United States Patent

[11] 3,618,778

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[73]	Assignee	Ethyl Corporation New York, N.Y.

[54] **LIQUID-TREATING APPARATUS**
8 Claims, 13 Drawing Figs.

[52] U.S. Cl. 210/150
[51] Int. Cl. B07b 7/00
[50] Field of Search 210/150, 151; 261/112

[56] **References Cited**

UNITED STATES PATENTS

3,227,429	1/1966	Renzi	210/150 X
3,232,865	2/1966	Quinn et al.	210/150 X
3,347,381	10/1967	Minch et al.	210/150 X
3,402,103	9/1968	Amberg et al.	210/130 X

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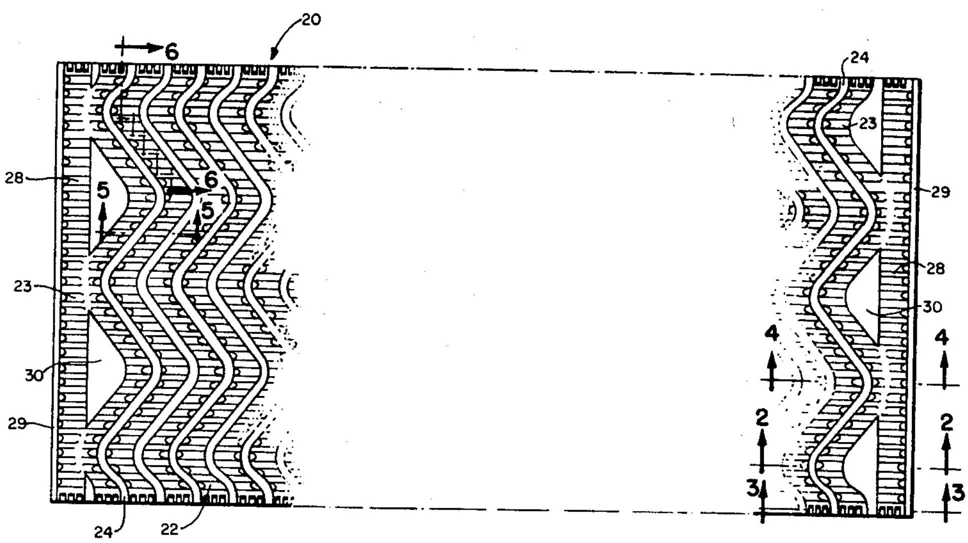
Assistant Examiner—Charles H. Hart
Attorney—Donald L. Johnson

ABSTRACT: A liquid-treating unit particularly suited for the treatment of liquid waste by aerobic bacterial action includes a module made of alternate flat and corrugated sheets of a thermoplastic material. The corrugated sheets are joined to the flat sheets at the apices of the corrugations. The corrugations have flat apices and reinforced sidewalls to enhance the strength of the module.



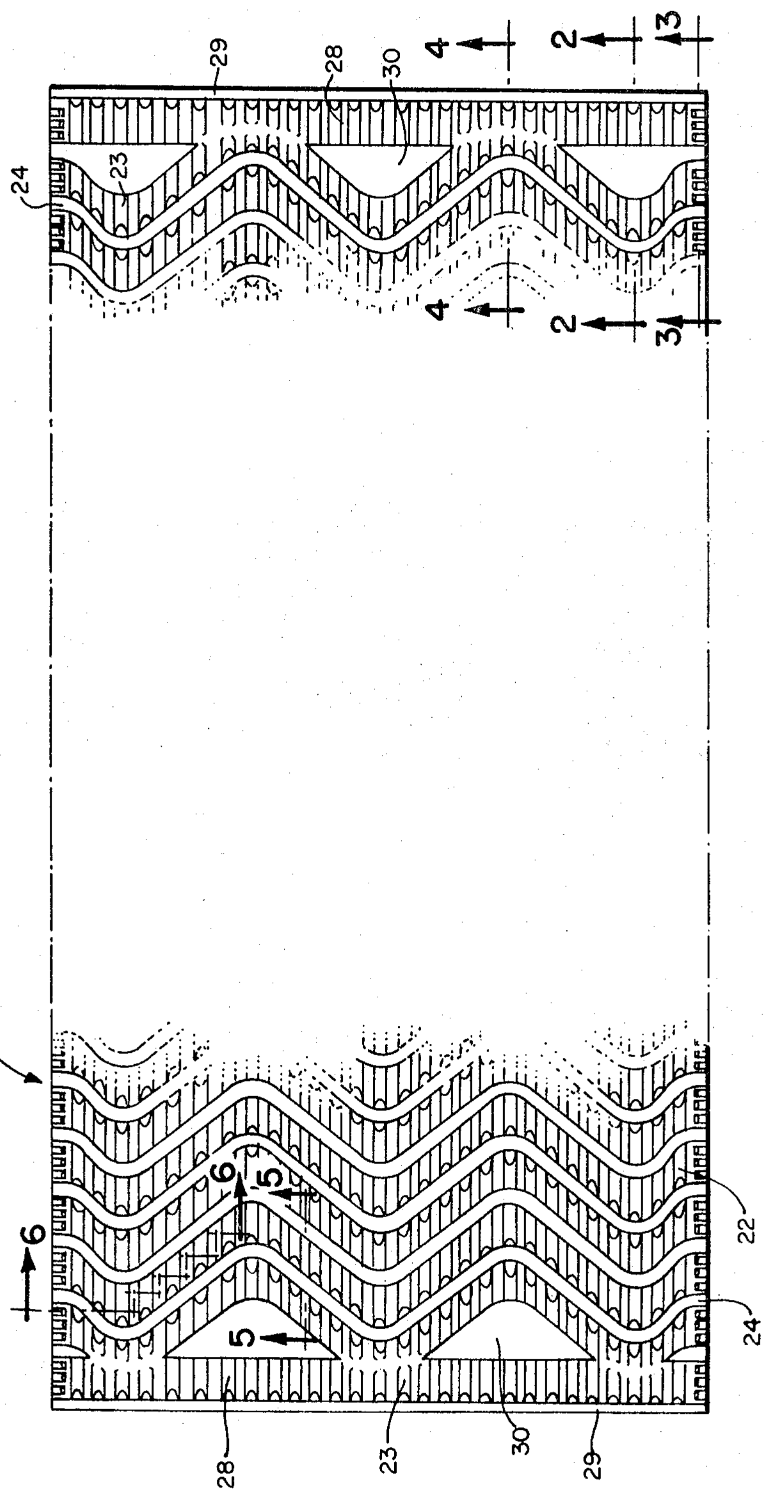


FIG. 1.

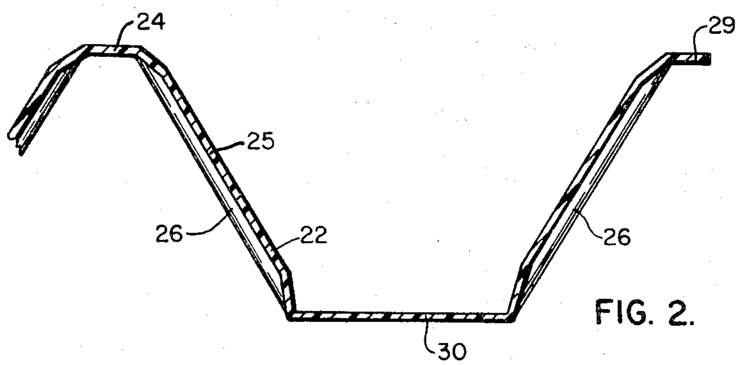


FIG. 2.

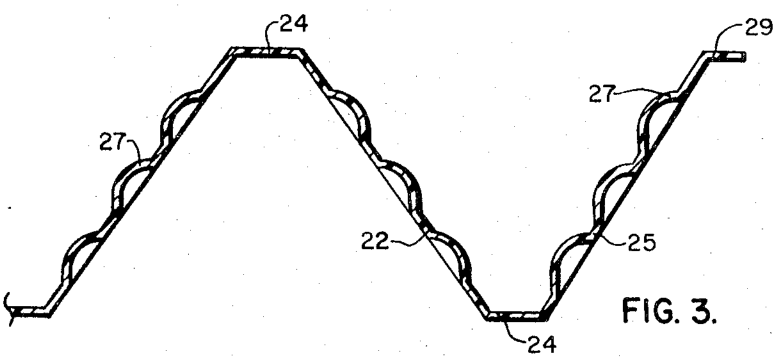


FIG. 3.

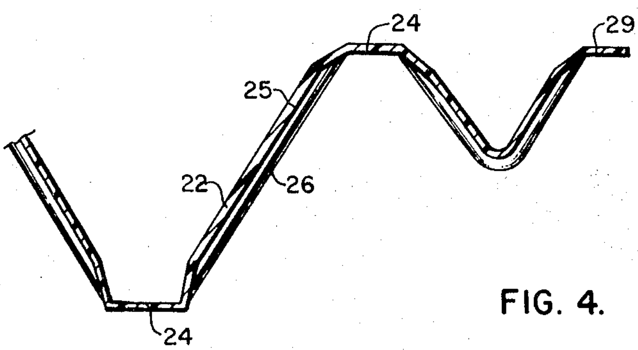


FIG. 4.

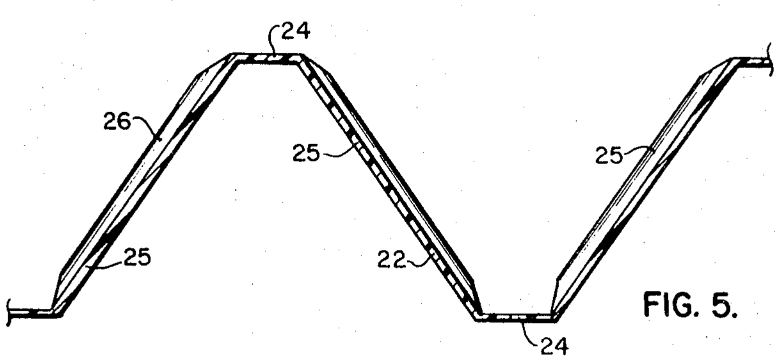


FIG. 5.

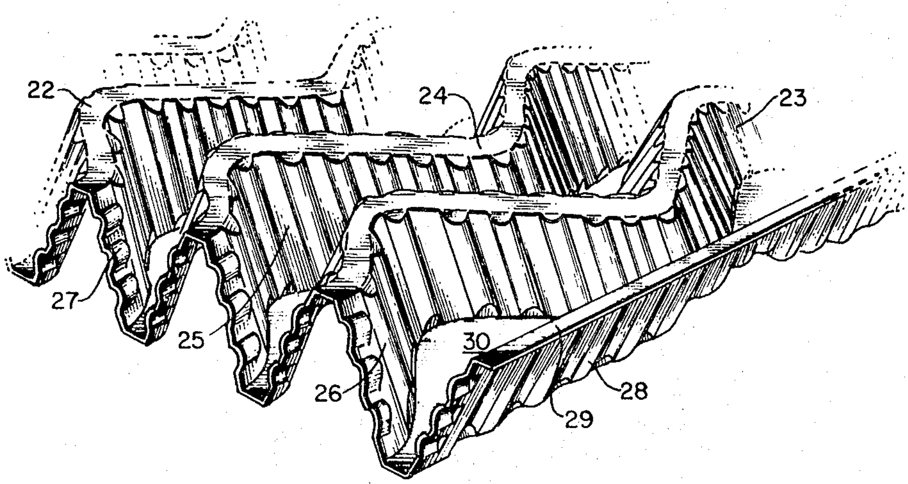


FIG. 7.

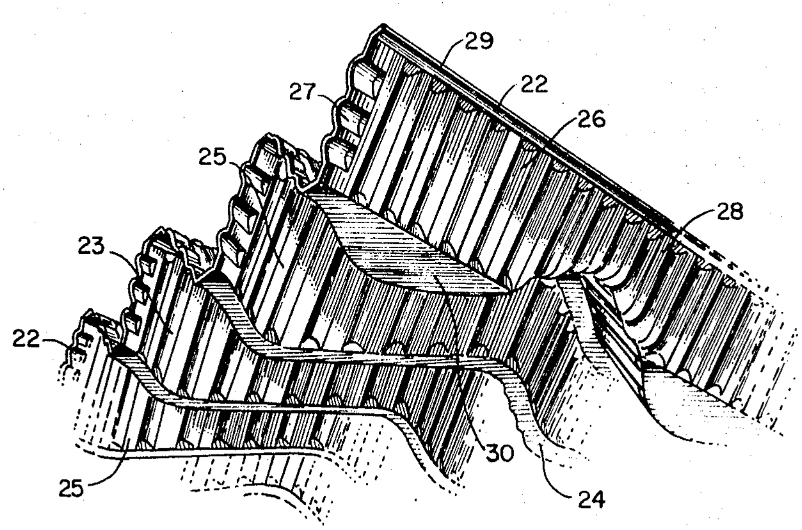


FIG. 8.

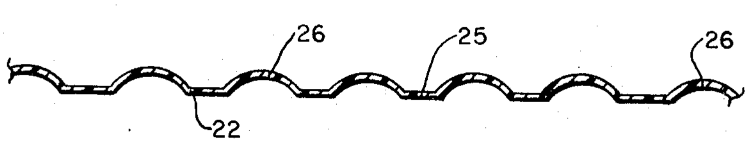


FIG. 6.

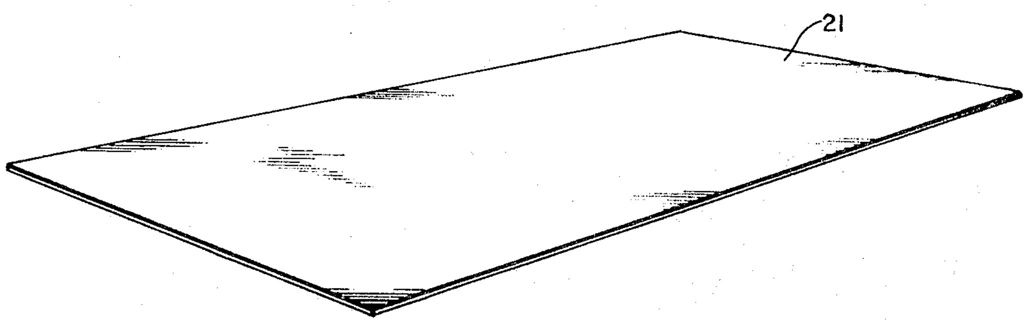


FIG. 9.

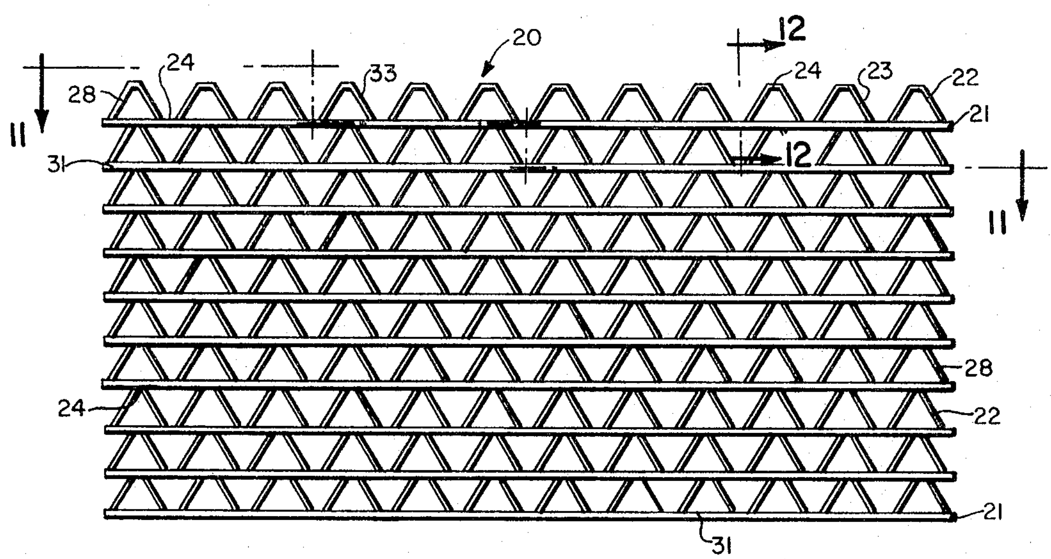


FIG. 10.

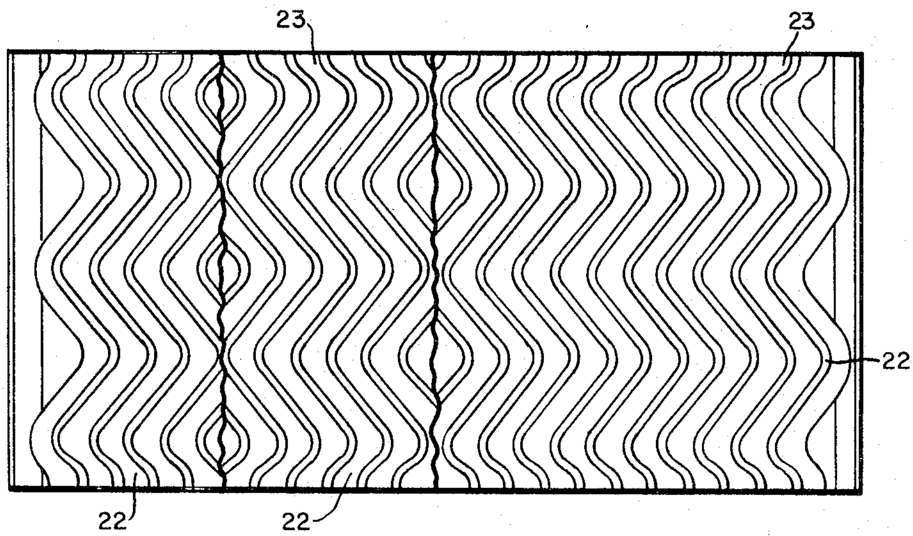


FIG. 11.

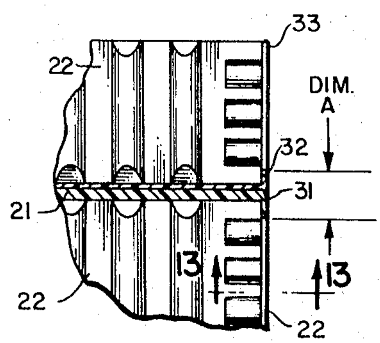


FIG. 12.

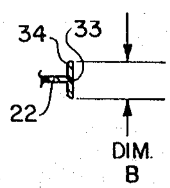


FIG. 13.

LIQUID-TREATING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved module or cube-shaped filter media unit for treatment of liquids wherein the liquids are allowed to flow down over the surfaces of a series of vertically stacked modules and are contacted with a gas. The module of this invention is particularly suited for use in bacterial oxidation of waste streams.

2. Description of the Prior Art

Trickling filters of various types have been used heretofore for the aerobic treatment of sewage and certain types of industrial waste. The classical treatment by means of rotating arms or spray heads over a bed of rocks having a growth of aerobic bacteria thereon. In most installations air is fed from the bottom of the treating vessel to provide the oxygen for consumption by the bacteria living on the surface of the trickling filter media.

Lightweight trickling filter media made of either alternate flat and corrugated sheets or corrugated sheets of a thermoplastic material are shown in prior art U.S. Pat. Nos. 3,281,307; 3,347,381; and 3,374,994. The trickling filter units disclosed in the aforementioned patents have been commercially manufactured and installed in a number of sewage and waste treatment plants in the United States or in foreign countries. While these types of trickling filter media have been commercially successful, nevertheless, there has been found a need to provide a trickling filter unit which possesses increased strength and rigidity over those used heretofore. In trickling filter units made from thermoplastic materials available heretofore, the corrugated sheets have been either joined at spaced apart points to the flat sheets at the peak of the crest of the corrugation or at the other edges of the sheets. This has provided some weakness in the units when subjected to high loading as occurs when the units are stacked to considerable depths, i.e., 20 feet or more without intermediate support structures or when extremely heavy biological growths are present on the large surface area provided by these types of packing units.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a liquid-treating unit or module which provides a large surface area for the growth of bacteria and possesses high-compressive strength.

It is another object of the present invention to provide a liquid-treating unit which is light in weight, yet has high-compressive strength.

Still another object of the present invention is to provide a liquid-treating unit which can be inexpensively manufactured and readily assembled on the site, if desired.

The foregoing objects and other advantages are provided in a liquid-treating unit which includes a plurality of substantially flat sheets of plastic material with a sheet of plastic material having a plurality of corrugations therein positioned between adjacent sheets of the flat plastic material. The corrugations are curvilinear over at least part of this length and have substantially flat apices in contact with the adjacent flat sheets. Means are provided joining the flat apices of the corrugated sheets, over at least a part of their length to the flat sheets.

Further objects and advantages will be apparent from the drawings and the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of a corrugated sheet used in a liquid-treating unit constructed in accordance with the present invention;

FIG. 2 is an enlarged sectional view of FIG. 1 taken along the line 2—2;

FIG. 3 is an enlarged sectional view of FIG. 1 taken along the line 3—3;

FIG. 4 is an enlarged sectional view of FIG. 1 taken along the line 4—4;

FIG. 5 is an enlarged sectional view of FIG. 1 taken along the line 5—5;

FIG. 6 is an enlarged cross-sectional view of FIG. 1 taken along the line 6—6;

FIG. 7 is a partial perspective view of a portion of the corrugated sheet used in the liquid-treating unit of the present invention;

FIG. 8 is another partial perspective view of the corrugated sheet used in the liquid treating unit of the present invention;

FIG. 9 is a perspective view of the flat sheet used in the liquid-treating unit of the present invention;

FIG. 10 is a top view of an assembled liquid-treating unit of the present invention made from alternate corrugated and flat sheets;

FIG. 11 is a sectional view of FIG. 10 taken along the line 11—11;

FIG. 12 is an enlarged sectional view of FIG. 10 taken along the line 12—12; and

FIG. 13 is an enlarged sectional view of FIG. 12 taken along the line 13—13.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 10, the liquid-treating unit, designated generally by the numeral 20, includes generally flat sheets 21 and alternate corrugated sheets 22. The individual corrugations 23 provided in the sheet 22 are generally sinusoidal in configuration. The corrugations 23 extend completely across the generally rectangular corrugated sheet 22 in the direction of its minimum dimension. It is preferred that the corrugations 23 in the corrugated sheets 22 be in the form of a truncated V in cross section. This construction provides a corrugation having a generally flat apex 24. As seen in FIG. 10, the apices 24 of each of the corrugated sheets are in contact with and are attached at one or more points to the flat surface of the flat sheet 21. They are preferably attached over their full length as by gluing. As can be seen more clearly in FIGS. 2-5, 7 and 8, the corrugations 23 have sidewalls 25—25 forming the sides of a truncated equilateral triangle. Each sidewall 25 is provided with a plurality of reinforcing ribs 26 which extend substantially the full height of the sidewall between the adjacent flat apices 24—24. The ribs 26 are provided by thermoformed, generally cylindrically shaped protrusions in the sidewall of each of the corrugations in the corrugated sheet. However, it is understood that the ribs may take other forms.

As can be seen more clearly in FIGS. 3, 7 and 8, the sidewall at the edge of each corrugated sheet is provided with a number of short length ribs 27 which extend in a direction substantially perpendicular to the length of the longer reinforcing ribs 26.

As seen in FIGS. 1, 6 and 7, the corrugated sheet 22 is provided at each end with a straight end wall section 28 that does not follow the generally sinusoidal shape of the remainder of the corrugations 23 therebetween. Each end wall 28 is provided with an out-turned flat terminal portion 29 at its end. The straight end wall section 28 is also provided with reinforcing ribs 26 similar to those provided in the sinusoidal corrugations. As can be seen in FIGS. 1, 2, 7 and 8, there is provided between each straight end wall section 28 and the adjacent sinusoidal corrugation 24 a large number of generally triangular, flat areas 30 which provide a large contact area between each of the corrugated sheets and the adjacent flat sheet.

As seen in FIG. 11, each alternate corrugated sheet 22 is rotated 180° so that the corrugations 23—23 in adjacent sheets are 180° out of phase. As pointed out in aforementioned U.S. Pat. No. 3,374,994, this provides a plurality of contact points wherein the corrugated sheets cross over each other and provides high areas of reinforcement and rigidity for the gas-liquid contact cube when using this arrangement. However, the invention is not limited to the arrangement wherein the alternate corrugated sheets are 180° out of phase. They may be all assembled with the corrugations aligned in the same direction, if so desired.

As seen in FIGS. **10**, **12** and **13**, the longitudinally extending edge **31** of each flat sheet **21** has an integrally formed, generally T-shaped reinforcement bead **32** thereon. The reinforcement may be produced on the longitudinally extending edges **31** of the flat sheets by clamping the assembled cube between hot upper and lower platens and applying pressure to the edges **31** of the flat sheets whereby they are fused and flattened to assume the generally T-shaped bead as shown in FIG. **12** having the dimension A. The provision of the reinforced edge on the flat sheets provides a wider footing whereby when cubes are stacked on one another a greater bearing surface is provided for the weight of the cube plus the weight of the biological material growing on the cubes. It has been found that one of the causes of failure for thermoplastic liquid-treating cubes used heretofore has been the splitting of the edges of the sheets because of the high-compressive forces applied to the sharp edge of the longitudinally extending flat sheets when the cubes are stacked one on another. Additionally, as shown in FIGS. **12** and **13**, the fusing of the edges **31** of the flat sheets also produces a fusion in the edge **33** of the corrugated sheet to provide a similar shaped reinforcement bead **34** having the dimension B. The provision of these reinforcing beads **34—34** provides a flattened area for the edge of each corrugated sheet whereby it provides a reinforced footing for contact with the adjacent cube to provide higher compressive strength. Dimensions A and B of the beads **32** and **34** may range from about one-eighth inch to about seven-sixteenths inch in width.

As pointed out hereinbefore, it is preferred that the corrugations **23** in the corrugated sheet **22** be generally in the shape of an equilateral triangle. However, other forms such as hemispherical toroidal or any arcuate-shaped surface desired may be sued as long as the corrugations provide sufficient open space for the passage of the liquid being treated.

In one particular embodiment of the present invention, the flat sheets were 24¼ inches by 48¼ inches and the corrugated sheets were also 24¼ inches by 48¼ inches. The equilateral triangle provided by the corrugation **23** in the corrugated sheet **22** has a base length of approximately 3¼ inches and a sidewall length of about 2¼ inches and the flat crest **24** provided at the apex of each corrugation had a width of about three-eighths inch. The reinforcing rib **26** in the corrugated section of the cube projected approximately one-eighth inch above the flat sidewalls of the corrugation and had an arcuate surface having a radius of five-sixteenths inch.

The cube is preferably assembled by applying a solvent or a glue over the entire surface of the flat apex **24** of each of the corrugations **23** and then pressing the corrugated sheet onto a flat sheet **21**. Additional corrugations are added between alternate flat sheets with glue being applied to the apices **24** of the corrugated sheets with glue being applied to the apices **24** of the corrugated sheets and also to the large flattened areas **30** adjacent each end wall corrugation of the corrugated sheets. Glue is also applied to the flat terminal portion **29** of tne end walls, and this is fixed to the terminal edge of the flat sheet. The cube is then placed between heated platens and the edges fused to provide the reinforcing beads **32** and **34**. This construction provides an extremely rugged cube with a very high-crush strength. The sheets may be joined at spaced points by means of a radiofrequency sealer or an ultrasonic powered tool, if desired, instead of using a glue or solvent.

The thermoplastic used to fabricate the flat sheets and the corrugated sheets may be any rigid thermoplastic material having a suitable rigidity, i.e., preferably a Young's modulus in the order of 10^5 pounds per square inch. Examples of suitable polymeric materials are polyvinyl chloride homopolymer, polyvinyl chloride copolymers, e.g., polyvinyl chloride-polyvinyl acetate copolymer, polyvinyl chloride-polyvinylidene chloride copolymer, polyvinylidene chloride homopolymer, polypropylene, high-density polyethylene, chlorinated polyvinyl chloride, chlorinated low-density polyethylene, chlorinated high-density polyethylene, polymethyl methacrylate, polystyrene, polyoxymethylene polymers and copolymers, and blends of the foregoing polymers with other polymers or copolymers.

Completed gas-liquid contact units described hereinbefore are stacked on top of one another in a conventional treating basin, such as one formerly used to hold rocks, with alternate layers of cubes rotated 90°. The cubes of the present invention may be stacked to a height of 24 feet without additional intermediate support. They have been found to withstand very high loading when subjected to tests. The material to be treated may be flowed over the stacked units in a manner used in conventional sewage treatment, i.e., rotating arms or spray nozzles. If desired, reinforcing support members may be provided in the treating basin, e.g., as shown in U.S. Pat. No. 3,347,381, FIG. **10**.

A preferred form of the liquid-treating cube of the present invention is made using homopolymer polyvinyl chloride wherein the flat sheets have a thickness of about 0.035 inch and the corrugated sheets have a thickness of about 0.025 inch (before thermoforming). Depending on the strength required, i.e., the height to which the cubes are to be stacked in the treating basin, any reasonable wall thicknesses can be used for the thermoplastic material used to make both the flat sheets and the corrugated sheets. Sheet thicknesses of the order form 0.010 inch to as much as 0.040 inch have been found to be satisfactory for manufacturing the liquid-treating cubes of the present invention.

In strength tests cubes constructed in accordance with the present invention have shown superior strength compared to all other commercial thermoplastic media presently available on the market. A test cube 2 feet square was made using alternating flat and thermoformed sheets as described hereinbefore from polyvinyl chloride homopolymer. The flat sheets were calendered at an approximate thickness of 0.035 inch. The corrugated sheets were thermoformed from flat polyvinyl chloride thermoplastic sheet material having an initial thickness of 0.025 inch. The cubes were formed by gluing the corrugated sheets to the flat sheets over the entire areas of contact between the flat crests **24** of the corrugations and the areas of contact with the flat sheets. The cubes were pressed against a hotplate to produce generally T-shaped flanges of about five-sixteenths inch width of opposite, longitudinally extending edges of both the flat and corrugated sheets. The cubes were allowed to cure for a few days prior to being put in the test frame. In the first test method, two cubes constructed as described above were placed in a frame with the corrugations in the same plane but with the edge surfaces of the cubes rotated 90° so the reinforced edges made contact with the adjacent cube at the maximum number of points. A load of 750 pounds per square foot was applied to the top cube and the compression of the two cubes measured. The cubes compressed only seven thirty-seconds of an inch under a load of 750 p.s.f. The load was maintained for 3 days and no additional compression was detected. The hydraulic cylinder loading the test cubes was then increased to apply a pressure of 1,060 p.s.f. to the two cubes. The compression measured during this load increase indicated that the two cube had moved only three thirty-seconds of an inch additionally. No failure, i.e., no cracking, splitting, or buckling of the cubes was observed. Samples of another commercially available cube were tested and failed abruptly at 1,000 p.s.f.

A second test method was used for the remainder of the tests to determine the long term strength. The load applied for each test was calculated from the following:

test load = tower height × operating load × modulus decay × safety factor

This corresponds to a tower design load calculated as follows:

design load × tower height × operating load

The modulus decay factor used in calculating the test load results from the fact that, in a plastic, the apparent flexure modulus decays with time under load due to creep. The apparent flexure modulus is calculated from the deflection of a beam of the material under load. As time under load increases, the deflection increases the calculated modulus decreases. The rate of change of modulus decreases with time so that, for rigid PVC, after about 1 year under load, the modulus has leveled out to its minimum value. Data for the decay of the apparent flexure modulus can be found in "-Materials Data Nomographs," by Peters, R. L. From this data, the instantaneous flexure modulus for rigid PVC is 4 times that at 1 year and the 4-day value is twice that at 1 year. The behavior after 1 year under load P can be determined from the behavior at 4 days under load 2P since the modulus is twice as great at 4 days as at 1 year. Negligible deformation after 4 days under test load 2P implies negligible deformation after 1 year at actual load P and due to leveling out of modulus, negligible deformation for all time. Thus, the 4-day test duplicates actual in-use performance. For the 4-day test load, the modulus decay factor is taken to be 2.5 and the safety factor is taken 1.25. The operating load is the sum of the weights of the module or cube and a maximum bacteria growth of 12.7 lbs./cu. ft. Table I gives design loads and test loads for various conditions.

One set of two cubes with 0.025-inch-thick corrugations, 0.035-inch-thick flats, and 5/16-inch-wide edge flanges was subjected to the 4-day test with a load of 806 p.s.f., simulating a 21.5-foot tower. There was no damage to the cubes after the test. In an attempt to determine the instantaneous failure load, the cubes were loaded to 1,200 p.s.f. and then to 1,500 p.s.f. for about 10 minutes at each load. Inspection showed no damage to the cubes. Later, these same cubes were restacked and loaded to 1,500 p.s.f. for 3 days. This caused local buckling of the flat sheets below some of the crossover points. However, there was no significant blockage of the fluid flow channels. In a second attempt to determine the instantaneous failure load, the load was raised gradually to 1,900 p.s.f. No abrupt failure occurred, only an increase in bending at the crossover points.

One set of two cubes with 0.025-inch-thick corrugations, 0.025-inch-thick flats, and ¼-inch–5/16-inch-wide edge flanges was subjected to the 4-day test with a load of 402 p.s.f.

TABLE I

Cube configuration (mil)		Tower height (ft.)	Maximum operating load (lbs./cu. ft.)	Design load (p.s.f.)	Test load (p.s.f.)
Flats	Corrugateds				
35	25	22.0	15.0	330	825
35	25	21.5	15.0	322.5	806
35	25	20.0	15.0	300	750
25	25	22.0	14.6	321.2	803
25	25	11.0	14.6	160.6	401.5
25	25	10.0	14.6	146.0	365

simulating an 11-foot tower. After 4 days at this load, there was no damage to the cubes.

As can be seen from the above tests, modules of the present invention that are made from 0.025-inch-thick corrugations and 0.035-inch-thick flats can easily withstand the normal loading that is encountered in a trickling filter tower when stacked on each other to a height of 21.5 feed without any intermediate support. Modules made using 0.025-inch-thick corrugations and 0.025-inch-thick flats can readily withstand the normal loading encountered in a trickling filter tower when stacked on each other to a height of 15 feet without any intermediate support.

While the invention has been described with reference to certain specific embodiments, it will be understood that there are many variations which would fall within the true spirit of the invention.

What is claimed is:

1. In a liquid-treating unit the combination comprising:
a. a plurality of substantially flat sheets of plastic material;
b. a sheet of plastic material having a plurality of corrugations therein positioned between adjacent sheets of said flat plastic material, said corrugations being curvilinear over at least a part of their length and having substantially flat apices in contact with said adjacent flat sheets, the sidewalls of said corrugations being provided with a plurality of generally arcuate-shaped reinforcing ribs; and
c. means joining said flat apices of said corrugated sheets, at least over a part of their length, to said flat sheets.

2. In the liquid-treating unit as set forth in claim 1 wherein said plastic material comprises a polyvinyl chloride homopolymer.

3. In the liquid-treating unit as set forth in claim 1 wherein the outer wall of each of the end corrugations in said corrugated sheet is substantially straight and provides a flat surface at its terminal end which is joined to one of said adjacent flat sheets.

4. In the liquid-treating unit as set forth in claim 1 wherein the end portions of the sidewalls of each corrugation is provided with short, arcuate-shaped projections extending generally in the direction of the median line through said corrugation.

5. In the liquid-treating unit as set forth in claim 3 wherein said end corrugations each provide at least one generally triangular-shaped flat area in its flat apex.

6. In the liquid-treating unit as set forth in claim 1 wherein the edges of said flat sheets and the edges of said sheets providing corrugations therein that lie in a plane perpendicular to the median line through said corrugations are of a greater thickness than the remainder of said sheets.

7. In the liquid treating unit as set forth in claim 1 wherein said flat apices of said corrugated sheet are joined to said flat sheet over the full length of said apices by means of an adhesive.

8. In the liquid-treating units as set forth in claim 6 wherein said edges are of a thickness of from about one-eighth inch to about seven-sixteenths inch.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,618,778 Dated November 9, 1971

Inventor(s) Joseph H. Benton et al

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

Column 1, line 14, after "treatment" insert -- for the streams is to distribute the material to be treated --. Column 1, line 34, reads "other edges", should read -- outer edges --. Column 3, line 32, reads "sued", should read -- used --. Column 3, line 39, reads "has", should read -- had --. Column 3, line 50, after "sheets" delete -- with glue being applied to the apices 24 of the corrugated sheets --. Column 4, line 22, reads "form", should read -- from --. Column 4, line 55, reads "cube", should read -- cubes --. Column 4, line 72, reads "increases the", should read -- increases and the --. Column 6, line 55, reads "units", should read -- unit --.

Signed and sealed this 4th day of July 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents