Development of a RTU (Road Transport Unit)
For the transport of Abalone.

Close-out Report
For
IDU Project 97/005
FRDC 19/407

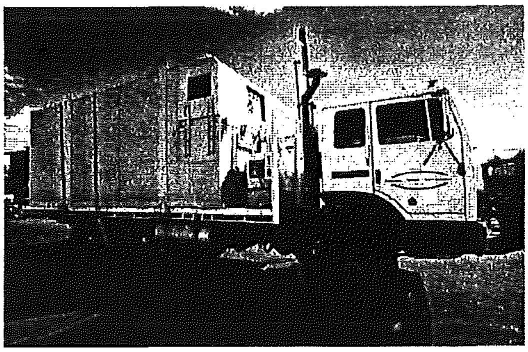
By: Vance Squires
Principal Investigator

Dated: 21st September 1999

Non-Technical summary

The intent of this WAFIC grant project was to undertake trials and develop methodologies that would provide the abilities to transport roei and greenlip abalone live from remote catch or fishing areas to the live export shipping point. The primary project target was to demonstrate that abalone could be maintained in a viable live state for shipment to South-East Asian markets. The transport distances between the catch area and the live export point can exceed 1500kms.

To this end design, development and construction of what has become known as the RTU (Road Transport Unit) was undertaken. The RTU mounted on a flatbed truck can be seen at in the photo at right.



The RTU project was conceived around a requirement to live export abalone however during the design and development stage it became apparent that the unit could be so structured as to cater for the live transport of a number of sea-food species. The ability to cater for a variety of catch species required flexibility in the control mechanisms for oxygen, air circulation, refrigeration capacities, filters and multiple logic processors (or CPUs). The unit can also serve as a portable laboratory facility to determine the parameters for differing product types.

A different way of viewing the RTU is to see the unit as a portable tank room with the ability to manipulate or manage the environmental conditions to suit the product that is being either held and/or transported.

Both static and road transport trials to 48 hours maximum have been completed and have proven up the workability of the concept. The road trials utilising Lobster product were conducted between fisheries located around the West Australian coast.

The RTU was completed late in 1998 after a setback caused by a break-in and vandalism at the premises of Live-Tech where the RTU was being constructed.

One RTU utilisation concept could be to develop a schedule between the transport operator and the fishery so that the RTU could be scheduled into the remote location at the time suitable to the fishermen. This, for instance, could see a RTU begin it's product collection run in Esperance, or even further around the West Australian coast, and progress in an arc around the coastline back to Perth. The number of collection points visited determined only by the RTU capacity.

The RTU, as described in the following pages and in the preceding photo at should be seen as a prototype. Further RTU builds would see a variety of capacity types, a much lighter unit and a refinement to the processes within the RTU.

The successful completion and trials of the RTU now opens the way for seafood exporters to take advantage of the financial gains to be made from the long distance transport and the live export of abalone, lobster and other species of sea-food.

Need
Before implementation of this project there had been only very limited attempts and none of them could be considered successful, at long distance live transport and export of abalone. To advance the returns available to the abalone fishery the technical means of transporting live abalone and retaining them in a viable state had to be investigated, developed and implemented.

Objectives
The original objective of the project was to develop a self contained, self monitoring system which allowed the transport to factory from fisheries in the South-west and Southern coast of Western Australia of live abalone with minimal levels of mortality and/or stress.

As stated in the preceding Non-technical summary. Once design and development had started it became obvious that extension of the development of the RTU for live abalone transport and export to embrace a variety of sea-foods added substantial value to the project outcomes.

Methods
The self-contained unit was to be developed with facilities which reproduced and maintained an environment that was as physically close as possible to the product's natural environment.

This approach meant that the engineering of the RTU needed to encompass technologies that achieved the following:

Dehydration
- The processing units of the RTU measure and regulate the humidity and control the spray cycles. There are micro-environments within the RTU.

- The gills of abalone (and other gillfish) rely on being wet to enable the uptake of oxygen. Without effective control of humidity and moisture via spray systems there is dehydration and damage to the gill system and a subsequent increase of mortality levels of the product.

Blood Oxygen and Carbon Dioxide Management
- This is achieved by direct measurement of blood in the viscera of the abalone. This provides an indication of blood acidoious increase. The RTU environment variables can then be adjusted to correct any trend increase in the acidoious.

- Blood oxygen and pH is measured by use of a microprobe implanted into the viscera of (selected) abalone.

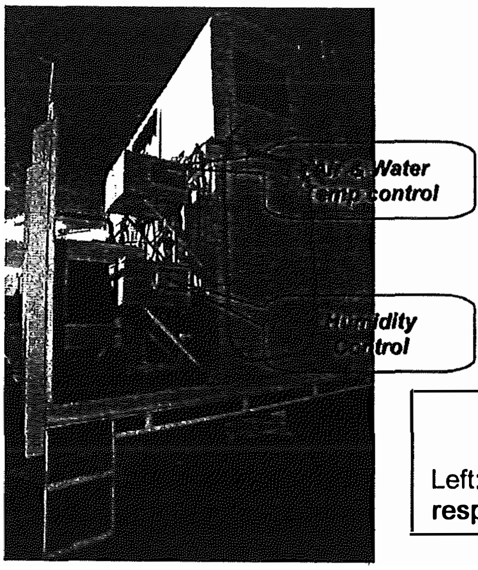
Temperature Management
- Temperature is measured by probes located within the RTU environment and measure water, air and abalone body temperature. The control of temperature is by a 0.2 degree Celsius controller.

- Lowering of the product body temperature has the effect of slowing the metabolic rate and thereby decreasing the demand for oxygen.

Oxygen Management

– The oxygen level within the RTU environment is monitored by the unit's processors and the level adjusted by releasing oxygen into the closed RTU environment.

The above categories of management of the product environment, the control mechanisms and the ability to alter the category aspects are via a number of CPUs contained on the RTU and real-time displays available to the vehicle cabin which can be seen in the following photos.



Above: **Cabin displays from CPUs**

Left: **Two Processors on mid left-hand side of RTU responsible for Management of RTU Environment.**

Waste Management

– Wastes from the product are washed from the basket by the movement of water from the spray bars located in the top of the RTU. The RTU processor units control the rate at which the spray operates and implement a spray cycle that is optimal to maintaining the health of the product.

Detailed Results

Please refer to attached Trial and Modification report sheets – Attached as Appendix A.

Benefits

The unit can be located as a remote depot or holding system for use by the local fishermen. It was found during trials that the RTU not only maintains the condition of the product but also enhances the product health.

Further Development

- Design and development of a comprehensive operator manual and technical manual.
- The rack system can be developed, enhanced and further improved.
- The ratio of unit weight to product can be greatly reduced and improved.
- As stated in the non-technical summary later models of the RTU would have capacity improvements; ratio of unit weight to product improved; rack system improvements.
- Reduced production cost due to improved material utilisation and prior experience.

Staff

Vance Squires –	Principal Investigator – Design, supervise and construction.
John Mason -	Biologist
David Birdling –	Electrical and Refigeration and Unit Construction
Matt Cheyne –	Technical Assistant
Phillip Fenn –	Refigeration Design and (part) construction
Dave Roberts –	Project Engineering, pumping calculations and general structural work.
Perth Scientific -	Technical Contribution

Final Cost
Final Cost of the RTU is tabulated on the attached cost sheet as Appendix B.

Initially Live-Tech/V Squires were the builders of the RTU. Subsequent to the break-in and consequent damage to the RTU the unit was repaired and ownership was transferred to V. Squires for a mutually agreed amount.

Terminology
Terms used to describe abalone handling are described in appendix C.

Appendix A

Bio-Filter Development

Product Used
40Kgs Brown Lip Abalone in Fishermen's Baskets

Period – 6 weeks

Daily Inspection – visual

After 8 days 1 mortality. Mortality due to foot of Abalone being lacerated during removal from rocks. Abalone being hemophiliac bled to death.

Balance of product lived through the 6 week development period.

Product was then shucked and discarded. Product had been affected by 6 weeks in a High Ammonia and Nitrate level containment.

Outcomes:
Period provided a good definition of Bio-Filter capacity.

Appendix A

Abalone Product Trial #1

Containment of Abalone in a static trial of RTU at Live-Tech premises.

Abalone – Local product from Perth beaches.

Setup –3 baskets of 5kgs each on CAD Flute.
Total 15kgs of product. One batch of 15 kgs in RTU and a benchmark batch of 15kgs in Live-Tech tanks

RTU Temperature set at 15degrees Celsius under continual high-pressure spray conditions.

Product was inspected every 2 hours with the last period a 6 hour duration.

Inspection 1 – 2 hours into trial
During this period 4 Abalone removed due to bleeding from foot lacerations.

Inspection 2 - 4 hours into trial
No further moralities.

Inspection 3 – 6 hours into trial
Removed micro-probes from product foot to log stress (pH level).
It was found that probes were causing hemorrhaging
Probes were re-inserted in skirt of remaining product.
Damaged (bleeding) product discarded.
Slime Layer of product was noted as having badly deteriorated.

Inspection 4 – 12 hours into trial
Product removed for detailed examination in Live-Tech facilities.

Post Trial Procedures

1. Weight comparison (after draining) using electronic lab scales.
2. Using surgical gloves the slime layer checked on foot and severe deterioration noted.
3. Microscopic inspection of foot against benchmark Abalone retained over same timeframe in Live-Tech tanks.
4. Inspection of Benchmark product in LiveTech tanks showed slime layer was in excellent condition
5. Comparative Inspection of slime layer of RTU product Vs Benchmark LiveTech product

Conclusion:

- RTU Abalone exhibited extreme deterioration of the layer and an overall poor product condition.
- RTU spray pressure too high and therefore causing extreme deterioration of slime layer.
- Benchmark abalone were not subjected to spray pressure and suffered no deterioration of slime layer.
- Temperature differential between benchmark abalone (17C) and RTU product (15C) – lower temperature contributed to poor condition outcomes.
- pH probe in skirt still continued to cause hemorrhaging problems.
- RTU abalone condition at end of trial #1 was not suitable to even shuck – Product was discarded.

Actions Arising:

- Drilled out the spray pipes to reduce pressure of spray to equivalent of what would be experienced from a hand-held watering can.
- pH probe insertion methodology to be re-examined in next trial.

Appendix A

Abalone Product Trial #2

Containment of Abalone in a static trial of RTU at Live-Tech premises.

Abalone – Local product from Perth beaches.
Setup – 3 baskets of 5kgs each on CAD Flute.
Total 15kgs of product. One batch in RTU and a benchmark batch in Live-Tech tanks

RTU Temperature set at 15degrees Celsius under continual (modified) low pressure spray conditions.

Prior to 1st period the product was closely inspected for cuts and nicks to the foot and skirt. Trial #1 experience indicated product containment problems arose quickly from any laceration to the product. Medical putty was used around probe insertion points in an attempt to prevent any bleeding. Spray pattern pressure now reduced to equivalent of a hand-held watering can to overcome deterioration of slime layer as happened in trial #1

Product was inspected every 2 hours with the last period a 6 hour duration.

Inspection 1 – 2 hours into trial
No loose product. **//see terminology appendix //**

Inspection 2 - 4 hours into trial.
No loose product.
Noticeable drop in pH levels.

Inspection 3 – 6 hours into trial.
Medical putty not successful in stemming the bleeding. Product removed and probes not re-inserted. pH measurement to be taken at defined inspection periods.

Inspection 4 – 12 hours into trial.
No product mortality noted.
Similar weight loss to trial #1 noted.
Product removed for detailed examination.

Post Trial Procedures

1. Weight comparison with benchmark product (after draining) using electronic lab scales.
2. Using surgical gloves the RTU product slime layer checked on foot and severe deterioration noted.
3. Microscopic inspection of foot of benchmark Abalone retained over same timeframe in Live-Tech tanks. Inspection of Benchmark product in Live-Tech tanks showed slime layer was in excellent condition. Comparative Inspection of slime layer of RTU product Vs Benchmark Live-Tech product

Conclusion:

- RTU Abalone exhibited marked improvement of the slime layer but was still not satisfactory compared to benchmark product.
- pH levels in RTU product very low indicating a continuing stress problem.
- RTU abalone condition at end of trial #2 was not suitable to even shuck – Product was discarded.

Actions Arising:

- pH probe insertion methodology to be re-examined in next trial.

Appendix A

Abalone Product Trial #3

Containment of Abalone in a static trial of RTU at Live-Tech premises.

Abalone – Local product from Perth beaches.

Setup – 3 baskets of 5kgs each on CAD Flute.
Total 15kgs of product.
One batch 15kgs to be in RTU and a benchmark batch of 15kgs in Live-Tech tanks

Both RTU & Livetech Tank Temperature set at 17degrees Celsius under continual (modified) low spray conditions. pH levels recorded at start of trial period.

Product was inspected every 2 hours.

Inspection 1 – 2 hours into trial
Visual examination only
pH measurement indicated an improvement over stress levels noted at same time frame in prior trials.

Inspection 2 - 4 hours into trial
No mortalities.
Improved pH (stress) levels continued to be exhibited but were still not as optimum as the benchmark pH.

Inspection 3 – 6 hours into trial
Same conditions as noted at 4 hour period.

Inspection 4 – 12 hours into trial
No Mortalities. Observations same as inspection 2 and 3.

RTU shut for a further 12 hours with no intervening inspection.
- Trial stopped at 20 hours.
Product then removed for detailed examination in Live-Tech facilities.

Post Trial Procedures

1. Weight comparison (after draining) using electronic lab scales.
2. Using surgical gloves the slime layer checked on foot and severe deterioration noted.
3. Microscopic inspection of foot against benchmark Abalone retained over same timeframe in Live-Tech tanks.
4. Inspection of Benchmark product in Live-Tech tanks showed slime layer was in excellent condition
5. Comparative Inspection of slime layer of RTU product Vs Benchmark Live-Tech product

Conclusion:

- RTU Abalone exhibited 4% weight loss.
- Slime layer improved but still unsatisfactory against benchmark product.
- RTU product noted as being much more active against previous trials and timeframes.
- Benchmark abalone were not subjected to spray pressure and suffered no deterioration of slime layer. Although against benchmark abalone RTU product still down in quality.
- In previous trials RTU product could not 'right' themselves however at end of this trial it was noted that some 85% could 'right' themselves. Which is a good indicator of the product's improved condition.
- Conclude that product foot must be kept submerged.
- Oxygen levels must be kept at 80% - 90%

Appendix A

Abalone Product Trial #4

Containment of Abalone in a static trial of RTU at Live-Tech premises.

Abalone – Local product from Perth beaches.
Setup – 6 baskets of 5kgs each on CAD Flute.
Total 30 kgs of product.
One batch 30kgs in RTU and a benchmark batch of 30kgs in Live-Tech tanks

Both RTU & Live-tech Tank Temperature set at 17degrees Celsius under continual (modified) low pressure spray conditions

6 Baskets at 3 levels used to test suspected oxygen imbalance
Logged basket weights
pH levels recorded of benchmark and RTU product taken at start of trial period.

RTU Locked – no open/shut for 24 hours – Unit run for 24 hours continuous

CPU logged a possible fault in oxygen system
Venting of CO_2
Super Saturating of oxygen – Raised mortality probability – Carbon dioxide (CO_2) imbalance

Product then removed for detailed examination in Live-Tech facilities.

Post Trial Procedures

1. Weight comparison (after draining) using electronic lab scales.
2. pH Basket levels – measured pH recorded for each basket level (Top/Middle/Bottom)
   Bottom – pH dramatic drop and product close to mortality.
   Middle – Negligible difference between RTU and benchmark product.
   Top – pH level down

Conclusion:

- Oxygen distribution probable in differing levels of RTU
- Oxygen supersaturating at bottom – CO_2 too high at top level – Middle level exhibited reasonable balances.

Actions:

Ceased all RTU trials. Focus changed to analysis and remedial activity of oxygen levels problem.

Appendix A

Remedial Action to RTU (Modifications)

MODIFICATIONS

- Split oxygen supply into 2 discharge points
- Installed slow speed circulating Fan above plate coil (air temperature controller) to circulate air.
- Replaced CO2 vents with a different vent manufacturer to improve efficiency.
- Two oxygen probes and 4 hand-held (remote) probes installed and connected to data-loggers.

Post Modification Activity

48 Hour run with no product in place.

Monitored oxygen levels via the additional probes.

Result – Good confidence level in equalisation of air distribution levels.

Abalone Product Trial #5

3 Baskets of RTU product and equivalent Benchmark Abalone.

pH and weight measurement taken at start.

36 Hour duration in 3 X 12 hour stages.

At each 12 hour stage pH was found to be comparable to benchmark abalone (in Live-tech tanks)

Inspection of foot-slime layer of RTU product indicated that there remained some problem with abalone condition.

There was a 6.5% weight loss – [Normally product will de-hydrate in the transition between natural environment and move to a tank environment and once product is placed in tank there is a reversal of the weight loss back to near the natural environment weight]. Therefore a continued weight loss [or no regain of weight] is an indicator of continuing product condition problems – ie the RTU environment is still not at an optimum setting.

Trial Pack-out (on completion of post modification Trial #5).

Trial pack-out of 8 Kgs

Opened trial packout 24 hours later. No mortality

Replaced product into Live-tech tanks and held for another 24 hours – No Mortality

Results - Further Modifications to process.

Constructed 3 special baskets. Installed solid base and a 20mm solid rise around the perimeter to retain sufficient water to keep product foot submersed. This was to prevent dehydration and loss of slime layer quality.

Abalone Product Trial #6

36 hour trial
3 X 5 kgs product in modified baskets against benchmark abalone.

Pre shut-in ph and weight measurements taken.

Results:
On opening: pH, slime layer and weight where found to be comparable to benchmark product.

5 abalone in RTU were found to have piggybacked and caused
a) condition problem to piggybacked abalone (and)
b) product carrying out the piggybacking suffered a weight loss.

ACTION:
Further Modifications to Baskets:

Development of a mesh layer to place on top of (loaded) product at outset. Placement of mesh layer then prevented movement of abalone towards piggybacking other product.

Abalone Product Trial #7

Repacked new product on same basis as previous trials.

Used 6 modified baskets. (Top layer Mesh, Solid base and 20mm solid side)

48 Hour duration – Normal start and end measurements of pH and weight taken.

RTU opened at 48 Hours.

- No weight loss
- No Mortality
- pH comparable to benchmark product.

PACKOUT Trial
36 Hours in 3 Eskys – 24 Kgs

On opening

No mortality
6% weight loss
Some product appeared weak indicated by lack of and or poor adhesion to CAD flute.

Product replaced into Live-Tech holding tanks for 12 hours.

At end of 12 hours
Weight loss restored to only a representative 2% loss (4% re-gain)
Product exhibited healthy parameters.

Review/Conclusion

RTU now considered set-up in a manner suitable for Road Trials.

Appendix A

RTU Road Trials – Lobster Product

1. Static trial in Dongara alongside the MG Kailis Fisheries Factory.

10 Baskets (250 Kgs) of Lobster product taken from Dongara Jetty to MGK factory weigh station.
Product weighed.
Not graded.
Not removed from baskets
Mesh Lids fitted to baskets
Sample product restrained on a flat board with Velcro straps and pH probes inserted.
Loaded into RTU situated alongside the factory.

RTU initial temperature setting 17C reduced to 14C over a 12 hour period.

RTU opened at 24 hours.

pH found to be stable (satisfactory) after 24 hours containment.
Visual examination showed product in good condition.

Product then Graded:
76% suitable for live export [Considered a more than satisfactory result considering grading not carried out prior to load into RTU]

Appendix A

RTU on Road Trial (Dongara – Canarvon – Dongara)

RTU to Canarvon for rendezvous with Lobster vessel scheduled for 3pm meet time.

Vessel had arrived at 1pm and, due to high salinity in ocean, product had been unloaded onto jetty out of vessels live holding tanks.

Product was on the jetty for 2 hours in an ambient temperature of 40c plus until RTU arrived at 3pm.

Product was loaded into RTU with temperature set at 18C (Air & Water) and reduced over the next 8 hours to 14C while RTU awaited arrival of next lobster vessel due at midday the following day.

On 2nd vessel arrival RTU then loaded with another 18 baskets (25 kgs each).

RTU temperature at this time was already functioning at 14C.

RTU departed Canarvon and arrived Dongara at 8:30pm same day (6 hour Journey).

Product then graded for Live export or Iced (for cooking).

1st product load (from first vessel) produced 45% for Live Export – Balance to cooking with 2 mortalities.

2nd Product load (from 2nd vessel) produced 74% for Live Export – Balance for cooking with no mortalities.

Appendix A

Static Trial at Dongara

10 Baskets (25kg each) weighed and pre-graded from Dongara jetty

72 hour duration.

RTU temperature set at 14C (Air and Water)

Unloaded at 72 hours –
Graded and 93% suitable for Live Export
No Mortality

Trial Packout (of same product)

36 Hour trial.

Comatosed at 5C

Unpack at 36 hours – 3% mortality

Rest of product returned to MG Kailis live holding tanks for 24 hours for further observation. No further mortalities.

Product moved to cooking process.

Appendix A

8 RTU road Trials to Donagara – Kalbarri – Dongara.

Trips took place over a non-sequential period – Timing was dependent on vessel arrivals.

Standard pattern of activity was a 9am rendezvous with Lobster boat at Kalbarri to start load.

RTU set at 14C

4:30pm departure to Dongara (3 hours trip duration).

It should be noted that prior to the RTU load 50% of the product was already 48 hours held in the vessel live tanks in comparatively high water temperatures.

On arrival at Dongara product was graded for Live Export or cooking.

70% was the average live export grade content for all 8 road trips/trials from Kalbarri.

This is a first time achievement for live export quality from Kalbarri.

Conclusion:

From Static and road trials it is determined that oxygen levels must be saturated to 90-100%. Temperature must be at 14C. (Air and Water) as optimum for Lobster.

No adverse results could be attributed to move/change from boat holding temperature to RTU setting of 14C.

Note:

The RTU road trial costs of fuel and labour could not be recovered from MG Kailis or other parties due to the ongoing patent process. This patent process involved multiple aspects of the RTU functionality.

The estimated cost of fuel and labour is put at a nominal $1 per kilometre.

The $9,000 cost estimate is not included in the cost table provide at Appendix B.

Appendix B

Detail and Summary of Expenditure related to WAFIC project for the RTU (Road Transport Unit) Facility.

V. Squires/MGK Loan

19/05/98	V Squires	RTU Loan	$5,000.00
16/06/98	V Squires	RTU Loan	$5,000.00
07/07/98	M. Cheyne	RTU Labour	$1,580.00
07/07/98	D Birdling	RTU Labour	$1,683.00
07/07/98	Perth Scientific	RTU Equipment	$5,204.00
24/07/98	M. Cheyne	RTU Batavia	$700.00
24/07/98	D Birdling	RTU Batavia	$1,590.00
24/07/98	J Nixon	RTU Labour	$140.00
04/08/98	D Birdling	RTU Labour	$780.00
		****Total MGK Loan**	**$21,677.00**

V. Squires/AMT Loan

25/08/98	D Birdling	RTU Labour	$640.00
11/09/98	D Birdling	RTU Labour	$500.00
16/09/98	Concord Plastics	RTU Materials	$635.60
25/09/98	Marine Metals	RTU Materials	$453.00
25/09/98	PolyTech Plastics	RTU Materials	$540.66
25/09/98	Stirling Irrigation	RTU Materials	$157.54
25/09/98	V Squires	RTU Costs	$488.33
05/10/98	M Cheyne	RTU Labour	$150.00
09/10/98	V Squires	RTU Costs	$1,130.45
22/10/98	V Squires	RTU Costs	$1,106.72
22/10/98	D Birdling	RTU Labour	$1,500.00
29/10/98	D Birdling	RTU Labour	$937.50
29/10/98	Stirling Irrigation	RTU Generator Set	$7,500.00
06/11/98	D Birdling	RTU Labour	$1,012.50
13/11/98	D Birdling	RTU Labour	$987.50
18/11/98	J Nixon	RTU Labour	$997.50
18/11/98	D Birdling	RTU Labour	$929.95
18/11/98	Aussie Fishery	RTU Costs	$1,400.00
23/11/98	PolyTech Plastics	RTU Materials	$550.70
23/11/98	Marine Metals	RTU Materials	$475.00
02/11/98	V Squires	RTU Costs	$1,952.21
26/11/98	Fenn Electrical	RTU Costs	$917.49
26/11/98	Aviate Engineering	RTU Costs	$348.00
26/11/98	Stirling Irrigation	RTU Materials	$87.14
01/12/98	Paterson Materials	RTU Materials	$120.00
01/12/98	D Birdling	RTU Labour	$787.50
01/12/98	D Birdling	RTU Labour	$675.00
09/12/98	Jardine Insurance	RTU Insurance Cover	$507.51
01/12/98	V Squires	RTU Costs	$2,208.42
16/12/98	Stirling Irrigation	RTU Materials	$251.55
16/12/98	Enzed	RTU Materials	$111.50
16/12/98	Project Engineering	RTU Labour	$2,549.98
16/12/98	PolyTech Plastics	RTU Materials	$577.40
16/12/98	Marine Metals	RTU Materials	$1,640.00
06/01/99	D Birdling	RTU Labour	$1,487.50
24/01/99	PolyTech Plastics	RTU Materials	$222.00
24/01/99	Independent Parts	RTU Materials	$40.32
27/01/99	D Birdling	RTU Labour	$1,187.50
06/01/99	M Cheyne	RTU Labour	$1,000.00
06/01/99	M Cheyne	RTU Costs	$53.76
18/02/99	Cheyne/Birdling Sal	RTU Labour	$2,000.00
25/02/99	Cheyne/Birdling Sal	RTU Labour	$1,000.00
26/02/99	Stirling Irrigation	RTU Materials	$30.67
04/03/99	Cheyne/Birdling Sal	RTU Labour	$1,000.00
12/03/99	V Squires	RTU Costs	$1,190.53
19/03/99	Project Engineering	RTU Labour	$151.11
03/05/99	V Squires	RTU Costs	$253.10
20/05/99	Enzed	RTU Materials	$508.67
20/05/99	Project Engineering	RTU Materials	$247.13
20/05/99	Stirling Irrigation	RTU Materials	$232.23
31/05/99	V Squires	RTU Costs	$434.80
26/06/99	V Squires	RTU Costs	$636.60
		****Total AMT Loan**	**$46,502.57**

****Total Cost To MGK/AMT Loan** **$68,179.57**

LiveTech

23/09/97	James Hardy	RTU Materials	$2,950.00
06/10/97	Skip Hiab Transport	RTU	$115.00
10/10/97	Bon Door	RTU Materials	$32.00
16/10/97	Concord Plastics	RTU Materials	$2,480.00
17/10/97	R Annear	Baskets	$2,743.00
05/11/97	Welshpool Coolrooms	RTU Materials	$330.00
05/11/97	C & A Adams	RTU Materials	$1,430.00
04/11/97	Park Auto Supplies	RTU Materials	$34.00
12/11/97	Bon Door	Fibre Glass	$50.00
18/11/97	Silverlock & Co	Baskets	$400.00
19/11/97	Adlam Industries	Door Parts	$252.05
18/11/97	Park Auto Supplies	RTU Materials	$39.40
25/11/97	Sweetman	RTU Materials	$34.81
28/11/97	Sweetman	Rivets	$29.58
09/12/97	Fenn Electrical	RTU Electrical Work	$6,612.62
06/01/98	Swan Hardware	RTU Materials	$49.14
06/01/98	Stirling Irrigation	RTU Materials	$116.49
06/01/98	Concord Plastics	RTU Materials	$98.05
06/01/98	Thardon Bught Mining	RTU Materials	$264.00
06/01/98	Marine Metal Fabric.	RTU Materials	$1,216.00
06/01/98	Swan Trade Centre	RTU Materials	$1,187.37
06/01/98	Polytech Plastics	RTU Materials	$4,923.00
08/01/98	Airfrig Supplies	RTU Materials	$6,712.34
30/01/98	Enzed Hydraulics	RTU Materials	$395.22
12/02/98	Project Engineering	RTU Materials	$787.50
03/03/98	Polytech Plastics	RTU Materials	$1,959.00
17/04/98	Stirling Irrigation	RTU Materials	$2,227.85
21/04/98	Project Engineering	RTU Materials	$491.00
22/04/98	Airfrig Supplies	RTU Materials	$473.98
22/04/98	Concord Plastics	RTU Materials	$182.00
22/04/98	Fenn Electrical	RTU Materials	$4,827.66
17/04/98	Swan Trade Centre	RTU Materials	$526.69
		****Total Cost To Live Tech**	**$43,969.75**

V. Squires

04/11/96	Actrol	Refigerant	$227.10
27/02/98	Airfrig Supplies	Flow Switch	$220.45
15/05/98	D. Birdling	Labour Equip wiring	$1,462.00
18/05/98	Enzed Hydraulics	Hoses	$114.65
15/05/98	Uniway Crane Hire	Freight	$607.00
29/05/98	Marine Metal Fabric.	Steel Fab	$453.00
05/06/98	Perth Scientific	ORP Probe	$129.00
08/06/98	Perth Scientific	DTLM Logger Kit	$100.00
10/06/98	Perth Scientific	Temp Meter & Probes	$1,458.00
10/06/98	Perth Scientific	Internal Temp Probes	$657.00
17/06/98	Perth Scientific	Dissolved Oxygen Mon.	$2,091.00
17/06/98	D. Birdling	Labour May/Jun	$2,040.00
17/06/98	Swan Trade Centre	Misc Hardware	$176.42
17/06/98	Swan Trade Centre	Misc Hardware	$23.44
23/06/98	Perth Scientific	DO Oxygen Monitor	$550.00
30/06/98	Stirling Irrigation	Misc. Parts	$150.90
01/07/98	Swan Hardware	Misc Materials	$28.60
06/07/98	Swan Hardware	Misc Materials	$34.65
24/07/98	Concord Plastics	RTU Mods	$825.60
24/07/98	M & B Wedge	Purch. Of RTU Truck	$30,000.00
		****Total V. Squires RTU Expenditure**	**$41,348.81**

Summary of Expenditure

MGK/V Squires RTU Loan Costs	$21,677.00
AMT/V Squires RTU Loan Costs	$46,502.57
Live Tech	$43,969.75
V Squires	$41,348.81
****Total Cost of RTU**	**$153,498.13**

ABALONE TERMINOLOGY:

FOOT: The exposed muscle that attaches the Abalone to the reef.

SKIRT: A (flesh) curtain that surrounds the 'Foot' and enables the abalone to effect a seal around the foot and secure the attachment to the reef.

SLIME: (or) Slime Layer – A mucus extruded through the foot to allow or facilitate the abalone mobility around the reef (can be likened to a snail's trail).

CAD FLUTE: Material used within the RTU as an artificial reef. Made from plastic coated corrugated cardboard.

LOOSE ON CAD FLUTE:
This term is used to describe condition of abalone attachment to the CAD FLUTE. If in attempting to move the abalone it does not respond by attaching itself more firmly then this is one of the first indicators that the product condition is deteriorating.

THE NIPPER GRIPPER

HOW TO STOP A BLUE CRAB FEELING BLUE

R. N. Stevens
V. R. Squires

April 1999

NIPPER GRIPPER

HOW TO STOP A BLUE CRAB FEELING BLUE

Abstract

An improved method of holding and transporting blue crabs has been devised. Blue Crabs stress on capture and, when held in live holding tanks tend to attack each other. Traditional methods of handling the claws, coupled with transport over the long distances encountered in Western Australia, result in unacceptable levels of limb loss.

A patented device that holds the claws of the crab slightly open while allowing the arms to move freely, has massively reduced limb loss in crabs. A new live transport vehicle that allows the driver continuously to monitor conditions in the back of the truck via a display in the cab, has been successfully tested. The driver can adjust conditions in the back of the vehicle (temperature; pH; dissolved oxygen; dissolved carbon dioxide, and dissolved ammonia) from the cab without stopping the vehicle.

Introduction

Blue Crabs (*Portunus pelagicus*) constitute a small but important fishery in at least three States of Australia. The crabs have a fine, white flesh and, when presented in good condition, the meat is a gourmet item. The crabs elicit a severe stress response on capture, and, if not handled properly, this response results in the release of a protease enzyme causing 'mushiness' in the meat that detracts from the value of crab. (Hughes & Stevens 1998, Anon 1987).

Blue crabs may be comatosed on capture by rapid chilling (in refrigerated (RSW) or iced (ISW) seawater); a process that takes from 15 to 30 seconds. If immersed for much longer then this the crabs die. (Stevens 1995).

The claws of blue crabs must be bound if the crabs are to be held alive for transport or in live holding tanks prior to sale. Binding methods vary but essentially involve holding the nipper on each claw together with a band, or binding the whole claw to the body of the crab. Both methods are effective but have disadvantages. The first method allows the crab to remove the binding, particularly if held over a long period of time, as the smooth, curved outer edges of the nippers allow the crab to move the band and loosen it. The second method is time consuming to apply and causes sever stress to the crab, often resulting in limb loss. In both methods crabs have been observed to make strenuous efforts to remove the binding, effort which kills an unacceptable number of crabs in live holding tanks.

During transport of both crustaceans and molluscs, the conditions under which the fish are held are critical for survival. Typically, the 'load' on the filtration system is initially high in ammonia, and the charges over time, with ammonia levels falling as nitrate and nitrate levels rise. Temperature, pH, dissolved oxygen and dissolved carbon dioxide levels are critical.

Introduction (Cont'd)

Where transport distance are relatively short (200 km or less) a "fill and dump" system may be used. Typically in Western Australia crustaceans and molluscs are transported over longer distances, often exceeding 1000km. Under these circumstances recirculating sea water systems are employed. This leaves the driver ignorant of the physical and chemical state of the water in the back of the truck, and the state of health of the fish being transported for many hours.

If there are high fish mortalities in the vehicle during transport the cause remains unknown and repetition of the event is difficult to prevent. Data loggers in the truck may point to deteriorating conditions but there are no systems that allow driver to monitor conditions without stopping the vehicle, still less to prevent a deterioration in conditions that may prove fatal to the fish being transported.

Developments in Western Australia have overcome both problems.

On-Board Handling

Most of the vessels catching crab in Western Australia are small (7m loa or less). Traditionally these boats set bottom grill nets, usually setting four 600m long nets each day, and leaving them overnight. In the morning the nets were pulled, and replaced with four similar nets. The pulled nets were then emptied of crabs and the nets repaired ready for setting the next day. The catch is landed every day.

The process of removing the crabs took up to two hours and most of the catch was in poor condition by the time it was landed. A shift to potting improved the quality of the catch (and allowed the return of small and berried female crabs alive). On board handling of pots on very small vessels presented a problem so collapsible pots are used, with about eighty pots per boat.

While the quality of crabs improved immeasurably, it was thought that the handling could be further improved. As the pots are circular, the crabs fall into a small arc of the pot when it is pulled. Instead of hauling the pot over a tipper (inherited from the Western Rock Lobster fishery) that turns the pot to the horizontal, the pot is now pulled via a block on a gantry. Tipping spread the crab across the base of the pot, and made them very active, nipping both the pot netting and each other. By leaving the pot in the vertical plane this does not happen. The whole of the pot is then dipped into a tank with sufficient ISW to cover the crabs (Fig 1a & 1b).

Fig 1A – Side View

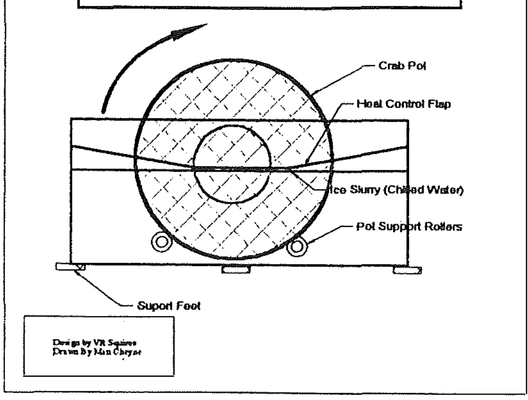
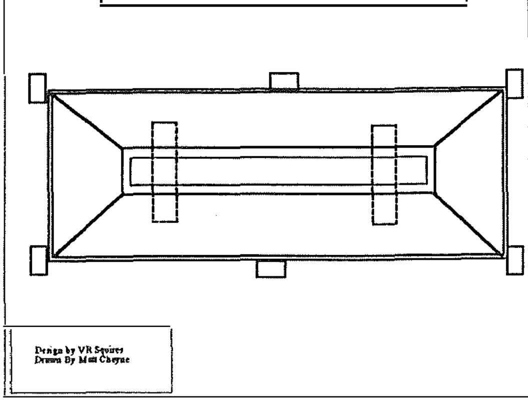


Fig 1B – Top View

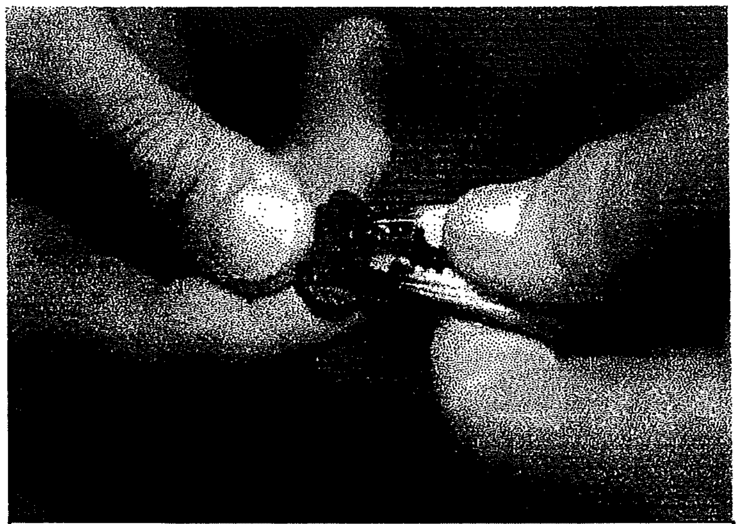


On-Board Handling (Cont'd)

While the crabs are chilling the pot is unlaced, and the bait removed and replaced with fresh bait. The comatose crabs are removed and the pot is ready to be reset. The changes reduce the time taken to handle each pot from 1½ minutes to about 30 seconds, removing nearly two hours from the fishing day, and landing the catch two hours earlier. Crabs are fitted with a unique 'nipper gripper' before being stored dry or beneath a seawater shower on the vessel.

The Nipper Gripper

The articulating claw of the blue crab is smooth and curved on its outer edges, the curve being more pronounced in female crabs. The inner edge is deeply serrated. A method of preventing the crabs from damaging each other that was cheap, easy to apply, effective and non-stressful was devised by designing a binding that fitted between as well as over the claw (Fig 2)



(Fig 2) The Nipper Gripper being applied to a Blue Crab claw

The clawed arm can move freely, and the claw itself can articulate slightly. The crabs will try to remove the band, but as it travels closer to the tips of the claw, the band forces the claw closed. The width of the centre band is such that it will not pass through between the tips of the claw, and the reaction of the centre band to compression tends to force the claw apart. These opposing forces combine and defeat the efforts of the crab to remove the band. Crabs quickly adapt to this situation. In trials held in commercial live tanks crabs thus handled were held alive for over one week without loss.

The Truck

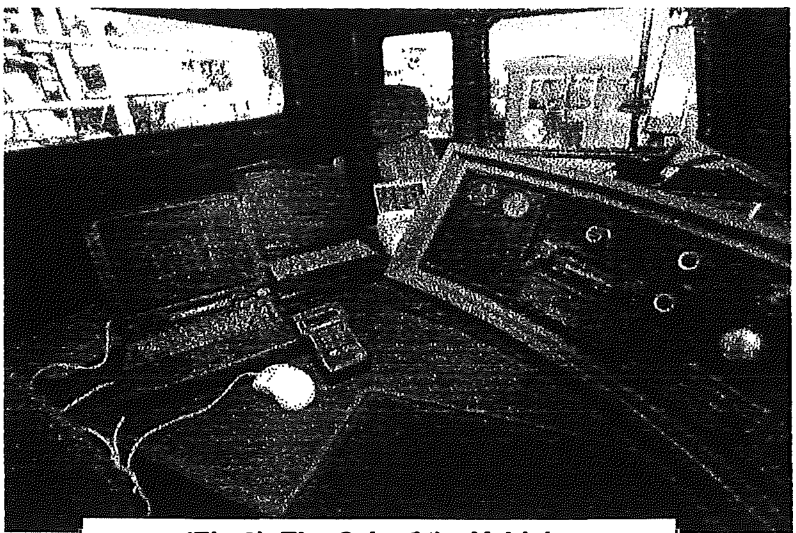
While most blue crabs are caught very close to Perth, and are landed for the domestic market, new fisheries are developing in Shark Bay and Exmouth Gulf, which are respectively 1000km and 1500km North of Perth. To bring crabs, or other molluscs or crustaceans alive to Perth by road presents difficulties.

The Truck (Cont'd)

To resolve this a vehicle was designed that allows constant monitoring of the conditions within its cargo bay. It was apparent in trials that a deterioration in the health status of the crabs (or lobster or abalone) caused a detectable change in an array of water quality paramaters. Monitoring water quality therefore gave an indication of health status or the species being carried. Modifying water quality could also reverse a decline in health status. The exact paramaters monitored are not for publication as they confer a commercial advantage on the owner of the vehicle.

It may be stated that moves such as ozone dosing to improve dissolved oxygen levels, and oxidise ammonia, while not raising the O^3 to levels detrimental to the filter bacteria are now routinely employed.

The modification of water quality can take place while the vehicle is in transit (fig 3). The design of the vehicle thus obviates the need for frequent stops to check the fish in the truck, stops which in themselves do nothing for product quality.



(Fig 3) The Cab of the Vehicle.
Laptops control conditions in the Bio Unit

Conclusion

The logistics problems of handling and transporting live seafood in large quantities over the distances encountered in Western Australia demand innovative solutions. Fishermen and processors in the state have combined to discover methods of handling and transporting sensitive live finfish, molluscs and crustaceans by road. This cost-effective solution to a problem will encourage the development of fisheries in areas from which the production of live seafood was formerly thought to be not possible.

References

ANON 1987
Investigation of Mushiness in Crabs.
Food Research and Technology Branch. Queensland Department of Primary Industries Brisbane Queensland.

HUGHES C J, & R N STEVENS 1998
The improvement in the quality of meat from frozen trawl caught Blue Crabs.
Fisheries Research and Development Corporation Canberra Australian Capital Territory.

PATERSON B D, P S LEY & R A SMITH 1994
Prolonging the Survival of Crabs.
Centre for Food Technology, Hamilton QLD.

STEVENS R N 1995
Improvement in the post harvest handling and marketing strategy for Blue Crabs.
WA Fishing Industry Council Perth Western Australia.

TOD P and P SPANOGUE 1997
Development of improved storage and transportation protocals for the Western Rock Lobster, *Panulirus cygnus.*
Fisheries Research and Development Corporation Canberra, ACT.

WALKER M H, PB WALSH, A P GIBSON & J A ROE 1994
An improved packaging system for Live Western Rock Lobster.

The Western Rock Lobster Development Association, Perth Western Australia.

Vance Squires
Consultant

Telephone: **08 9524 7778**
Fax: **08 9524 8158**
Mobile: **0419 853 553**

14 Sao Jorge Green
Secret Harbour Centre
WA 6173
AUSTRALIA

19 October 1999

Mr Richard Stevens
R&D Manager
WAFIC
Suite 6
41 Walters Drive
Osborne Park
WA 6017

Dear Richard

Please find enclosed the final report for the investigation into the feasibility of transporting Abalone over long distances at high ambient temperatures.

Also attached are two copies of the Exploitation Licence for this project, both of which I have signed. If you would please sign both copies and return one to me, I would be grateful.

Finally, I enclose my full and final account in respect of the above research project.

Yours sincerely,

Vance Squires

The Directors
Live-Tech Pty Ltd
29 Weatherburn Way
KARDINYA WA 6163

10th August 1998

Gentlemen,

IDU PROJECT 97/005

It is my understanding that the directors of Live-Tech Pty Ltd. have agreed to the transfer of ownership of the live transport unit to the Principal Investigator of this project, Mr Vance Squires.

Mr Squires has agreed to take sole responsibility for the project when the transfer of the unit has been effected.

Under these circumstances, the materials purchased with IDU funds are WAFIC equipment and still remain the property of WAFIC until the project has been completed, and a decision made on their disposal. They may not be disposed of in whole or in part without the express written permission of the WA Fishing Industry Council. To do so would be in breach of the contractual obligations of Live-Tech Pty Ltd. and require the return of the $23,000 given to the company for the project.

Mr Squires, has aquitted the IDU expenditure on this project, with copies of receipts, for materials used.

We agree that the responsibility for the project will, on transfer of the unit, pass to Mr Squires alone. Mr Squires has agreed to take full responsibility for the project, and the remaining of Live-Tech Pty Ltd. will then be absolved from responsibility for the project.

Yours sincerely

Richard Stevens
R&D Manager

Vance Squires

RS:C:/IDU/19 May 1998 Livetech Sale of Business.doc

AN INVENTION EXPLOITATION AGREEMENT

between

WAFIC

- and -

VANCE SQUIRES

INTELLECTUAL PROPERTY RIGHTS EXPLOITAION AGREEMENT

AN AGREEMENT made the 21 October 1999.

This agreement is made between Vance R Squires of 14 Sao Jorge Green, Secret Harbour ("VRS") of the first part and the Western Australian Fishing Industry Council Incorporated of suite 6, 41 Walters Drive, Osborne Park, WA 6017, Western Australia ("WAFIC") of the second part.

BACKGROUND

A. An agreement dated *15/8/97* was made between Live-tech Pty Ltd ("LiveTech") and WAFIC whereby Live-Tech would carry out a research and development project into the feasibility of developing a suitable vehicle for the road transportation of live Abalone in Western Australia, with WAFFIC contributing part of the total project costs and, in return, owning 8.11% of any resulting intellectual property rights.

B. A further agreement dated 12/8/98 made between VRS and Live-Tech assigned all the relevant terms and conditions of the first above agreement previously held by Live-Tech to VRS.

C. An Australian provisional patent application with the Invention Title "Artificial Environment for Aquatic Animals and Method Associated Therewith" was applied for in the name of VRS for a Road Transport Unit suitable for the live transport of Abalone.

D. VRS has now completed the above research and development project and is mindful to exploit commercially the results of the research and development project and/or the subject matter of the above Australian provisional patent application.

Now, therefore, in consideration of the promises and mutual undertakings that follow below, the Parties **AGREE** as Follows:

1 VRS, or any successor in title, to Australian provisional patent application titled "Artificial Environment for Aquatic Animals and Method Associated Therewith" or any corresponding application, will pay to WAFIC a sum of 8.11% of any net royalty, or any other net lump sum, that he receives by means of any agreement to licence the manufacture of products of the subject matter of this patent within 30 days of receiving any such money.

Note 1: *For the avoidance of doubt WAFIC is not required to contribute any further funds for any subsequent research and development, or marketing efforts to locate and/or negotiate any licence agreement.*

Note 2: *For the further avoidance of doubt, "net royalty" or "net lump sum" means the amount left of any royalty after all reasonable expenses by VRS have been made which relate directly to the marketing of any proposed licence agreement.*

2 VRS may negotiate and agree to any suitable terms and conditions within a licence agreement as he may so wish, providing that for a period of twelve months from the date of the signing of this Agreement he sends a quarterly report to WAFIC informing them of any progress that has been made in the marketing of a licence agreement for products directly incorporating the subject matter of the said Australian Provisional Patent Application.

3 VRS may assign all his rights in this Agreement and/or the said Australian provisional patent application or any corresponding patent application, to any third party, providing he serves notice on WAFIC informing them of this assignment within 30 days of any such assignment becoming effective.

4 Any further agreements relating to the exploitation of the subject matter of said Australian provisional patent application made by VRS, or any future assignee, will incorporate all the terms and conditions of this Agreement.

5 VRS may use, modify or otherwise dispose of the present test road vehicle registration DN4445 and all of its associated equipment in any manner whatsoever without further reference or payment to, or from, WAFIC.

6 This Agreement is governed by the law in force in Western Australia and each party irrevocably and unconditionally submits to the non-exclusive jurisdiction of the courts of Western Australia and courts of appeal from them.

Signed on for and on behalf of
Western Australian Fishing Industry Council Inc

Richard Stevens) R Stevens
R&D Manager

Witnessed by) K Adams

Occupation) CONSULTANT

Address:) 16 HUMMINGBIRD GDNS
BALLAJURA 6066

Vance Squires) V R Squires

Witnessed by) [illegible]

Occupation) Accountant

Address:) 437 Cambridge St
Floreat 6014

P/00/009 28/5/91
Regulation 3.2

ORIGINAL

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: "Artificial Environment for Aquatic Animals and Method Associated Therewith"

The invention is described in the following statement:

TITLE

"Artificial Environment for Aquatic Animals and Method Associated Therewith"

FIELD OF THE INVENTION

This invention relates to an artificial environment for accommodating and maintaining aquatic product and especially aquatic animals such as shellfish and fish, and a method related thereto.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

The invention has particular utility with transporting live shellfish such as rock lobster and abalone and/or live fin fish, from the fishery where such product is caught, to a port for subsequent reconditioning and ongoing transportation to market.

BACKGROUND ART

During transport of aquatic animals, the conditions under which such product is held are critical for survival. Typically in the case of shellfish in particular, the transposition of such from their natural environment to an artificial environment in a live condition, creates stress on the animal, which is exacerbated by the effect that the animal has on the artificial environment itself. Thus, controlling the conditions of the artificial environment under which the aquatic animal is held is critical for survival of the product.

Where transport distances are relatively short, for example 200 kilometres or less, a "fill and dump" system is normally used. In this system, a vehicle having a compartment with a cooler is simply filled with the product at the port of call of the vessel which has caught the product and the vehicle driven as quickly as possible to the processing plant or port for "dumping". At this locale, the product maybe reconditioned and revitalised for market.

Unfortunately, there is a relatively high mortality rate of product during this initial transportation stage, which can have a marked commercial effect as a consequence of the difference in market value between a live product versus processed product. Live product can attract up to 10 tons the price of processed product, or more.

Typically, the mortality rate of product increases with increased transport distances. In particular geographical localities such as Western Australia where crustaceans and molluscs are transported over longer distances than in other parts of the world, often exceeding 1000 kilometres, the "fill and dump" system is not practical in achieving optimum live product returns. Consequently, it has become necessary to pay more attention to creating an adequate artificial environment within the vehicle in order to improve the survival rate of the product during transportation over such distances. At present transportation systems have reached the stage of establishing a container or compartment within which product is stored, which has a recirculating sea water system involving sprinklers or sprayers.

Such systems have been successful in improving survival rates of product for up to approximately two hours, however, there is a marked drop off in survival rates of product involving transportation for periods of more than two hours.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide for an artificial environment that is capable of maintaining live aquatic product for periods well in excess of two hours. It is a preferred object of the invention that the artificial environment be capable of adaptation to a transportation system to allow conveyance of such product over long distances.

In accordance with one aspect of the present invention, there is provided an artificial environment for maintaining live aquatic product including aquatic animals such as shellfish and fish comprising:-

a closed compartment housing a storage area for accommodating live aquatic product in a wet environment including water and air;

primary filtering means for filtering macroscopic bi-product from the water;

secondary filtering means for filtering microscopic bi-product from the water;

circulating means circulating air within the storage area;

pumping means for circulating water through the compartment;

primary filtering means and secondary filtering means to combine the air to create the wet environment;

measuring means to measure a number of different parameters characterising the environment;

data processing means to process the measurement of the parameters and establish data values in relation thereto;

display means to display the data values to a remote operation of the environment; and control means to effect an operation to selectively affect a condition of the environment in order to maintain or establish certain prescribed parameters within a prescribed range or threshold.

In accordance with another aspect of the present invention there is provided a method for creating an artificial environment for aquatic products such as shell fish and fish, the method including:-

sensing and measuring prescribed parameters of an artificial environment;

processing data in respect of the sensing and measuring and establishing data values in real time indicative of the parameters or certain conditions associated with the artificial environment; and

effecting an operation to selectively affect a condition of the environment in order to maintain or establish certain of the prescribed parameters with a prescribed range or threshold in order to provide an optimum environment for the product

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood in the light of the following description of one specific embodiment thereof. The description is made with reference to the accompanying drawings wherein:-

Figure 1 is a side view of the truck and container;

Figure 2 is a view of the interior of the driver's cabin from the driver seat showing the console and desktop;

Figure 3 is a front view of the compartment containing the oxygen control CPUs, with the cover closed;

Figure 4 is a front view of the compartment shown in Figure 3 showing the internal arrangement of the compartment and the oxygen control CPUs;

Figure 5 is a side view of the front of the container showing the compartments for the temperature control CPU and the humidity control CPU;

Figure 6 is a is a similar view to Fig 5, but showing the compartment for the second condenser and the left hand side of the bio-filter compartment;

Figure 7 is a side view of the right hand side of the rear of the driver's cabin in front of the compartment, showing the compartment for the oxygen concentrator and the auxiliary power unit;

Figure 8 is a schematic diagram of the general layout of the environment within the container;

Figure 9 is a schematic diagram showing the water circulation within the environment;

Figure 10 is a schematic diagram showing the gas circulation within the environment;

Figure 11 is a schematic plan view of the water circulation system within the environment;

Figure 12 is a rear view of the container with the doors open showing the inside of the environment;

Figure 13 is an internal view of the container showing the storage trays for holding product and part of the water circulation system;

Figure 14 is a similar view to Fig 13 but showing the end of the environment, closer to the front of the container;

Figure 15 is a view of the protein skimmer within the environment; and

Figure 16 is a sample display of data values representative of measured parameters that appear on the monitor.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

The embodiment is directed towards an artificial environment for maintaining live aquatic product in the form of aquatic animals such as shellfish or fin fish provided in a specially designed container, which is adapted for mounting on the rear of a vehicle for road transportation.

As shown in figure 1, the container 11 is fixedly mounted upon the rear tray 13 of a truck 15 having a driver's cabin 17 specially designed to include a control area 19 for the environment.

The environment is best shown in Figs 8 to 10 and essentially comprises a closed compartment 51 within the container 11, a primary filtering means in the form of a foam fractionator, more commonly known as a protein skimmer 59, a secondary filtering means in the form of an aerobic bio-filter 61, air circulating means including a thermostatic fan 63, water pumping means in the form of a pair of system pumps 65, measuring means in the form of a number of different transducers disposed within the compartment 51, data processing means in the form of central processing units (CPUs), display means in the form of monitors 23, and control means also provided via the CPUs.

The compartment 51 is divided into a storage area 53, for accommodating the product in a series of baskets 55 held in shelves, and a hardware area 57, for accommodating certain other internal components of the environment, namely the protein skimmer 59, the fan 63, the system pumps 65, and various drainage and circulating piping for the water. The compartment 51 is accessible from the rear of the container 11, where a pair of large swing doors 75 are mounted to open out and expose the entire rear of the compartment as shown in Fig 12 for loading or discharge of product, or maintenance of the compartment.

The internal configuration and components of the container will be described in more detail later.

The external components of the system are shown principally in Figs 1 to 7 and will presently be described.

Commencing with the driver's cabin 17, the control area 19 essentially accommodates interface means for the data processing means and control means to enable remote operating and controlling of the artificial environment within the container 11, from the driver's cabin, without having to stop the vehicle and enter the compartment 51.

As is shown in figure 2 of the drawings, the inside of the drivers cabin 17 has a specially configured console between the driver and the passenger to define a desktop 21 on which are located two laptop personal computers (PCs) 23a and 23b which provide the interface means. The PCs include the monitors 23 for displaying data values, such as shown in Fig 16, and keyboards for manually effecting operation of the control means, if necessary.

The first PC 23a is connected to four separate CPU's which are located at three separate locations at the front of the container 11. These CPU's are connected to appropriate measuring means in the form of discrete transducers to measure a number of different parameters characterising the environment within the container 11 and form part of control means to effect an operation which selectively affects a condition of the environment in order to maintain or establish certain of the measured parameters within a prescribed range or threshold.

The first location is situated within compartment 25 disposed centrally at the front of the container as shown in figures 3 and 4. This compartment houses two CPUs 67a and 67b to monitor oxygen levels via oxygen transducers within the compartment and inject oxygen thereto, when the level has dropped below a prescribed threshold.

The CPU 67a monitors an upper oxygen level measuring transducer 69a in the ceiling of the compartment and controls operation of the oxygen concentrator within the compartment 35 to inject oxygen into the compartment. The CPU 67b monitors a lower oxygen level measuring transducer 69b in the floor of the compartment and similarly controls operation of the oxygen concentrator to inject oxygen into the compartment.

The second location is within an upper compartment 27 disposed at the front left hand side of the container 13, as shown in figure 5 and the third location is in a lower compartment 29 located below the upper compartment 27 as similarly shown in figure 5.

The CPU in the compartment 27 monitors and controls the temperature of the air and water within the environment and the CPU in the compartment 29 monitors and controls humidity.

The second PC 23b is interfaced with a separate sensing means for sensing the actual condition of selected animals within the environment. In the present embodiment, the sensing means (not shown) is involved with the measurement of three particular parameters of an animal, namely the internal pH, internal oxygen saturation level and metabolic rate. Essentially, these three parameters provide an indication of the stress of the animal and are input feedback to an operator of the environment.

The internal pH is measured by the insertion of a microprobe into the animal. This is connected to a data logger and the PC 23b that reads out the pH level at timed intervals.

Blood oxygen saturation is measured by the insertion of an oxygen saturation microprobe into the animal, which is similarly connected to a data logger and the PC 23b to take a reading of the oxygen saturation level at timed intervals.

The metabolic rate ideally would be measured with a purpose built microprobe that would provide a direct measurement of the metabolic rate, however these are not readily available. Accordingly, the metabolic rate in the present embodiment is measured indirectly by a heart monitor connected to the animal, whereby a measurement is made in respect of the pulse rate of the animal's blood circulation or internal organs. The monitor is similarly connected to a data logger and the PC 23b for display.

Two condensers 71 are respectively housed within a compartment 31 disposed at the right front of the container 11 adjacent the compartment 25, and a second compartment 33 disposed at the left front of the container 11, adjacent the other side of the compartment 25. Each condenser 71 is connected to a corresponding refrigeration coil 73a and 73b to form a dual refrigeration system under the control of the control means by means of the CPU for controlling the temperature. One of the condenser/coil arrangements 71/73a constitutes the main refrigeration system for controlling the temperature of the air and water within the environment and the other condenser/coil arrangement 71/73b constitutes a booster refrigeration system, which is controlled by the temperature control CPU to cut in and boost cooling of the environment when the system is under load, such as when the vehicle is loaded with product or when carbon dioxide (CO_2) gas venting occurs, which will be described in more detail later.

An oxygen concentrator is housed within a compartment 35, also disposed at the front of the container 31 behind the driver's cab 17, for injecting oxygen into the environment through the bio-filter 61 when required. This will also be discussed in more detail later.

An auxiliary power unit in the form of a generator set 37 is disposed adjacent the oxygen concentrator to provide on board power for driving the various internal and external components of the environment that require power. The generator set has provision for connection to the mains, to provide an alternative power source when the vehicle is stationary and is able to access such.

The aerobic bio-filter 61 is situated at the front of the container 11, extending transversely across the vehicle, beneath the condenser compartments 31 and 33 and the front CPU compartment 25. The bio fiter essentially filters microscopic bi-product from the water of the environment in order to maintain the water condition so that it may be recirculated. The arrangement of the bio-filter 61 is different to conventional bio-filters and will be described in more detail later.

Now describing the arrangement of the interior components of the container 11 and the peripherals situated therein, reference is made to figures 8 to 11 in particular.

As shown, the container 11 forms a closed compartment 51, whereby the baskets 55 are shelved on three-tiered racks 77. Two sets of racks 77a and 77b are arranged to extend longitudinally along the compartment 51, one on each side, leaving a central passageway 79 for access along and into the rear of the compartment. The number of racks are essentially determined by the type of product being transported. Three tiers is suitable for lobster or crabs, more than this may be provided for abalone, or less than this may be provided for transporting fin fish.

Plastic curtains 81 shroud the periphery of the racks 77 to help maintain a wet or moist environment around the product in the baskets 55. The racks are structure so that the product can be end loaded through the curtains 81 and the baskets 55 slid forward along the rack so as to minimise the affect of environmental changes particularly when the container is loaded in hig temperatures. Above each rack 77 is disposed a sprayer or sprinkler system which water is delivered for spraying or sprinkling via a spray bar 83. Importantly the spray bars are correspondingly arranged that each rack deliver conditioned water of the same quality to each basket 55. Beneath each rack 77 is disposed a water catching tray 85 for collecting water passed through product within the baskets 55 disposed in a corresponding rack for drainage and recycling.

Drainage piping 87 is connected to each water catching tray 85 to return water to a main collection tank 89 disposed in the floor of the container, from whence it is pumped through the protein skimmer 59 and then the bio-filter 61 by the system pumps 65 for treatment and reconditioning.

The protein skimmer 59 filters macroscopic bi-product from the water such as excreta and detached parts from the product using foam fractionation, whereby such bi-product is skimmed off the top 59a of the protein skimmer as waste.

A normal protein skimmer pulls air from the atmosphere to be used in the foam fractionation of protein in the water. The protein skimmer 59 of the present embodiment can pull from two different supplies. Normally, it will pull from the product storage area 53 of the compartment. However, when the upper and lower oxygen transducers 69a and 69b sense that there is a drop in O_2, the air inflow to the protein skimmer is changed by the control means to instead draw oxygen from the O_2 saturated bio-filter, as will be described in more detail later.

This primary filtered water is then transferred via appropriate piping through the front of the container and to the top of the bio-filter 61. From the top of the bio-filter 61, it is then trickled down through the bio-mass 89 of the bio-filter to where it is collected at the bottom and transferred as conditioned water into a main water holding tank 91, also located in the floor of the container.

The conditioned water in the water holding tank 91 is then pumped to the spray bars 83 for spraying or sprinkling through the product as previously described.

The general circulation of water is shown in Figure 9, whereby the arrows 93 show the flow of conditioned water, and the arrows 95 show the flow of spent water requiring conditioned.

As indicated, the container 11 has two water tanks, the main collection tank 89 and the main holding tank 91, used for its water supply. On initial load up of product, water is sent from the bio-filter 61 initially, directly to the spray bars 83. This is then held in the main collection tank 89 and trickle fed back to the bio-filter 61, since it will by high in ammonia from the product. Once the product has gone through initial wash off, they are supplied with water from the main holding tank 91, via the bio-filter.

The compartment 51 includes a false ceiling 97 which works in conjunction with the thermostatic fan 63 to provide for air circulation within the environment. Moreover, the false ceiling 97 creates a heat differential between the external atmosphere to the container, which is typically hotter than the internal cooled atmosphere of the compartment, and thus generates a natural thermosyphon of the air within the compartment, circulating it through the compartment. This air circulation is important to assist in preventing gill dehydration of the product.

A measure of problems occurring in this regard is the humidity of the environment. Thus a further transducer (not shown) for sensing the humidity of the environment is connected to the humidity control CPU within the compartment 29.

The refrigeration system of the present embodiment has in fact two different cooling systems - one to control the water temperature and one for the air temperature of the environment - which are used in conjuntion with each other. If fish are taken from the ocean and dropped in a low temperature too quickly, they stress and die. Most systems use either air cooling or water cooling, but not both in conjunction with each other. Accordingly, the present embodiment uses the flow of water sprays to pass on the oxygen to the product, and thus it is necessary to control the temperature of the water and then also the air that the water is passing through, otherwise the water takes on the air temperature. If this air temperature is high, then the water will be heated and not cooled.

The separate cooling of air and water provides the opportunity to make minute changes to the internal environment whilst monitoring the biological state of the product. The present embodiment, the water temperature can be varied anywhere from a minimum of 6 degrees Celsius to a maximum of 24 degrees Celsius and the air temperature from a minimum of 8 degrees Celsius to 23 degrees Celsius.

The air and water temperature within the environment are measured by the appropriate sensors and the control means is operated to maintain the temperature of the environment at a prescribed level. This level varies from product type to product type and is established via appropriate setting through the temperature control CPU in the compartment 27. The control means also switches in the booster condenser/coil to supplement cooling on the occurrence of large temperature losses, such as would arise when opening the rear doors 75 and loading or discharging product as previously mentioned.

An important aspect of the present embodiment is the use of oxygen in the environment. Moreover, the container is provided with a carbon dioxide vent 99 in the false ceiling 97 to vent excess CO_2 build up in the compartment, and appropriate solenoid valves for injecting pure oxygen into the compartment at required times, depending upon the oxygen content within the compartment.

As previously described, one group of transducers 69a are mounted to the top of the compartment and another group of transducers 69b are mounted to the bottom of the compartment so that a difference measure of oxygen content can be obtained within the environment. This difference measure is a good indication of CO_2 levels within the compartment, which can be detrimental to the health of the product.

Moreover, CO_2 tends to build up as a result of the action of the bio-filter and needs to be vented from the environment at regular intervals. At this time, the CO_2 vent 99 is opened and pure oxygen is injected into the environment through the protein skimmer venturi by operation of a solenoid by the oxygen control CPU, to vent through the top of the protein skimmer 59 and into the compartment 51. Gas circulation at such time is as shown in Fig 10, whereby the arrows 103 show the flow of injected oxygen through the environment, and the arrows 105 show the flow of CO_2 out of the environment.

In the present embodiment, the control means is set so that if the upper oxygen transducer 69a senses an oxygen level that is less that 80 per cent of the oxygen level sensed by the bottom oxygen sensor 69b, then the control means automatically operates the thermostatic fan 65 and injects oxygen into the compartment 51.

Simultaneously, the CO_2 vent 99 is opened and accumulated CO_2 at the top of the compartment is vented to the external atmosphere therethrough by the action of the air circulation within the compartment. At this time, the air circulation is forced by the injection of oxygen and the operation of the fan 59.

The oxygen injection into the compartment 51 arises from a diversion of normal oxygen injection into the bio-filter 61. Moreover, the injection of oxygen alternates between the bio-filter 61 and the compartment 51 in accordance with a predetermined duty cycle determined by the control means so as to maintain the oxygen level at the prescribed threshold in the compartment, whilst ensuring oxygen saturation of the bio-filter.

Essentially, when the upper oxygen transducer 69a senses that the oxygen level has returned to normal in the compartment 51, the oxygen injection into the compartment is terminated by closing the appropriate solenoid valve completing the duty cycle.

Operation of the thermostatic fan 65 is controlled to assist in making sudden changes in temperature, by forcing more rapid circulation of cooled air within the storage area. Thus, if it is desired to drop the temperature of the environment by 4°C, which is a normal requirement after completing the initial loading of product, where the temperature may have been elevated by this amount as a result of the rear doors being opened for a period of time, this can be achieved within approximately 3 to 4 minutes by using the fan 65 in conjunction with both condensers, in a controlled manner. Another reason for doing this is that the reduction in temperature of between 3 to 4 degrees over a period of minutes, reduces the metabolic rate of the animal, and hence reduces its requirement for oxygen.

The bio-filter 61 is different from bio-filters of conventional design. Moreover, bio-filters normally rely on air to oxygenate the bacteria in the bio-filter. The oxygen allows the bacteria to convert nitrite and ammonia to produce nitrate and CO_2. The oxygen in a normal system is gained from the atmosphere for this conversion.

The bio-filter 61 of the present embodiment, on the other hand, is different in that it is fully enclosed and is flooded from the bottom with O_2. This forces the CO_2 out of the top of the bio-filter via the vent 101 and into the atmosphere. This also gas strips the ammonia from the water as well. It also allows the bacteria to convert nitrite and ammonia to nitrate up to double the capacity as would normally be the case, as a consequence of saturating the CO_2.

Thus it is possible to halve the size of the bio-filter and still have the same if not better capacity bio-filter.

Transducers for measuring certain other parameters of the environment are provided in the bio-filter. These include a bio-filter water level sensor, a water temperature sensor, a water conductivity sensor, a salinity sensor, a dissolved oxygen in water sensor, a pH sensor and an oxygen reduction potential (ORP) sensor. All of these are connected to relevant CPUs for measurement and data processing to produce meaningful data values in relation to the sensed parameters. These data values are subsequently displayed to the operator of the environment in the driver's cabin on the monitor of the PC 23b. They also enable the control means to effect operation of various components of the system to selectively affect a condition of the environment in order to maintain or establish certain of these prescribed parameters within a prescribed range or threshold to optimise the environment for the product.

As shown in figure 16, a sample read out of conditions in the artificial environment as would be displayed on the monitor 25a is illustrated. The data processing means can be set so that regular print outs of the data values of these prescribed values are accumulated every two minutes or so and added to the data table so as to provide a continuous time related indication of the conditions of the artificial environment, stipulating date and time. Some of the parameters identified in the display are self explanatory and self evident, such as date, time, water level in the bio-filter and water temperature. Some of those which require further explanation are detailed below.

Measuring the conductivity (COND) provides an indication of icing over of either of the cooling coils 73a or 73b. If the data processing means indicates a conductivity measure reaching a prescribed threshold, the control means will automatically switch the appropriate condenser off until such time as the ice melts and conductivity returns to an acceptable value.

Conductivity is also a fine measure of salinity and can be used as an indication of such which may have some utility when initially loading on water, to check on the water suitability.

The salinity (SAL) is also measured directly and is required to ensure that the water being loaded into the container initially on water take up, has the correct salinity levels.

The measurement of dissolved oxygen in the water (DO) in the bio-filter 61, as a percentage of oxygen saturation in the water, provides a measure of the bio-filter efficiency. Accordingly, variations from a prescribed range of acceptable values as established by the data processing means will result in the control means altering the duty cycle of injected oxygen into the bio-filter 61 to maintain the oxygen saturation levels of the water in the prescribed range.

The measurement of dissolved oxygen (DO) in milligrams per litre (mg/l) is made via a suitable transducer probe in the water feed to the sprayers or sprinklers and provides a second measurement of oxygen levels which is related more to the condition of the environment immediately affecting the aquatic product in the storage area of the compartment. This enables optimum setting of oxygen saturation levels in the water for product and be maintained by the control means again adjusting the duty cycle in respect of the injection of oxygen into the storage area via the protein skimmer, as previously described. For example an oxygen saturation level of 0.8 mg/l at 14°C is ideal for crabs. As a result of maintaining this type of a parameter at an optimum setting for the animal, product can arrive in better condition than when originally loaded, which is the opposite to what presently occurs in the industry.

The data processing means and control means of the present invention are particularly adapted to keep the O_2 saturation in appropriate proportion to the temperature in the compartment. For example, the conditions may be initially maintained at 20° C and 100% O_2 saturation. If it was desired to drop the temperature to approximately 16°C to slow down the metabolic rate of the aquatic animals, it is still necessary to keep the O_2 level at 100% saturation, otherwise the O_2 level would super-saturate the environment by changing the oxygen pressure, which would be fatal for some species of animal, such as lobster. This is achieved by controlling the venting of the CO_2 and the input of regulated O_2 by a system of solenoids and valve controls.

Measuring the pH of water within the environment is important for maintaining water condition. For example, water in Western Australia, typically tends be more alkaline than in other parts of the world, and thus it is important to maintain this alkalinity. In the present embodiment, pH is adjusted via a carbonate hardness buffer doser (not shown) which can be disposed at any convenient location in the water circulation path, and is operated from the driver's cabin, manually. Alternatively, it may be connected into the control means to be automatically monitored and operated, in accordance with a prescribed algorithm for controlling same.

The measurement of oxidisation reduction potential (ORP) provides a measure of water purity. It is measured directly via a pair of electrodes, in millivolts (mV), where typically a value of 200 mV is considered to be good. If the value falls by up to 25 mV together with a fall in pH, this is indicative of a build up in ammonia levels (NH_3), which is excreted by the animal when stressed. In the present embodiment, the control means is designed to effect operation of the ozone generator to inject ozone into the protein skimmer 59 and then vent it to the atmosphere. It should be noted that it is important for the ozone to be confined to treatment of water within the protein skimmer only, as any substantive introduction of ozone into the environment in the storage area 53 would immediately kill the product. The ozone oxidizes the ammonia, nitrite and other impurities in the water to clean it, which consequently elevates the ORP back to acceptable levels.

Essentially the introduction of ozone into the protein skimmer is principally called upon at the start, when the container is initially loaded with product. It essentially supplements the operation of the bio-filter until a steady state condition is reached, whereupon it basically cuts out and leaves the control of the water condition in the environment to the protein skimmer and the bio-filter thereafter. Typically, the ozone generator will be caused to be switched in by the control means after approximately $^1/_2$ hour from the time that product is loaded, and is switched out after approximately 3 hours, to when a steady state condition is attained.

Another parameter which is measured, but not illustrated, is turbidity. Turbidity provides another measure as to whether the bio-filter is operating properly, and is directly measured by a sensor located in the bio-filter.

An important feature of the present embodiment, is the ability of the driver to monitor the environment and make changes to the same without having to leave the drivers cabin. This optimises the travelling time and so avoids any unnecessary delays where time is of the essence in transporting live product. Further, the control means is designed to allow the driver or operator to turn off the automatic control of certain operations and enable manual control or operation of same by the driver or operator, if particular parameters or conditions measured within the environment become too severe and require manual intervention or overriding.

Another important feature of the embodiment is the ability to correlate the condition of an animal in the artificial environment with the condition of the environment in real time, and subsequently maintain the optimum conditions of the environment. Furthermore, such correlation is provided to the driver, remote of the actual environment itself.

A further important feature of the embodiment is the ability of the environment to be varied to suit different types of product. For example, the ability to vary oxygen saturation levels in the storage area is important for different animals. Moreover, if Western rock lobster are held in oxygen saturation levels of over 100%, they take on oxygen faster than they can get rid of carbon dioxide and therefore acidosis sets in. However, if blue swimmer crabs are being transported, due to them not being reef dwellers and other biological factors, they respond better to super-saturation oxygen levels.

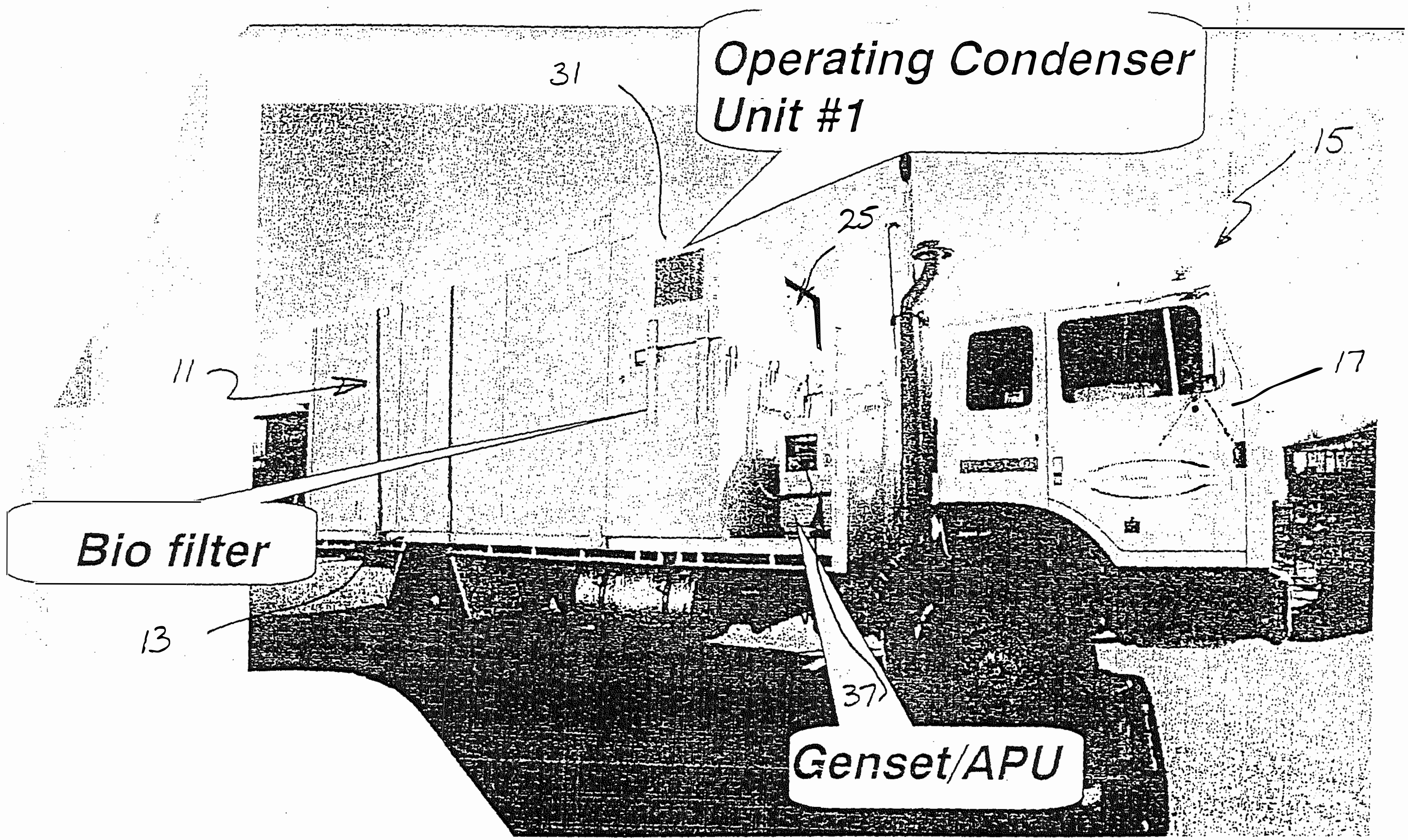
Importantly, the environment can be monitored, controlled and altered to ensure optimum conditions for the product enabling it to be transported over long distances for long periods of time.

It should be appreciated that the scope of the present invention is not limited to the particular embodiment described herein. In particular, the environment can be adjusted to suit different product types requiring different environmental conditions which require different parameter settings, ranges and threshold. In addition, the invention is not limited to the creation of an artificial environment for road or other transportation only. It also has utility in the creation of an artificial environment for a static research laboratory situation for the purposes of conducting research into aquatic product.

Dated this day of .

Applicant

Wray & Associates
Perth, Western Australia
Patent Attorneys for the Applicant(s)



Operating Condenser Unit #1
31
25
15
11
17
Bio filter
13
37
Genset/APU

FIG. 1

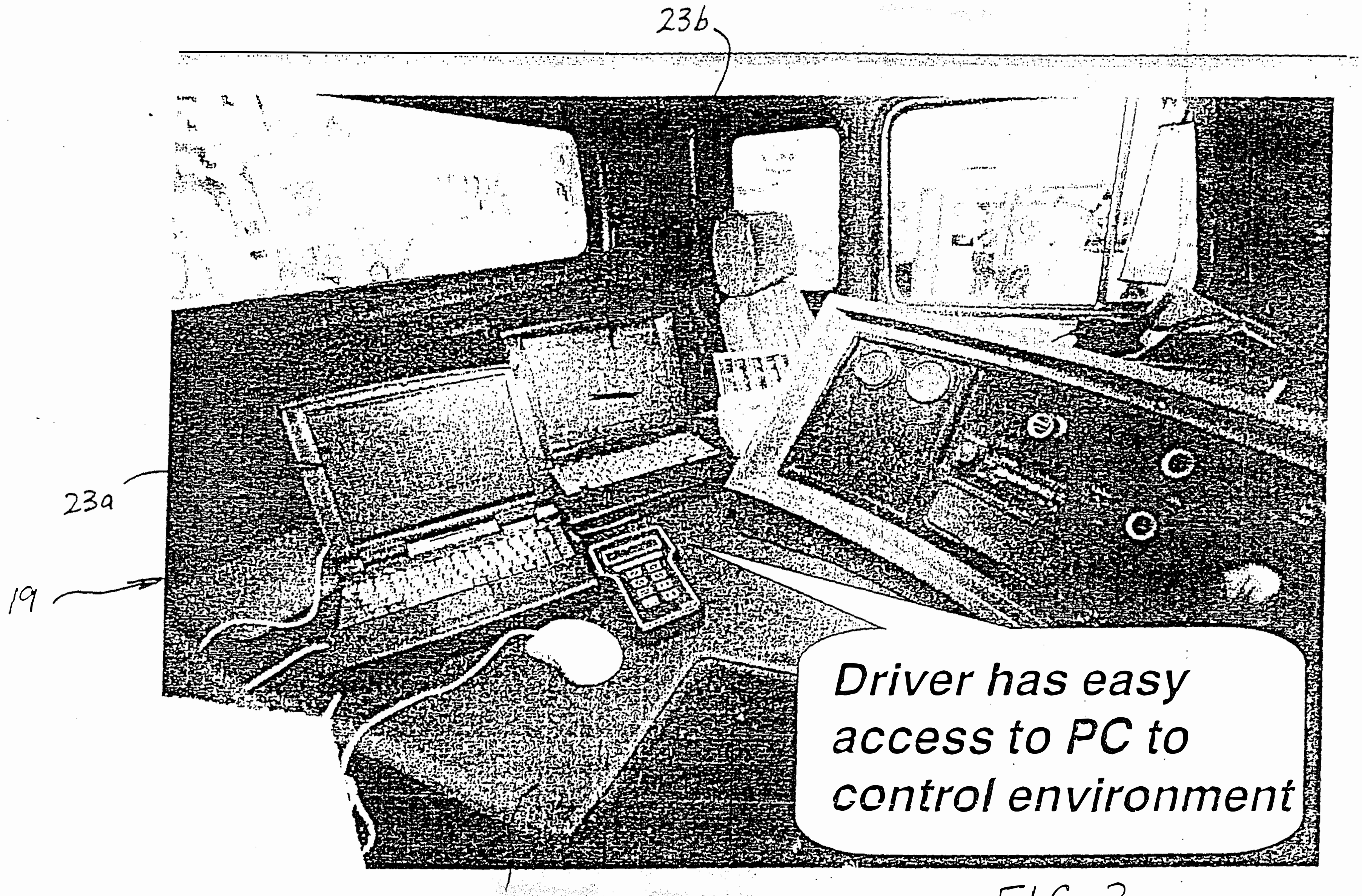

23b
23a
19
Driver has easy access to PC to control environment

FIG 2

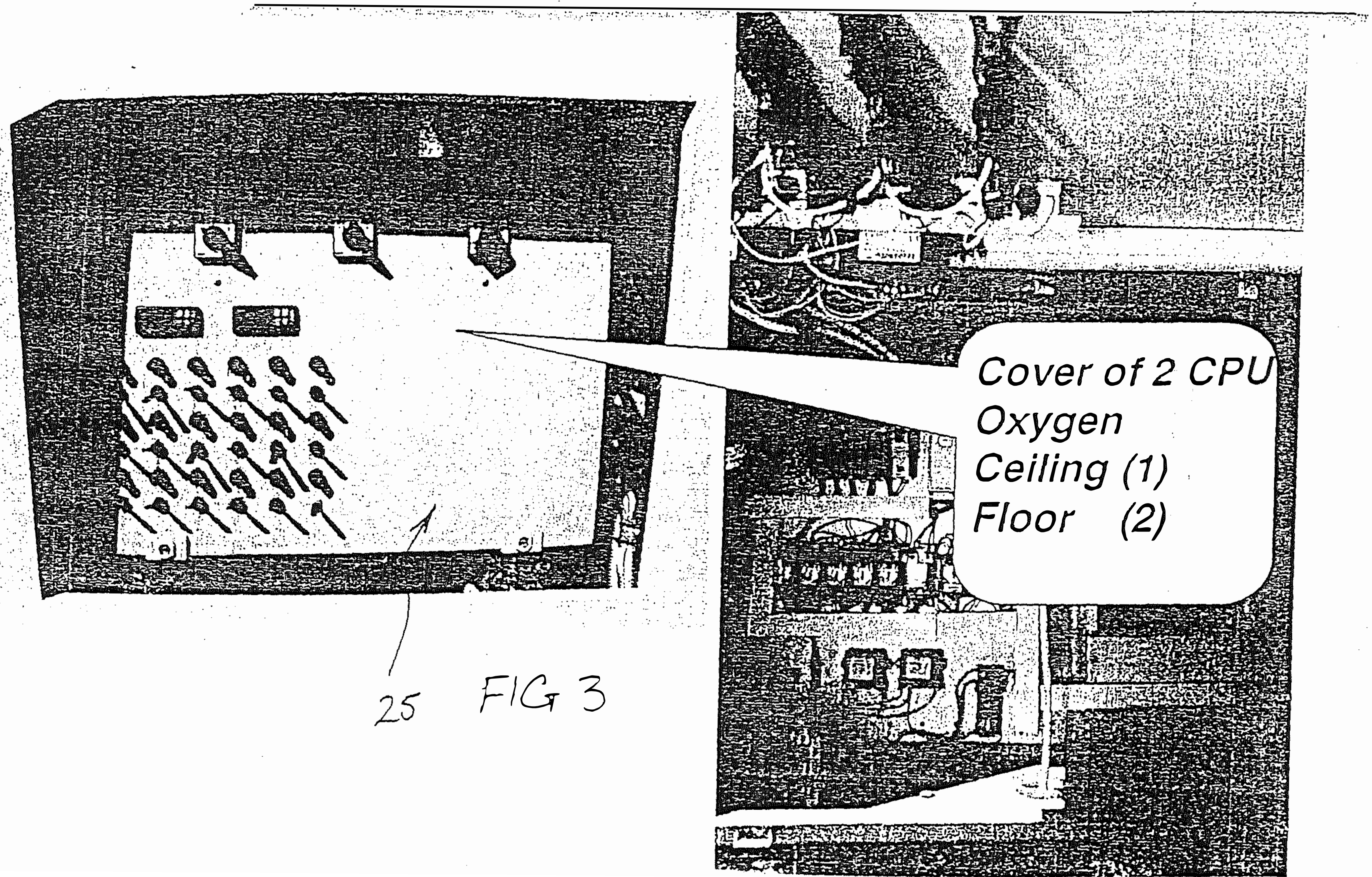


FIG 3

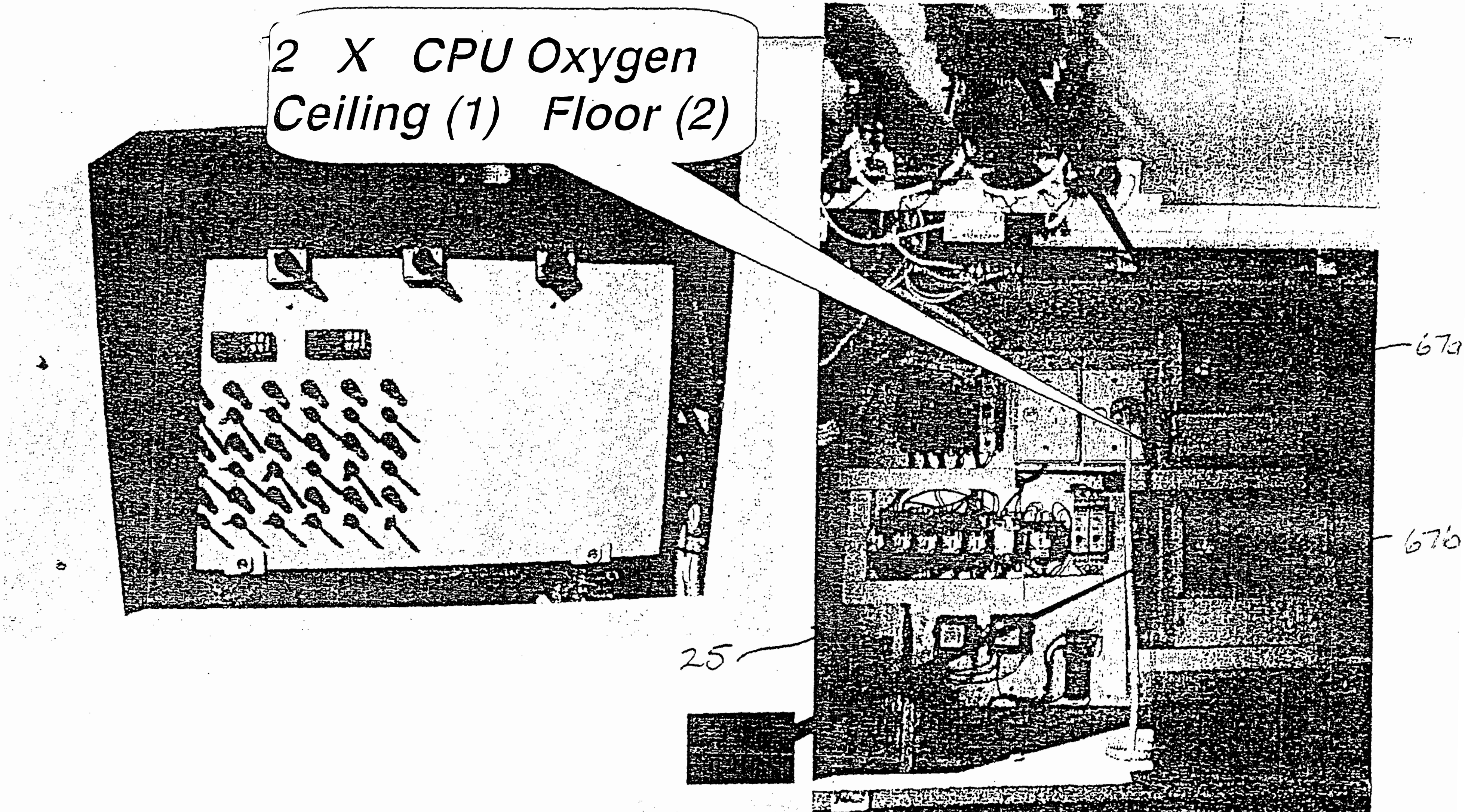


FIG. 4

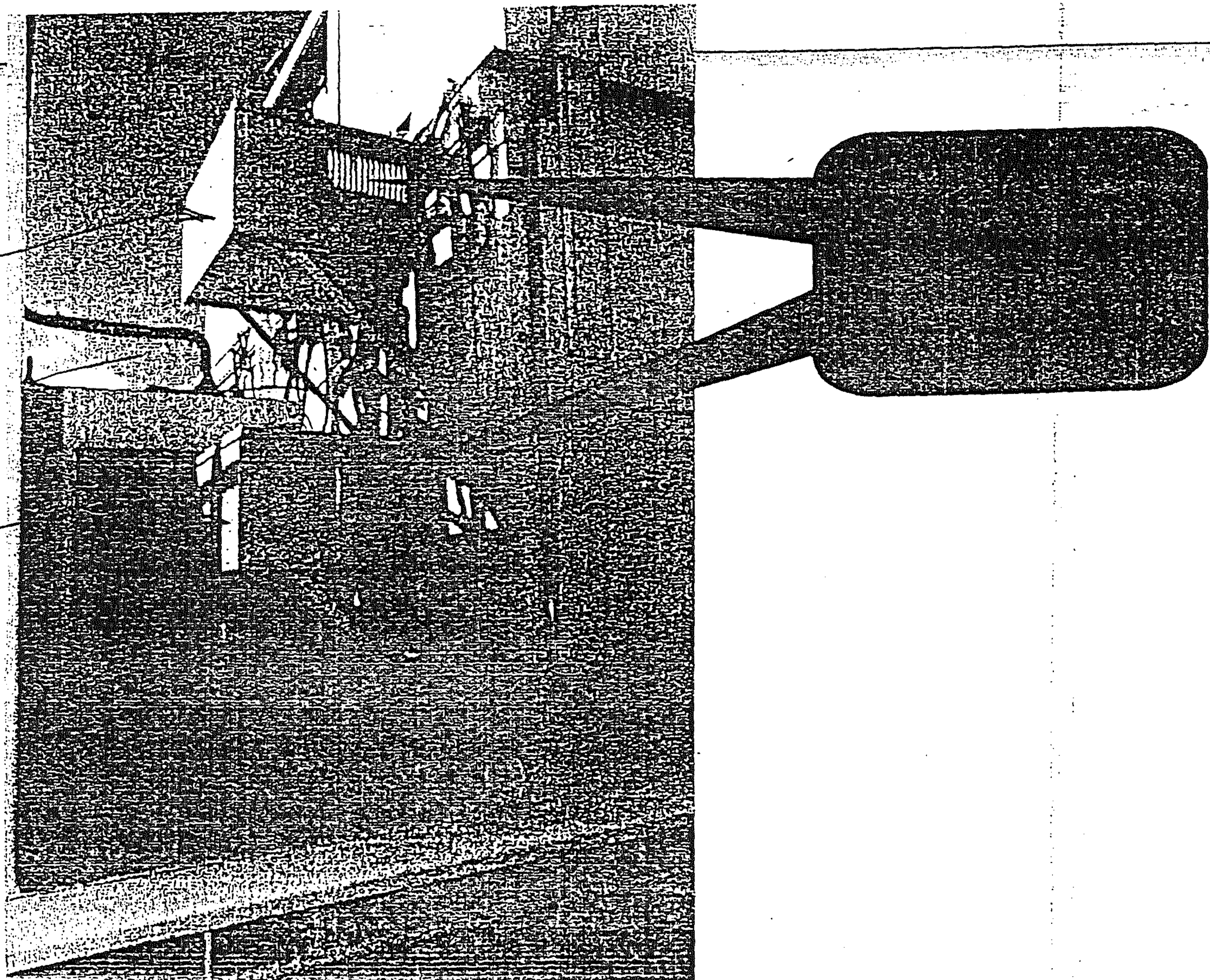


FIG 5

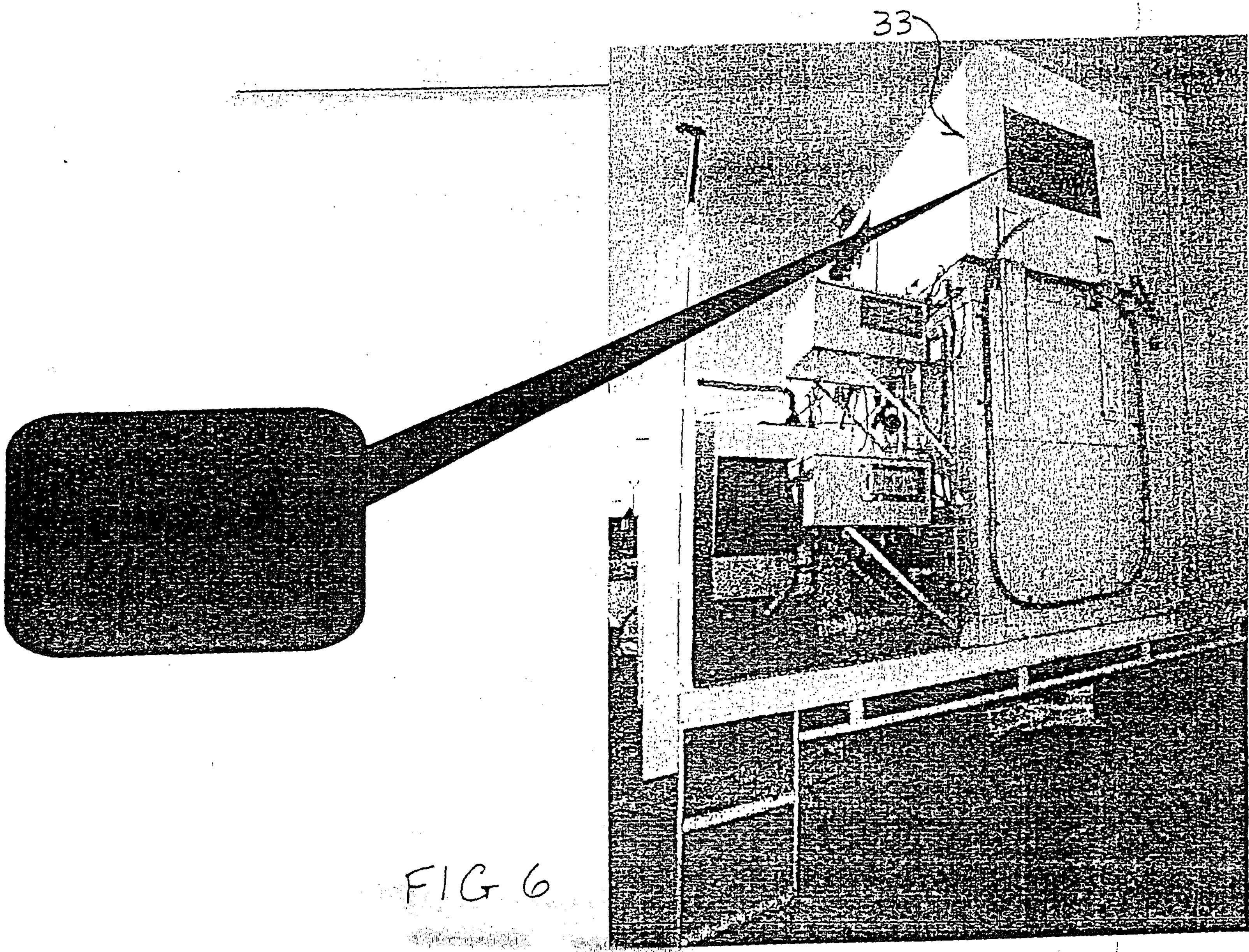


FIG 6

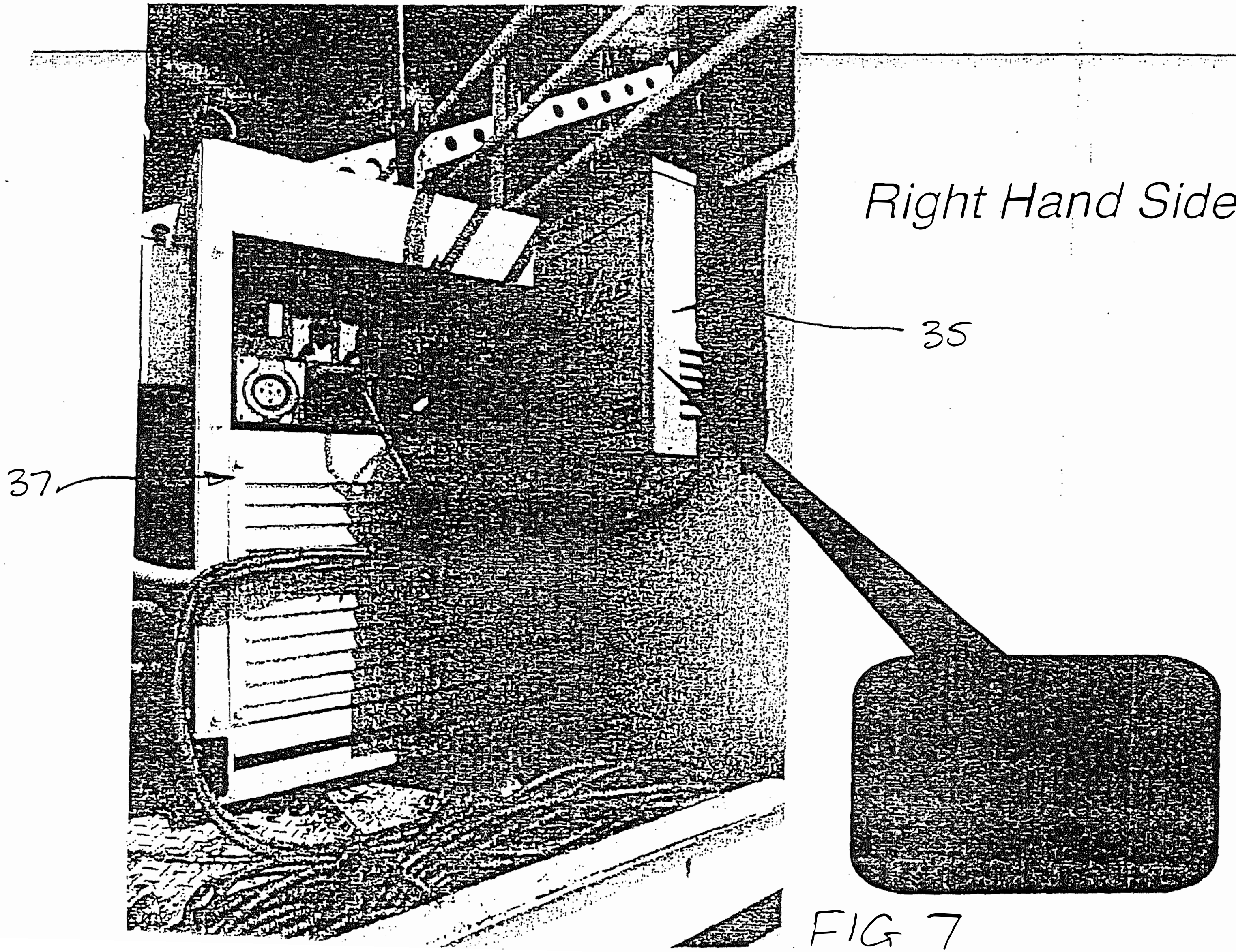


FIG 7

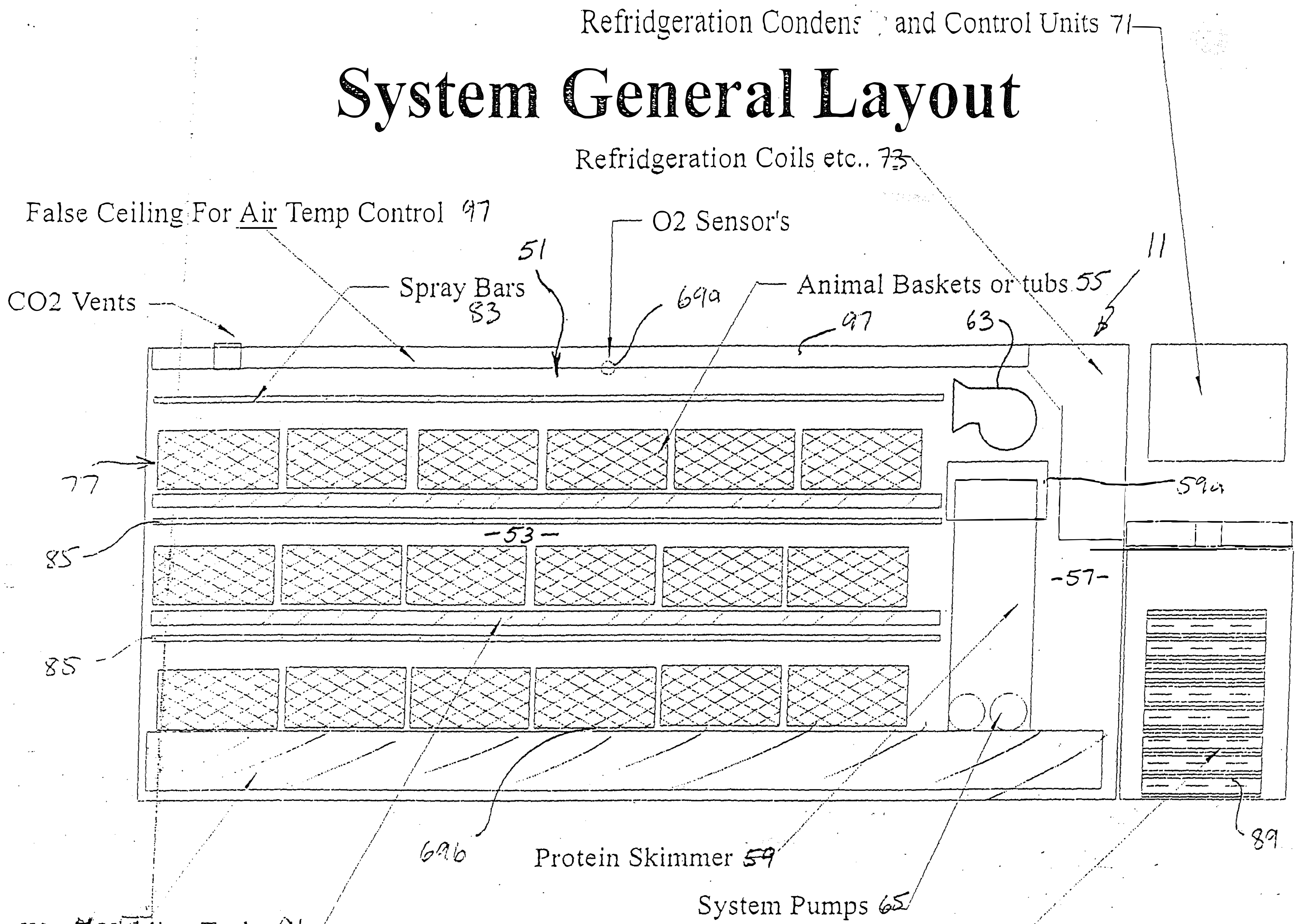

Refridgeration Condens
and Control Units 71
System General Layout
Refridgeration Coils etc.. 73
False Ceiling For Air Temp Control 97
O2 Sensor's
51
11
Spray Bars
83
Animal Baskets or tubs 55
CO2 Vents
69a
97
63
77
59a
85
-53-
-57-
85
89
69b
Protein Skimmer 59
System Pumps 65
ding Tanks 91
Sealed Oxygen Inriched Biofilter 61

FIG 8

System General Layout

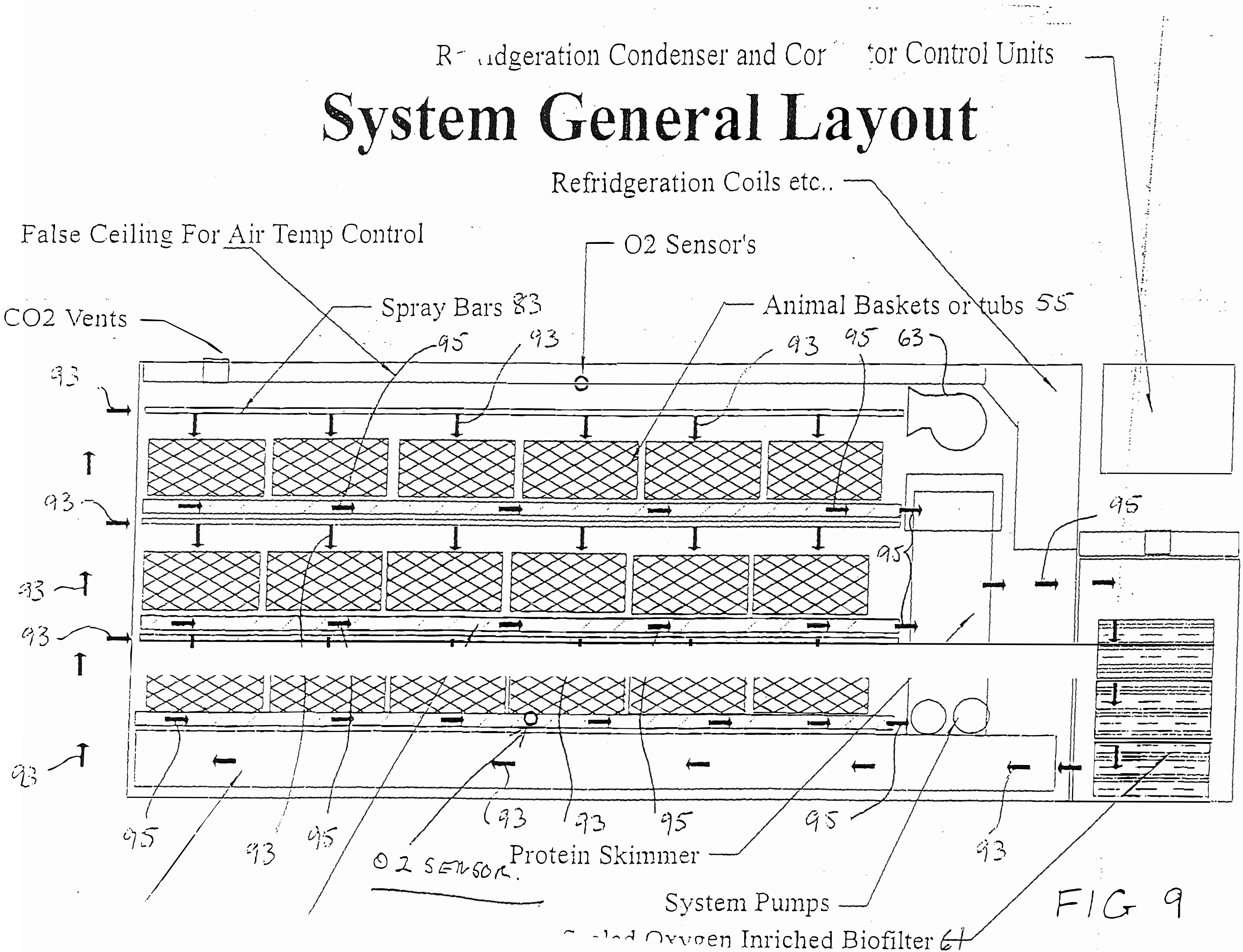


FIG 9

System General Layout

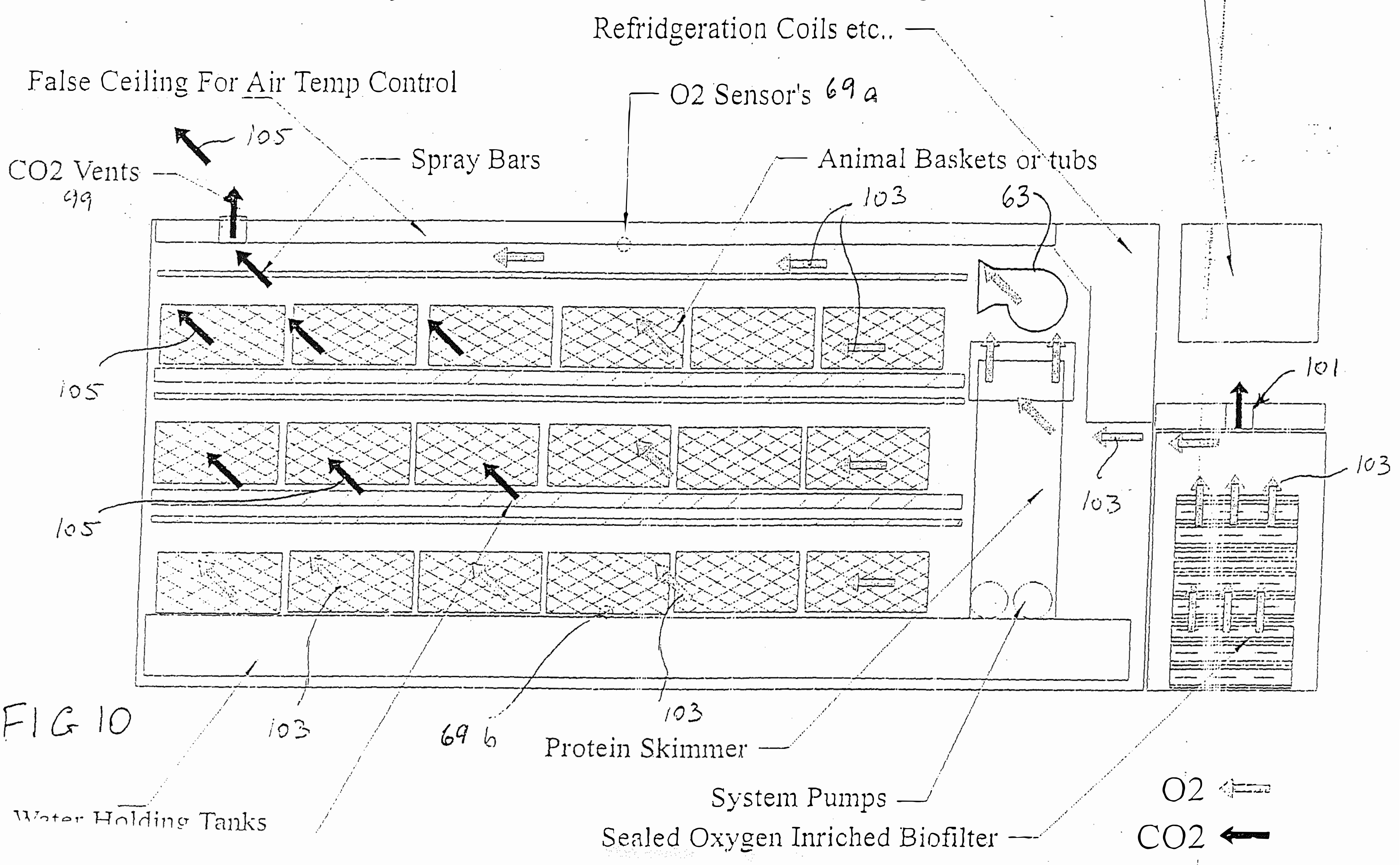


FIG 10

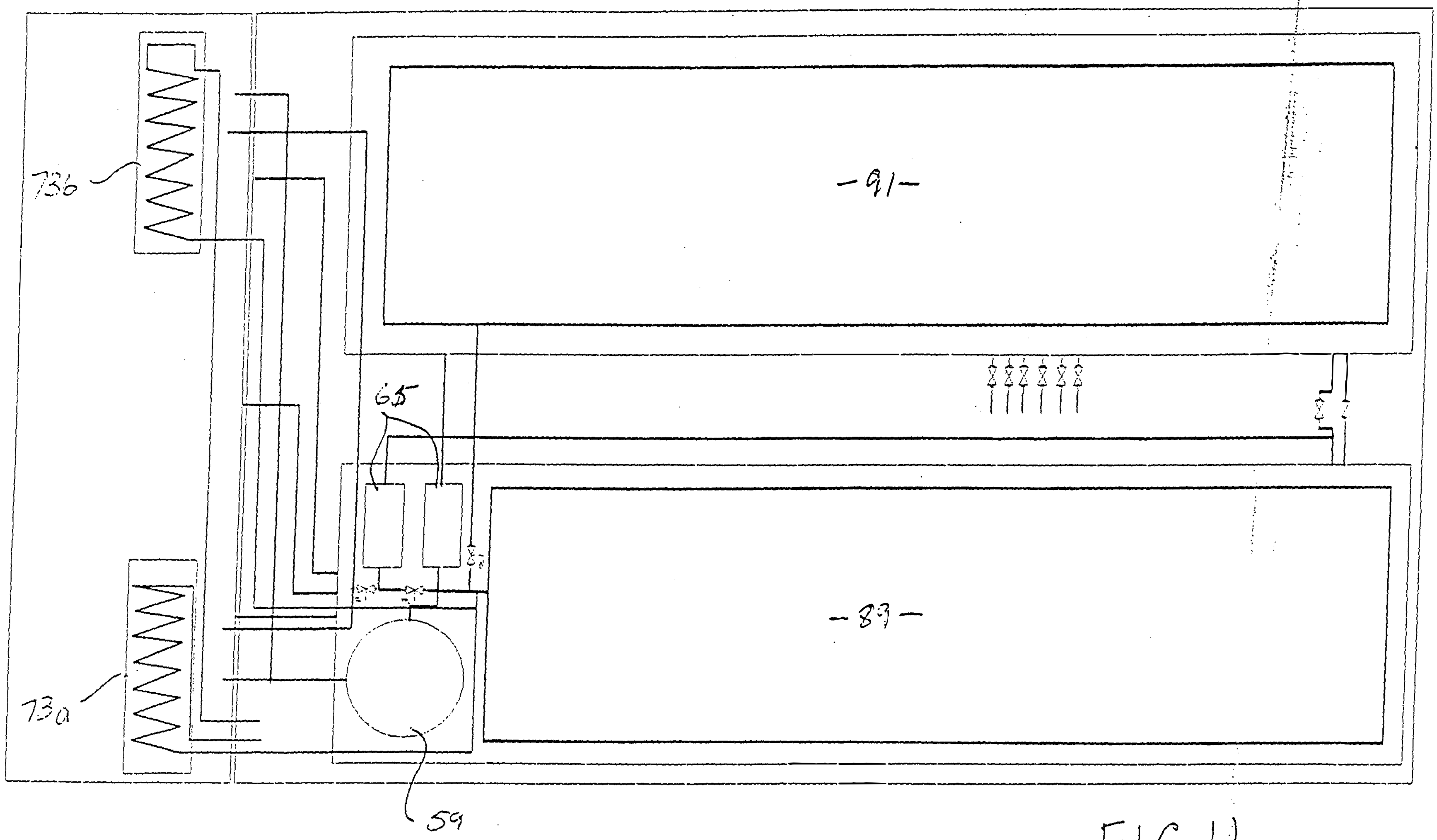
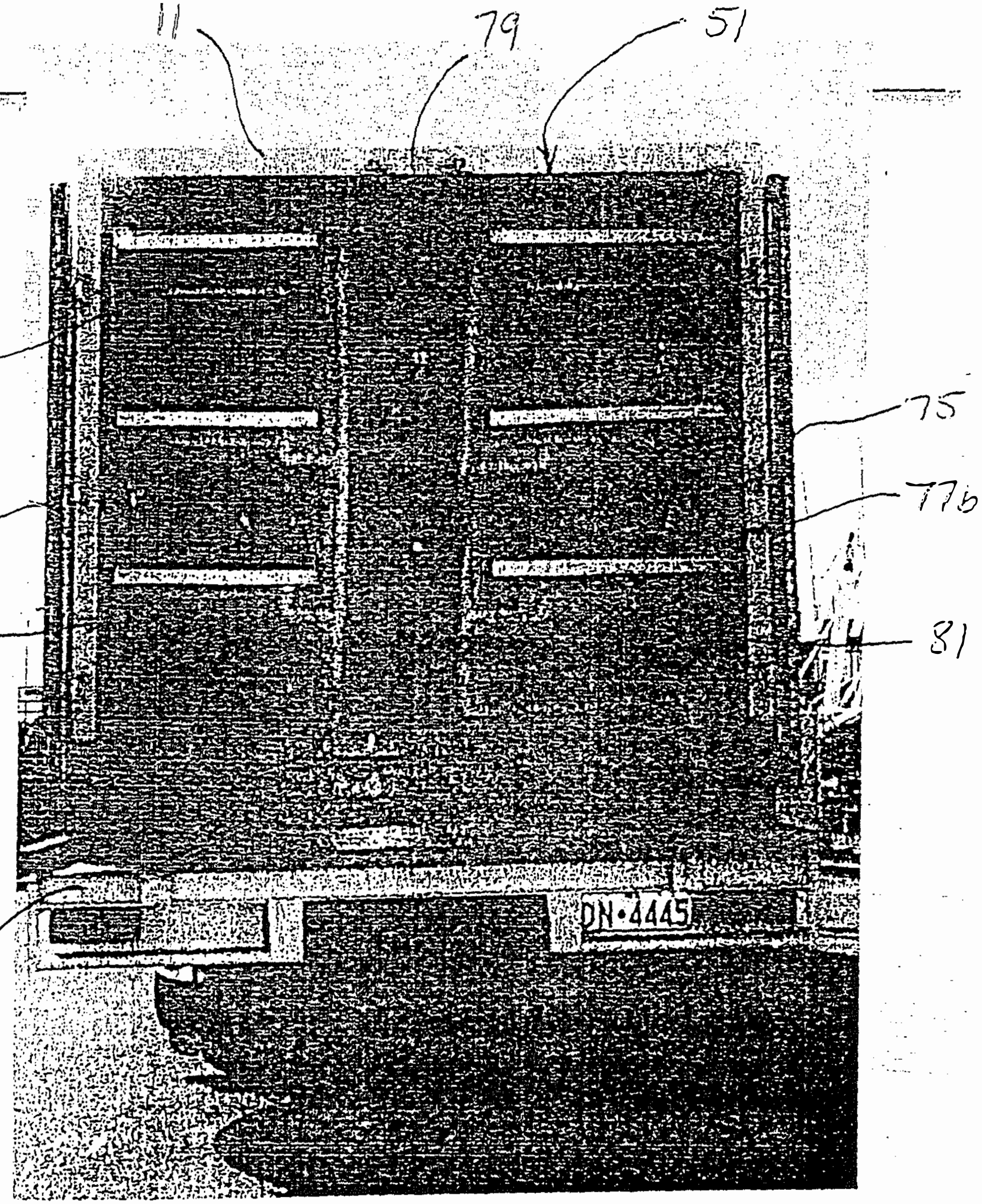
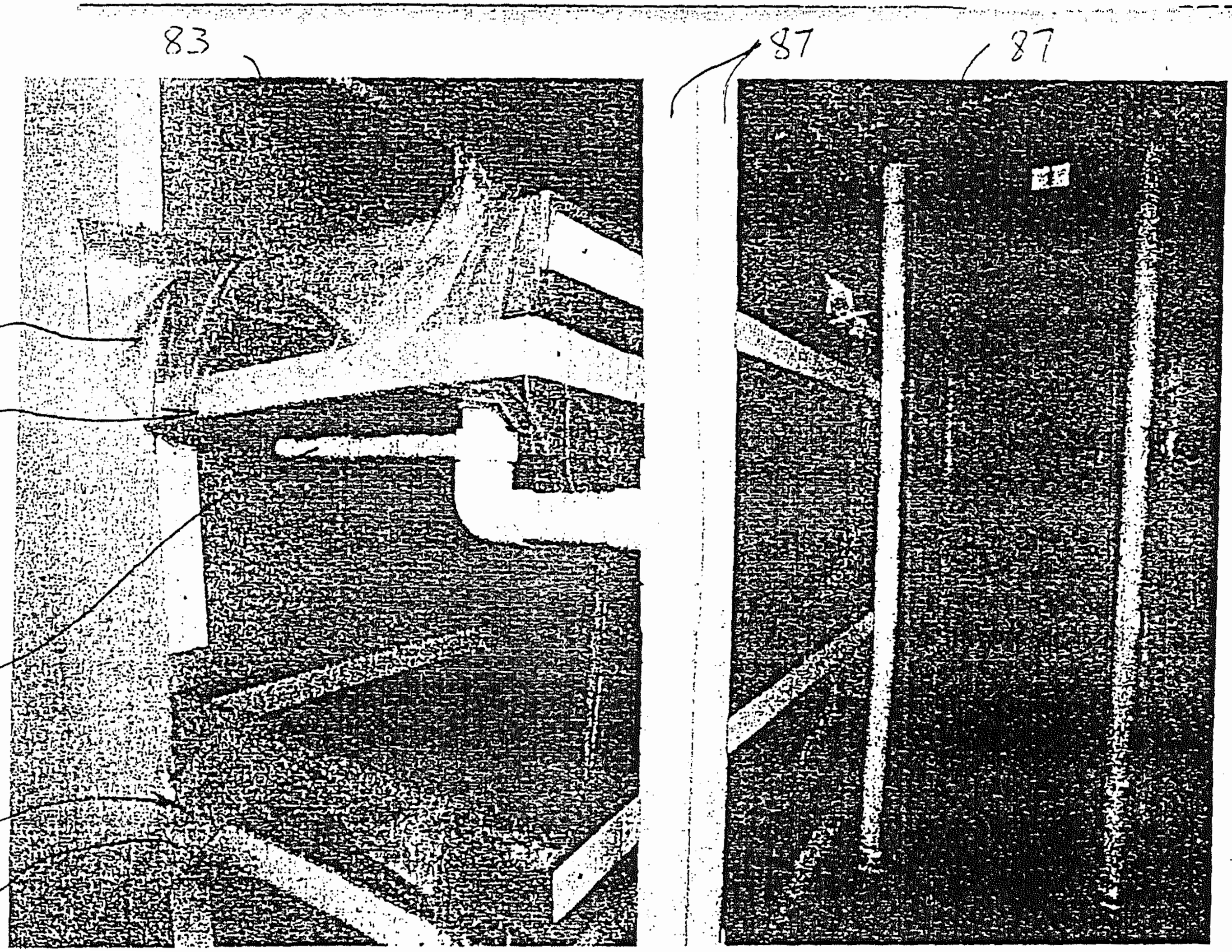


FIG 11

RTU from the rear - Doors Open

FIG 12





BIO Unit from Left side rear

FIG 13

FIG 14

2 More views of internals of BIO Unit

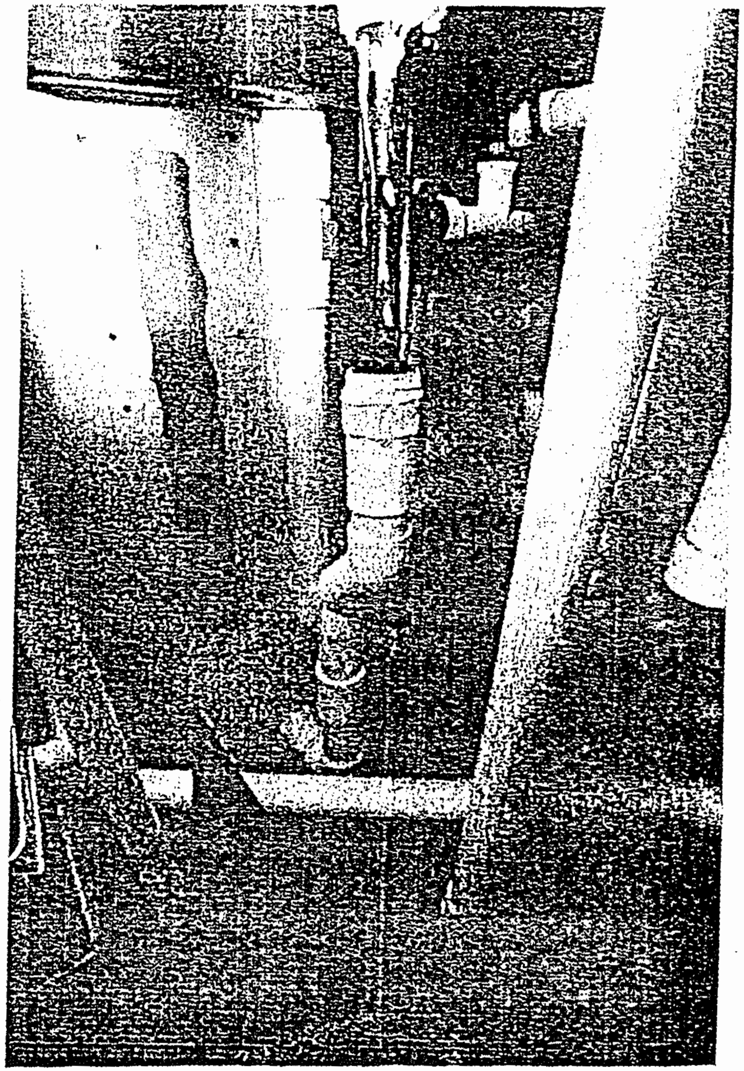


FIG 15

AUTO LOGGED DATA
SERIAL NUMBER: 103

SAM NUM	DATE	TIME	BIO Water Level	TEMP C	COND ms/cm	SAL ppt	DO %sat	DO mg/l	PH pH	ORP mv
1	14/02/99	15:08:00	.5	13.8	52.3	34.4	96.2	6.8	8.38	176
2	14/02/99	15:10:00	.5	13.8	52.3	34.4	104.7	7.4	8.38	166
3	14/02/99	15:12:00	.5	13.8	52.3	34.4	111.8	7.9	8.32	153
4	14/02/99	15:14:00	.5	13.8	52.3	34.4	116.2	8.2	8.34	146
5	14/02/99	15:16:00	.5	13.8	52.3	34.4	111.4	7.9	8.32	144
6	14/02/99	15:18:00	.5	13.9	52.3	34.4	111.1	7.8	8.31	143
7	14/02/99	15:20:00	.5	13.9	52.3	34.4	107.2	7.5	8.31	148
8	14/02/99	15:21:00	.5	13.9	52.2	34.4	107.9	7.5	8.31	153
9	14/02/99	15:24:00	.5	14.1	52.2	34.3	113.0	7.9	8.34	160
10	14/02/99	15:26:00	.5	14.1	52.2	34.3	111.8	7.9	8.32	162
11	14/02/99	15:28:00	.5	14.1	52.2	34.3	113.1	7.9	8.33	164
12	14/02/99	15:30:00	.5	14.1	52.2	34.3	114.0	8.0	8.33	165
13	14/02/99	15:32:00	.5	14.0	52.2	34.3	116.2	8.2	8.34	164
14	14/02/99	15:34:00	.5	14.1	52.2	34.3	118.4	8.3	8.34	163
15	14/02/99	15:36:00	.5	14.1	52.2	34.4	113.8	8.0	8.33	164
16	14/02/99	15:38:00	.5	14.0	52.2	34.4	129.4	9.1	8.39	162
17	14/02/99	15:40:00	.5	14.1	52.2	34.4	126.2	8.9	8.37	160
18	14/02/99	15:42:00	.5	14.1	52.2	34.4	133.3	9.4	8.30	159
19	14/02/99	15:44:00	.5	14.1	52.3	34.4	133.8	9.4	8.31	157
20	14/02/99	15:46:00	.5	14.0	52.2	34.4	123.9	8.7	8.37	160
21	14/02/99	15:48:00	.5	14.0	52.3	34.4	106.1	7.5	8.33	163
22	14/02/99	15:50:00	.5	14.0	52.2	34.4	118.4	8.3	8.35	163

Sample PC Screen Readout

FIG 16