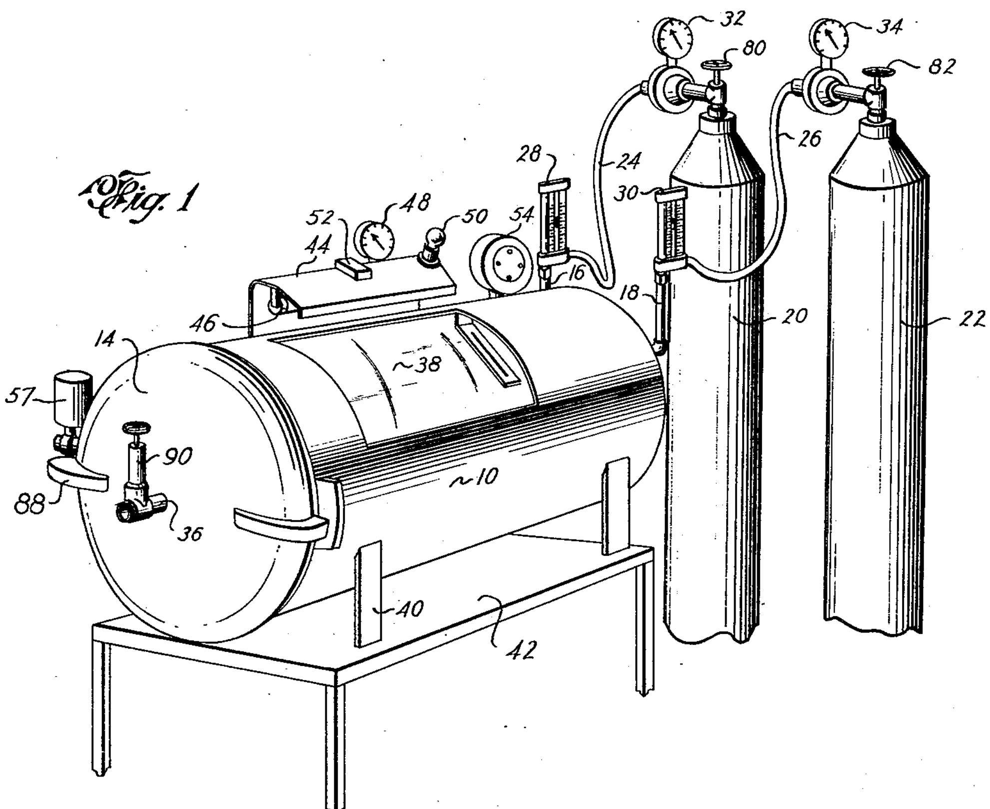
Oct. 22, 1957 A. P. BLOXSOM 2,810,384

METHOD OF AND MEANS FOR RESUSCITATION
OF THE ASPHYXIATED NEWBORN

Filed Feb. 23, 1950 3 Sheets-Sheet 1

Fig. 1



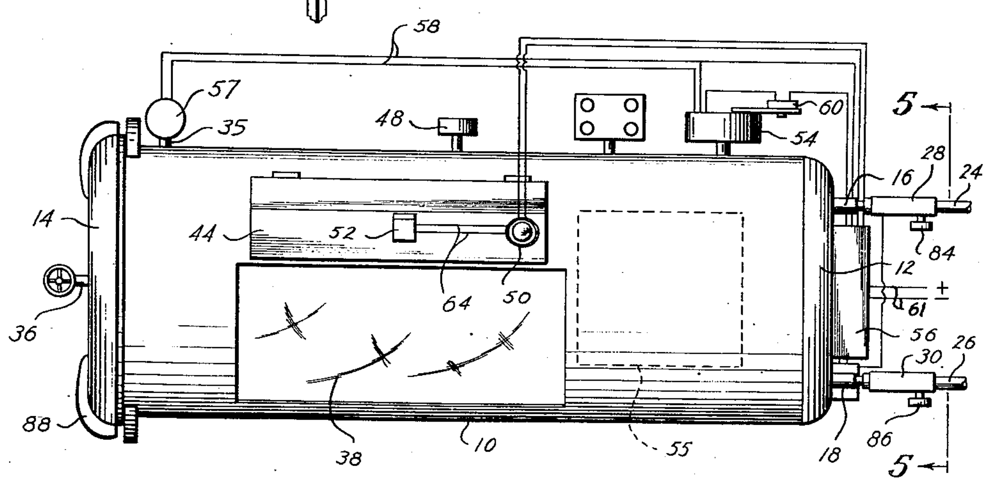


Fig. 2

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3 Sheets-Sheet 2

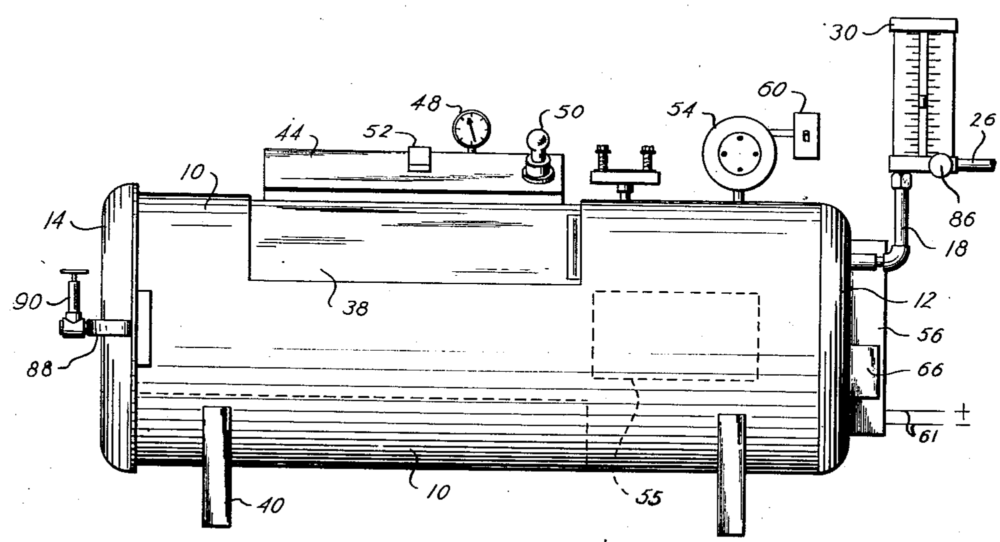

Fig. 3

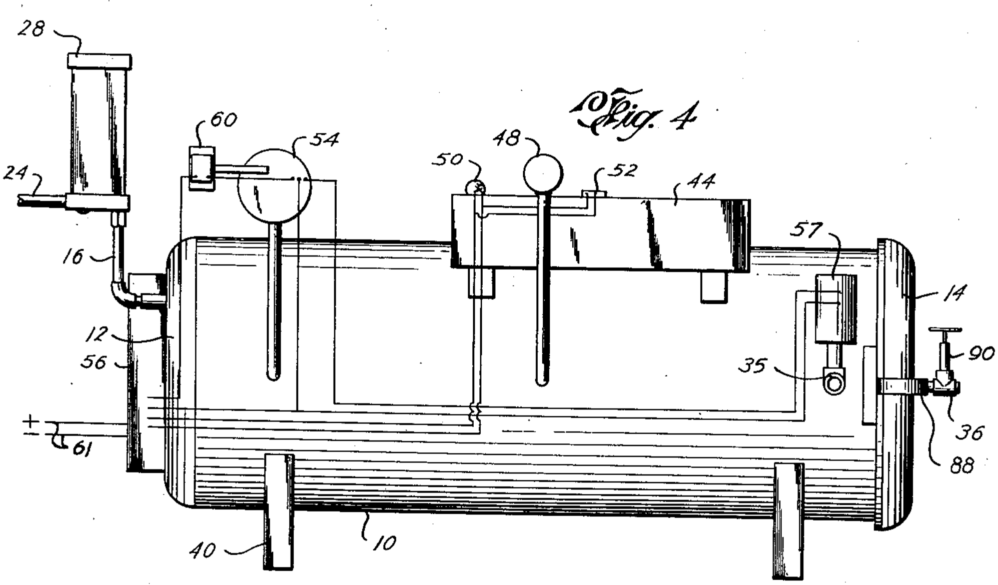

Fig. 4

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METHOD OF AND MEANS FOR RESUSCITATION OF THE ASPHYXIATED NEWBORN

Filed Feb. 23, 1950 3 Sheets-Sheet 3

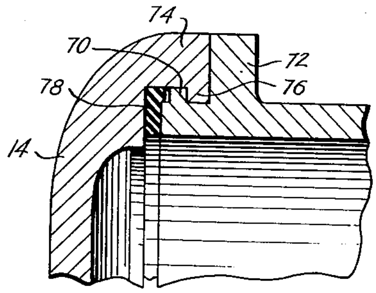


Fig. 6

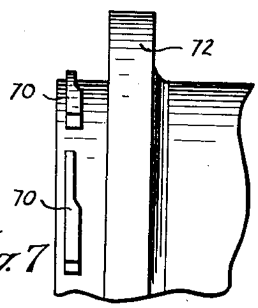
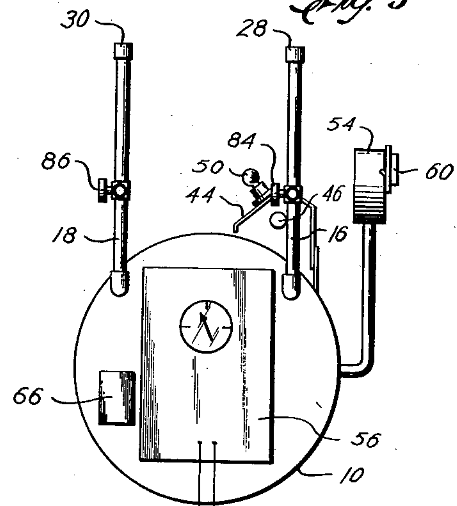


Fig. 7

Fig. 5



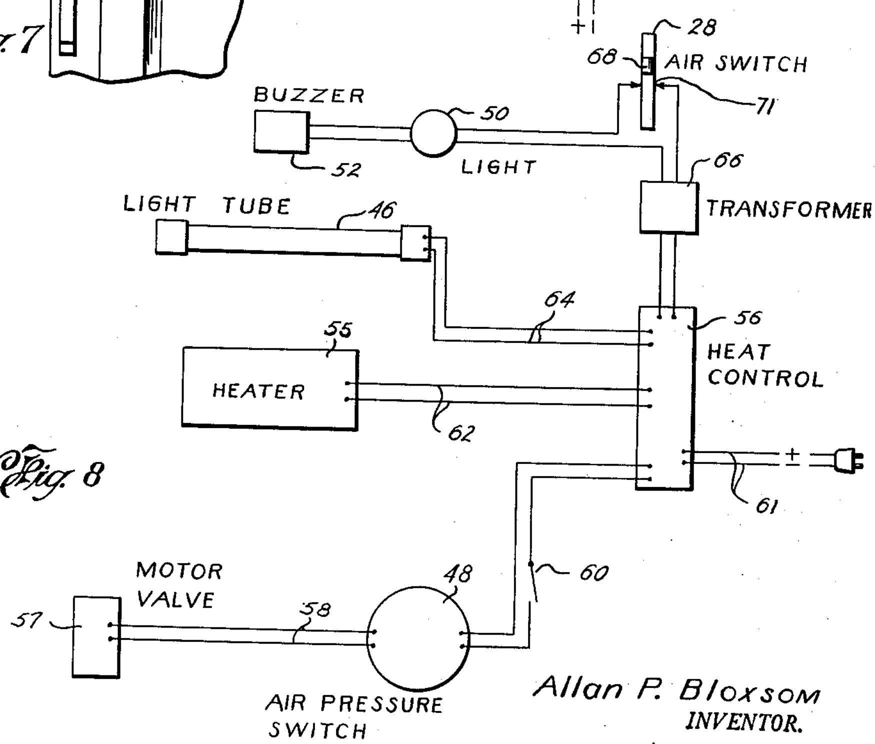


Fig. 8

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United States Patent Office

2,810,384

Patented Oct. 22, 1957

2,810,384

METHOD OF AND MEANS FOR RESUSCITATION OF THE ASPHYXIATED NEWBORN

Allan P. Bloxsom, Houston, Tex., assignor of three-fourths to George W. Waldron and Robert H. Perlitz, Houston, Tex., as trustees

Application February 23, 1950, Serial No. 145,705

10 Claims. (Cl. 128—28)

This invention relates to a method of and means for resuscitation of the asphyxiated newborn and, more particularly, relates to a method of and means for resuscitation of such newborn based on continuing after birth the physiological methods used by the mother.

I believe the purpose of labor of the mother to be duo-fold. One purpose that is obvious is the birth of the infant, and the other purpose, which I believe to be just as important, is the conditioning of the foetus to promptly start his respirations upon birth. Asphyxia of the newborn infant results when the events and forces that introduce oxygen into the foetus are lacking or a barrier is produced making the pressure gradients of oxygen and carbon dioxide nonoperative. For example, Cesarean section, narcotization, prolonged induction of anesthesia, long periods of severe anoxia resulting from premature separation of the placenta, and toxemias of pregnancy, all of which can disturb the pressure gradients of oxygen and carbon dioxide for the foetus are a few of the major conditions leaving the infant with an initial shortage of oxygen and an excess of carbon dioxide. The immediate problem of resuscitation and treatment of the asphyxiated newborn appears to be one of not only getting the respiratory center to function properly, but to prevent a damaging anoxia of the cells of the central nervous system until adequate external respiration will provide a full blood oxygenation for internal respiration.

In the art at the present time midwives and obstetricians are practicing resuscitation methods and procedures comprising peripheral stimuli, such as wiping out the throat vigorously with gauze; chilling the newborn infant, such as retaining the infant in the delivery room for a short period, thumping the feet or vigorously paddling the infant; and, recently, utilizing a gas machine to pressurize the lungs at what I believe to be too great a pressure and too fast a rate, ordinarily from 5 to 30 times a minute.

The present invention is based upon the discovery that the varying positive intrauterine pressures have an important part in the oxygenation and preparation of an infant to quickly initiate his respiration, both external and internal upon delivery, and that surprisingly such varying pressures may be again utilized after birth rather than maintaining conditions substantially simulating ordinary respirations. Thus I propose to subject the newborn infant having difficulty in beginning oxygenation and adequate respirations to pressure conditions existing in utero and at the same time supply heat and sufficient oxygen to the infant and expose him to slow gentle stimuli similar to those received in utero. Thus, unexpectedly, there may be a more favorable outcome, not only to the infant's immediate existence, but to the future optimal development of his central nervous system.

During labor of the mother the foetus is placed under pressure which increases at unhurried intervals the oxygenation of the foetal blood, maintains adequate warmth and produces stimuli to initiate respiration of the foetus. Salerno (Observation on Intrauterine Pressure During First Stage of Labor, American Journal of Obstetrics and Gynecology 36:294–302 (August) 1938), has found that the relative intrauterine pressures may vary from 1 to 3 pounds during labor pains, and at the end of the second stage of labor such pains may occur once every one to three minutes. It seems manifest that the foetus is accustomed to such a rate of stimulation and I believe that the more rapid rate in general use at the present time represents an unphysiological effort on the part of the physician to resuscitate the newborn infant.

Accordingly, it is a prime object of my invention to provide a method of and means for resuscitating the asphyxiated newborn by continuing pressure conditions existing in utero.

A further major object of my invention is to provide a method of and means for resuscitating the asphyxiated newborn by providing sufficient oxygen and gentle stimuli to the newborn similar to that received in utero.

A still further and major object of my invention is the provision of a method of and means for resuscitating the asphyxiated newborn by varying the diffusion pressure gradients of oxygen and carbon dioxide while maintaining the newborn under pressure at all times.

A still further object of my invention is to provide a method of and means for varying the cycling of the above diffusion pressure to substantially approximate the timing of labor pains at the end of the second stage of labor.

It is an important object of my invention to condition a foetus in order to promptly commence his respirations.

It is yet a further and important object of my invention to prevent a damaging anoxia of the cells of the central nervous system until external respiration provides a full blood oxygenation for internal respiration.

It appears that a number of newborn infants at birth are in a state of considerable shock or are listless and all of the tissues of the body have a poor tone. Moreover, with the condition of shock that a number of these infants appear to be in, it may be that stagnation of the blood in the lungs makes it more difficult for the infant to absorb oxygen and give up carbon dioxide. It may well be that a number of asphyxiated infants who were thought to have atelectasis are in a considerable degree of shock with an impairment of their pulmonary circulation and can use oxygen only under difficulty.

Accordingly, a still further important object of my invention is to correct or prevent a further increase in shock, to increase the blood pressure and the tissue turgor in addition to the introduction of oxygen to the asphyxiated newborn infant.

It is a still further feature and object of my invention to accomplish the above objects and provide the above features by physiological means and without the use of physical stimulation.

Other objects and features will be apparent from the following description of my invention.

In general my invention comprises maintaining an infant under a constant flow of air and oxygen containig an excess of oxygen and maintaining the infant under pressure at all times. The cycle of pressure on the infant may vary from 1 to 3 pounds per square inch and such cycling may occur over a period of from 45 seconds to two and a half minutes, although other cycling approximating labor pains may be utilized. I have found that to reduce the pressure from 3 pounds to 1 pound in approximately 15 seconds and to slowly raise the pressure from one to three pounds in approximately 30 seconds is satisfactory for my purpose. Upon the initiation by the infant of regular respiration the pressures may be decreased at steady levels for varying periods.

By varying the positive pressure on the newborn infant it is possible to provide a regular transport system of oxygen to the alveolar sacs and to provide removal of carbon dioxide. It has been found that this transport system operates with a minimum of pressure lag, being estimated by Barach (Immobilization of Lungs Through Pressure, American Review of Tuberculosis 42:586 (1940)), to be five to six cm. of water due to the resistance offered by the bronchial tree to gases diffusing in the smaller spaces. This pressure lag is necessary for respiratory stimulation and resuscitation and the gentle compression and expansion of the chest from the resistance interposed by the tracheo-bronchial tree to the passing of air into and out of the lungs is a feature utilized in my method of resuscitation. Thus, I provide a relatively slow rate of increase of pressure to oxygenate the infant with respect to decompression whereby oxygen has a longer period to diffuse to the infant, and the quick decompression aids in pulling out mucus and carbon dioxide, which diffuses some 30 to 50 times as quickly as oxygen. As I have indicated heretofore I vary the cycling of the pressures to approximate the timing of labor pains at the end of the second stage of labor, which may approximate one cycle every one to three minutes.

I have developed a suitable means to carry out the purposes of my invention and one form thereof suitable therefor is illustrated in the accompanying drawings, where like character references refer to like characters throughout the several views, and where:

Fig. 1 is a perspective view of an airlock illustrating an embodiment of my invention,

Fig. 2 is a plan view of the airlock illustrated in Fig. 1,

Fig. 3 is a front elevation thereof,

Fig. 4 is a back elevation thereof,

Fig. 5 is taken along the line 5—5 of Fig. 2,

Figs. 6 and 7 illustrate details of securing a cover to the airlock, and

Fig. 8 is a schematic wiring diagram of suitable electrical control means for the unit.

Referring to the drawings and particularly Figs. 1–4 inclusive, my airlock for resuscitation of the asphyxiated newborn includes a cylindrical body member **10** closed at one end **12** and releasably closed at the other end by the cover **14**.

In order that a constant supply of oxygen and air may be supplied under pressure at all times I have provided the inlets **16** and **18** respectively. Oxygen and air are supplied to inlets **16** and **18**, respectively, from a suitable source, such as the cylinders **20** and **22**, by the flexible conduits **24** and **26** secured to the flow gauges **28** and **30**, which are in turn connected to inlet members **16** and **18**, respectively. As indicated conventional pressure gauges **32** and **34** may be placed in the lines **24** and **26** in order that the pressure of the gases flowing from the containers **20** and **22** may be regulated. These pressure gauges are conventional and no further description is deemed necessary.

The flow gauges **28** and **30** are of conventional design and in one of them I have provided a safety device to indicate when the flow of gases therethrough is less than a predetermined minimum. A description thereof is given later herein and I have found that a constant flow of 8 liters each of oxygen and air per minute is a satisfactory rate for my purpose. Manifesty, this rate may be varied, but at this rate the infant inside the airlock is in an atmosphere having an excess in the amount of 60% of oxygen which is desirable for my purpose.

As illustrated in Figs. 2 and 4 I have provided the outlets **35** and **36** to permit the oxygen and air constantly flowing into the airlock to be exhausted therefrom in a controlled manner described hereinafter.

As illustrated in Figs. 1–3 I have provided the transparent window **38** in order that the newly born infant may be viewed when inside my airlock and the body portion **10** is suitably braced by the legs **40** whereby my apparatus may be placed on the conventional supporting table **42**. I have provided the upwardly extending and outwardly and downwardly turned light shield **44** to secure the light, such as the light tube **46**, in order that the infant may be clearly viewed, and extending from the cylinder **10** is a conventional pressure gauge **48** in communication with and indicating the pressure of oxygen and air inside the container. A light **50** and buzzer **52** are conveniently secured to the shield to indicate when the flow of gases, particularly air, falls below the rate of 8 liters per minute, as described hereinafter.

In order that the incoming air and oxygen may be heated to the proper temperature and properly humidified, I have provided the conventional heating and humidifying element **55** controlled by the conventional control means **56**, and, inasmuch as these units in and of themselves form no part of the present invention and are in widespread commercial use in conventional incubators, no more description thereof is deemed necessary. Examples of suitable arrangements for heating and humidifying the incoming air and oxygen are illustrated in U. S. Patent No. 1,688,200, granted October 16, 1928, on the application of H. J. Morgenthaler entitled Enclosed Bed for Premature and Feeble Infants; U. S. Patent No. 2,369,396, granted February 13, 1945, to E. L. Higginbotham entitled Incubator for Premature Babies; U. S. Patent No. 2,246,820, granted June 24, 1941, to T. A. Taylor entitled Infant Incubator; U. S. Patent No. 2,104,024, granted January 4, 1938, to J. A. Conboie entitled Air Conditioned Sleeping Cabinet; and U. S. Patent No. 2,347,326, granted April 25, 1944, to H. M. Kirschbaum entitled Combined Infant Resuscitator and Incubator. Thus, it will be understood that any satisfactory heating and humidifying arrangement may be used and, accordingly, no further description thereof is deemed necessary.

In order that the asphyxiated newborn may be under a constant pressure of an atmosphere containing an excess of oxygen and in order that the pressure gradients of oxygen and carbon dioxide may be varied in accordance with my invention, I have provided the double acting mercury solenoid switch **54** which actuates the valve-operating means, such as the motor or air valve **57**, by means of the electrical conductors **58**. Referring to Fig. 8 which illustrates a schematic diagram of the electrical portions of my device, a source of electrical energy is supplied to the heat and humidity control unit **55** by the conductors **61**. Electrical energy is supplied to the solenoid air pressure switch **54** and a manually operated contact switch **60** is connected across the conductors supplying potential thereto. The valve-operating means **57** is electrically connected to and energized by the air pressure switch **54** by means of the conductors **58** whereby the valve associated with the outlet **35** is opened and closed. The heater and humidifier **55** is supplied with electrical energy by means of the conductors **62** and controlled by the conventional heat control unit **56**. The light means or neon tube **46** is supplied with electrical energy by means of the conductors **64** and the air switch or flow gauge **28** is connected to the secondary of the transformer **66**, the former energizing the light **50** and buzzer **52** when the rate of flow through the flow gauge **28** falls below a predetermined minimum. The air switch **28** contains the floating conductor **68** which engages a pair of electrodes **71** when the rate of flow therethrough falls below the predetermined minimum thereby providing an electrical contact and thereby energizing the light and buzzer **50** and **52**. No more description is given of the electrical portion of my development inasmuch as the control means are of conventional design, have been in long use and may be purchased commercially, and in and of themselves form no part of the present invention. For example, satisfactory motor valves and motors for actuating valves are illustrated in U. S. Patent Re. 21,881, reissued August 19, 1941, on the application of W. A. Ray and C. R. Ray entitled Solenoid Construction; U. S. Patent Re. 21,767, reissued April 8, 1941, on the application of W. A. Ray entitled Solenoid; and U. S. Patent No. 2,098,197, issued November 2, 1937, on the application of W. A. Ray entitled Solenoid. Satisfactory pressure-responsive switches controlling the actuation of a motor-type valve or solenoid-actuated valve are described and illustrated in U. S. Patent No. 2,288,436, granted June 30, 1942, to A. M. Cahan entitled Resuscitating Device; U. S. Patent No. 2,391,877, granted January 1, 1946, to A. M. Cahan entitled Respiration Apparatus; U. S. Patent No. 2,304,802, granted December 15, 1942, on the application of M. W. Crew entitled Pressure Controller; and U. S. Patent No. 2,418,034, granted March 25, 1947, on the application of Arthur J. Kizaur entitled Respiration Apparatus (see Figure 8 and beginning line 24 in column 15). It will be understood that any suitable motor-type valve and arrangement and pressure-responsive switch may be used and, accordingly, no more description thereof is deemed necessary.

In order that the removable cover **14** may be removed from the cylinder **10** and the infant placed therein, I have provided the spaced lugs **70** extending about the outer periphery of the open end of the cylinder **10** and have provided the radial and outwardly extending flange **72** against which downwardly turned flange **74** of the cover **14** may snugly engage. I have further provided the spaced lugs **76** on the inner periphery of the flange **74** to cooperate with the lugs **70** whereby the cover may be placed over the open end of the cylinder **10** and rotated slightly to readily secure the same to the cylinder. As illustrated a gasket member or ring **78** may be utilized to prevent the leakage of pressure around the connection.

In using my airlock and performing my method, before placing an infant into the lock and securing the door or cover **14**, I start a flow of air and oxygen each at the rate of 8 liters per minute by manipulating the valves **80** and **82**, connected to the cylinders **20** and **22**, and the valves **84** and **86**, associated with the flow meters **28** and **30** respectively (see Fig. 2). When the rate of flow of oxygen and air into the cylinder **10** is 8 liters per minute each, as indicated by the flow meters **28** and **30**, an oxygen concentration of 60% will be provided therein. The asphyxiated newborn infant free of all clothing or all covering may the be placed into the cylinder **10** and the cover **14** inserted by rotating it a quarter of a turn, which may be conveniently manipulated by means of the handles **88**. The manually operated valve **90** should be closed and the mercury solenoid air switch **54** controlling the release of air and oxygen from the cylinder **10**. The pressure in the airlock is permitted to rise to a predetermined maximum level, such as 3 pounds per square inch, and when this level is reached the mercury switch energizes the valve-operating means **57** thereby permitting oxygen and air to be released from the chamber **10**. When the pressure inside the chamber **10** reaches a predetermined minimum level, such as 1 pound per square inch, the duo-acting solenoid switch will again energize the valve-operating means **57** thereby closing the outlet **34** and permitting the pressure to increase to the predetermined maximum. This cycling of pressure may vary and I have found that a period of from forty-five seconds to two and a half minutes is satisfactory. Also, periods of approximately 15 seconds to reduce the pressure and 30 seconds to raise the pressure, depending upon the volume of oxygen flowing in the lock, are satisfactory. Upon initiation by the infant of regular respiration the pressures may be held at decreased steady levels by manipulating the switch **60** and by regulating the valve **90**, thereby cutting off the automatic control means and thereafter regulating the pressures manually. It is an important part of my invention to maintain the child under a constant pressure in an atmosphere having an excess of oxygen as such tends to aid the infant in its respirations. After the infant has been maintained under a constant pressure in the airlock for varying periods of time until regular respirations have been established, the infant may be removed from the airlock. This may be accomplished by opening the cover **14** and cutting off the flow of oxygen and air into the cylinder **10**.

Example 1

The following example indicates the behavior of the initially asphyxiated infant delivered by Cesarean section when utilizing my means for and method of resuscitation. The initially asphyxiated infant was delivered by Cesarean section after a rather long induction of anesthetic and was gently placed in the airlock with no attempt at resuscitation. The infant was quite limp, slightly cyanotic and was making no effort to breathe. Blood was gently wiped from the outside of his mouth and from the opening to his nose and he was placed in the airlock within 30 seconds after being lifted from the mother's abdomen. As indicated heretofore 8 liters per minute each of air and oxygen were flowed into the airlock and with the initial increase in pressure the infant's skin began to turn pink, showing some absorption of oxygen, not only through the upper respiratory track, but apparently by diffusion through the skin. As the pressure inside the airlock continued to increase and specifically at 2½ pounds pressure per square inch a little clear frothy fluid appeared at one nostril. The pressure increased to 3 pounds and the mercoid solenoid switch opened the exhaust valve and the pressure started to decrease. A little more fluid appeared at the nostril at once and when the pressure reached 1 pound the initial respiratory effort was made by the infant. The same series of events took place during the second and third cycles of the airlock. The infant's color was excellent from the time full pressure was initially obtained in the airlock and regular respirations became established shortly thereafter. The cycling was discontinued by opening the switch **60** and thereafter the infant was maintained at 2 pounds pressure for a short period of time by opening and adjusting the manually operated valve **90**; and, finally, the pressure was reduced to 1 pound, the infant being maintained at such pressure for a short time and then released from the airlock. The infant had spent some 55 minutes in the airlock and at that time, after delivery, was breathing normally and in excellent condition. During the first 24 hours and subsequent thereto there was no grunting or swelling of the eyelids seen so frequently in this type of infant.

Thus it is manifest that my invention is of wide scope and application and that many changes may be made therein. For example, if desired, the cylinder **10** may be made of a suitable plastic in order that the child may be viewed readily, and means may be placed in the bottom of the cylinder to maintain the child in a comfortable position during resuscitation. Also, an asbestos partition may be placed between the heating and humidifying portion and the portion holding the infant in order to prevent accidental burning of the child. Any type of automatic arrangement may be utilized to vary the pressures and varying pressure gradients and relative amounts of oxygen and carbon dioxide may be used. It is preferable to have an excess of oxygen at all times but the child may be maintained under air pressure only at all times. I believe, however, that an excess of oxygen is beneficial to the infant.

While I believe that the theories propounded explain the successful results of my invention, I do not wish to limit myself to any particular theory developed but only by the scope of the following claims:

I claim:

1. A method of resuscitating an asphyxiated newborn infant comprising, maintaining the infant in an atmosphere containing a relatively high concentration of oxygen, maintaining such atmosphere about the infant at all times at a minimum pressure greater than atmospheric, increasing such atmosphere about the infant to a maximum pressure, decreasing such pressure from such maximum pressure to such minimum pressure, and cycling

such increase and decrease of pressure at a rate substantially the same as occurring during terminal stages of labor.

2. A method of resuscitating an asphyxiated newborn infant comprising, providing a substantially constant supply of oxygen and air to the infant, maintaining at all times a minimum pressure above atmospheric of such oxygen and air about such infant, increasing such pressure of oxygen and air about such infant from the minimum pressure to a maximum pressure, decreasing the pressure of such oxygen and air about such infant from such maximum pressure to such minimum pressure, and cycling such increase and decrease of pressure at a rate substantially the same as occurring during terminal stages of labor.

3. The method of claim 2 where the oxygen and air are each provided at a substantially constant rate of approximately 8 liters per minute.

4. The method of claim 2 where the cycle of increase and decrease of the pressure of oxygen and air is approximately 45 seconds to 2.5 minutes.

5. The method of claim 2 where the pressure is increased relatively slowly and decreased suddenly.

6. The method of claim 2 where the pressure is increased for a period of approximately 30 seconds and is decreased for a period of approximately 15 seconds.

7. The method of claim 2 where the minimum pressure is approximately 1 pound per square inch and the maximum pressure is approximately 3 pounds per square inch.

8. A method of resuscitating an asphyxiated newborn infant comprising, providing a substantially constant supply of air to the infant, maintaining at all times a minimum pressure above atmospheric of such air about the infant, increasing the pressure of the air about such infant from the minimum pressure to a maximum pressure, decreasing the pressure of the air about such infant from such maximum pressure to such minimum pressure, and cycling the increase and decrease of such pressures at a rate substantially the same as occurring during terminal stages of labor.

9. An apparatus for resuscitating an asphyxiated infant comprising, a substantially air-tight pressure chamber adapted to receive an infant, means to inject a substantially-constant flow of oxygen and air into the chamber, an outlet valve in the chamber, automatic valve-operating means for opening and closing said outlet valve, said valve-operating means including means in communication with and responsive to pressure in the pressure chamber to actuate said valve for opening said valve when the pressure in the chamber reaches a predetermined maximum and for closing the valve when the pressure in the chamber reaches a predetermined minimum so that when said outlet valve is closed the substantially-constant injection of oxygen and air into the pressure chamber gradually increases the pressure therein to said maximum pressure at which such maximum pressure the valve-operating means opens the outlet valve thereby permitting rapid escape of oxygen and air from the pressure chamber and providing a sudden decrease in the pressure in the pressure chamber, said valve-operating means closing said outlet valve on reaching said minimum pressure in said pressure chamber thereby providing regular cycles of gradual increase and sudden decrease in pressure in the chamber while maintaining a constant supply of oxygen and air to the chamber, and alarm means in communication with the means to inject the substantially-constant flow of oxygen and air into the chamber for indicating when the rate of flow to the chamber falls below a predetermined minimum.

10. An apparatus for resuscitating an asphyxiated infant comprising, a substantially air-tight cylindrical pressure chamber adapted to receive an infant to be resuscitated, means to inject a substantially-constant flow of oxygen and air into the chamber proximate one end thereof, an outlet proximate the other end of the chamber to expel oxygen and air therefrom, a valve in the outlet for opening and closing the outlet, valve-operating means responsive to pressure in the pressure chamber for opening said valve when the pressure in the chamber reaches a predetermined maximum and for closing the valve when the pressure reaches a predetermined minimum so that when said outlet valve is closed and substantially-constant injection of oxygen and air into the pressure chamber gradually increases the pressure therein to said maximum pressure at which such maximum pressure the valve-operating means opens the outlet valve thereby permitting rapid escape of oxygen and air from the pressure chamber and providing a sudden decrease in the pressure in the pressure chamber, said valve-operating means closing said outlet valve on reaching said minimum pressure in said pressure chamber thereby providing regular cycles of gradual increase and sudden decrease in pressure in the chamber while maintaining a constant supply of oxygen and air to the chamber, and alarm means in communication with the means to inject the substantially constant flow of oxygen and air into the chamber for indicating when the rate of flow to the chamber falls below a predetermined minimum.

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