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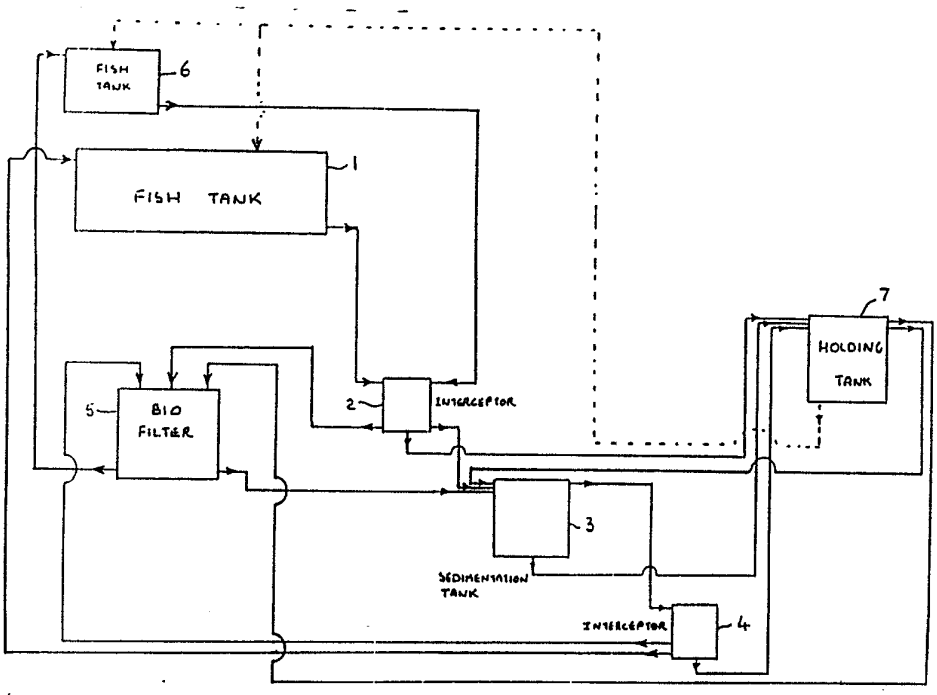
(54) Title: AQUACULTURE

(57) Abstract

An aquaculture system includes an aquatic animal rearing tank arrangement (1 + 6) and an array of separators (2, 3, 4) connected in series for receiving water and water borne materials and life forms from the tank arrangement (1 + 6) and separating out materials and life forms. The array of separators (2, 3, 4) is also connected for providing a return flow to the tank arrangement (1 + 6) after passing through the array. A biological filter (5) is connected with the array of separators (2, 3, 4) for receiving flow from the array and returning the flow to the array after biological treatment. A holding tank (7) is connected with the array of separators (2, 3, 4) for receiving separated out materials and life forms to be held therein for return to the tank arrangement (1 + 6). This holding tank (7) is also connected for providing a return flow to the array of separators (2, 3, 4) and to the biological filter (5). As the system is operated over a period of time continuous circulation of water borne materials and life forms around the system results in an ever-increasing growth of micro-aquatic life, and hence of aquatic animals feeding thereon, so that accelerated animal growth is achieved.



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AQUACULTURE

This invention is concerned with aquaculture.

According to the present invention there is provided an aquaculture system comprising an aquatic animal rearing tank arrangement, an array of separation means connected in series for receiving water and water borne materials and life forms from the tank arrangement and separating out materials and life forms, this array being also connected for providing a return flow to the tank arrangement, biological filter means connected with the array of separation means for receiving flow from the array and returning flow to the array after biological treatment, and a holding tank connected with the array of separation means for receiving separated out materials and life forms to be held therein for return to the tank arrangement, the holding tank being also connected for providing a return flow to the array of separation means and to the biological filter.

In a particular form of the system just defined the biological filter means is also connected for providing a return flow after biological treatment to the aquatic animal rearing tank arrangement.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a schematic diagram of an aquaculture system;

Figure 2 is a diagrammatic cross-sectional view of an interceptor included in the system of Figure 1;

Figure 3 is a diagrammatic cross-sectional view of a sedimentation tank included in the system of Figure 1;

Figure 4 is a diagrammatic cross-sectional view of another interceptor included in the system of Figure 1;

Figure 5 is a diagrammatic cross-sectional view of a biological filter included in the system of Figure 1;

Figure 5A shows on a larger scale a detail of the biological filter of Figure 5;

Figure 6 is a plan view of part of an enlarged version of the system;

Figure 7 is a diagrammatic cross-sectional view of a further interceptor included in the enlarged system of Figure 6; and

Figure 8 is a diagrammatical cross-sectional view of a digester included in the enlarged system of Figure 6;

Figure 9 shows on a larger scale a detail of the digester of Figure 8; and

Figure 10 is a side view of a collector provided in the system of Figure 6.

In the aquaculture system of Figure 1 there is a gravity return from a main fish or other aquatic animal rearing tank 1 to a first interceptor 2, construction of which is described below with reference to Figure 2. From the first interceptor 2 there is a gravity overflow to a sedimentation tank 3, the construction of which is described below with reference to Figure 3, and from the sedimentation tank 3 to a second interceptor 4 (described with reference to Figure 4). From the interceptor 4 there is a pumped connection to a biological filter 5 (described with reference to Figure 5). There is also a pumped connection from the first interceptor direct to the biological filter 5. From the biological filter 5 there is a gravity return

to the sedimentation tank 3 and a pumped connection to a supplementary fish or other aquatic animal rearing tank 6. From this supplementary fish tank 6 there is a gravity return to the first interceptor 2.

Material settling in each of the interceptors 2 and 4 and in the sedimentation tank 3 is pumped to a holding tank 7. Liquid is pumped from the tank 7 to the sedimentation tank 3 and to the biological filter 5. Substantially non-liquid material extracted from the holding tank 7 is fed to the fish tanks 1 and 6.

Referring to Figure 2, the first interceptor 2 is a tank having inlets 8 and 9 from the fish tanks 1 and 6, an outlet 10 to the sedimentation tank 3 and an outlet 11 to the biological filter 5. A downwardly directed baffle 12 shaped to force incoming water upwards and a weir 13 downstream thereof within the interceptor 2 produce turbulence within the interceptor 2 such that water borne materials and life forms tend to settle in the bottom of the interceptor as indicated at 14, from where they pass via an outlet 15 to the holding tank 7.

The sedimentation tank 3 (Figure 3) has inlets 16, 17 and 18 from the outlet 10 of the first interceptor 2, from the biological filter 5 and from the holding tank 7 respectively. Each of these inlets 16, 17, 18 opens into the upper end of an upright cylindrical mixing chamber 19, within the sedimentation tank 3, the upright wall of which is of corrugated formation to assist mixing within the chamber. To assist mixing further the inlet 17 terminates in an upwardly directed port 17A which is below a downwardly directed port 18A terminating the inlet 18. The lower open end of the mixing chamber 19 is some distance above the base of

the sedimentation tank 3. Remote from the mixing chamber 19 near the top of the sedimentation tank 3 there is an outlet 20 to the second interceptor 4. Within the tank 3 this outlet 20 commences at an upwardly directed port 20A. Water borne materials and life forms collecting at the bottom of the sedimentation tank 3 as indicated at 21 pass via an outlet 22 to the holding tank 7.

The second interceptor 4 (Figure 4) is a tank having an inlet 23 from the outlet 20 of the sedimentation tank 3, this inlet terminating within the interceptor 4 at an upwardly directed port 23A. Remote from the port 23A are two outlets 24 and 25 to the main fish tank 1 and the biological filter 5 respectively. In the upper part of the interceptor 4, between the inlet 23 and the outlets 24, 25, there is a wall 26 dividing the upper part into two. From the lower end portion of this wall 26 a horizontal impeder grid 27 extends towards the outlets 24, 25 to terminate at the top of a further wall 28 upstanding from the base of the interceptor. The flow from the inlet 23, under the wall 26, through the impeder grid 27 and over the wall 28 to the outlets 24, 25 results in depositing of water borne materials and life forms as shown at 29A, 29B. These pass via an outlet 30 to the holding tank 7.

The biological filter 5, (Figures 5 and 5A) is of a generally conventional construction having a cylindrical corrugated wall 31 upstanding from a base sump 32. Above the base sump 32 there is a filter and microbe trap 33 which is below a finger drain 34. From the finger drain 34 upwards there are layers 35 to 39 of stone of progressively reducing grade size. Above these layers there is a layer 40 of coke and above this layer is a multi-armed rotating sprayer 41 carrying

deflectors 41A (Figure 5A) on its spray arms 41B that ensure a wide spray pattern over the layer 40. Inlets 42, 43, 44 from the outlet 11 of the first interceptor 2, from the inlet 25 of the second interceptor 4 and from the holding tank 7 respectively are connected to the sprayer 41. An outlet 45 including a submersible pump 46 is connected to the supplementary fish tank 6. Such supply to the supplementary fish tank 6 has passed at least once through the first interceptor 2 and the biological filter 5. Another outlet 47 is connected to the inlet 17 of the sedimentation tank 3.

The holding tank 7 is a rectangular tank having at its top inlets from the outlet 15 of the first interceptor 2, the outlet 22 of the sedimentation tank 3 and the outlet 30 of the second interceptor 4. From the top of the holding tank 7 there are outlets to the inlet 18 of the sedimentation tank 3 and the inlet 44 of the biological filter 5 respectively. Materials and life forms can be extracted from the base of the tank 7.

Operation is as follows. The supplementary fish tank 6 is for fry or parr (where salmon are to be reared) which are transferred to the main fish tank 1 for rearing therein. In normal fashion as feeding takes place in the tanks 1 and 6 amoeba develop and faeces, unconsumed food and other debris collect in the bottoms of the tanks. From the bottoms of the tanks the water borne materials and life forms pass to the first interceptor 2 of the array of separating devices connected in series that is constituted by the interceptor 2, the sedimentation tank 3 and the interceptor 4. In the first interceptor 2 some of the materials and life forms present are deposited to be pumped to the tank 7.

The main flow from the first interceptor 2 is to the sedimentation tank 3, in the mixing chamber 19 of which it is combined with flows from the biological filter 5 and the holding tank 7. Flow also takes place from the first interceptor 2 direct to the biological filter 5, the proportion of the total flow from the interceptor 2 flowing in this direction being selected as desired.

Within the mixing chamber 19 of the sedimentation tank 3 thorough mixing of the flows thereinto is promoted. Water borne materials and life forms deposited at the bottom of the tank 3 are pumped to the holding tank 7 whilst the main flow is to the second interceptor 4, this being the only supply to this interceptor. Further deposit of water borne materials and life forms takes place in this interceptor 4 and can be enhanced, if desired, by placing a fine screen over the impeder grid 27. The deposited water borne materials and life forms are pumped from the interceptor 4 to the holding tank 7. The main flows from the interceptor 4, and hence from the array of separator devices 2/3/4, are to the biological filter 5 and to the main fish tank 1. This supply to the main fish tank 1 has passed at least once through the first interceptor 2, the sedimentation tank 3 (where mixing with flows from the biological filter 5 and the holding tank 7 has taken place) and the interceptor 4.

The biological filter 5 receives flows from the first interceptor 2, the second interceptor 4 and the holding tank 7. Outflow from the biological filter 5 is to the sedimentation tank 3 and to the supplementary fish tank 6. Preferably the biological filter 5 is provided with heating equipment, which can utilise

methane gas produced elsewhere in the system, to give a temperature at the top of the filter of about 30°C. The outflow to the supplementary fish tank 6 should be at about 14°C for salmonoids and this can be achieved, when heating equipment is provided, by a heat exchange arrangement, heat extracted thereby being utilised in the heating equipment.

The holding tank 7 is supplied from the first interceptor 2, the sedimentation tank 3 and the second interceptor 4.

Within the fish tank 1 there will be micro-aquatic life which the fish will consume and very little if any will remain in the effluent which passes to the interceptor 2. Effluent from the tank 6 will contain a much higher proportion of micro-aquatic life as this tank contains only small fry or parr. Within the remainder of the system growth of micro-aquatic life is encourage by re-circulation of the water borne solids and life forms that collect in the two interceptors, in the sedimentation tank and in the holding tank. Growth is further encouraged by aerating the water flow in the system, conveniently by permitting air to enter at the pumps. Thus in the first interceptor 2 growth of micro-aquatic life from the main fish tank 1 is encourage by the mixing with flow from the supplementary fish tank 6 containing a much higher proportion of such life. Growth is further encouraged in the sedimentation tank 3 where flow from the first interceptor 2 is mixed with the flow rich in micro-aquatic life from the biological filter 5 supplemented as required from the holding tank 7. Extensive aeration of these flows takes place at the inlet to the mixing chamber of the sedimentation tank 3. Still further growth takes place in the second interceptor 4,

from whence the supply is to the main fish tank 1, and to the biological filter 5 if and when encouragement of micro-aquatic life growth therein is required. The micro-aquatic life thus fed to the main fish tank 1 is food for the fish therein. As the system is operated over a period of time the continuous circulation of water borne materials and life forms in the manner just described around the system results in an ever-increasing growth of the micro-aquatic life, and hence of the fish feeding thereon, so that accelerated fish growth is achieved.

It will be appreciated that appropriate valves and by-pass flow lines are provided for controlling the various flows as necessary to obtain optimum operation.

So far there has been described a basic system. Preferably there is a larger number of fish tanks, for example as illustrated in Figure 6 where in addition to the tanks 1 and 6 there are at least a tank 48 larger than the tank 1 and further small tanks such as those shown at 49 and 50. The connection of the tank 1 to the first interceptor 2 is via a valve 51 and with this valve closed flow from the tank 1 is to the tank 48. Flow to the tanks 49 and 50 is from the second interceptor 4 and from these tanks to the tank 48. Associated with the tank 48 is a third interceptor 52 which is shown in Figure 7. This interceptor has an upright cylindrical corrugated wall 53 at the top of which there is an inlet terminating in a downwardly directed port 54. Remote from the port 54 there is a wall 55 depending from the top of the interceptor 52 to near the base thereof and dividing the interior of the interceptor into major and minor chambers. From the top of the minor chamber there is an outlet 56. The base of the interceptor 52 is formed by a shell-like

sump 57 having an outlet 58 from which water borne materials and life forms collecting in the sump can be pass to the holding tank 7. When desired the interceptor 52 can be operated in conjunction with a biological filter 59 (Figure 6). At the top of the interceptor 52 there is an oxygen injector 60 for injecting oxygen into the supply entering via the port 54.

The supply to the port 54 of the interceptor 52 is from the fish tank 48 (Figure 6). The outlet 56 of the interceptor 52 is to the first interceptor 2. In addition the outlet 56 can supply to a digester 61 (Figures 8 and 9). This digester is a cylindrical tank set below ground level and filled with coke 62. Opening into the top of the digester 61 there is an inlet/outlet 63 that is connected to the holding tank 7. Another inlet/outlet 64 enters the digester 61 at the top and extends down the digester to open near the bottom of the digester. An outlet/inlet 65 is open either to the top of the digester 61 at 66, or at the bottom of the digester at 67. The digester 61 increases the capacity of the system as a whole for accelerating growth of micro-aquatic life.

In a first mode of operation using the digester 61 the outlet/inlet 65 is operated as an outlet from the digester, closed at 66 and open at the bottom of the digester at 67. The outlet 65 in this mode supplies to the first interceptor 2 (chain dot line in Figure 6). The inlet/outlet 64 is operated as an inlet to the digester, supplied from the outlet 56 of the interceptor 52. At the bottom of the digester 61 this supply is subjected to pneumatic injection at a compressed air/pressure water injection arrangement 68 (Figure 9). The inlet/outlet 63 is operated as an

inlet supplying from the holding tank 7 (chain dot line in Figure 6) a trickling flow down through the coke 61, which is opposed by a flow of white water (that is aerated water) which is drawn upwards from the bottom of the digester by operation of a compressed air diffuser 69 (Figure 9) in the bottom of the digester below a grating 70 supporting the coke 62. Within the digester 61 the supply from the holding tank 7 is treated and there is flow of treated water from the bottom of the digester via the outlet 65 to the first interceptor 2, the rate of flow being determined by the rate of supply at the inlets 63 and 64.

In a second mode of operation using the digester 61 the inlet/outlet 63 is operated as an outlet, the inlet/outlet 64 is also operated as an outlet, and the outlet/inlet 65 is operated as an inlet to the top of the digester at 66. The compressed air/pressure water injection arrangement 68 is not operated, but the compressed air diffuser 69 is operative. The inlet 65 supplies from the interceptor 52. The outlet 64 supplies to the fish tank 48 (dotted line in Figure 6), the outlet 63 supplies to the holding tank 7 (also dotted line in Figure 6) and the digester 61 operates as a biological filter.

The system of Figure 6 also has in its fish tank 48 several, for example four, collectors 71 as illustrated in Figure 10. Each of these collectors is a drum the cylindrical wall 72 of which is formed by a mesh material. This wall is supported by radial spokes 73 which are carried by a central tube 74. This tube is mounted in bearings carried by a framework (not shown) so that the axis of the tube 74 is horizontal and radial with respect to the tank 48, the wall 72 being partially submerged in the water 75 in the tank

48. The action of currents in the water 75 on paddles 76 projecting from the wall 72 will rotate the collector 71. The interior of the collector 71 is filled with a mass of filamentary material 77. As the collector rotates water borne materials and life forms in the water in the tank are caught up in the filamentary material 77 to be lifted from and returned to the water in the tank, this action encouraging growth of micro-aquatic life. In addition any water supply to the tank 48 that is aerated is supplied to the tank 48 through an appropriate one of the collectors 77, so that in passing through the collector the air bubbles are removed.

There has been described in detail above a basic system and it has been indicated how the system can be extended. In practice the system described will be at the heart of a considerably larger arrangement including main tanks for different species of fish or other aquatic life selected to suit the environment in particular tanks as determined by the stage of growth of micro-aquatic life fed thereto.

CLAIMS

1. An aquaculture system comprising an aquatic animal rearing tank arrangement, an array of separation means connected in series for receiving water and water borne materials and life forms from the tank arrangement and separating out materials and life forms, this array being also connected for providing a return flow to the tank arrangement, biological filter means connected with the array of separation means for receiving flow from the array and returning flow to the array after biological treatment, and a holding tank connected with the array of separation means for receiving separated out materials and life forms to be held therein for return to the tank arrangement, the holding tank being also connected for providing a return flow to the array of separation means and to the biological filter.

2. An aquaculture system as claimed in claim 1, where the biological filter means is also connected for providing a return flow after biological treatment to the aquatic animal rearing tank arrangement

3. An aquaculture system as claimed in claim 2, wherein the aquatic animal rearing tank arrangement includes a main tank and a supplementary tank, the array of separation means being connected for receiving from both the tanks but for return flow only to the main tank, the biological filter means being connected for return flow only to the supplementary tank.

4. An aquaculture system as claimed in claim 1, 2 or 3, wherein the biological filter means is connected to the array of separation means to receive flow from the most upstream and the most downstream of the separation means of this array.

5. An aquaculture system as claimed in claim 1, 2, 3 or 4, wherein the connection of the biological filter means to provide return flow to the array of separation means is to a separation means of the array that is between the most upstream and the most downstream of the separation means of the array.

6. An aquaculture system as claimed in any one of claims 1 to 5, wherein the holding tank is connected to each of the separation means of the array for receiving separated out materials and life forms.

7. An aquaculture system as claimed in any one of claims 1 to 6, wherein the connection of the holding tank to provide return flow to the array of separation means is to a separation means that is between the most upstream and the most downstream of the separation means of the array.

8. An aquaculture system as claimed in any one of the preceding claims and including a digester connected to receive water borne materials and life forms from the remainder of the system for return, after passing through the digester, to the system.

9. Material produced in the holding tank by operation of the system as claimed in any one of claims 1 to 8.

10. An aquaculture system substantially as hereinbefore described with reference to Figures 1 to 5 with or without Figures 6 to 10 of the accompanying drawings.

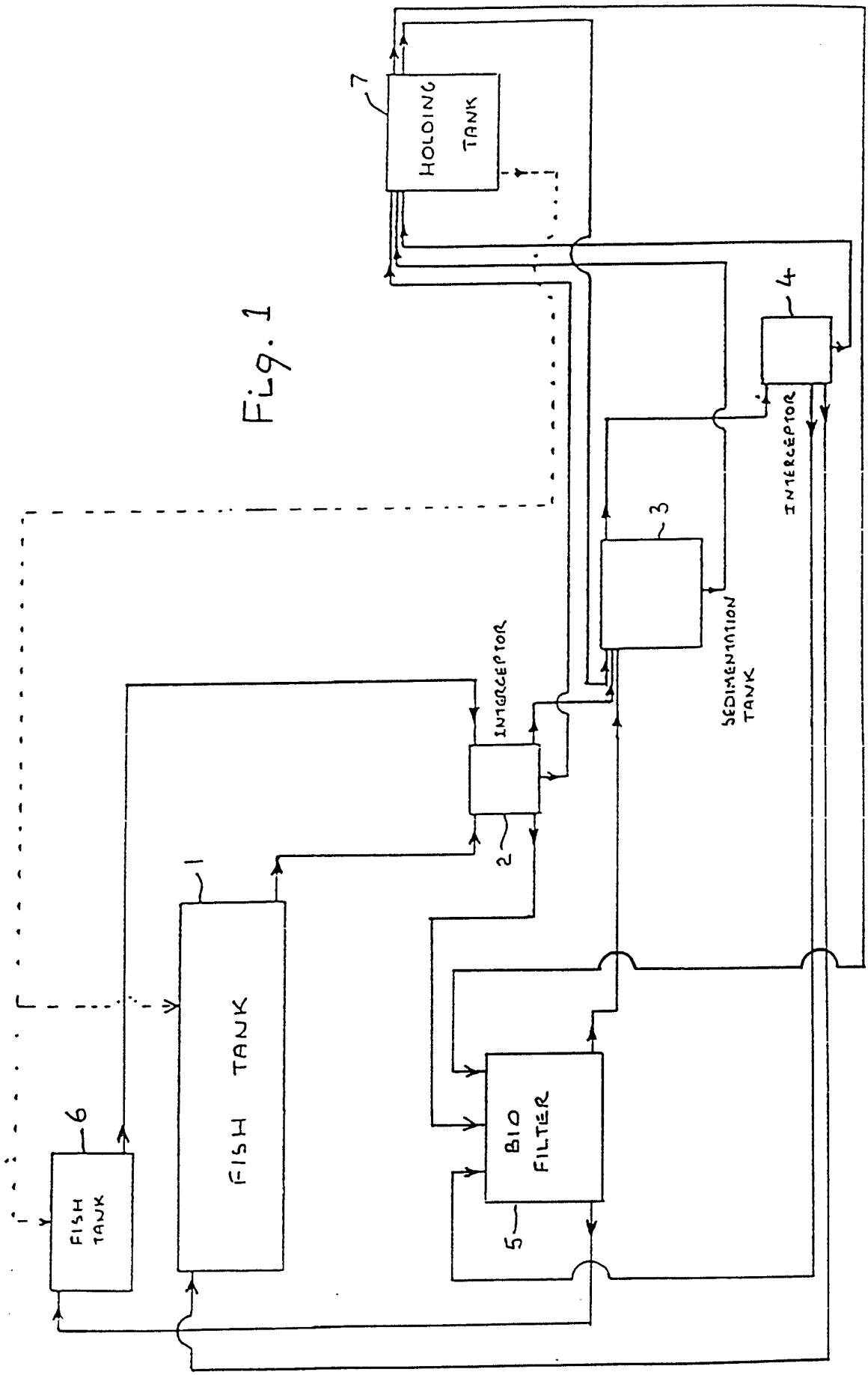

HOLDING TANK
7
4
INTERCEPTOR
3
SEDIMENTATION TANK
INTERCEPTOR
2
1
FISH TANK
BIO FILTER
5
6
FISH TANK

Fig. 1

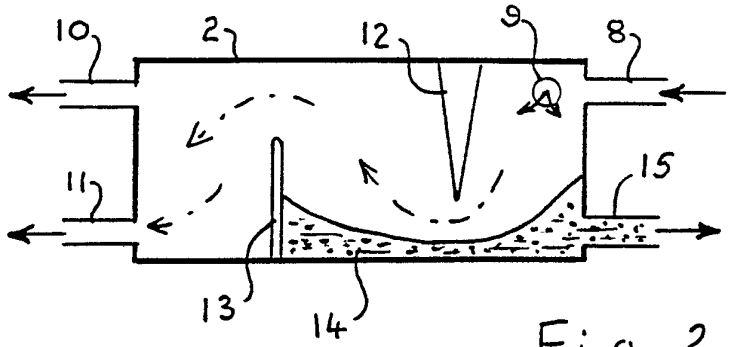


Fig. 2

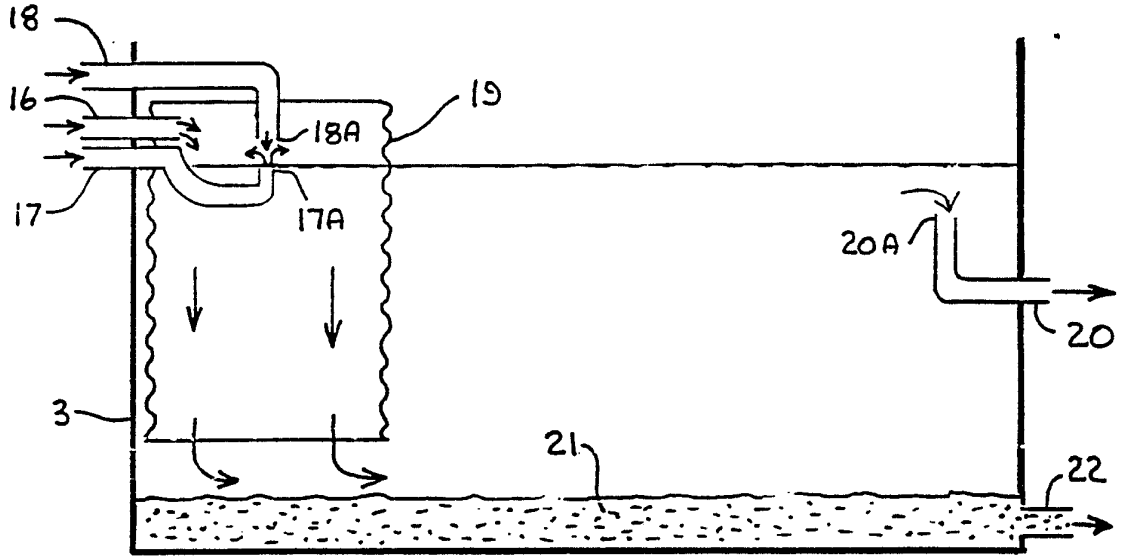


Fig. 3

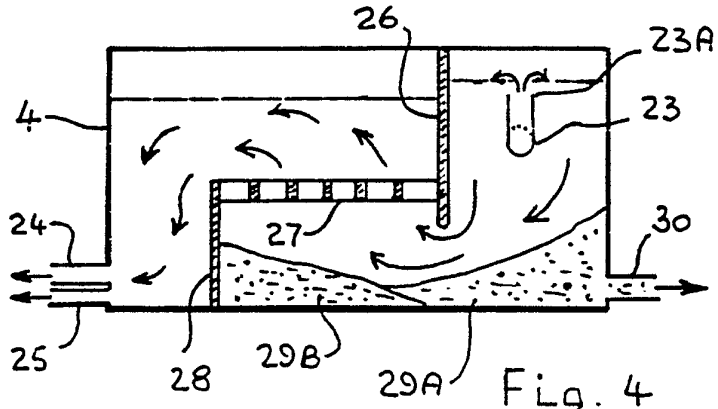


Fig. 4

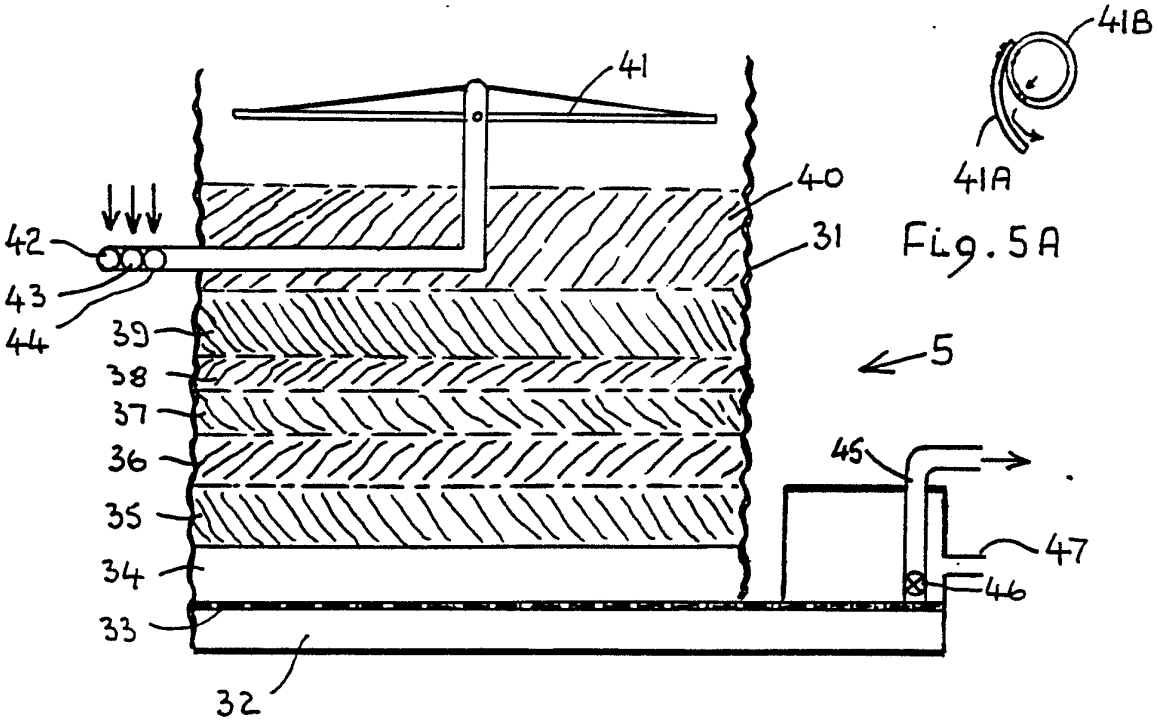


Fig. 5A

Fig. 5

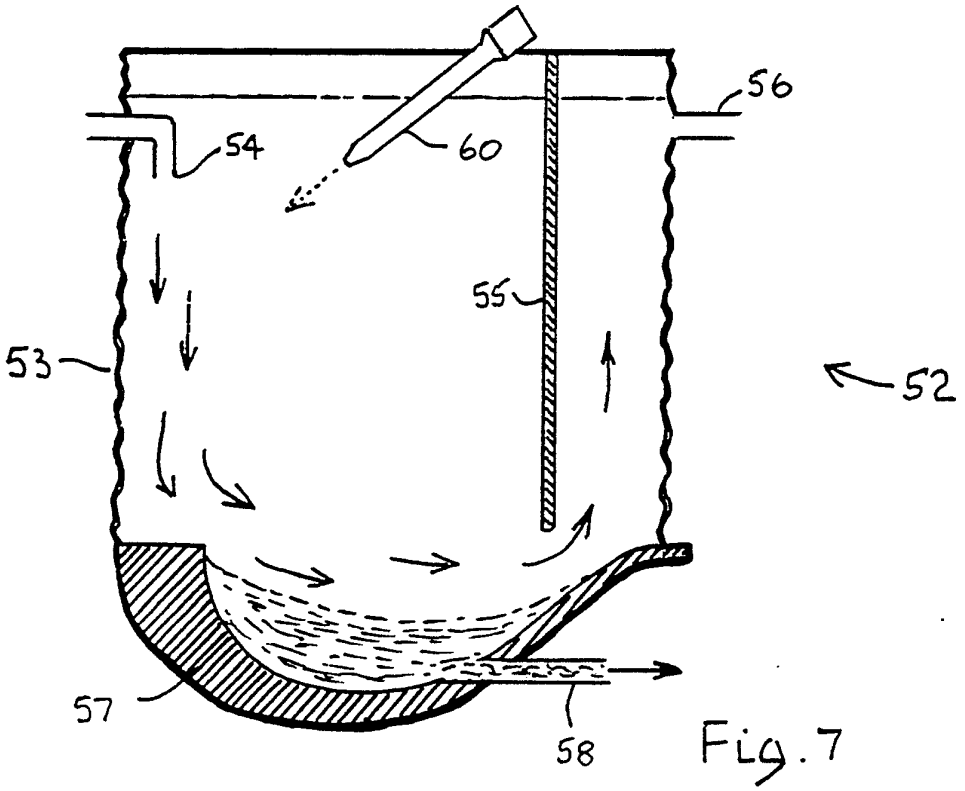


Fig. 7

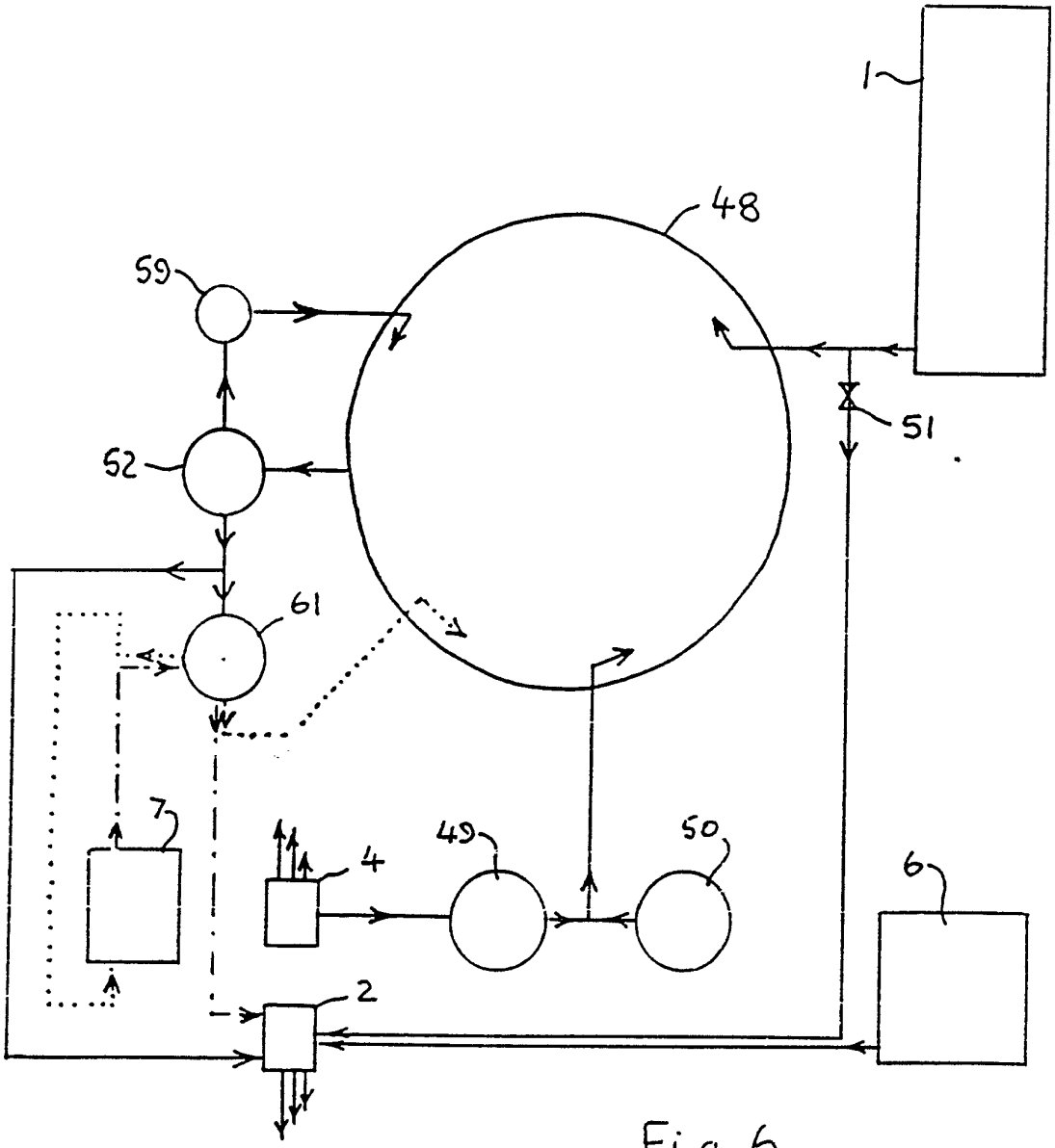


Fig. 6

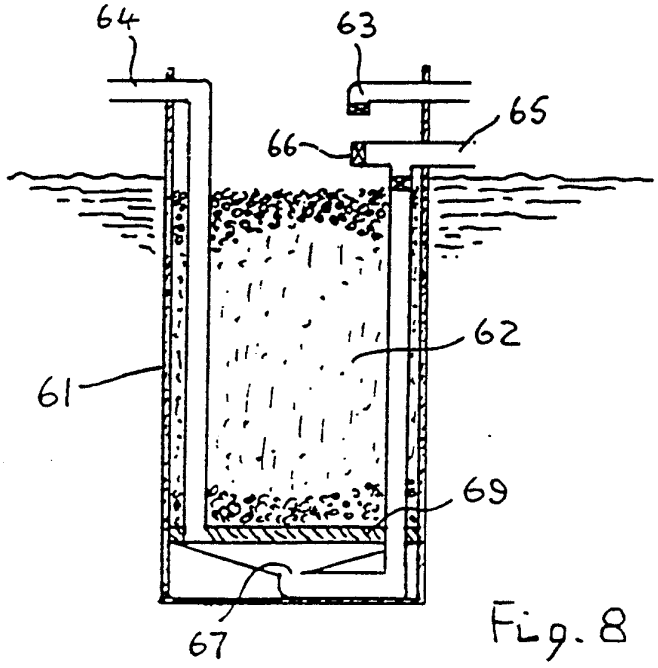
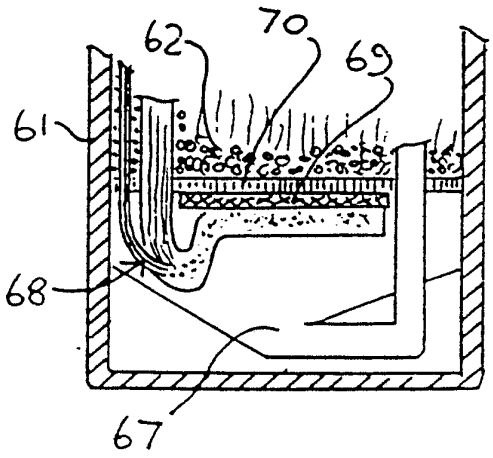


Fig. 8

Fig. 9



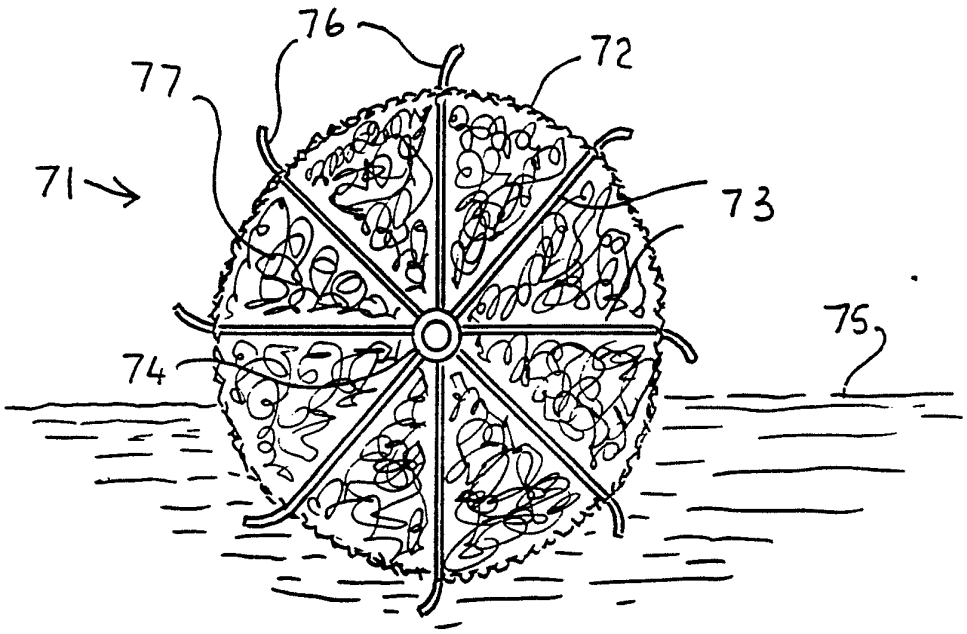


Fig. 10

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/00319

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 A01K63/04

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	A01K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X A	US,A,4 043 299 (BIRKBECK) August 23, 1977 see column 3, line 12 - column 8, line 64; figures 1,2	9,10 1,2,4-7
A	US,A,3 116 712 (OGDEN) January 7, 1964	
A	FR,A,2 413 876 (BORCHELD) August 3, 1979	
A	US,A,3 957 017 (CARMIGNANI) May 18, 1976	
A	US,A,3 661 262 (SANDERS) May 9, 1972	

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
30 MAY 1991	19. 07. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	VON ARX V.U.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 91/00319

SA 45069

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 30/05/91
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US-A-3116712		None	
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