June 1, 1971 A. J. MILLER 3,582,400

APPARATUS AND METHODS FOR CLEANING STRIP MATERIALS

Filed Nov. 21, 1969 4 Sheets-Sheet 1

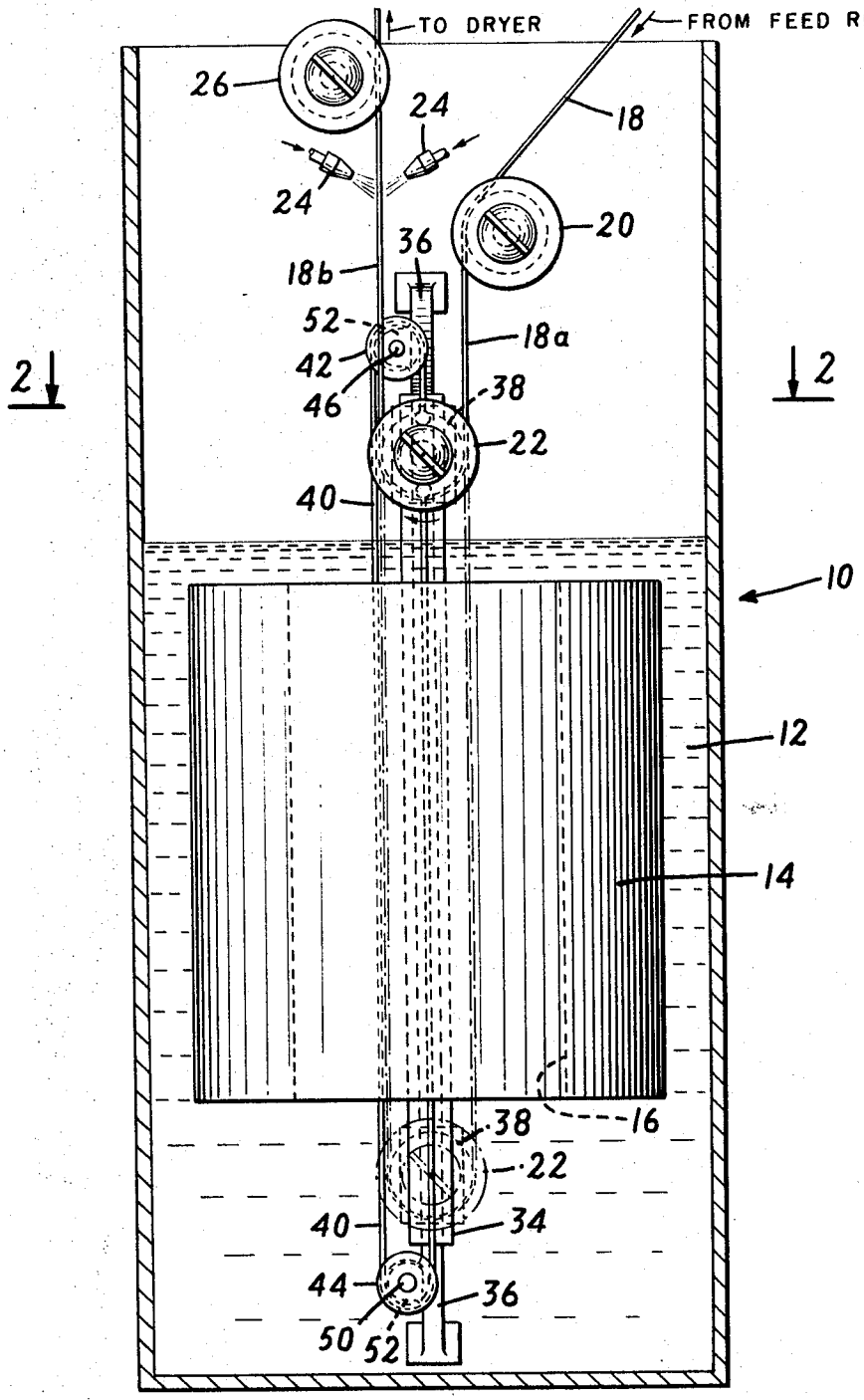

FIG. 1

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APPARATUS AND METHODS FOR CLEANING STRIP MATERIALS

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FIG. 4

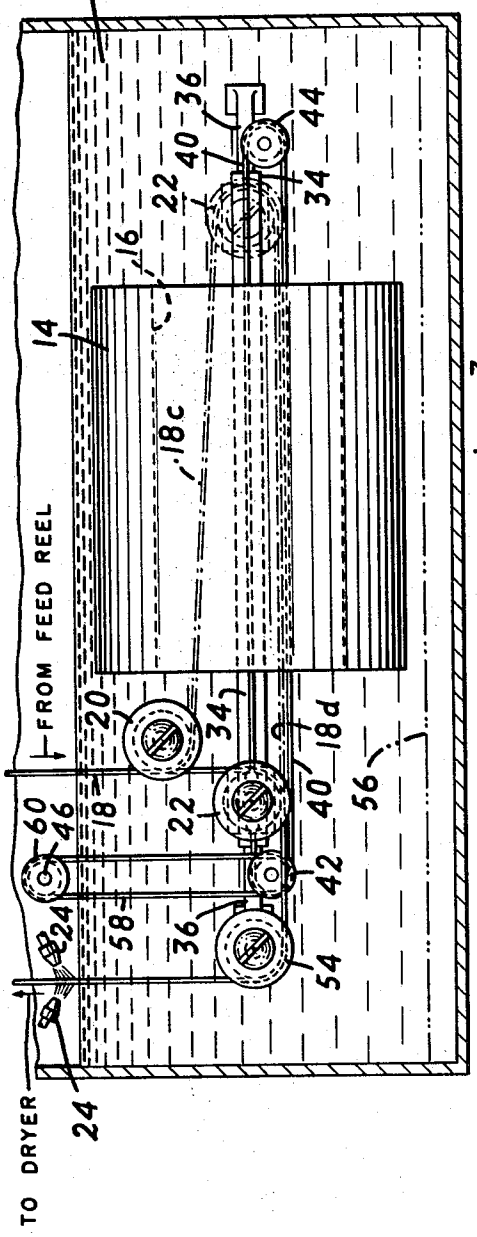
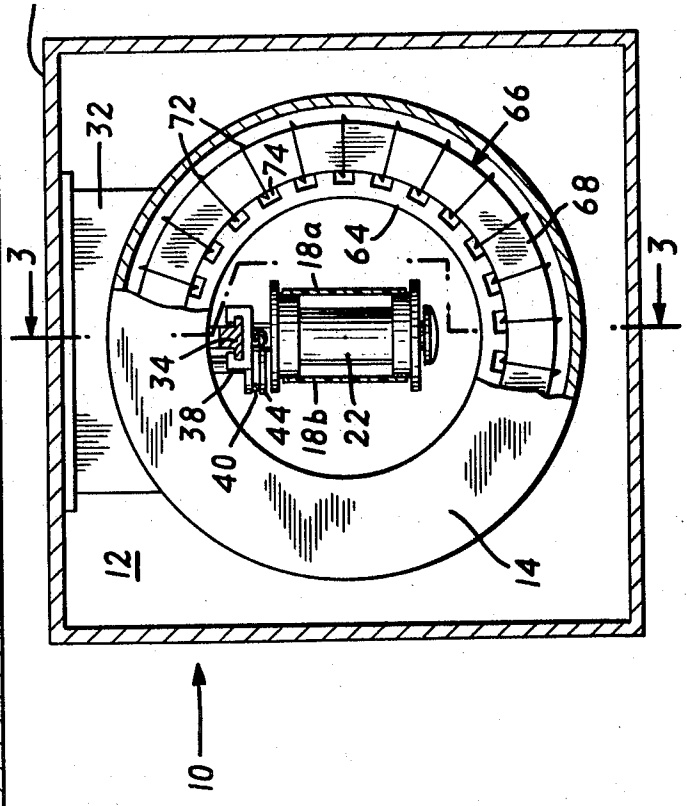


FIG. 2



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APPARATUS AND METHODS FOR CLEANING STRIP MATERIALS

Filed Nov. 21, 1969 4 Sheets-Sheet 3

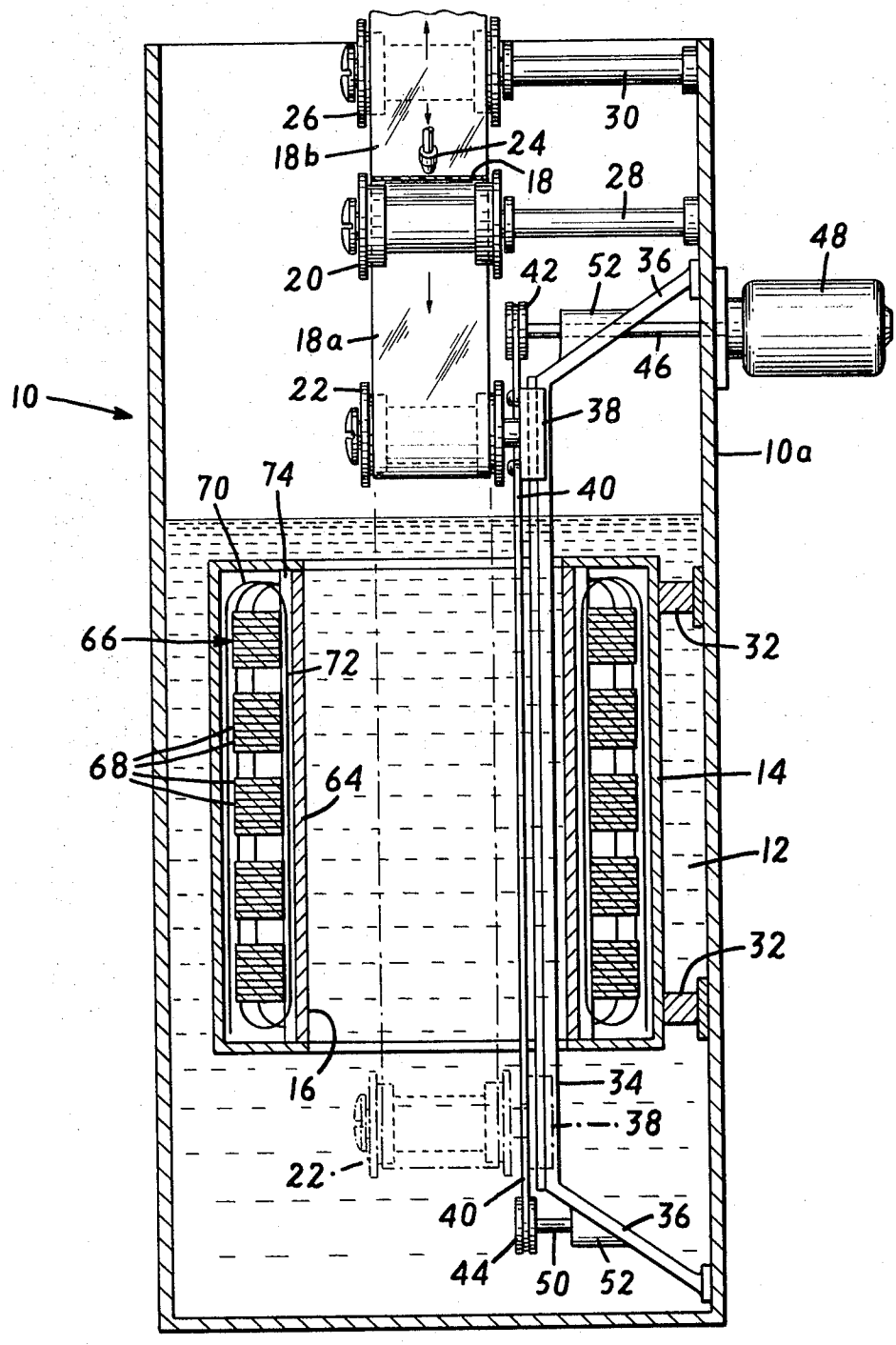

FIG. 3

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APPARATUS AND METHODS FOR CLEANING STRIP MATERIALS

Filed Nov. 21, 1969 4 Sheets-Sheet 4

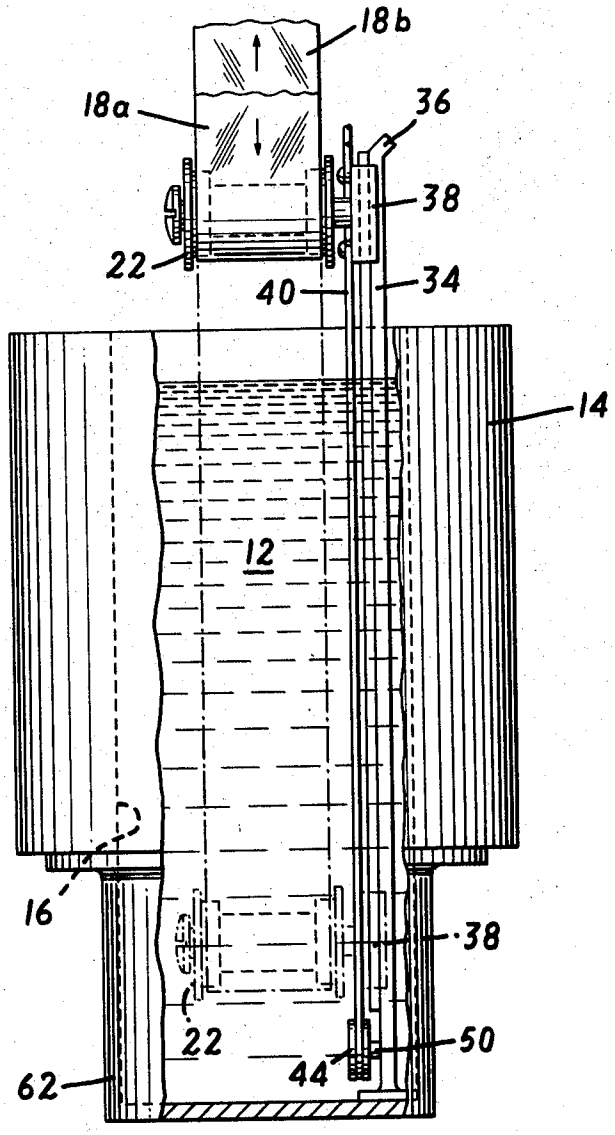

FIG. 5

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United States Patent Office 3,582,400 Patented June 1, 1971

3,582,400

APPARATUS AND METHODS FOR CLEANING STRIP MATERIALS

Arthur J. Miller, Horizon Towers N., Fort Lee, N.J. 07024

Filed Nov. 21, 1969, Ser. No. 878,771
Int. Cl. B08b 7/00
U.S. Cl. 134—1 17 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus and methods for ultrasonically cleaning fragile strip materials, such as motion picture film and the like. The strip material is passed in a double run through a solvent bath located within the bore of a generally cylindrical electromechanical transducer. A material transport mechanism, in part selectively reciprocable between a threading position adjacent one end of the transducer bore and a running position adjacent the other end of the bore, allows ready introduction of the material into the bore for cleaning and also facilitates material threading and removal. The solvent bath is maintained within the bore by immersing the transducer in an external solvent bath or by enclosing one end of the transducer bore to contain the solvent within the transducer itself.

BACKGROUND OF THE INVENTION

The present invention relates broadly to apparatus and methods for cleaning strip materials, and more particularly to improved ultrasonic cleaning apparatus and methods for use with fragile strip materials such as motion picture film, magnetic and video tape, and the like.

Because strip materials of the type mentioned have a great tendency to attract and retain foreign matter, and especially particulates such as dust, lint, etc., it is common practice in the use and the processing of these materials to clean them periodically in order to avoid the deleterious effects which result from the presence of foreign matter on the record-bearing surfaces of the materials. Such effects often include, for example, actual damage to the materials themselves, or a degradation in the fidelity of the reproduced record, or both.

Typically, cleaning of the strip materials, for instance, motion picture film, is accomplished by passing the film through a solvent bath, usually agitated ultrasonically, then through a rinsing station where contaminants picked up in the solvent bath are rinsed from the film surfaces, and finally through a dryer where the solvent or other moisture adhering to the film is removed.

With such cleaning apparatus, it is highly desirable that the cleaning be carried out at the maximum film feed rate possible commensurate with thorough cleaning of the film surfaces and the preservation of the film in an undamaged condition. For economy of space and operation, it is also desirable that the high film feed rates be achieved without corresponding increases in the size of the cleaning apparatus, the quantity of solvent used or in the number or power consumption of the transducers needed to agitate the bath.

Still another important consideration is that the film must be easily recoverable intact from the solvent bath at the end of, or at any interruption of, a cleaning run. Again, all components of the film transport mechanism used to carry the film through the apparatus, including the components which pass the film through the solvent bath, must be readily accessible to the operator both to facilitate threading of the film on the transport mechanism and to permit removal of the film from the mechanism without delay.

These and other requirements of the prior art are fulfilled by the novel cleaning apparatus and methods of the present invention.

SUMMARY OF THE INVENTION

In accordance with the invention, fragile strip materials such as motion picture film, magnetic and video tapes, and the like are cleaned upon being passed at high speed in a double run through the axial bore of a generally cylindrical electromechanical transducer. A solvent bath suitable for cleaning the material is provided within the bore and is agitated ultrasonically upon energization of the transducer, thus subjecting the material to a vigorous cleaning action as it travels through the bore.

A transport mechanism for carrying the strip material includes a first roll located adjacent one end of the transducer for guiding the material axially into the transducer bore and a second roll, movable between a threading position adjacent the first roll and a running position at the other end of the transducer, for receiving the strip moving from the first roll and returning it axially through the bore in the opposite direction. The movable second roll is slidably mounted on a guide track which extends axially through the transducer bore and is selectively reciprocated therealong between the threading and running positions by an appropriate drive system.

The transducer may be immersed in a solvent bath with one or both ends of the bore open to the bath, or the solvent bath may be contained in the bore, in which case one end of the bore is capped with a fluidtight enclosure. The first roll and the threading position of the second roll are spaced axially outward of one end of the bore, while the running position of the second roll preferably is spaced axially outward of the opposite end of the bore. Where the solvent bath is contained within the bore, the running position of the second roll is located within the enclosure closing off the one end of the bore, but preferably is still axially outward of the end of the bore.

In a preferred embodiment of the invention, the bore of the transducer is located in a generally vertical plane, with the location of the first roll and the threading position of the second roll being selected to be above the level of the solvent bath. Accordingly, both the first and second rolls are readily accessible for threading of the strip material at the beginning of the cleaning process. By the same arrangement, the strip material is easily withdrawn from the solvent bath at any time.

The present invention, therefore, allows the high speed cleaning of strip materials at low operating cost, and additionally yields a markedly compact unit that affords significant savings in space and solvent usage over prior art cleaning devices.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be made to the following description of an exemplary embodiment, taken in conjunction with the figures of the accompanying drawings, in which:

FIG. 1 is a side elevational view, partly in section, of strip cleaning apparatus constructed in accordance with the invention;

FIG. 2 is a horizontal sectional view taken along the line 2—2 of FIG. 1 and looking in the direction of the arrows, with parts broken away to show the details of a preferred type of magnetostrictive transducer;

FIG. 3 is a vertical sectional view taken along the line 3—3 of FIG. 2 and looking in the direction of the arrows;

FIG. 4 is a side elevational view, partly in section, of an alternative embodiment of the invention; and

FIG. 5 is a side elevational view of still another embodiment of the invention, with parts broken away for clarity.

DESCRIPTION OF A REPRESENTATIVE EMBODIMENT

For convenience and to avoid redundancy, a representative embodiment of the invention is described herein with reference to the cleaning of motion picture film. It will be understood, however, that the invention is equally applicable to the cleaning of other perishable strip materials, such as magnetic tapes, video tapes, and the like.

Referring first to FIG. 1, film cleaning apparatus constructed in accordance with the invention includes a cleaning chamber **10** of any convenient configuration, for example, square, rectangular or circular, as space considerations may require. A bath **12** of a solvent suitable for cleaning the film is provided within the chamber **10** in sufficient quantity to receive, and preferably submerse, an electromechanical transducer 14.

In accordance with an important feature of the invention, the transducer **14** is generally cylindrical in form, having a hollow, axial bore **16** extending therethrough which is open to the solvent bath at least at one end. Any suitable electromechanical transducer may be used, including those of the magnetostrictive, electrostrictive and piezoelectric types. It need only be sufficiently compatible with the solvent to be used without an elaborate protective housing for the vibratory elements and have a capacity sufficient to agitate vigorously the portion of the solvent bath contained within the axial bore **16**. To this end, appropriate electrical leads (not shown) are provided to connect the transducer to a source of electrical power.

While cylindrical transducers are preferred, because of the savings in space and the amount of solvent required flowing from that configuration, other forms of hollow transducers can be used. It will be understood, therefore, that the transducer is described herein as cylindrical merely to indicate the preferred type of transducer.

In the embodiment of the invention depicted in FIGS. 1 to 3, the film **18** to be cleaned passes from a feed reel (not shown) and over a guide roll **20** to be guided downward toward the vertically oriented bore **16** of the transducer **14**. The film is received in its downward run **18***a* by a return roll **22** which reverses the direction of movement of the film and directs it in an upwardly run **18***b* that, as shown, is generally parallel to the downward run **18***a*. In the upward run **18***b*, the film is rinsed in a conventional manner by sprays of clean solvent issuing from a pair of opposed spray heads **24** and is thereafter passed to a dryer (not shown) where solvent adhering to the film surfaces is removed. If desired, a third guide roll **26** may be provided to maintain the upward run **18***b* of the film in proper alignment with the spray heads **24** and the dryer.

The guide rolls **20** and **26** are mounted in a rotatable manner on shafts **28** and **30**, respectively, carried by a wall **10***a* of the cleaning chamber **10** (see FIG. 3). Similarly, the transducer **14** is also supported, as by the brackets **32**, from the wall **10***a*, Other mounting arrangements for the rolls and transducer may of course be used, the foregoing being merely illustrative of one possible arrangement.

In contrast to the rolls **20** and **26** which are fixed, the return roll **22** is intended to move vertically through the transducer bore **16** between an upper position, shown in the drawings in solid lines, and a lower position, shown in dashed lines. To this end, the roll **22** is slidably mounted on a guide track **34** which extends through the transducer bore and is rigidly attached at either end to the chamber wall **10***a* by brackets **36**.

Any suitable means may be used to secure the roll **22** to the guide track **34**, so long as sliding movement of the roll along the track is facilitated and placement on or removal from the roll of the film is not impeded. Advantageously, the track **34** is generally T-shaped in cross section (see FIG. 2) and the roll **22** is rotatably carried at one end only by a generally C-shaped slide **38** that fits in sliding relation over the T-shaped track **34**. A cable **40** connected at either end to the upper and lower ends, respectively, of the slide **38** forms with the slide a complete loop that passes tautly over a driven pulley **42** at its upper end and an idler pulley **44** at its lower end.

The shaft **46** of a reversible electric motor **48** (see FIG. 3) drives the pulley **42**, and through it the cable **40**, either clockwise or counterclockwise, as the case may be, to raise or lower, respectively, the return roll **22**. The shaft **46**, and a corresponding shaft **50** for the idler pulley **44**, may be conveniently journaled in lugs **52** formed on the brackets **36** supporting the guide track **34**, while the electric motor **48** preferably is mounted outside of the cleaning chamber wall **10***a*.

Appropriate electrical controls (not shown) are provided so that the motor **48** can be selectively energized to reciprocate the return roller **22** between the upper and lower positions. If desired, microswitches (not shown) connected in the motor energization circuit may be located adjacent each end of the guide track **34** to be contacted by the slide **38**. and hence deenergize the motor, when it reaches the proper end positions. These positions, ideally, are axially outward of the ends of the transducer bore **16**. So spaced from the bore, the roll **22** and its associated mounting structure are not directly exposed to the high level ultrasonic energy within the bore, and, perhaps more importantly, the film is subject to the cleaning action of the solvent over the full length of the transducer.

By the foregoing construction, significant advantages are realized by the present invention over prior art film cleaning apparatus. In particular, it will be appreciated that by passing the film through the bore of the trandsucer in a double run higher film feed rates are obtainable without any sacrifice in the thoroughness with which the film is cleaned. Consequently, the film can be cleaned in a correspondinly shorter time, with the result that it is more quickly available for further use. Also, the cleaning apparatus is freed sooner for processing other film.

Another important feature of the invention is that the guide roll **20**, return roll **22**, and the guide roll **26**, if used, are readily accessible for threading of the film over the rolls and, conversely, for removing the film from the rolls at the end of a cleaning run or in the event a cleaning run is interrupted. This results in part because the guide rolls **20** and **26** and the upper, or threading, position of the return roll **22** are spaced outside of the adjacent end of the transducer bore **16**, and preferably are located above the level of the solvent bath **12** (see FIGS. 1 to 3 and 5).

It will be appreciated, therefore, that the film may be quite easily threaded over and removed from the rolls when the return roll **22** is in the upper position.

It is significant also that the invention includes a very simple, yet highly reliable, provision for introducing the film into and for withdrawing the film from the solvent bath **12**. Thus, after the film has been threaded over the guide roll **20** and return roll **22**, the motor **48** is energized to move the return roll from the threading position to the lower, or running, position where it remains throughout the cleaning run. At the end of the cleaning run, or in the event of an interruption in the run, the film may be withdrawn from the solvent bath simply by again energizing the motor **48**, this time in the reverse direction, to raise the return roll **22** to the threading position. The film is therefore at all times easily recoverable intact from the solvent bath, with virtually no risk that the soft film surfaces will be damaged or that the film will be broken.

Economies of space and operation are also realized by the invention inasmuch as both the size of the solvent chamber **10** and the quantity of solvent required for the bath **12** are minimized. As is more fully described hereinafter, further economies of this nature can be obtained by eliminating the separate cleaning chamber **10** and utilizing the transducer **14**, in effect, as a cleaning chamber.

In any event, the invention affords a compact, yet highly efficient, cleaning unit that is adapted for use in a

variety of applications. One such application, for which it is particularly suited, is in the film cleaning apparatus of the copending application Ser. No. 838,760, filed July 3, 1969 by Messrs. Arthur J. Miller, Raymond Perkins and Harold E. Sullivan. That apparatus incorporates solvent recovery and recycling systems which complement, and hence enhance, the solvent saving characteristics inhering to the present invention.

In applications where space limitations are of secondary importance, the transducer **14** may be arranged horizontally within the cleaning chamber **10** (see FIG. 4). With this arrangement, the guide roll **20** and the return roll **22** when at the running position, that is, when at the right hand end of the guide track **34** as viewed in FIG. 4, cooperate to pass the film **18** through the bore **16** in two generally horizontal runs **18***c* and **18***d*. On the return run **18***d* the film passes over a guide roller **54**, which may be mounted on the bracket **36** for the guide track **34** or on a wall of the cleaning chamber **10**, and is directed vertically out of the solvent bath **12** toward the spray heads **24** and the dryer.

As indicated in FIG. 4, the guide rollers **20** and **54**, the return roller **22**, and of course the guide track **34** and its associated cable **40** and pulleys **42** and **44** are all submerged in the solvent bath. Accordingly, when it is desired to thread the film **18** on or to remove it from the rolls, the solvent bath preferably is drained off to a level **56** somewhat below the position of the rolls. The reversible motor (not shown) used to reciprocating the return roll **22** along the guide track **34** is, however, preferably mounted above the solvent bath. For this purpose, a second pulley groove is provided on the pulley **42** to receive an endless cable **58** leading from a drive pulley **60** on the motor shaft **46**.

As previously mentioned, the size of the cleaning apparatus can be reduced still further by using the transducer itself as the cleaning chamber and eliminatiing the separate cleaning chamber **10**. In the embodiment of the invention shown in FIG. 5, therefore, the vertically extending bore **16** of the transducer **14** is capped at the lower end by an enclosure **62** has an axial length sufficient to allow the running position of the return roll **22** to be spaced axially below the bottom end of the transducer bore **16** so as not to subject the roll **22**, slide **38** and idler pulley **44** to the intense ultrasonic energy existing within the bore. This of course is merely the preferred arrangement, and, if desired, the running position of the return roll **22** may be located within the bore **16**. In the latter instance, the bottom end of the transducer **16** may simply be closed off with a plate to confine the solvent bath **12** within the bore.

Although the cap **62** is represented as being separate from the transducer, it will be appreciated that it may be formed integrally therewith. Also, even if separate, it need not be flanged as depicted in FIG. 5, but may take any suitable configuration as design considerations may require. Similarly, the guide track **34** may be attached to the cap **62** in any suitable manner, for example, by screw fastners (not shown) received in the bottom or side wall of the cap.

Returning now to FIGS. 2 and 3, the structural details are shown of a magnetostrictive transducer that is especially suited for use with the present invention. Such a transducer is the subject of United States Pat. No. 3,406,-302, issued Oct. 15, 1968 to the Westinghouse Electric Corporation, Pittsburgh, Pa., and includes, in brief, a hollow cylinder **64** and one or more arrays **66** of annular magnetostrictive elements **68** in vibratory coupling at their inner peripheries to the outer circumferential wall of the cylinder **64**. An energizing coil **70** is toroidally wound around the arrays **66**, with the turns **72** of the coil **70** being received within axial slots **74** formed in the outer wall of the cylinder **64**.

Upon energization of the coil **70**, the arrays **66** of magnetostrictive elements are caused to vibrate in a radial mode with respect to the axis of the cylinder **64**, thereby imparting a corresponding radial vibration to the cylinder member **64** and hence to the solvent bath **12** located within the bore of the cylinder. Because of the high sound intensity levels generated within the bore **64** by this transducer construction, the solvent bath is vigorously agitated throughout both the axial and radial extents of the bore. Both sides of the film are accordingly subjected to a very thorough cleaning action as the film travels through the transducer bore.

It will be understood by those skilled in the art that the above-described embodiments are intended to be merely exemplary, in that they are susceptible of modification and variation without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. Apparatus for ultrasonically cleaning strip material comprising:

a generally cylindrical electromechanical transducer having an axial bore open at at least one end, the transducer being adapted to direct ultrasonic vibrations radially into the bore,

means for providing a solvent bath within the bore to be agitated by the ultrasonic vibrations, and

means for passing a strip of material axially through the bore in one direction and for returning it axially through the bore in the opposite direction to expose the strip to the ultrasonically agitated solvent within the bore.

2. Apparatus according to claim **1** in which the means for passing the strip through the bore includes:

a first roll positioned adjacent the one end of the transducer bore for guiding the strip into the bore in the one direction,

a second roll for receiving the strip moving in the one direction from the first roll and for guiding it in the return direction, and

means for reciprocating the second roll axially through the bore between a threading position adjacent the one end of the bore and a running position adjacent the other end of the bore, the second roll when at the running position adjacent the other end of the bore, the second roll when at the running position cooperating with the first roll to pass the strip axially through the bore in the one direction and to return it axially through the bore in the opposite direction and when at the threading position to facilitate threading of the strip on and removal of the strip from the rolls.

3. Apparatus according to claim **2** in which the means for reciprocating the second roll includes:

a guide track extending axially through the transducer bore,

means for mounting the second roll on the guide track for sliding movement therealong, and

drive means for selectively sliding the second roll along the track between the threading position and the running position.

4. Apparatus according to claim **3** in which the position of the first roll and the threading position of the second roll are spaced axially outward of the one end of the transducer bore.

5. Apparatus according to claim **4** in which:

the longitudinal axis of the transducer bore is located in a generally vertical plane with one end uppermost, and

the position of the first roll and the threading position of the second roll are above the level of the solvent bath, thereby to withdraw the strip from the solvent bath when the second roll is at the threading position.

6. Apparatus according to claim **4** in which:

the transducer bore is open at both ends,

the runing position of the second roll is spaced axially outward of the other end of the bore, and

the means for providing a solvent bath within the bore includes means enclosing in fluid tight relation

the other end of the bore and the running position of the second roll.

7. Apparatus according to claim **4** in which the means for providing a solvent bath within the transducer bore include:

a chamber containing a solvent bath, and

means for mounting the transducer within the chamber with the one end in communication with the solvent bath.

8. Apparatus according to claim **7** in which:

the transducer bore is open at both ends, at least one of which is in fluid communication with the solvent bath in the chamber, and

the runing position of the second roll is spaced axially outward of the other end of the bore.

9: Apparatus according to claim **8** in which:

the longitudinal axis of the transducer bore is located in a generally vertical plane, and

the first roll and the threading position of the second roll are above the level of the solvent bath within the chamber, thereby to withdraw the strip from the solvent bath when the second roll is at the threading position.

10. Apparatus according to claim **8** in which:

the longitudinal axis of the transducer bore is located in a generally horizontal plane, and

the means for passing the strip through the bore further includes a third roll for receiving the strip moving in the return direction and for guiding it vertically out of the solvent bath.

11. Apparatus according to claim **1** in which the transducer comprises a magnetostrictive transducer having a hollow cylinder member and an array of annular magnetostrictive elements in vibratory coupling at its inner periphery to the outer circumferential wall of the hollow cylinder member, whereby the solvent located within the transducer bore is vigorously agitated by high intensity sound energy.

12. A method for ultrasonically cleaning strip materials comprising:

providing a solvent bath within the bore of a generally cylindrical transducer having an axial bore therethrough,

energizing the transducer to agitate ultrasonically the solvent within the transducer bore,

passing a strip of material to be cleaned axially through the transducer bore in one direction and returning the strip of material axially through the transducer bore in the opposite direction, thereby to subject the strip material to the cleaning action of the ultrasonically agitated solvent within the bore.

13. A method according to claim **12** in which the strip material is passed through the transducer bore by:

threading the strip material over first and second rolls positioned axially outward of one end of the bore, and

moving the second roll with the strip material thereon axially through the bore to a position axially outward of the other end of the bore.

14. A method according to claim **13** further comprising withdrawing the strip material intact from the solvent bath after cleaning.

15. A method according to claim **14** in which the strip material is withdrawn from the solvent bath by returning the second roll axially through the transducer bore to a position axially outward of the one end of the bore.

16. A method according to claim **15** in which the strip material is easily damaged, fragile material.

17. Apparatus according to claim **1** in which the strip material is easily damaged, fragile material.

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MORRIS O. WOLK, Primary Examiner

J. T. ZATARGA, Assistant Examiner

U.S. Cl. X.R.

134—15, 122, 184

PO-1050
(5/69)

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,582,400 Dated June 1, 1971

Inventor(s) Arthur J. Miller

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 57, comma (,) should be period (.);
Column 4, line 21, period (.) should be comma (,);
Column 4, line 32, "trandsucer" should be --transducer--;
Column 4, line 36, "correspondinly" should be --correspondingly--;
Column 5, line 40, after "62" insert --which is bolted, welded or otherwise sealingly connected to the lower end of the transducer. Preferably the enclosure 62--;
Column 6, line 40, omit "adjacent the other end of the bore, the second roll when at the running position";
Column 6, line 63, insert after "with" --the--;
Column 7, line 14, "runing" should be running--.

Signed and sealed this 25th day of April 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents