Feb. 4, 1969 T. BILICHNIANSKY ET AL 3,425,357

PERISTALTIC PUMP WITH REGULAR AIR BUBBLE INTRODUCTION

Filed Aug. 23, 1967 Sheet 1 of 3

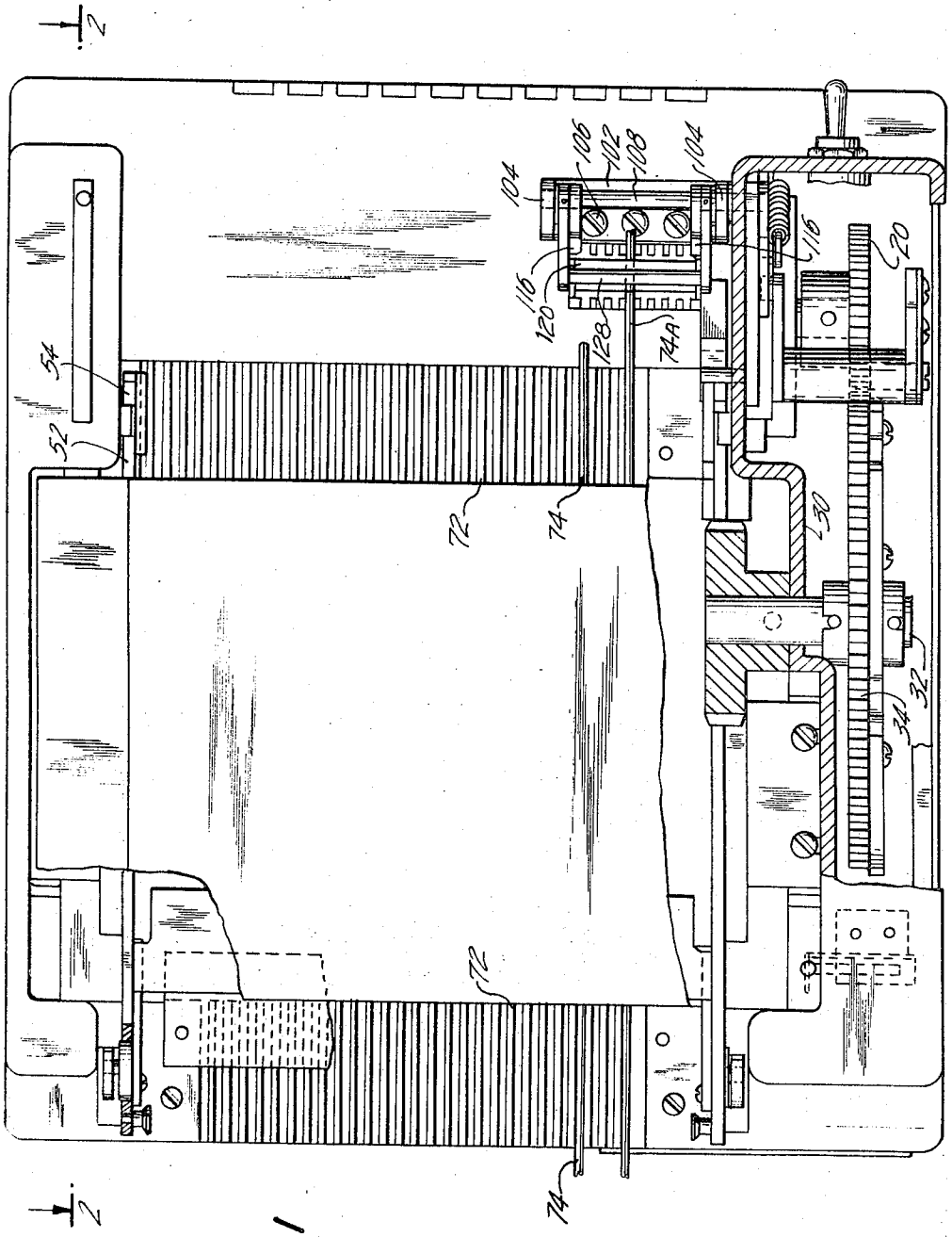


FIG. 1

INVENTORS
THEODORE BILICHNIANSKY
JACK ISREELI
WILLIAM J. SMYTHE

ATTORNEY

Feb. 4, 1969 T. BILICHNIANSKY ET AL 3,425,357

PERISTALTIC PUMP WITH REGULAR AIR BUBBLE INTRODUCTION

Filed Aug. 23, 1967 Sheet 2 of 3

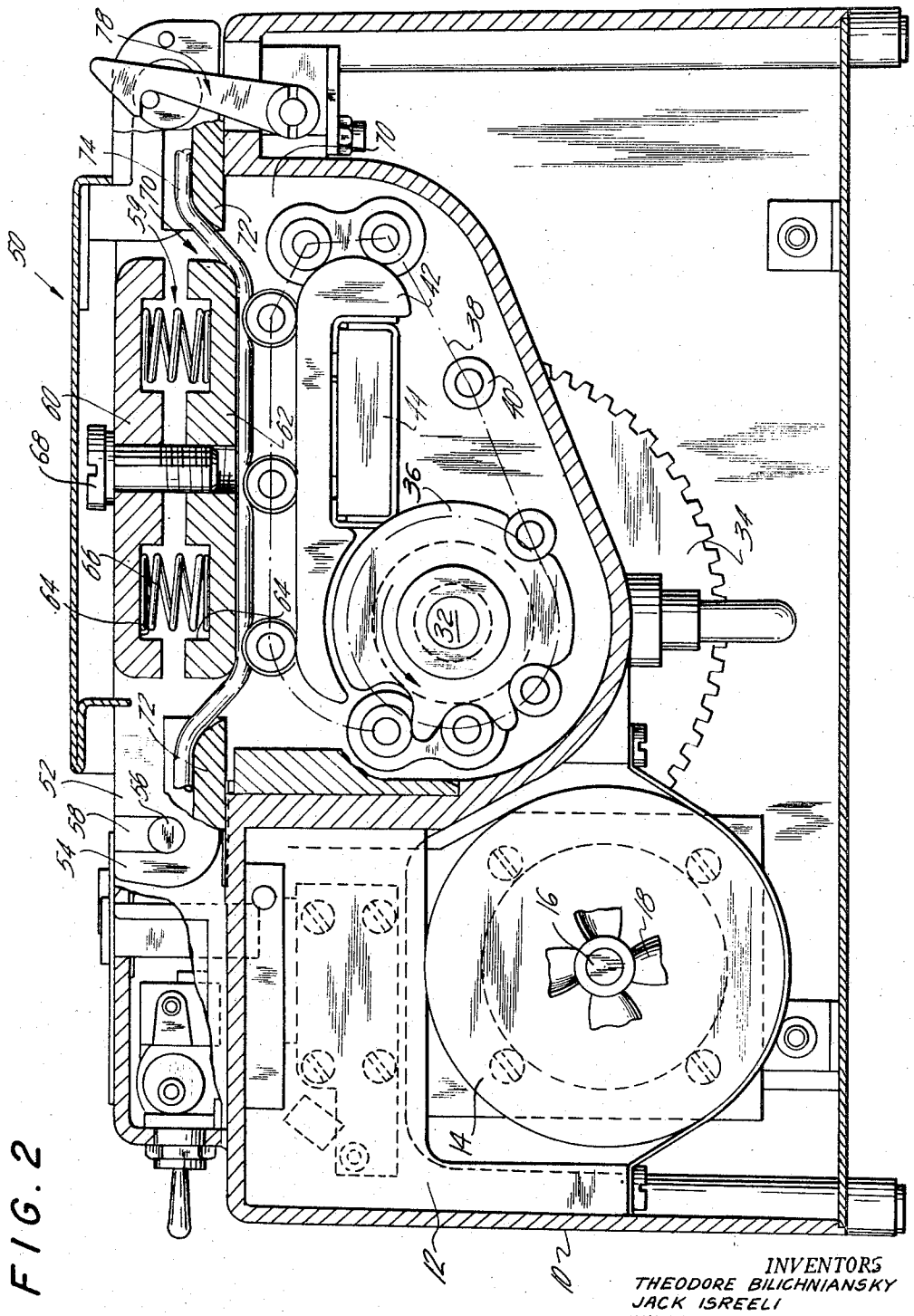


FIG. 2

INVENTORS
THEODORE BILICHNIANSKY
JACK ISREELI
WILLIAM J. SMYTHE

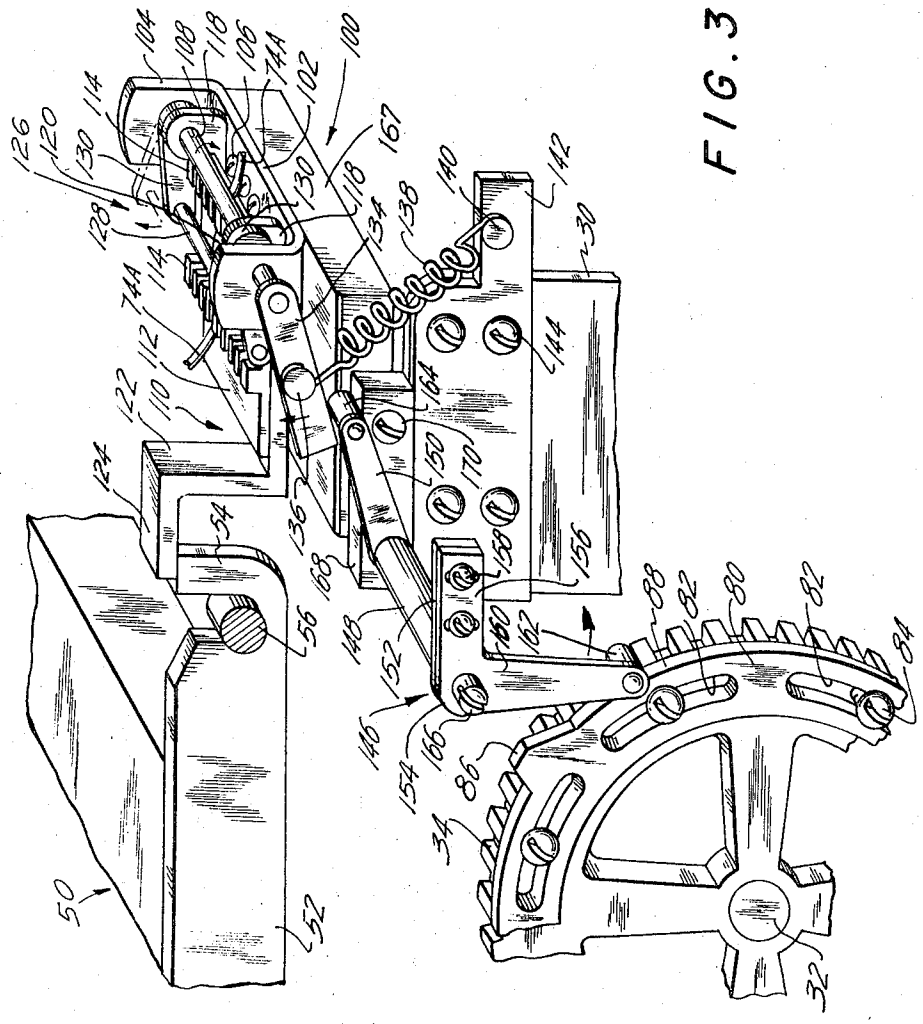
ATTORNEY

Feb. 4, 1969 T. BILICHNIANSKY ET AL 3,425,357

PERISTALTIC PUMP WITH REGULAR AIR BUBBLE INTRODUCTION

Filed Aug. 23, 1967 Sheet 3 of 3

FIG. 3



INVENTORS
THEODORE BILICHNIANSKY
JACK ISREELI
WILLIAM J. SMYTHE

ATTORNEY

United States Patent Office 3,425,357
Patented Feb. 4, 1969

3,425,357

PERISTALTIC PUMP WITH REGULAR AIR BUBBLE INTRODUCTION

Theodore Bilichniansky, Hopewell Junction, Jack Isreeli, Mamaroneck, and William J. Smythe, Rye, N.Y., assignors to Technicon Corporation, a corporation of New York

Filed Aug. 23, 1967, Ser. No. 662,795
U.S. Cl. 103—149 5 Claims
Int. Cl. F04b 43/12

ABSTRACT OF THE DISCLOSURE

A peristaltic type pump has a plurality of pump tubes in side by side relation and a plurality of rollers, each operable in sequence to concurrently engage against a platen, to progressively occlude the tubes along their lengths, and to release the tubes, to advance fluids therethrough; an additional assembly including a pressure pin and a pad for normally occluding therebetween at least one of the pump tubes; and adjustable means for causing the pin and pad to release the tube periodically, once between the occasions of successive rollers releasing the tubes. A linkage is provided coupling the platen to the additional assembly, so that release of the platen from the tubes causes a release of the pin and the pad from the tubes.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to fluid pumps, and particularly to flexible tube or peristaltic type proportioning pumps which are advantageously utilized in flowing stream analytical systems.

Description of the prior art

In systems of this kind, a flowing stream of sample liquid, which stream may be a continuous monitoring stream, or a stream of sequential liquid samples, is continuously mixed in a predetermined proportion with one or more reagents, and otherwise processed to provide a color reaction, the optical density of which at a particular wavelength is responsive to the concentration of a constituent of interest in the original sample. Such a system was initially disclosed in U.S. Patent No. 2,797,149, issued to L. T. Skeggs on June 25, 1957. Customarily, the flowing stream of sample plus reagent is divided into sequential segments, each succeeding segment of sample plus reagent being spaced from the preceding segment by a gas segment. Each segment of sample plus reagent is then mixed up as it flows along in the stream, as shown in U.S. Patent No. 2,933,293, granted to A. Ferrari, Jr. on April 19, 1960. The streams of sample and reagent are supplied in a predetermined proportion to a junction by a peristaltic proportioning pump, such as is shown in U.S. Patent No. 2,935,028, granted to A. Ferrari Jr. et al. on May 3, 1960, or U.S. Patent No. 3,227,091, granted to J. Isreeli et al. on Jan. 4, 1966. In such a pump a plurality of resiliently compressible tubes are disposed in side by side relation, and are all concurrently, and each progressively, occluded by a series of rollers, to positively advance fluids through these tubes. The relative proportion of volumetric rate of flow of these fluids are substantially determined by the relative inner cross-sectional areas of the respective tubes.

In U.S. Patent No. 3,306,229, granted to W. J. Smythe on Feb. 28, 1967, it is taught that the relative proportions of volumetric rate of flow through the tubes do not remain constant during the period of operation of the pump. When the leading roller fully occludes the tubes, the relative proportions are constant. However, as the

leading roller rises away from the tubes, the porportions will change if the tubes are of different internal diameters. This transient change in proportions between the sample and the reagents may affect the accuracy of the analysis system, which accuracy is premised on constant proportions. The solution to this problem taught by U.S. Patent No. 3,306,229 is the provision of a peristaltic pump having a plurality of rollers and a plurality of pump tubes, one tube for advancing the sample, one or more tubes for advancing one or more reagents respectively, and a tube for advancing a different, immiscible therewith fluid, such as a gas, the outlets of said tubes being connected to a junction means, and means to admit a volume of the gas from its tube to said junction means in synchronism with the withdrawal and disengagement of each roller from all of said tubes. The uniformly periodic gas segment serves to provide identical liquid segments of sample plus reagents. While such liquid segments initially may not be of uniform proportion throughout the length thereof, subsequent mixing is provided to homogenize each such liquid segment. This results in successive liquid segments, each having uniform proportions throughout their respective lengths, and each such segment being identical to the others in such proportions.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved peristaltic pump having an auxiliary means for occluding the gas tube and timing the release of gas therefrom, wherein provision is made for the release from compression of all of the tubes, including the release of compression of the gas-supply tube by said auxiliary means, when the pump is not in use, thereby precluding the development of a permanent set in any of these tubes. Another object is the provision of means for easily adjusting the phasing between the release of the tubes by the leading roller and the admission of the gas segment to the junction means to segmentize the flowing stream of sample plus reagent.

In accordance with the present invention the gas supplying tube is normally occluded between an anvil and a cross-pin, the cross-pin being withdrawn from the tube periodically in phase with the withdrawal of the leading roller from the sample and reagent supplying tubes. When the pump is deactuated, means are provided to withdraw the anvil from the gas supplying tube. Further, a cam is provided, which is adjustably coupled to the drive means for the rollers, to periodically actuate the release of the cross-pin from the gas-supply tube.

BRIEF DESCRIPTION OF THE DRAWING

There and other objects, features and advantages of the present invention will be apparent from the following description considered in conjunction with the accompanying drawing, in which:

FIG. 1 is a top view in plan of a peristaltic proportioning pump embodying this invention;

FIG. 2 is a side view in elevation, taken along plane 2–2 of FIG. 1; and

FIG. 3 is a detail, broken away, in perspective, showing the gas supply tube valving assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As seen in the drawing, the embodiment of the invention is incorporated into a peristaltic type pump of the type shown in U.S. Patent No. 3,227,091.

Briefly, the pump includes an outer housing **10**, within which there are fixed two support plates **12**, and to which there is fixed a motor **14** with an output shaft **16**. A fan blade **18** is fixed to one end of the shaft **16**, and a drive gear **20** is fixed to the other end.

Two inner side walls **30** are fixed within the housing and a cross shaft **32** is journaled between and through these inner side walls. External to one side wall, a driven gear **34** is fixed to the shaft **32** and is meshed with the drive gear **20**. Within the side walls, two spaced apart sprocket wheels **36** are fixed to the shaft **32**. Each sprocket wheel **36** meshed with a respective endless sprocket chain **38**. A plurality of rollers **40** are journaled to and between the two chains and, during the upper run of the chains, pass over two spaced apart guide plates **42**. The guide plates are fixed to a cross-bar **44** which is fixed between the side walls **30**.

A cover assembly **50** has two side walls **52**, each of which has a hook portion **54** adapted to fit under and pivot about a respective horizontal stud **56**. Each stud **56** is fixed to a respective sidewall of the main housing **10**. A multi-piece resilient platen **59** is mounted within the cover assembly, and includes an upper part **60** which is secured to and between the side walls **52**, and a lower part **62**. These two parts have a plurality of mutually opposed cavities **64** into which are disposed a respective of compression springs **66**. The lower part is mutually captured to the upper part by a plurality of machine screws **68**. An aperture **70** is formed in the top of the main housing **10**, and the platen extends therethrough. A pair of grooved, spaced apart, pump tube locating blocks **72** are releasably mounted to the top of the housing adjacent to the aperture and a plurality of pump tubes **74** may be disposed between the two blocks over the aperture in side by side relation. When the cover assembly is swung down, to the position shown in FIG. 2, and locked in place by a lock assembly **78**, the pump tubes are pressed downwardly by the lower face of the lower part **62** of the platen assembly against those rollers **40** which are riding on the upper edges of the guide plates **42**, and the tubes are occluded by these rollers. When these rollers are advanced by the sprocket chains, they progressively occlude these tubes along their respective adjacent lengths, advancing such fluids as are contained therein. It will be noted that at least two rollers are always in occluding engagement with the tubes.

When the pumping operation is discontinued, either to replace pump tubes or otherwise, the lock assembly **78** is released, and the cover assembly is pivoted upwardly about the studs **56**, thereby removing the platen from the pump tubes and releasing them from compression by the rollers.

As shown in U.S. Patent No. 3,306,229, it is desirable to limit the flow of the segmentizing gas from one or more of the pump tubes into the sample conduit to intervals of uniform duration which occur regularly, periodically, between those occasions when the rollers **40** are leaving the pump tubes. This is accomplished by closing the downstream end of such gas advancing pump tubes, except when a volume of gas is to be introduced into the sample conduit. Specifically those gas advancing pump tubes are normally pinched closed, except when the gas volume is to be released. It is also desirable that this pinching be released when the pumping operation is discontinued.

As is most conveniently seen in the perspective view of FIG. 3, a cam ring **80** is adjustably secured to the gear **34**, which gear is secured to the sprocket cross shaft **32**. The cam is provided with a plurality of interrupted annular slots **82** through which the shanks of respective clamping screws **84** pass into threaded bores on the gear **34**. The cam ring **80** has a plurality of rises **86** regularly disposed along its peripheral camming surface **88**. Depending on the tooth ratios of the gears **20**, **34**, the sprocket wheels **36** and the chains **38**, there is one rise **86** for each roller **40**.

A gas tube block assembly **100** is disposed on the top of the main housing **10**. This assembly **100** includes a U-shaped block support **102** having two spaced apart, upstanding legs **104**. The support **102** is fixed to the main housing **10** by a plurality of machine screws **106**. A shaft **108** is journaled between and through these legs **104**. A gas tube block support **110** is pivotally journaled on the shaft **108**. This support includes a horizontal plate portion **112**, having two spaced apart pluralities of upstanding spaced apart teeth **114**, each plurality of which provide tube receiving grooves therebetween. Forwardly of these teeth, the plate has two spaced apart arms **116** which terminate in two upstanding ears **118**, through which passes the shaft **108**. A resilient pad **120** is adhered to the plate between the two pluralities of teeth. Rearwardly, the plate **112** has an inverted-L-shaped portion **122**, whose toe **124**, rests on and is raised by the end of the hook portion **54** of the cover assembly, when the pump is in the pumping posture. When the pump is in the non-pumping posture, the end of the hook is pivoted away from the toe of the portion **122** and the plate pivots downwardly, about the shaft **108**, until it is halted by the main housing. A pressing pin unit **126** is fixed to the shaft **108**. This unit includes a pressing pin portion **128** which has two spaced apart arms **130** whose distal ends are fixed to the shaft **108**. A pressing pin actuator arm **134** is fixed at one end thereof to one end of the shaft **108**. This arm has a stud **136** intermediate its length to which is secured one end of a tension spring **138**. The other end of the spring is secured to a stud **140** fixed to a bracket **142** which is mounted by a plurality of machine screws **144** to the side wall **30**.

A cam follower assembly **146** includes a cam link unit having a cylindrical body **148**, an arm **150** extending from one end thereof and an arm **152** extending from the other end thereof. An adjustable cam link assembly **154** is adjustably fixed to the arm **152**. This assembly includes an arm **156** having elongated bores therein, through which pass a plurality of machine screws **158** into threaded bores on the arm **152**, and an arm **160** which has a cam follower roller **162** journaled to its distal end. A camming roller **164** is journaled to the distal end of the arm **150**. A bearing, not shown, is disposed through the body portion **148** and the junction of the arm **156** and **150**, and a machine screw **166** passes through this bearing to pivotally mount the assemblies **146** and **154** through a pad **168** and the sidewall **30** to a support plate **167**. The plate **167** is fixed to the main housing by a plurality of machine screws **170** and **106**.

The roller **162** rides on the peripheral surfaces **88** of the cam **80**, while the roller **164** is spaced slightly from the lower edge of the arm **134**. The angle included between these two rollers with respect to the axis of rotation through the machine screw **166** may be finely adjusted by means of the elongated slots and the machine screws **158**, and will control the length of the interval that each cam rise **86** will cause the pin **128** to clear the pump tubes.

The tension spring **138** maintains the arm **134** downwardly with a corresponding downward bias of the pressure pin **128**, occluding any pump tube, such as **74A**, which may be disposed through the grooves between the teeth **114**, and the resilient pressure pad **120**. When the cover assembly **50** is raised, the hook **54** releases the portion **124**, the plate **112** drops downwardly, with the resilient pressure pad **120**, to release these tubes from contact with the pressure pin **128**. Thus, the compression of these pump tubes **74A** during an interval of non-pumping is avoided, and such permanent deformation of those tubes as might be caused by such compression is precluded.

It will be appreciated that, as previously mentioned, the fine adjustment of the arms **156** and **158** permits adjusting the length of the air bubble. The ramp on the cam rise **86** forces the roller **162** to work against the spring **138**. The adjustment can be such that the roller **164** engages the arm **134** when the roller is at the bottom of the ramp for a long air bubble, or at the top of the ramp for a short air bubble.

While a preferred embodiment of this invention has been shown and described, it will be understood that the

invention may be embodied otherwise than as herein specifically illustrated or described, and that changes in the form and arrangement of the parts and in the specific manner of practicing the invention may be made without departing from the underlying principles of the invention within the scope of the appended claims.

What is claimed is:

1. A peristaltic type pump comprising:

a plurality of pump tubes; releasable means for causing said tubes to pump including a platen and a plurality of rollers, each roller operable in sequence to concurrently engage said tubes against said platen, to progressively occlude said tubes against said platen along their lengths, and to release said tubes; and

an additional assembly including occluding means for normally occluding at least one of said pump tubes downstream of said platen and said rollers, and adjustable means coupled to said means for causing said tubes to pump, for causing said occluding means to release said normally occluded pump tube periodically, once between the occasions of successive ones of said rollers releasing said pump tubes, and intermediate means coupled to said means for causing said tubes to pump and to said occluding means for causing said occluding means to release said normally occluded pump tube in response to said means for causing said tubes to pump being released from said tubes.

2. A pump according to claim 1 wherein said occluding means includes a pressing pin and a pad for compressing said one tube therebetween, and said intermediate means serves to space said pin and said pad apart to release said tube in response to said platen being spaced from said rollers to release said tubes.

3. A pump according to claim 2 wherein said means for causing said tubes to pump includes:

a motor coupled to and driving a shaft on which are fixed two sprocket wheels, which engage and drive two spaced apart endless sprocket chains, which carry therebetween said rollers;

said adjustable means includes a cam coupled to said shaft and a linkage operated by said cam coupled to said occluding means for spacing said pin from said pad, said cam being adjustable in phase angle to said shaft.

4. A pump according to claim 2 wherein said intermeditae means includes a linkage coupled between said platen and said pad, whereby when said platen is moved away from said rollers to release said tubes, said pad is moved away from said pin.

5. A pump according to claim 3 wherein said linkage is adjustable to vary the length of time interval during which said pin is spaced from said pad by the operation of said cam.

References Cited

UNITED STATES PATENTS

2,935,028	5/1960	Ferrari et al.	103—149
3,227,091	1/1966	Isreeli et al.	103—149
3,306,229	2/1967	Smythe	103—149

WILBUR J. GOODLIN, *Primary Examiner.*

DONLEY J. STOCKING, *Assistant Examiner.*