A TANK RESPIRATOR CONSTRUCTED IN CAPE TOWN

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Cape Town

During the recent poliomyelitis epidemic, there has been a scarcity of mechanical respirators. A large number of the patients, particularly in the younger age groups, are suffering from either weak intercostals or from interference with the diaphragm, and it has been necessary to assist their breathing in the initial and recovery stages. During the infective period, all patients have been treated at the City Hospital where a number of respirators are available, and all those who have required continuous treatment by mechanical means, have been retained in that hospital until they can continue outside a respirator for long periods.

In other hospitals where active treatment has been carried on, difficulties have arisen because many of these patients, while being able to survive outside mechanical respirators, have still considerable weakness of their intercostals, and this, together with the colder weather, makes them peculiarly liable to embarrassment from naso-pharyngeal or respiratory infections. As a prophylactic against serious chest complications, it is necessary that these patients be treated intermittently in the respirator in order to provide a full aeration of their lungs and avoid serious complications.

It is realized that obviously a large number of additional respirators cannot be made available at short notice, and, moreover, the cost, which is in the nature of £1,200 to £1,400, makes this economically difficult. For this reason, the possibility was investigated as to whether a Tank Respirator fulfilling all the requirements of the imported model could be manufactured and supplied in Cape Town.

With this in view, I approached Mr. J. Consani of Consani's Engineering Works, and put the problem to him with some suggestions as to how such an Iron Lung might be constructed. He told me that never before had his factory undertaken such work, but he was willing to try and with co-operation of those doctors dealing with polio cases, he felt that a satisfactory solution might be found.

After some 6 weeks' work, the first iron lung was produced, and tested at the Conradie Hospital. The original model was designed for children under the age of 5, and although mechanically sound and able to carry out its function satisfactorily, certain minor improvements were necessary. The first model was then returned to the factory and the second model was produced.

The present lung is able to take a patient of up to 6 feet 3 inches tall, and it has been tested and compared within the last few weeks and found to be completely satisfactory.

1. *The Body of the Lung*

The body of the lung is constructed of 1/8 inch steel plate. This material is used because although it is heavy, it is also extremely strong and much easier to work than duralumin or any of the light alloys. The problem of moving the lung from place to place is not a great one in South Africa where we have an ample supply of manual labour to assist us.

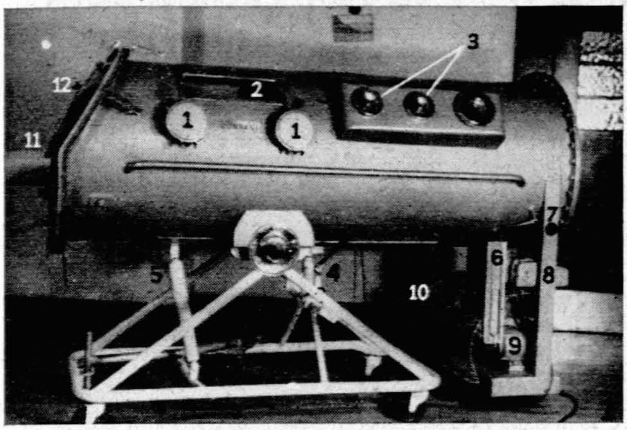

Fig. 1

1. Hand-holes, two on each side.
2. Inspection aperture covered with perspex, one on each side.
3. Inlet and outlet valves with variable pressure.
4. Jack for tilting the lung.
5. Hydraulic shock absorber to control the tilt.
6. U Tube to act as gauge for pressure.
7. Switch for lighting and heating.
8. Switch for electric motor.
9. ¼ Horse-power electric motor.
10. Wire guard covering motor and gear box.
11. Head rest.
12. Clamp to secure rubber valve air lock.

II. *The Pump*

I have always felt that a pump constructed separately from the lung is unnecessary; it certainly makes for difficulty in moving the lung about and is much more easily damaged.

Secondly, the tube through which the air is sucked in and out of the lung gives rise to draughts and also increases the dead space, a factor which must be seriously considered when dealing with a child. An increase in the amount of air to be sucked in and out of the lung assumes paramount importance when the body of the patient is small, because the elasticity of air and the relative diminution of suction necessitates an increase in the excursion of the pump in order to secure proper pressure. Any increase in the relative amount of air space in the lung or in the tube, together with a natural resilience, tends to diminish the suction power. For this reason, the pumping mechanism is placed directly at one end of the lung. The body of the lung is cylindrical in shape and is covered at the pumping end by a sheet of ¼ inch rubber; the centre of this rubber sheet is connected by large washers to a driving arm which moves to and fro and draws the rubber sheet in and out of the cylinder, so that the patient lies virtually within the body of the pump.

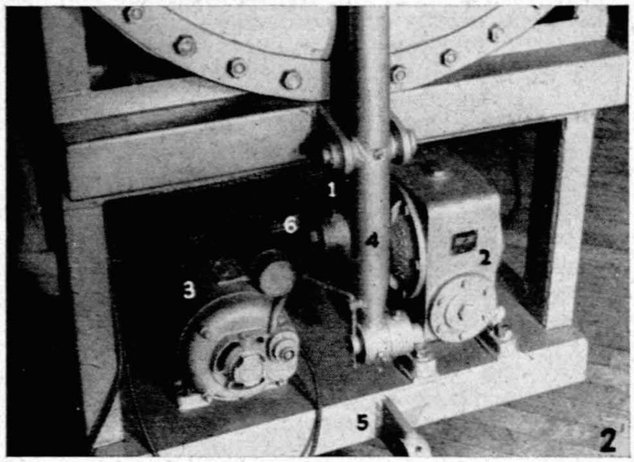

Fig. 2. Motor Unit

1. Driving wheel perforated in three places giving rise to different excursions of the driving arm.
2. Gear box.
3. ¼ Horse-power electric motor.
4. Driving arm.
5. Bracket to secure emergency hand apparatus.
6. Pulley belt.

The question has arisen as to how long this rubber sheet will last, being under intermittent tension? The size of the large washers which are both inside and outside of the sheet vary, so that the same amount of tension is not applied on each side. This diminishes the wear and tear on the rubber sheet.

The Motor

The motor is an ordinary ¼ horse power electric motor, which is connected first by pulley to a reduction gear which enables the pump to work at various speeds either 12, 16, or 22 excursions per minute. The reduction gear drives a steel wheel which is perforated at various levels to receive the connection link of the driving arm of the pump.

The reason for this is that the excursion of the pump can be varied to a considerable extent, so as to ensure that when a small patient is placed within the pump, adequate pressure can be achieved, particularly in suction.

The Stretcher

At the other end of the pump there is an aperture for the head with two small arms protruding, so that a sling can support the head outside the pump.

The stretcher inside the pump is on ball bearings and rollers, and is connected with the opening end of the pump, so that when the spring clips are released, this end of the respirator, together with the stretcher, can be drawn out to about 4½ feet.

The air lock is secured in the conventional manner to the head, opening by means of metal clamps, and consists of the usual sponge rubber neck piece with zip fasteners, although latterly we have been experimenting with an oblique fitting collar which seems to be much more satisfactory since it is variable in size. (Normally there have to be five or six sizes of the sponge rubber collar in order to secure a satisfactory air lock for all patients.)

Closure of the door is effected by 6 spring fasteners and the rubber collar ensures that an adequate air lock is produced.

Observation and Nursing

There are two perspex windows placed one on either side of the body of the pump, and below them, about 18 inches from the head end, are two arm holes on each side, all equipped with spring quick-release locks. Rubber valves inside these locks prevent the air excursion, when it is necessary for the nurse to put her hands inside the pump in order to treat the patient. The provision of two hand holes on either side ensures that two nurses each looking through the relative perspex window are able to administer the patient at one time.

The Control of Negative and Positive Pressure

The control of negative and positive pressure is achieved by means of two cone valves placed on the side of the pump. By this means both the positive and negative pressures can be individually controlled and their fine adjustment made possible. In addition, a U tube containing oil is fixed to the side of the pump which gives an accurate reading of the pressures. In testing this lung, it was shown that a far greater control of both negative and positive phases can be achieved in this lung than with most of the imported models.

Tilting

Often in nursing patients in an iron lung, it is necessary to tilt the lung itself in order that mucous and other respiratory exudates do not run down into the bronchi. The tilting mechanism is produced by means of a jack similar to a car jack placed under the lung, together with an hydraulic shock-absorber which allows the lung to be tilted to nearly 45°. This tilting is carried out smoothly and slowly; in addition, the inner side of the door of the lung is equipped with rubber pads so that the patient's shoulders are not pressed too hard against the door.

Mobility

The solid framework of this lung rests on 4–4½ inch rubber wheels which allows it to be wheeled about within the ward or from ward to ward. It is however, rather heavier than the conventional Iron Lung, but it is not impossible for it to be lifted on to a truck or lorry for transportation. Its heaviness is compensated for by the fact that it is of extremely strong construction and will stand a fair amount of knocking about.

Emergency Power

As with all machinery which relies upon electrical motors for power, the lung is subject to breakdown, and this may prove serious if the power is temporily cut off. For this reason, an emergency handle has been provided which takes about 15 to 20 seconds to slip into place, so that the lung may be worked by hand. It is found that one nurse can carry this out quite easily without exhaustion for about 10 or 15 minutes, but relays of orderlies would be able to carry on keeping the lung working for an indefinite period.

SUMMARY

This iron lung has the following advantages:

1. *The Price:* The price of this lung is less than that of the imported models.

2. *Construction:* It is constructed entirely in South Africa and all materials are purchased in the Union except the electric motor.

3. *Resistance to Damage:* The extremely solid construction makes it unlikely to be damaged by any normal accident.

4. *Control:* It is extremely easy to control and to work in both elements of pressure.

5. *Emergencies:* In emergencies the lung may be completely worked by hand.

I should like to thank Mr. J. Consani for his work in the production of this lung and for the many ideas and for the tremendous enthusiasm which he has displayed in this work.