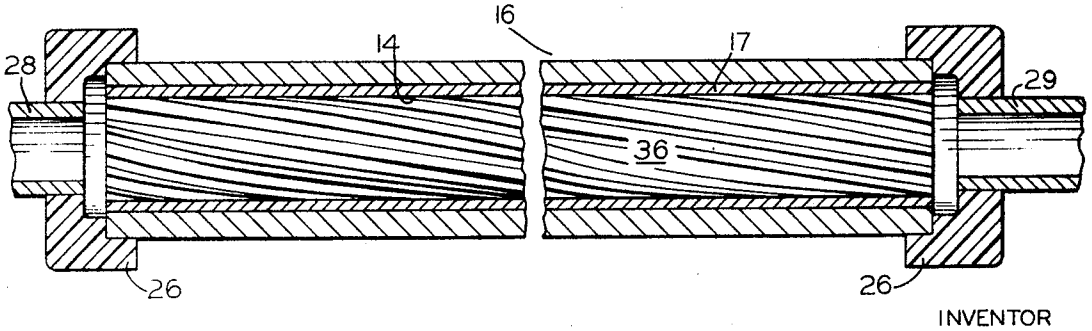


Fig. 4

INVENTOR
Joseph D. DiBenedetto
Walter M. Kisner
BY
Harry M. Saragovitz, Edward J. Kelly,
Herbert Berl, & Albert E. Arnold Jr.
ATTORNEYS

METHOD OF FORMING RIFLING IN A GUN BARREL BY CHEMICAL MILLING

BACKGROUND OF THE INVENTION

This invention relates to methods of forming rifling in gun barrel bores and pertains more particularly to a method of forming rifling in gun barrel bores by chemical milling.

The methods used almost entirely today in the manufacture of rifled gun barrels employ broaching or swaging techniques which are excellent for production type operation where the metal being worked is steel although the machines and tooling required are relatively expensive and the techniques require skilled operators. It is impractical, however, to utilize these techniques in production type operations to form gain twist rifling in barrels having a bore surface of refractory material because of the machining characteristics thereof.

It is therefore a principal object of this invention to provide a method of forming rifling with a gain twist in a barrel having a bore surface of a refractory material, which is practical for production operations.

It is a further object of this invention to provide a method of forming rifling in a gun barrel bore, be it constant or gain twist, or of a multilayer or monolithic construction or otherwise composed of metallic material, which does not require the expensive machines and tooling of the broaching and swaging techniques and which does not require skilled operators to perform the method.

It is another object of this invention to provide a method of forming rifling in a gun barrel tube in which maintenance costs respective to cooling are minimal.

It is still another object of this invention to provide a method of forming rifling in a gun barrel bore in which the method of gaging the depth of the rifling grooves is incorporated in the forming method.

These objects are achieved by a novel method of utilizing the chemical milling process in the technique of forming rifling in a gun barrel tube. In this method the rifling is formed by use of a selected acid especially suited to corrosively attack the material in which the rifling is to be formed and which is controlled in its attack by a template of rod configuration pressed with a tight fit into the barrel bore. The template rod is provided with channels and uninterrupted surfaces therebetween in the image of the desired rifling to be formed in the barrel bore. The rod is fabricated from an acid resistant material which has a limited radial compressibility, such as teflon, and has a diameter slightly greater than that of the bore so that when the rod is pressed thereinto the uninterrupted surfaces have liquid tight contact with the bore surface.

The fluid acid is pumped at a predetermined pressure to one end of the barrel and after passing through the channels in the rod the acid is clarified, and the gases vented, and then is returned to the pump for recirculation. A pressure gage is located in the circulating system between the pump and barrel to indicate the pressure at which the acid is applied to the barrel. As the rifling grooves are formed the resistance to the flow of the acid from the pump is decreased and the amount of this decrease indicates the depth to which the grooves are then formed.

Further objects and advantages of the invention will become apparent from the following specification, and the accompanying drawing which is for the purpose of illustration only.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic view of the apparatus by which the method of this invention is performed;

FIG. 2 is an enlarged cross-sectional view taken along line 2—2 of FIG. 1 and shows the barrel bore before the chemical milling process is initiated;

FIG. 3 is a view similar to FIG. 2 but showing the barrel bore after the rifling has been formed therein; and

FIG. 4 is an enlarged cross-sectional view taken along line 4—4 of FIG. 1 prior to chemical milling.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Shown in the drawings is an apparatus for performing one method of forming rifling **12** by chemical milling in the surface bore **14** of a barrel **16** having a liner **17** of a refractory material, which rifling comprises a plurality of spiral grooves **18** and lands **20** located therebetween. This method uses apparatus comprising a liquid circulating system **22**, as shown in FIG. **1**, for delivering to and from barrel **16**, as hereinafter described, a fluid in the form of an acid selected as best suited for eroding the metal from which liner **17** is fabricated. The acid is supplied to system **22** by means of a conduit **23**, and a shut-off valve **24** from source **25**.

System **22** comprises a pair of connectors **26** which fit, respectively, over the opposite ends of barrel **16** to make liquid sealed contact with the outside surface thereof, as shown in FIG. **4**. One of the connectors **26** is connected by conduit **28** to a pump **30** which supplies the acid under pressure to that end of barrel **16** and which is adjustable to a specific pressure output. A pressure gage **32** is located in system **22** between pump **30** and barrel **16** to indicate the pressure at which the acid is supplied thereto.

The other one of the connectors **26** is connected by conduit **29** to a suitable type clarifier **34** which serves to separate any foreign, solid matter from the acid and to vent from system **22** those gases which are generated by the chemical milling process. Clarifier **34** is connected to pump **30** by conduit **31**. A three-way valve **42** is located in system **22** forwardly of barrel **16** to provide means for stopping the passage of the acid thereto and opening that end of the barrel to the passage of water or suitable acid neutralizer thereto. A similar valve **44** is introduced into system **22** after the barrel to provide means for either directing the acid to clarifier **34** or the flushing water or neutralizer from the system.

Rifling **12** is formed in the surface of bore **14** through the controlled application of the acid thereto by a template rod **36** having a plurality of spiral channels **38** formed in the outside thereof in the image of grooves **18** to be formed in the surface of bore **14** and uninterrupted portions **40** of the outer surface of the rod, between the channels, which are in the image of lands **20**. Rod **36** has the same length as bore **14** and is formed from a material which is acid resistant and has slight degree of radial compressibility, such as Teflon. The diameter of rod **36** is slightly greater than that of bore **14** so that when the rod is force fitted thereinto uninterrupted portions **40** make liquid tight contact with the surface of the bore and so protects the contacted sur-

face from the erosive action of the acid when passing through channels **38**.

Thus, with pump **30** adjusted to a specific pressure output, acid is supplied thereby to one end of barrel **16** and then is forced along channels **38**, and grooves **18** after their formation is initiated, and out the opposite ends thereof for delivery by conduit **29** to clarifier **34** where any solid matter and the gases generated by the erosion of the bore surface is separated from the acid before being returned to the pump for recirculation. Passage of the acid through channels **38** permits erosive action of the acid on the areas along bore **14** which are not protected by uninterrupted portions **40** thereby forming grooves **18** to the desired depth.

The amount of metal removed from the surface of bore **14** along channels **38** is determinable by the pressure indicated by gage **32** because, as the metal is removed, the resistance to the flow of the acid through barrel **16** is correspondingly decreased, as shown by comparing FIG. **2** to FIG. **3**. When the pressure indicated on gage **32** reaches the amount predetermined as being the pressure of the acid supplied to barrel **16** when grooves **18** are formed to the correct depth, pump **30** is stopped. Valve **42** is then turned to stop the flow of the acid to barrel **16** and permit the flow of water or an acid neutralizer thereto and valve **44** is turned to permit the discharge of the water or neutralizer after passing through the barrel. When grooves **18** are thoroughly washed, barrel **16** is uncoupled from connectors **26** and rod **36** is removed from bore **14** ready to be used in another barrel because no wear is made upon the rod by this process.

It is also possible to predetermine a fixed time for sufficient chemical reaction to occur for forming grooves **18** to the desired depth and thereby eliminate the necessity for gages. It is also possible to form rifling **12** by photoengraving with bore **12** being selectively masked by photographic techniques.

We wish it to be understood that we do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

We claim:

1. The method of forming a rifling by the chemical milling process in the surface of a bore in a gun barrel, said rifling having a plurality of spiral grooves and lands formed therebetween, said method including the steps of masking said surface of said barrel bore by forming in a rod of acid resistant material and having a limited radial compressibility, a length similar to that of said barrel and a diameter slightly greater than that of said bore a plurality of spiral channels conforming to the contours of said grooves and uninterrupted portions of the surface of said rod to effect an image of said rifling, pressing said rod into said bore with a force fit thereby making liquid tight contact between said uninterrupted portions and said surface of said bore, and passing a fluid acid through said channels until the corrosive attack thereof against the surface of said bore at said channels forms said rifling to the desired depth.

2. The invention as defined in claim **1** and including the steps of installing said barrel in a closed, liquid circulating system, pumping said acid to one end of said bore for passage through said channels, and removing any foreign solid matter and the gases generated by the chemical milling process from said acid before being returned to said pump for recirculation.

3. The invention as defined in claim **2** and including the steps of adjusting said pump to a specific pressure output, gaging the pressure of said acid as supplied to said barrel, and comparing the pressure gaged to that determined as being the pressure of the acid to the barrel according to the adjusted pressure when said grooves are formed to the desired depth.

4. The invention as defined in claim **2** and including the step of stopping the erosive action of said acid on said bore surface after a period of time predetermined as being sufficient for the formation of said grooves to the desired depth.

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