Aug. 25, 1970 M. H. CHRABLOW 3,525,243

WIRE CLEANING APPARATUS

Filed June 15, 1967 2 Sheets-Sheet 1

Fig. 1.

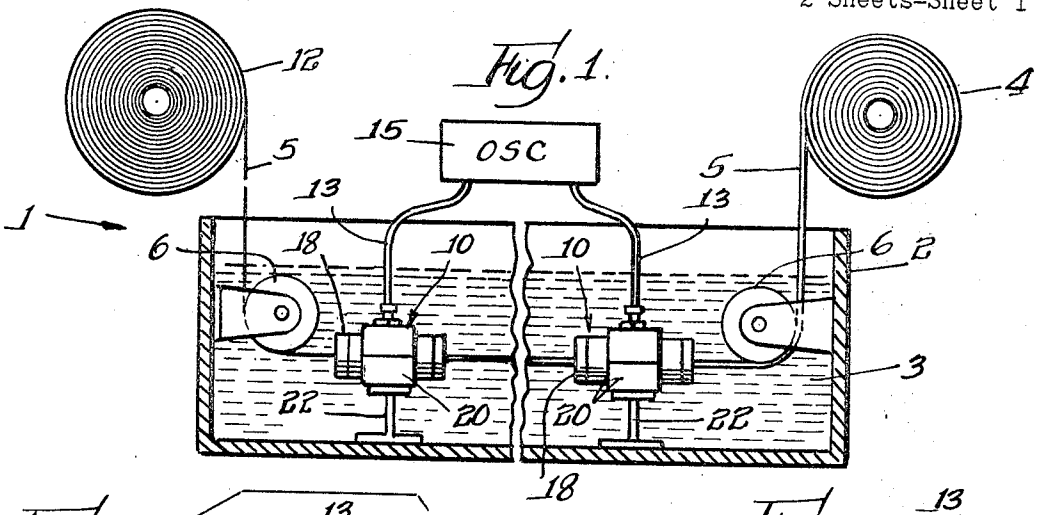


Fig. 2.

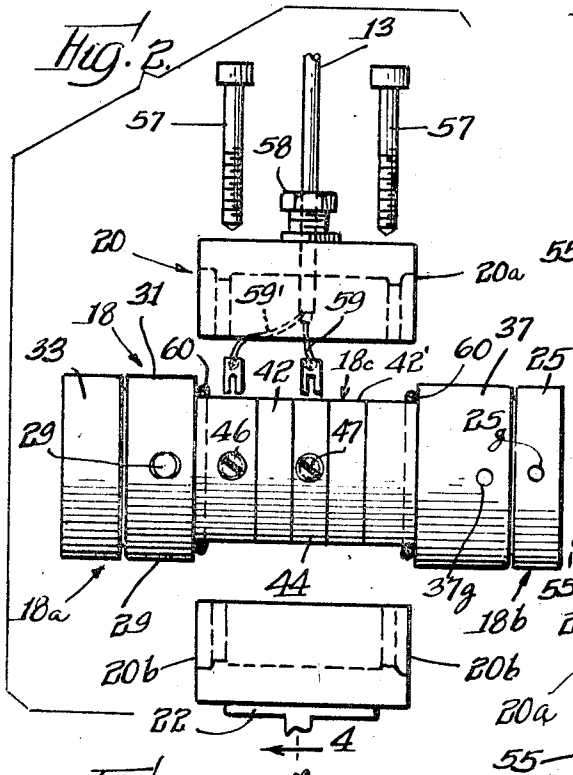


Fig. 3.

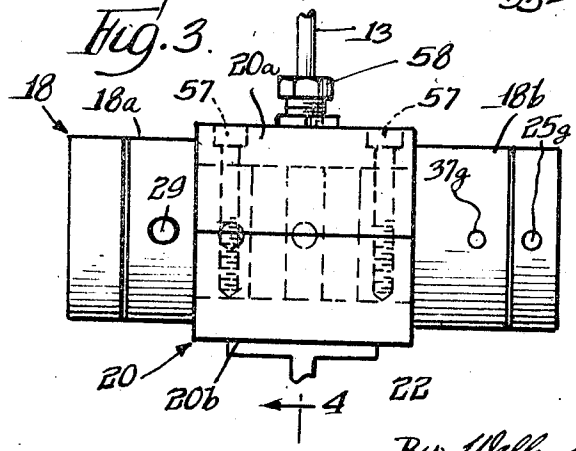


Fig. 4.

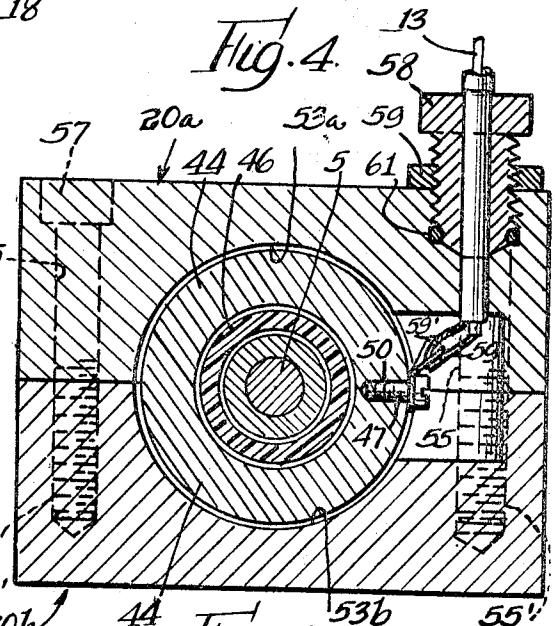
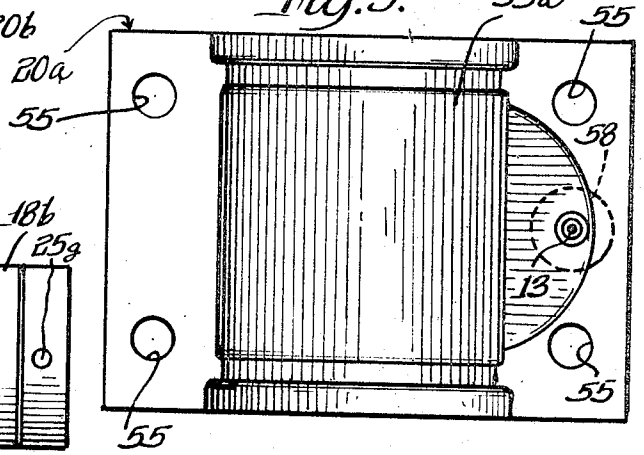


Fig. 5.



Inventor
Marshall H. Chrablow

By: Wallenstein, Spangenberg, Hattis & Strampel
Attys.

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WIRE CLEANING APPARATUS

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Fig. 6.

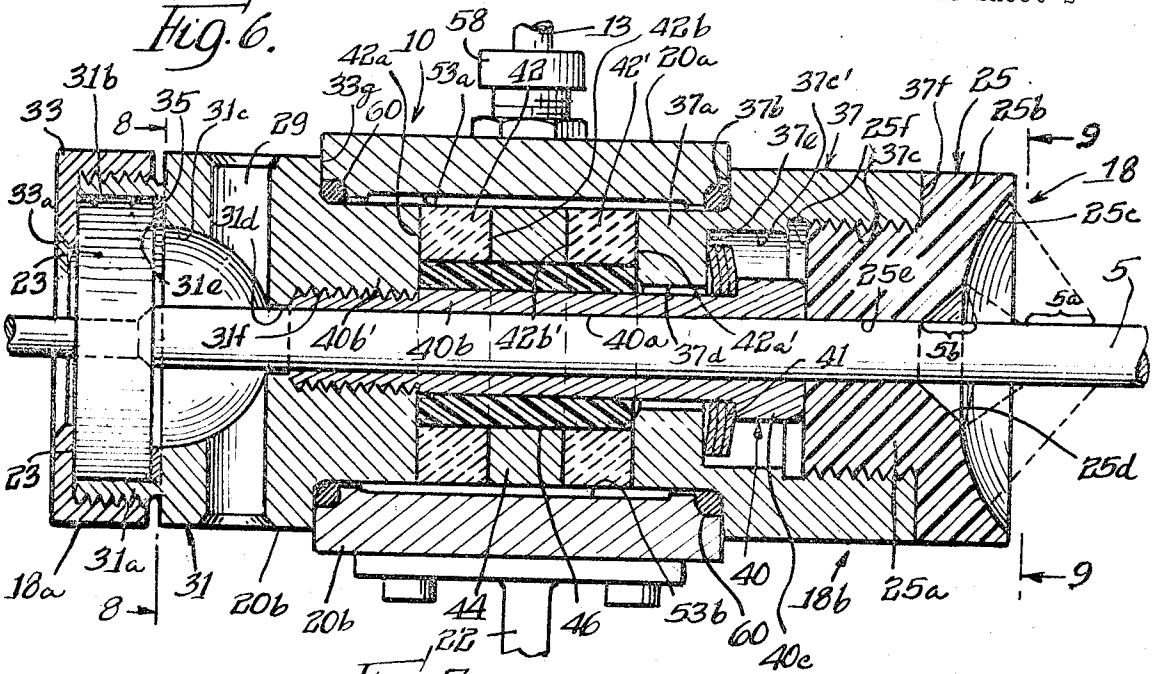


Fig. 7.

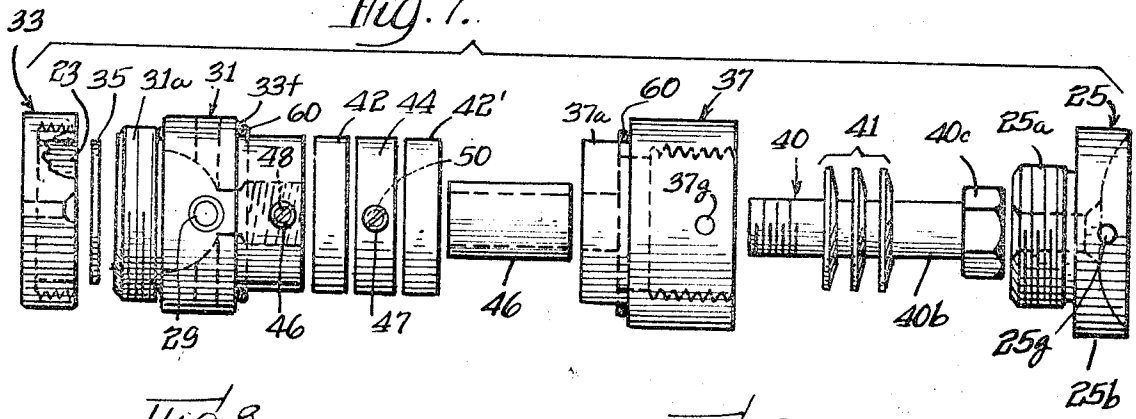


Fig. 8.

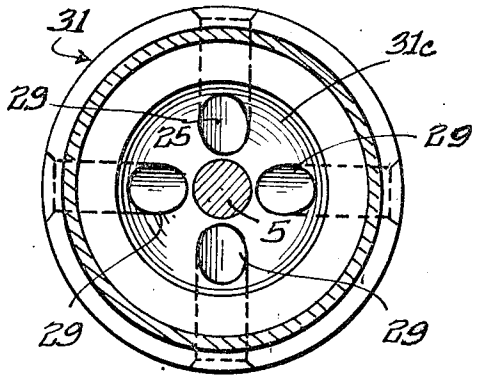
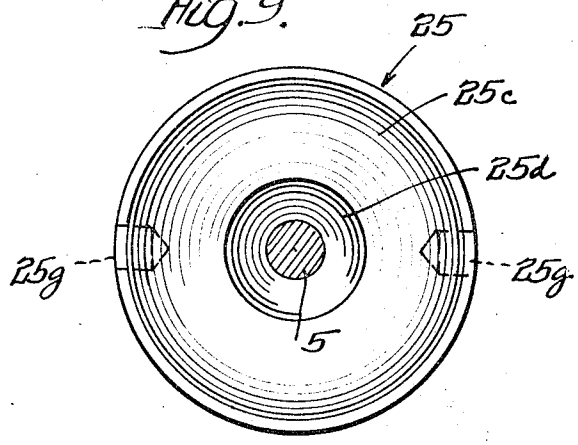


Fig. 9.



Inventor

Marshall H. Chrablow

By: Wallenstein, Spangenberg, Hattis & Strampel Attys

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WIRE CLEANING APPARATUS

Marshall H. Chrablow, Mundelein, Ill., assignor to Gulton Industries, Inc., Metuchen, N.J., a corporation of New Jersey

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Int. Cl. B21b 45/04; B21c 43/00
U.S. Cl. 72—39 7 Claims

ABSTRACT OF THE DISCLOSURE

The present invention relates to apparatus for cleaning elongated articles and has its most important application in the cleaning of wire in preparation for a wire drawing operation.

The surface condition of wire is an important factor in the performance of many electronic components. Some imperfections in wire are introduced in the operation of drawing the wire through a diameter-reducing die. Thus, frequently particles removed from the wire during a wire drawing operation cause partial blockage of the die and particle imbedment or scratching of the wire as the wire is drawn through the clogged die. However, the source of most surface imperfections is in the pick-up of foreign matter by the wire from the surrounding environment, primarily from the wire drawing equipment and the liquid lubricant used in the wire drawing operation.

The present invention provides an exceedingly simple and effective means for cleaning elongated articles of constant cross section, particularly wire in advance of a wire drawing operation, and for minimizing or eliminating particle blockage in wire drawing dies. In accordance with a feature of the invention, a cleaning unit is provided for cleaning elongated articles of constant cross section, particularly wire, comprising a hollow vibratable body having a longitudinal article-receiving bore therein. An electrical vibration producing transducer is associated with the hollow body for imparting longitudinal vibratory motion thereto. The hollow body is provided with an annular acoustic focusing lens having an article-receiving opening aligned with the article-receiving bore of the hollow body. The acoustic focusing lens responds to the longitudinal vibratory motion imparted to the hollow body by directing a focused beam of acoustic energy in the liquid in which the body is immersed which beam strikes a segment of the article extending around the wire and causes cavitation in the liquid which cleans the article. The acoustic focusing lens is most advantageously located at the inlet end of the hollow body where the acoustic beam is directed outwardly of the hollow body so the material removed from the surface of the article is on the outside of the hollow body where it cannot clog the narrow bore therein.

In accordance with another feature of the invention, the electrical transducer forms an integral part of the hollow body and preferably includes one or more annular piezoelectric discs which are clamped between end sections of the hollow body so as to be under an initial compression.

In accordance with still another feature of the invention, the hollow body is provided with an outer housing assembly forming a liquid-tight enclosure around the intermediate piezoelectric section of the hollow body. A liquid tight cable extends through the outer housing assembly to and includes conductors electrically connected to terminals on the piezoelectric discs. Seal forming means are provided on the inside of the hollow body for keeping liquid in the bore of the hollow body from contacting the piezoelectric discs.

In accordance with a further feature of the invention,

the compressive force applied to the piezoelectric discs is provided by a hollow screw member having a central longitudinal bore forming part of the aforementioned article-receiving bore, the screw member having a threaded shank portion threading into one of the end sections of the hollow body and a head portion bearing against the other end section of the body. In accordance with a related feature of the invention, the seal forming means which keeps the liquid in the bore of the hollow body from the piezoelectric discs is an insulating sleeve compressed between the expanded shank of the hollow screw member and the inner margins of the piezoelectric discs.

In accordance with another aspect of the invention, a wire drawing unit is provided which incorporates in a single, compact, lubricating liquid submersible body a wire drawing die, an electrical die vibrating transducer, and an annular acoustic focusing lens which focuses acoustic energy in the lubricating liquid around a segment of the wire approaching the die so as effectively to clean the surface of the wire. The combined wire drawing and cleaning unit is most advantageously constructed like the cleaning unit above described, with the acoustic focusing lens at the inlet end of the hollow body and the wire drawing die at the outlet end of the hollow body.

It is well known that the vibration imparted to a wire drawing die decreases the pulling force necessary to draw the wire through the die. However, the prior vibrating wire drawing units did not include as an integral part thereof, means for cleaning the wire before it reached the die. In these units, cleaning of the wire was effected, if at all, by vibrating the lubricating liquid containing tanks in which the wire drawing units were located. The cleaning action achieved by this arrangement left much to be desired.

A further feature of the invention is the provision in a wire drawing unit having a vibrated hollow body through which the wire is passed of lateral openings communicating with a space at the inlet side of the wire drawing disc so that the particles removed from the wire in the drawing operation are readily carried by the lubricating liquid to the outside of the wire drawing unit where they cannot clog the die.

The above and other advantages and features of the invention will become apparent upon making reference to the specification to follow, the claims and the drawings wherein:

FIG. 1 is a view of a wire drawing system incorporating wire drawing and cleaning units of the invention;

FIG. 2 is an exploded view of the main sub-assemblies making up each of the wire drawing and cleaning units shown in FIG. 1;

FIG. 3 is a view of the components shown in FIG. 2 in assembled relation;

FIG. 4 is an enlarged transverse sectional view through the assembled components shown in FIG. 3, taken along section line 4—4 thereof;

FIG. 5 is a bottom plan view of the upper half of the outer housing assembly forming part of the unit shown in FIGS. 1–4;

FIG. 6 is an enlarged longitudinal sectional view through the wire drawing and cleaning unit of FIGS. 1–4;

FIG. 7 is an exploded view of the various components making up the inner body assembly of the wire drawing and cleaning unit of FIGS. 1–4;

FIG. 8 is a transverse sectional view taken substantially along the lines 8—8 in FIG. 6; and

FIG. 9 is a transverse sectional view, taken substantially along the line 9—9 in FIG. 6.

Refer now more particularly to FIG. 1 which shows the present invention applied to a wire drawing machine

including a tank **2** containing a lubricating and cooling fluid **3** which may, for example, be Freon TF or similar material. A roll **4** of the rod stock **5** of much larger diameter than the wire to be fabricated therefrom is supported for rotation above the tank **2**. The rod stock unwinds from the roll and passes into the tank **1** where it is guided by rollers **6** in a preferably horizontal path which passes through one or more wire drawing and cleaning units each generally indicated by reference numeral **10**. Each of the wire drawing and cleaning units **10** reduces the diameter of the wire fed to the inlet side by a given predetermined amount. When the wire has finally been reduced to the desired diameter, it passes out of the tank where it is wound upon a take-up roll **12**. The wire is pulled through the wire drawing machine in any suitable way (not shown) well known in the art. The invention deals only with the features of the wire drawing and cleaning units **10**. (As previously indicated, certain aspects of the invention have a utility in the ultrasonic cleaning of elongated articles generally, although the most important application thereof is in the cleaning of wire in a wire drawing machine.)

In the most advantageous form of the invention, both wire drawing and wire cleaning operations are carried out in each of the units **10** which can be readily incorporated in any existing wire drawing installation. Each wire drawing and cleaning unit **10** includes an inner hollow body assembly **18** and an outer housing assembly **20**. The wire drawing and cleaning unit **10** is securely anchored in any suitable way, as by a bracket or base support **22**, to the walls of the tank **1**. The hollow body assembly **18** preferably has as an integral part thereof an intermediate electrical vibrator section **18***c* (FIG. 2) which is energized by an oscillator **15** (FIG. 1) through conductors in a flexible cable **13**. The energization of the vibrator section **18***c* imparts longitudinal vibrations to end sections **18***a* and **18***b* of the hollow body assembly **18** at a frequency, for example, of the order of 20–30 k.c. or higher. A substantial amount of heat may be generated in the unit **10** which is carried away by the liquid **3** which also acts as a lubricating fluid for the wire drawing operation. The vibration section **18***c* is sealed externally from the liquid **3** by the housing assembly **20** and is also sealed internally in a manner to be described.

The end section **18***a* of the hollow body assembly **18** includes a conventional type wire drawing die **23** (FIGS. 6 and 7) which die is removably mounted therein in a manner to be described. The end section **18***b* of the hollow body assembly **18** as illustrated includes an acoustic lens unit **25** preferably made of synthetic plastic material and removably mounted therein in a manner to be described. The hollow body assembly **18** is acoustically approximately one-half wave length long, and, when the vibrator section **18***c* is energized from the oscillator **15**, the hollow body assembly **18** vibrates longitudinally with a nodal point located somewhere between the opposite ends of the housing body so that maximum longitudinal vibrations are imparted to the wire drawing die **23** and the acoustic lens **25**. With proper selection of the materials and the configurations of the elements making up the end sections **18***a* and **18***b*, the vibration energy can be proportioned as desired between the die **23** and the lens **25**.

The lens **25** is designed to transfer into the liquid **3** the maximum amount of vibratory energy delivered thereto as a high energy acoustic beams directed inwardly and away from the end of the hollow body assembly **18** so as to encompass one or more segments **5** and **5***a* (FIG. 6) of the wire approaching the hollow body assembly before it enters the confined interior portions thereof. The acoustic beam, among other things, causes cavitation of the liquid around the wire entering the body assembly and removes from the surface thereof surface embedded particles and foreign matter to clean the wire.

The hollow body assembly **18** has a straight longitudinal bore therein, as best shown in FIG. 6, through which the wire **5** is drawn. Adjacent the wire drawing die **23**, the bore is greatly enlarged at **31***c* to provide a wall of tapered thickness at the end section **18***a* to increase the amplitude of the longitudinal vibrations imparted to the wire drawing die **23**. Additionally, it forms a large space into which the metal particles stripped from the wire **5** by the die **23** can be entrained in the liquid **3** and carried to the outside of the hollow body assembly by a number of radially or laterally extending passageways **29** extending to the outside thereof. The passageways **29** permit the ready circulation of the liquid **3** through the hollow body assembly at the inlet side of the die **23**.

The wire drawing and cleaning units **10** are extremely flexible in their application, since each selectively can be used only for a wire drawing purpose, or only for a wire cleaning purpose, or for both purposes, as desired. For example, if it is desired to utilize practically all of the useful vibration energy in the wire drawing operation, the lens **25** of each unit **10** is replaced by a relatively heavy dense piece of metal to mass load the end section **18***b*, so little or no longitudinal vibration will be imparted to the end section **18***b*. Where the unit is to be used for only cleaning purposes, the wire drawing unit **23** is replaced by a heavy dense piece of metal which will mass load the end section **18***a* to apply most of the vibrational energy at the other end of the unit **10**.

Now that the general features of the wire drawing and cleaning units have been described, the preferred constructional details thereof will be described.

The end section **18***a* of the hollow body assembly **18** preferably includes a die holder body **31** and a cap nut **33** which threads around an externally threaded reduced end portion **31***a* of the die holder body. The cap nut **33** has an inwardly extending lip **33***a* which retains the wire drawing die **23** within a cylindrical recess **31***b* centered in the reduced end portion **31***a* of the die holder body **31**. An annular compression washer **35** is sandwiched between the wire drawing die **23** and a shoulder **31***e* on the die holder body. The aforementioned bore enlargement **31***c* at the inlet end of the wire drawing die **23** is a concave recess centered on the die holder body. The aforementioned radial or lateral passageway **29** formed in the die holder body **21** intersects the inner end portion of the concave opening **31***c*. The inner, narrow end of the concave recess is intersected by a short axial bore **31***d* which, in turn, opens onto an axial threaded bore **31***f*. The inner end portion of the die holder body **31** is reduced in diameter from the adjacent portion thereof to form an inwardly axially facing annular shoulder **33***g* for reasons to be explained.

The end section **18***b* of the hollow body assembly **18** includes a lens retainer body **37** which has a reduced inner end portion **37***a* which provides an inwardly axially shoulder **37***b*. The lens retainer body **37** has a centered axial bore with a threaded outer portion **37***c* and an unthreaded inner portion **37***c'*. The inner bore portion **37***c'* intersects a smooth surfaced bore **37***d* of reduced diameter located in the reduced end portion **37***a* thereof, an outwardly facing annular shoulder **37***e* being provided at the plane of the intersection thereof. The threaded bore portion **37***c* of the lens retainer body **37** removably receives an externally threaded reduced end portion **25***a* of the lens **25**. In the illustrated form of the invention, the lens **25** has an enlarged outer end portion **25***b* which engages the outer end face **37***f* of the lens retainer body, and a centered axial bore **25***e* which receives the wire **5**. The lens **25** has an outermost centered axial concave recess **25***c* which intersects a centered axial chamfered recess **25***d* which, in turn, terminates in the axial bore **25***e* which opens onto the inner end face **25***f* of the lens **25**.

As previously indicated, the lens **25** upon receiving longitudinal vibrations produces a focused beam of ultrasonic energy encompassing a segment **5***a* of the wire moving into the confined portions of the hollow body assembly

18. As best shown in FIG. 6, the outermost concave recess focuses a beam inwardly and outwardly of the hollow body assembly. The chamfered recess 25*d* provides a focused acoustic beam encompassing a segment 5*b* of the wire 5. It is desired that the lens 25 form an acoustic impedance matching the transformer which maximizes the acoustic energy coupled to the liquid medium 3 involved.

The focusing lens 25 may be readily removed from the threaded bore 37*c* by any suitable means, such as by a tool which engages one or more apertures 25*g* in the lens 25 (FIG. 2). The rest of the hollow body assembly may be held stationary during the rotation of the lens 25 by use of a tool which extends into one or more apertures 37*g* formed in the lens retainer body 37.

The end sections 18*a* and 18*b* of the hollow body assembly 18 are compressed together about the intermediate vibration section 18*c* by means preferably including a hollow screw 40. The hollow screw 40 has a straight central longitudinal bore 40*a* which extends completely through the screw and forms a continuation of the bore 25*e* of the lens 25. The screw 40 has a shank portion 40*b* having a threaded end portion 40*b'* threading into the threaded portion 31*f* of the die holder body 31. The screw 40 has a head 40*c* which compresses against conically shaped lock washers 41, the washers bearing against the outwardly axially facing shoulder 37*e* at the inner end of the bore portion 37*c'* of the lens retainer body 37.

The intermediate vibrator section 18*c* preferably includes a pair of axially spaced piezoelectric ceramic discs 42–42' having electroded outer axially facing surfaces 42*a*–42*b* and 42*a'*–42*b'*. The discs 42 and 42' are prepolarized in the conventional way and in the same relative direction; that is, it has the same relative axial pre-polarization between the faces 42*a* and 42*b* and 42*a'* and 42*b'*. The innermost electroded faces 42*b* and 42*b'* engage the opposite faces of a metal disc 44 sandwiched between the ceramic discs 42 and 42'. The electrodes faces 42*a* and 42*a'* of the ceramic discs respectively engage the innermost faces of the die holder body 31 and the lens retainer body 37 which are made of a suitable conductive material. In one form of the invention, the die holder body 31 was made of titanium and the lens retainer body 37 was made of aluminum. The ceramic discs 42 and 42' and the metal disc 44 surround a cylindrical insulating sleeve 46 which, in turn, surrounds the shank portion 40*b* of the screw 40. When the screw 40 is tightened, the resultant expansion caused by the compression of the shank portion of the screw causes the insulating sleeve 46 to expand to form a liquid tight, electrically insulating barrier between the hollow screw 40, which may be made of metal, and the discs 42, 42', and 44. The outermost electroded faces 42*a* and 42*a'* of the ceramic discs 42'–42 are electrically connected together through the die holding body 31, hollow screw 40, washer 42 and the lens retainer body 37. It is apparent that the piezoelectric ceramic discs 42 and 42' are connected in parallel aiding relationship so as to produce vibrations in the same direction as alternating current signals are applied across their corresponding electroded faces. External electrical connections to the ceramic discs 43 and 44 are made through suitable terminals, such as metal screw terminals 45 and 47 which are threaded into bored holes 48 and 50 respectively formed in the die holder body 31 and the metal disc 44.

The screw terminals 45 and 47 and the adjacent discs 42, 42' and 44 are sealed from the liquid 3 on the outside of the hollow body assembly 18 by the aforementioned housing assembly 20. The housing assembly may be formed from two metal blocks 20*a* and 20*b* which have confronting recesses 53*a* and 53*b* which receive the outer surfaces of the die holder body 31, the discs 42 and 42' and 44, and the lens retainer body 37 located between the inwardly axially facing annular shoulders 33*g* and 37*b* of the die holder body 31 and the lens retainer body 37, as best illustrated in FIG. 6. The housing assembly blocks 20*a* and 20*b* are clamped tightly around the hollow body assembly 18 by any suitable means, such as by bolts or screws 57 passing through holes 55 in one of the blocks and threading through the holes 55' in the other block. Mechanical isolation and a liquid-tight seal is achieved between the housing assembly 20 and the hollow body assembly 18 by compressible O-rings 60—60 which extend around the inner end portions of the die holder body 21 and the lens retainer body 37 which O-rings are compressed between the clamped together housing blocks 20*a* and 20*b*.

The aforementioned base support 22 for each of the wire drawing and cleaning units 10 is secured to the associated bottom housing block 20*b*. The flexible cable 13 sealing extends through a hollow screw 58 held in place by a lock nut 59. The screw 58 threads into the housing block 20*a* as best shown in FIG. 4 and bottoms against a sealing ring 61. The flexible cable 13 has two conductors 59—59' which respectively extend to and are anchored to the screw terminals 46 and 47. It is advantageous that the connection between the screw terminals 46 and 47 and the cable 13 be through flexible connections. This is satisfied by the flexible nature of the conductors themselves.

It is apparent that the preferred form of the present invention provides a combination wire drawing and cleaning unit where particles removed from the wire during a wire drawing operation is readily carried away through the passageways 29 and the wire is cleaned by the focusing of high energy acoustic beams upon segments of the wire before it moves within the narrow interior portions of the unit.

It should be understood that numerous modifications may be made in the most preferred form of the invention described above without deviating from the broader aspects thereof.

I claim:

1. A wire drawing unit to be inserted into a liquid medium, said unit comprising, in combination, a hollow body having a wire-receiving bore therein with open wire inlet and outlet ends through which wire to be reduced in size is to be drawn, a diameter-reducing wire drawing die mounted on the hollow body and through which the wire passes as it traverses the wire-drawing bore therein, said hollow body having an electrical body vibrating transducer associated therewith for imparting longitudinal vibratory motion thereto, and acoustic focusing means attached to said body for receiving the longitudinal vibratory motion imparted to said body and directing a focused beam of acoustic energy onto a limited area of the portion of the wire approaching the wire drawing die.

2. The wire drawing unit of claim 1 wherein said acoustic focusing means is located adjacent the inlet end of said wire-drawing bore and directs said acoustic beam outwardly of said body to contact the wire before it enters said bore.

3. The wire drawing unit of claim 1 wherein said body is an assembly having end sections to which said wire drawing die and acoustic focusing means are respectively separately removably attached.

4. The wire drawing unit of claim 1 wherein said body is an assembly having end sections to which said wire drawing die and acoustic focusing means are attached, and said body vibrating transducer includes at least one piezoelectric element sandwiched between said end sections of said body assembly.

5. A wire drawing unit to be completely submerged in a liquid medium, said wire drawing unit including a hollow body assembly comprising axially aligned annular end sections and an intermediate annular body vibrating transducer section axially aligned with and sandwiched between said end sections for imparting to said end section longitudinal vibratory movement, an annular wire-drawing die attached to one of said end sections, said

annular end and intermediate sections of said hollow body assembly and said wire-drawing die forming a wire-receiving bore extending axially through the body assembly and the other end section of the body assembly having attached thereto acoustic focusing means for receiving the longitudinal vibratory motion imparted to said body and directing a focused beam of acoustic energy onto a limited area of the portion of the wire approaching the wire-drawing die.

6. The wire drawing unit of claim 5 wherein said acoustic focusing means includes axially spaced and facing inwardly converging surfaces for focusing acoustic energy at different points on the wire approaching said bore.

7. A wire drawing unit to be completely submerged in a liquid medium, said wire drawing unit including a hollow body assembly comprising axially aligned annular end sections and an intermediate annular body vibrating transducer section axially aligned with and sandwiched between said end sections for imparting to said end sections longitudinal vibratory movement, an annular wire-drawing die attached to one of said end sections, said annular end and intermediate sections of said hollow body assembly and said wire-drawing die forming a wire-receiving bore extending axially through the body assembly, the intermediate and end sections of the hollow body assembly being held together by a hollow screw member having a central longitudinal bore through which the wire passes, said screw member having a threaded shank portion threading into one of said end sections and a head portion which bears against the other end section of the body assembly, and seal-forming means comprising an insulating sleeve compressed between the shank of the screw member and the inner margins of the intermediate transducer section of said body assembly.

References Cited

UNITED STATES PATENTS

2,109,312	2/1938	Dimmick	72—39 X
2,568,303	9/1951	Rosenthal	72—39 X
1,835,462	12/1931	Busey	72—39
2,484,014	10/1949	Peterson	264—23
2,962,695	11/1960	Harris	134—1 X

CHARLES W. LANHAM, Primary Examiner

A. L. HAVIS, Assistant Examiner

U.S. Cl. X.R.

72—274; 134—1; 264—23