Oct. 18, 1966 A. L. SCHWARTZ 3,279,773

GAS DISTRIBUTING STRUCTURE

Filed Oct. 31, 1963

Fig. 1

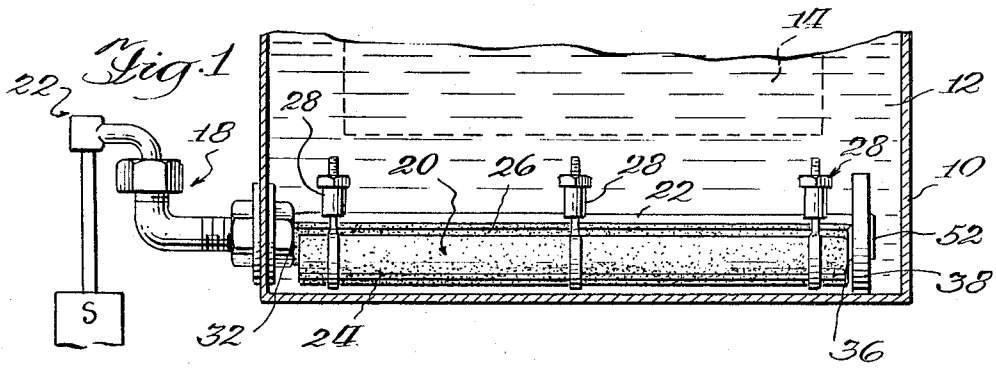
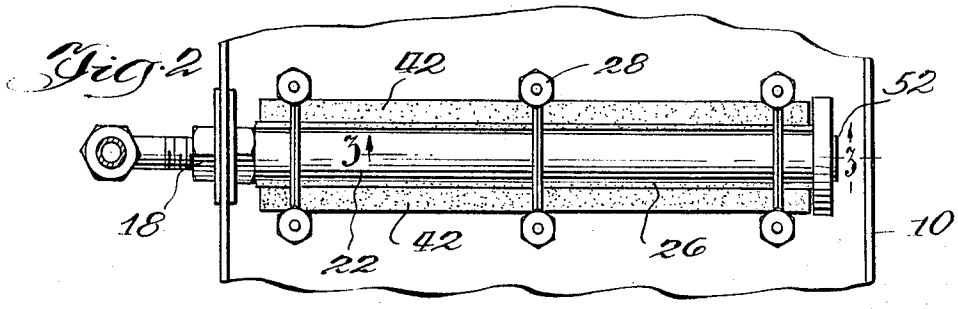
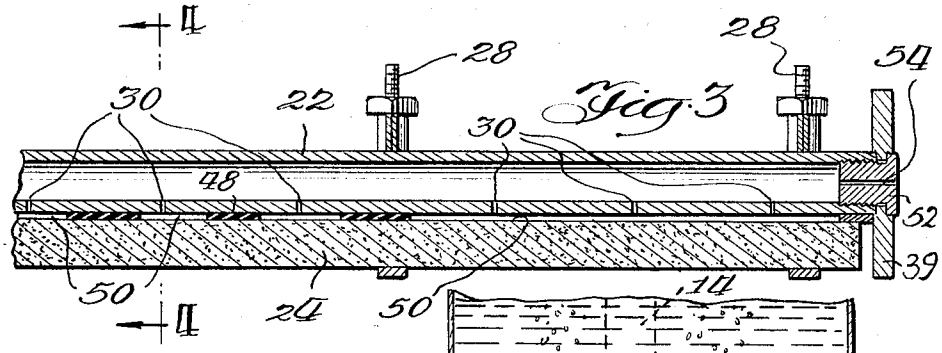


Fig. 2





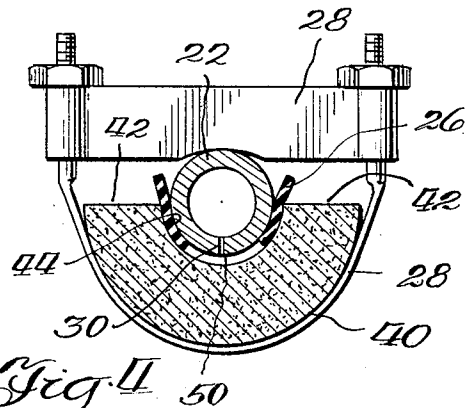


Fig. 4

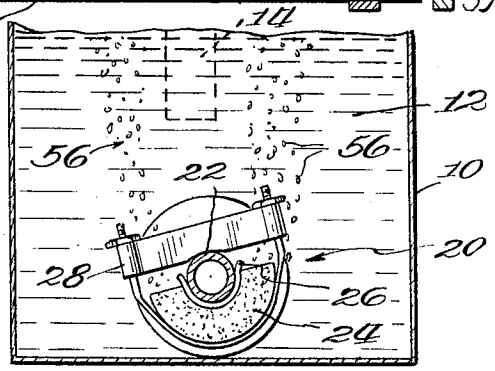


Fig. 5

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GAS DISTRIBUTING STRUCTURE

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This invention relates generally to gas burst fluid agitation apparatus and more particularly, concerns a novel gas distributing structure or plenum for use in said agitation apparatus, said plenum capable of discharging intermittent bursts of tiny bubbles of gas into a solution uniformly over the axial length of said plenum for agitating the solution.

The advantages of utilizing bursts of gas for agitation of solutions are well known. Gas burst agitation systems are particularly useful in photographic film processing procedures where proper agitation of processing chemicals can be a critical factor in achieving the desired processing results. Systems of this character generally include, in addition to a source of pressurized gaseous fluid, control valve means for adjusting the pressure of said gas and valve means for delivering the gas in intermittent bursts to a gas distributing means commonly referred to as a plenum. Heretofore, the plenum comprised an elongate hollow tube having a plurality of spaced holes in the circumferential wall along the length thereof. The plenum was closed off at one end and connected at the other end thereof to the source of gas through the control valve means. The plenum usually was installed at the bottom of the processing tank. Intermittent bursts of gas were introduced into the solution from the said openings so as to agitate the solution by travel to the surface thereof. Regardless of the fineness of said openings in the plenum the gas was released in the form of relatively large bubbles which travelled to the surface of the processing fluid in streams non-uniform over the length of the plenum. One major disadvantage of serious consequence in previous agitation of photographic processing chemicals, for example, caused by such uneven release of gas in large bubbles, was the considerable variance in the distribution of the chemical reactants over the sheet of film. Streaking and/or other similar undesirable processing results are encountered. Great effort has been directed toward reducing the size of the bubbles, but no solution was available which did not itself have its own dominating disadvantages.

In addition to the problem of such uneven streaming and large bubbles, prior structures required the use of large volumes of gas to assure sufficient agitation. However, when large gas volumes were used, an excessive rise and fall of solution level was experienced during each burst of gas. While gentle rise and fall of liquid level is desired for its scrubbing action upon the film sheet, the rise and fall action of the solution from large volumes of bubbles of gas results in uneven distribution of the processing solution over the film sheet to again result in non-uniform processing results. Further, large bubbles also caused displacement of and damage to the thin film sheets by buffeting thereagainst thereby to urge one sheet into contact with another or with the sides of the tank.

It has been known that bubble size may be reduced through the use of a porous dispersing medium as a plenum structure such as an elongate tube of porous stone material. Gas may be introduced into the porous tube, be dispersed therein to pass through the interstices of said porous medium to be discharged into the solution. The use of a porous stone plenum entails certain disadvantages which limit use thereof in gas burst systems. Among these disadvantages are the return seepage of the processing solution into the porous tube during intervals between bursts of gas. Upon initiation of each burst of gas, a substantial weight of solution is required first to be moved before the gas is permitted first to pass through the length of the tube and then to pass through the porous dispersing walls of the tube to produce even distribution of discharge. Rather than move such a weight of solution, the gas seeks a path of least resistance and tends to be discharged at the immediate vicinity of the entrance of the gas interior of the plenum. Substantial agitation thus is experienced at one end of the plenum while only a few gas bubbles are released at the far end thereof. Solution impervious linings have been utilized interior of the tube and along the entire length thereof. Such linings were provided with a series of laterally spaced openings arranged whereby some gas was trapped to remain interior of the plenum between bursts. Although the non-uniformity of burst was reduced by the last described expedient, the gas was still discharged unevenly into said solution, with larger volumes of bubbles being discharged at perhaps one or more areas of the plenum. During the course of the manufacture of the porous stone tubes, as by casting, it is necessary to slightly taper the bore thereof. Such tapering, although relatively minor, produces stone tubes of uneven wall thickness. It is believed that in such prior stone plenum tubes, the gas preferentially will rush to and through areas of lesser wall thickness. Therefore at each gas burst, more gas would be released through the porous wall portions of lesser wall thickness than through the other portions of the wall with resulting uneveness of gas discharge to the solution in the processing tank.

Accordingly, it is a principal object of the invention to provide a gas distributing structure or plenum for use in a gas burst fluid agitation system wherein the disadvantages of prior structures enumerated above are substantially eliminated.

Another object of the invention is to provide a plenum as described which includes a porous member having means for preventing gas introduced thereinto from rushing to any area of lesser wall thickness and to insure the discharge of tiny bubbles of gas uniformly over the entire length of the plenum.

Still another object of the invention is to provide a plenum of the character described which includes an elongate tube or pipe of fluid impervious material closed at one end and connected at its other end to a source of gas by means of conventional conduit and valve arrangements, means for introducing gas into the plenum in intermittent bursts while said plenum is submerged within a fluid solution to be agitated, said tube being provided with a row of minute passageways in the circumferential wall and along the length thereof, said tube having a jacket of porous material covering a portion of said wall, a gasket of resilient material interposed between the tube and jacket in sealing relation thereto, said gasket having at least a pair of elongate slots formed therethrough, the tube and gasket arranged so that the minute passageways are aligned with the slots to open thereinto, the gasket forming a barrier to prevent the gas from rushing to any area of the porous jacket which is of lesser wall thickness and clamping means are provided for securing tube, jacket and gasket in tight assembly.

A further object of the invention is to provide a plenum of the character described hereinabove wherein the porous jacket is formed as an elongate porous stone member of arcuate cross section having a pair of planar upper surfaces separated by an elongate groove running parallel thereto, said groove having a radius of curvature substantially the same as that of the said fluid impervious tube whereby the latter may be received within said groove with the gasket sandwiched therebetween and

the passageways of the tube facing the wall of said groove.

A still further object of the invention is the provision of a plenum structure which includes a porous stone gas diffusing member formed as a longitudinal section of a conventional, elongate tube of porous stone material so that one tubular member can be used to form at least a pair of porous jackets in accordance with the invention, each one of which pair is capable of use in a different plenum.

The invention has a further object thereof the provision of a plenum of the character described wherein the stream of bubbles discharged from the plenum takes the form of two distinct columns rising to the solution surface without creating a vortex thereof close to the plenum body and in which the relative volume of bubbles in each column may be controlled, thereby permitting greater adaptability of the plenum structure for use with tanks of differing width.

Other objects and advantages of the invention include the provision of a plenum which is easily assembled and taken apart for service and/or replacement of parts, which is formed of parts easily and economically manufactured and which may be provided with bleed means, adjustable or non-adjustable, attached thereto or merely connected therewith for regulating the interior pressure of gas in the plenum during periods of quiescence between bursts.

The foregoing and other objects of the invention will be apparent as the description of a preferred embodiment of the invention ensues in conjunction with the accompanying drawing. It is contemplated that minor variations in the arrangement, proportions, dimensions and construction of the several parts may occur to one skilled in this art without departing from the scope or sacrificing any of the advantages of the invention.

Referring now to the drawing:

FIG. 1 is a vertical sectional view taken through a processing tank containing a photographic processing solution and illustrating the plenum of the invention operatively installed therein.

FIG. 2 is a plan view of said plenum in said processing tank, partially shown.

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2 and in the general direction indicated.

FIG. 4 is an enlarged sectional view taken through said plenum along lines 4—4 of FIG. 3 and in the general direction indicated.

FIG. 5 is a sectional view taken along lines 5—5 of FIG. 2 but with the plenum axially tilted to vary the direction of flow of the gases discharged therethrough.

Referring now to the drawing, in FIG. 1 plenum **20** embodying the invention is illustrated installed submerged in a tank **10** containing processing fluid **12** to be agitated. The fluid **12** comprises a photographic processing chemical solution and a sheet of film negative **14** is shown suspended in said fluid. A source S of pressurized gas, preferably nitrogen, is connected by means of conduit **16** and suitable coupling means shown generally at **18** through the tank **10** to the plenum **20**. Suitable regulatory means **22** may be coupled to said source for regulating and controlling the timing and pressure of the gas supplied to the plenum **20** whereby the gas is supplied in intermittent bursts with low pressure or quiescent intervals between bursts.

The plenum **20** comprises an elongate tube or pipe **22** formed of fluid impervious material such as of plastic, metal or glass, a jacket member **24** of porous material and a resilient gasket **26** sealably sandwiched therebetween and held by suitable clamps **28**. The tube **22** is provided with a series of spaced, passageways **30** in the circumferential wall and along the length thereof. The pipe **22** also may be provided with suitable interior and exterior threading at both ends to permit one end **32** of gas and the other end **36** to be closed off by plate assembly **38**.

The porous jacket **24** is of semi-cylindrical elongate configuration having an arcuate surface **40** and a pair of planar top surfaces **42**, said planar surfaces **42** being separated by the arcuate groove **44** along the full length of the jacket **24**. Surfaces **42** preferably will lie in the same horizontal plane. The jacket **24** preferably is formed by severing an elongate hollow tube of porous stone material, such as commonly available under the trademark of "Carborundum," into a pair of half-sections, each half-section then being utilized as a jacket **24** for a plenum **20**. In this manner, jackets for at least two plenums may be formed from a single length of stone tubing. The groove **44** is adapted to receive the tube **22** therein and therefore has a radius of curvature substantially equal to the radius of curvature of the tube **22**. The jacket is chosen to be of a length slightly less than the tube **22** so that the latter tube extends past the ends of the jacket for ease of sealing off and connection in the system.

The gasket **26** comprises an elongate, relatively flat, and generally rectangular strip of resilient material such as rubber, plastic or the like, and is adapted to be seated within the groove **44** of jacket **24** with the tube **22** placed thereupon. The gasket **26** is provided with at least a pair of elongate slots **50** formed therethrough and extending lengthwise of the gasket **26**. The slots **50** are separated one from the other by portions of the gasket which may be referred to as bridging portions **48**. The gasket is placed within the groove **44** so that slots **50** are located also within the said groove. The tube **22** is disposed upon said gasket **26** whereby the passageways **30** are aligned with the slots **50** so as to open thereinto.

The assembly comprising tube **22**, gasket **26** and jacket **24** is held together with suitable clamps of a conventional nature such as U-shaped clamps **28**. The end **36** of the tube **22** is closed off with a plate assembly **38** which includes a plug **52** threaded at its narrow end and having its wider end or head set within a coupling plate **39**. The threaded plug is provided with a small diameter bore **54** adapted to function as bleed means for relieving any excessive gas pressure remaining in the interior of the tube **22** during quiescent periods. Other conventional bleed means (not shown) may be utilized which is not part of the plenum but is connected somewhere in the agitation system. The said plate **39** also serves as a support or rest to hold the uncoupled end **36** of the plenum substantially parallel to the floor of the tank **10**. When the plenum **20** is so assembled, and the clamps **28** tightened, the gasket **26** is tightly sealingly sandwiched between the tube **22** and the jacket **24**. When the gas is introduced into the plenum, same will pass along the interior of the tube **22** for the entire length thereof. The gas will pass out of the tube **22** through the passageways **30** into chambers formed by the slots **50** of the gasket **26**. The gasket seals off these chambers so that no gas may flow therepast. The gas is thus forced to travel through the porous wall of the jacket. It is believed that because the gas is prevented by the gasket from rushing immediately to any areas of lesser wall thickness of the jacket, there is sufficient gas pressure along the entire length of the plenum to assure discharge of said gas evenly along the entire length thereof. In this way the deleterious effect of uneven wall thickness upon the evenness of gas discharge is neutralized.

During periods between bursts of gas, a residual gas supply remains within the tube **22** permitting the gas to have access to the full length of the interior of the tube **22** without the necessity of moving a substantial weight of solution. Excessive pressure of gas between bursts may cause continued agitation during these periods. Such agitation is not desired. Excessive pressure of gas may be reduced by the bleed means comprising the small diameter bore **54** formed in the end plug **52**. A needle valve of conventional design (not shown) may be in-

serted within the bore **54** to render the said bleed means adjustable. Although the embodiment of the invention described discloses bleed means as an element which is a part of the plenum, it is contemplated that other bleed means may be utilized where the same is not directly a part of the plenum. The specific location of the bleed means within the system is not critical to the invention. It is advantageous to include such bleed means as a part of the agitation system in preference to omitting the same, although important advantages of the plenum embodying the invention can be realized without the bleed means.

The flow pattern of the gas discharged from the jacket **24** takes the form of two distinct columns **56**. The bubbles of gas rise evenly along the length of the jacket **24**. However, the volume of bubbles contained in the two columns may vary. If the planar surfaces **42** are parallel to floor of the tank, as shown in FIG. 1, then each of the columns is substantially of equal volume. If on the other hand, the plenum **20** is tilted by rotating same on its axis so that surfaces **42** are disposed on a plane which intersects a horizontal plane parallel to the floor of the tank, a portion of the arcuate surface **40** will be placed at a greater distance from the floor of the tank than the remaining portion which will be disposed closer to the floor of the tank. A greater volume of gas bubbles will be released from the former portion than from the latter portion. In this manner the volume of gas in each column may be controlled simply by axially tilting or rotating the plenum.

The pair of columns **56** released from the plenum, either in the position shown in FIG. 1 or tilted as in FIG. 5, tend to remain separated until they transverse some distance from the plenum. Control thus is not only capable of being achieved over the volume of gas being discharged from each side of the plenum but some control of the direction of flow of said columns **56** also may be exercised by axially rotating the plenum so that the planar top surfaces **42** lie in a plane other than parallel to the floor of the tank.

The plenum **20** may serve to produce agitation sufficient for a tank of greater width than heretofore was capable of being serviced by a single prior plenum structure. Further, utilizing a pair of prior plenum structures in a wider tank involved the production of substantial agitation in the area between plenums with lesser agitation evolved at the side portions of the tank. Even where a pair of plenum structures **20** of the invention are utilized side by side, the gas columns rising in the area therebetween would tend to merge. Since the volume of the respective columns may be controlled, the plenums **20** may be rotated axially so that their respective planar surfaces **42** face away from one another. In this manner, a larger volume of gas will be discharged along that portion of each plenum which is adjacent the side of the tank, the remaining portion of each of the plenum which are adjacent one another, or at the area between the pair of plenums, will produce fewer bubbles. These fewer bubbles rise in columns which may combine into a single column. The volume of gas in the thus combined columns, instead of being twice the colume of the columns adjacent the sides of the tank, is merely about the volume normally expected with a single plenum's column when its planar surfaces are in a parallel plane relative that of the floor of the tank.

An actual installation has revealed that the maximum advantages of the invention may be obtained with a semi-cylindrical section of stone. Even when a quarter of an inch is removed from each of the surfaces **42** so that the same are no longer in the same plane, the formation of the distinct columns rising for a distance from the plenum is markedly effected. The columns actually produced by such a modified plenum tend to come together at a distance much closer to the said plenum than encountered in the embodiment thereof utilizing a semi-cylindrical cross-section stone. While such variation in the dimension of the arcuate exterior surface of the plenum reduces the effectiveness of the invention so far as the obtaining of distinct columns is concerned, the significant advantage involving uniformity of discharge of gas bubbles over the entire length of the plenum structure is not affected significantly by reduction in said available arcuate surface so that even longitudinal third or quadrant sections may be successfully utilized. All that is required so far as the realizing the principal advantage of uniformity of discharge over the length of the plenum is concerned, is that the jacket **24** be in sealed engagement over the edges of the slots formed in the gasket. An arcuate surface slightly greater than 180 degrees of arc may also produce evenness of burst, although increasing said arcuate surface may result in movement of the two columns of bubbles closer together nearer the plenum structure.

To obtain proper operation of the plenum, it is required that a residual amount of gas remain in pipe **22** after bursting or discharge of gas through jacket **24** to solution **12**. This is realized by controlling the member and size of passageways **30** so that not all the gas introduced into pipe **22** will pass through passageways **30** and a residual amount of gas will remain in pipe **22** between burts. Further, where an excessive residual amount of gas remains in pipe **27**, the bleeds means is effective to withdraw excess gas. Under certain circumstances, it may be desirable to enlarge certain of the passageways **30** so that more uniform gas burst will result where the device has been tilted relative to horizontal and remained in this position for some time between bursts. It may be necessary to use such an enlarged passageway to eliminate any liquid accumulation in pipe **22** at an end thereof.

A practical plenum structure according to the invention was constructed having parts of the following dimension:

Jacket **22**:
- 10 inches long.
- 1.75 inches in diameter.
- 7/8 inch groove width.
- 5/16 inch in groove depth.

Gasket **26**:
- 10 1/16 inches long.
- 1.5 inches in width.
- 2 slots, 4 5/8 inches long, 3/8 inch wide.

Tube **22**:
- 11 1/8 inches long.
- 5/8 inch outer diameter.
- 1/2 inch inner diameter.
- 4 passageways, each 1/32 inch in diameter.

What I claim is:

1. In a gas burst fluid agitation apparatus in which a plenum is immersed in a tank of liquid for agitation thereof and a gas from a source thereof is introduced into and distributed by the plenum in intermittent bursts; a plenum structure comprising an elongate hollow tube of fluid impervious material having one end thereof for connection to a source of intermittent bursts of gas and the other end thereof closed off, said tube having a plurality of spaced passageways of small diameter formed in the circumferential wall of the tube and along the length thereof, an elongated jacket of porous material adapted to cover a portion of said wall and a fluid impervious resilient gasket interposed between the tube and the jacket, said gasket having at least a pair of separated slots therethrough, said passageways of the tube and said slots of the gasket being aligned whereby said passageways open into said slots, means for clamping said tube, jacket and gasket together for forming said structure, the gas being introduced into the tube passing through the passageways to emerge in fine bubbles uniformly over the full length of the jacket regardless of variations in the thickness of the jacket wall.

2. The plenum as claimed in claim 1 in which said jacket is of semi-cylindrical configuration.

3. The plenum as claimed in claim 1 in which bleed means for relieving excess gas pressure within the tube is connected at the said other end of the tube.

4. The plenum as claimed in claim 1 in which said jacket is formed as an elongated longitudinal section severed from an elongate tube of porous stone material.

5. The plenum as claimed in claim 4 in which said jacket comprises a substantially half section taken longitudinally along a tubular stone member.

6. The plenum as claimed in claim 1 in which said jacket has an arcuate cross-section of less than 180° and greater than 90° of arc.

7. A gas distributing structure for gas burst fluid agitation apparatus including a source of gas and means for supplying gas in bursts to the interior of structure, a generally cylindrical gas impervious tube closed off at one end thereof and connected to said source at the other end thereof, said tube having a plurality of spaced small diameter passageways formed therein along the length thereof, a compressible gasket member adapted to overlie a portion of the arcuate surface of said tube and a jacket member adapted to be tightly engaged over said gasket member, said gasket member having at least a pair of separated elongated slots formed along the length thereof, said passageways and said slots being aligned to permit passage of gas therethrough, the portions of the gasket

defining the slots being sealably engaged with both tube and jacket at said slots to prevent rush of gas to areas of lesser jacket wall thickness whereby the gas passes into the jacket wall through said slots whereby to be dispersed through the porous wall and be discharged in uniform bubble bursts over the length of said jacket.

8. The structure as claimed in claim 7 in which said one end of the tube has bleed means operatively connected thereto.

9. The structure as claimed in claim 7 in which said jacket has a pair of planar top walls separated by a groove, the radius of curvature of said groove being substantially the same as the radius of curvature of said tube.

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