BABY INCUBATORS

— BY —

JOHN ZAHORSKY

MILDRED,

Age 1 year, weight $16\frac{1}{2}$ pounds (7500 grams). When 2 weeks old she weighed about $2\frac{1}{4}$ pounds (1135 grams) For history see page 113.

BABY INCUBATORS

A CLINICAL STUDY OF THE PREMATURE INFANT, WITH ESPECIAL REFERENCE TO INCUBATOR INSTITUTIONS CONDUCTED FOR SHOW PURPOSES.

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PREFACE.

This little book grew out of a series of articles on my experience with premature infants reared in an institution which was conducted for show purposes at the Louisiana Purchase Exposition. The articles appeared in the *St. Louis Courier of Medicine*, 1905. While the study is based on institutional work the several questions discussed apply to premature infants anywhere. Whether some of the conclusions reached are perfectly sound only future experience can verify.

As to the final outcome of the infants kept in the incubators on the "Pike," it need only be said that as far as I could learn only one infant died after leaving the institution. All others are doing well. Mildred, the smallest one of all, is a happy girl. (See frontispiece).

Quite a number of errata occur through this book, all of which are so obvious that they need not be pointed out here.

I take pleasure in thanking my friend, Dr. E. W. Saunders, for many practical suggestions in regard to the care of premature infants.

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BABY INCUBATORS.

I.

ALTHOUGH I have taken some pains to search medical literature, a comprehensive account of results obtained at the so-called show incubators was not found. Neither can I find to whom we owe this new method of entertaining and instructing the people. The *London Lancet* of May 29, 1897, editorially discusses the care of infants in incubators and gives an account of the first public incubators in England. After narrating a brief history of the baby incubators and discussing their success in foreign countries, it is stated that in England the question of incubators is of particular interest, for though the general death-rate of infants had decreased considerably, the death-rate due to premature births had, on the contrary, greatly increased.

Some authorities had placed this increase at 40 per cent. The London tables of mortality show that whereas the deaths registered as due to premature births amounted to 1930 in 1886, this figure rose to 2534 in 1896. "Under these circumstances any successful attempt to improve the construction of incubators and to render this life-saving apparatus available to the general public must be welcome." It is furthermore stated that they "were informed" that this had been achieved at Earl's Court, but does not give any source of the information. In these editorial notes we are informed that Messrs Samuel Schenkein and Martin Coney had opened an exhibition of baby incubators during the Victorian Era Exposition at Earl's Court.

"The main feature of this new incubator is the fact that it requires no constant and skilled care. [! !] It works automatically; both ventilation and heat are maintained without any fluctuation whatever, not only for an hour but for days." The writer evidently obtained his information from the dealers in incubators. He later admitted that the variations were no more than 2°C. The incubators used were the Altmann incubators. From the description I judge that it was a modification of the Lion incubator.

The ventilation was accomplished by a pipe conducted through the wall or window which delivered the air to a box fastened to the side of the incubators, where it was moistened and washed by passing through a layer of cotton over a saucer containing water or an *antiseptic solution*. We are really surprised to hear that the air passed over an antiseptic solution. This must also be some information obtained from the dealers. Medical science is not aware of any antiseptic which destroys bacteria in the air and at the same time is harmless to breathe, especially for young infants.

The description of the air and heating apparatus corresponds to the incubators used in St. Louis, except that the thermostat was different. The thermostat was in the shape of a W made of two metals, one of which expanded and contracted while the other did not. This unequal expansion turned off the gas or turned down the lamp. It was said to have been very delicate, the slightest change affecting it, etc.

Most remarkable is the assertion that as the incubators were so perfectly constructed *skilled attendance was not required*, as if the keeping a box up to a constant temperature is the whole difficulty in the care of premature infants.

A further description of the institute is found in the *London Lancet* of July 17, 1897. After announcing that the members of the press were invited to inspect the incubators at Earl's Court, it is stated that the incubators are in charge of a trained nurse from Paris who is assisted by the wet nurses who furnish food for the infants.

The institute comprises three compartments: On one side were sleeping accommodations for the two wet nurses and the trained nurse; on the opposite side was a nursery where the babies were fed, washed, etc. The public was admitted to the central room where the incubators stood. Messrs Coney and Schenkein, and two physicians attend. We can not but help smiling on reading that the babies were fed every two hours in day time and at night the watchman awakened the nurses every three hours that they might feed the infants. They were generally fed from the breast.

I have given the description of this public incubator institute somewhat at length since it is the only one that can be found. That this system had great defects in construction and was defective in its nursing capacity is self evident. How much improvement these gentlemen accomplished at other institutions of similar character (Berlin, Buffalo and New York) I can not state. That the editor of the *Lancet* could grow enthusiastic over it only emphasizes the general ignorance of such institutions at that time.

The financial success of the incubator shown at Earl's Court seems to have invited many other showmen to open such an exhibition, and we find Messrs Coney and Schenkein in an open letter (*London Lancet*, September 18, 1897) deeming it their "duty to warn members of the medical profession, also nurses, parents and public institutions not to entrust their children to any applicant whatsoever without first taking the precaution to assure themselves that they will not be made the victims of showmen, as well of inexperienced or irresponsible persons who seek to trade upon the established reputation of an invention that has been recognized by both the medical and lay press." Is this not the voice of pure commercialism?

Indeed, in the following year (*London Lancet*, Feb. 5, 1898) the editor regrets that the success at Earl's Court has attracted the cupidity of public shownen. The methods used at the London World's Fair are attacked especially because the air is not obtained from the outside. The incubators at Barnum & Bailey's Circus seem to have been under better management, but the *Lancet* indignantly exclaims: "What connection is there between the serious matter of saving human life, and the bearded woman, the dog-faced man, the elephants, the performing horses and pigs, and the clowns and acrobats, that constitute the chief attraction of Olympia!"

Some notion of this incubator is obtained from an editorial in *Pediatrics*, April 1, 1898. It seems, however, that this periodical obtained most of its data from an English newspaper. I quote—"one of the most popular of the 'side-shows' at Olympia, now the headquarters of Bailey's Greatest Show on Earth is the baby incubator department. These incubators are of English manufacture throughout, and are, moreover, far more elaborate contrivances than their German and French prototypes. All the infants treated by this method are exceedingly delicate, one of them weighing only 20 ounces, while another is barely 9 inches long, yet it is asserted that between 80 and 90 per cent are saved alive." Then follows a description of the incubator; the air is received from the outside through a metal pipe; the baby lies in a hermetically sealed glass chamber; the air is filtered by passing through cotton which has been impregnated with a powerful germicide. Infants are fed every two hours in the day time and three times at night. The greatest care is taken to prevent their inhalation of the outside air during feeding. Sterilized milk, well diluted, is the food. There is an automatic regulator of the heat, and when anything is wrong an electric bell rings.

We read that in all these incubators the results are very good. But such reports are utterly worthless, since no exact statistics have been published. In order to ascertain whether the results were very good we should have to know the number, age and weight of the babies admitted and the exact death rate. This has never been furnished by physicians in charge of these incubators. Why?

The accusation made against some of them is that babies weighing less than a certain number of ounces and under seven and a half months' gestation are not received, but I have no way of verifying this statement.

The feeling of the medical profession is against the show incubators, of this there can be no doubt. On the one hand there is a prejudice that showmen can not have the proper sentiment toward these little ones and may sacrifice proper requirements of care for show purposes; on the other hand, we feel it degrading to human sentiment to make an exhibition of human misfortunes, especially in the shape of tiny infants. It is perfectly rational, then, to inquire into the advantages that an incubator institute has to offer. In the first place, such an institution, when connected with a large Fair or Exposition is financially able to give these young infants attention which could not be procured otherwise. When it is recalled that each infant at the St. Louis Fair cost the company about $15 a day, the magnitude of the task is apparent, and if this expenditure is life-saving it would be a great boon to the poorer class. Money is necessary to save the life of premature infants. It is questionable whether any hospital or asylum could undertake this work unless the State would give a liberal support.

In the second place, such an institution has a great educational value and, no doubt, these exhibitions have contributed largely to the general feeling that a effort should be made to save premature infants and not allow them to die as a matter of course.

In the third place, such an institution serves the purpose of a hospital where premature infants may be scientifically studied, and in this way advances our knowledge and improves our methods of rearing them. Unfortunately, as far as I am aware, the material at these exhibitions in the past have not been utilized; or, at least, the scientific world has not received any increment to its knowledge from this source. It is for this reason especially that I take pleasure in giving the full particulars of the incubators at the Louisiana Purchase Exposition, and record the details of our efforts to save life during the three months in which I had charge.

But there is one objection to these exhibitions which must be carefully considered, and this objection holds good for all infant hospitals and asylums—namely, the death-rate of infants in such institutions is probably much higher than in private families. The danger of "hospitalism" can not be denied, but more of this later.

After all, as long as the people are interested in such exhibitions, and will pay a good admission fee, these institutions will flourish and it behooves the medical profession to see that safeguards are thrown around them, and rules of conduct must be accurately formulated. On the construction and management more will be told later.

The Incubators on the Pike.

The Imperial Concession Company, a company formed principally of St. Louis business men, with Mr. E. M. Bayliss manager, opened the incubators about June 1, 1904. While the purpose of this company was simply to make money, the character of the men governing the institution, precluded the entertainment of the notion that the infants would be neglected in any way. These business men did not claim to know anything about the care of premature infants (neither do the capitalists who build our hospitals possess any special knowl edge concerning the care of the sick) but they were willing to do anything that science has taught was necessary. Miss Kelly, a trained nurse, who had had considerable experience with premature and other babies was put in charge, a physician was procured who had gone East especially to study the care of these infants, and only trained nurses were employed to take care of the babies.

Everything went very well until the hot weather, when, through some error, a very virulent pathogenic micro-organism was introduced and the catastrophe of an epidemic summer diarrhea started among the babies. The losses of very young babies was increased by the death of several "graduates," and the mortality was altogether higher than was desired. On September 1st the death-rate had been about 50 per cent—the death-rate of infantile hospitalism.

The attending physician resigned and during the month of August others were employed.

Meanwhile, certain "specialists" in incubator exhibitions, probably chagrined by the fact that they had not obtained the concession, although they had experience in many other expositions, began to assail the management in every conceivable way. Some sensational newspapers tried to make a scandal out of the baby incubators on the Pike.

But the management and the officials of the Exposition took up the subject; a committee of the best local physicians was appointed to investigate the exhibition and a few changes in the building were ordered, one of which was that a glass partition should separate the incubators from the public. But these alterations, while helpful, had little to do with improving the conditions. The catastrophe was almost over. The management spared no expense in trying to remedy every defect. Vast sums were spent in some things which really were impracticable—such as a gas pump to increase the gas pressure, electric heaters, etc. The gas pump failed to operate at times and the electric heating of water was too slow.

How to avoid these catastrophes, as Finkelstein has aptly termed them, has been clearly laid down, but occasionally, in spite of care, it may occur. What seemed especially hard was the bitter attacks of these "specialists" in incubator institutes, although the report of Major Raymond, U. S. A., showed that the death-rate in incubator babies was but 50 per cent. These figures are no higher than those of Adriance—60 per cent, and about the same as those of Voorhees', 50 per cent; consequently, these scandalous vituperations were uncalled for.

Still this rivalry among different individuals, who wish to conduct incubators for show purposes, can have only a healthful influence, in that rivals will watch each other and attempt to find fault with the management. This will stimulate all to do their best.

I took charge of the medical management on September 1st, and was ably assisted, first by Dr. O'Neal and later by Dr. F. N. Gordon, who were the resident physicians. I made two, but more often three, visits to the incubators daily. This study then includes our experience from September 1 to November 30, 1904. I feel it would be unjust to make a complete report on the previous experiences of the other physicians as I have incomplete data, but I shall take the liberty to refer to some phases of it, as shown by the clinical records in my possession.

II.

The Building.

The incubators and nursery were in a brick fireproof building, while the dormatories for nurses and other attendants were in a separate part of the building which was constructed, as most other exposition buildings, of a wooden frame work and staff. (Fig. 1).

ROOM FOR THE INCUBATORS.

The incubators, twelve in number, stood in a narrow hall about three feet apart and separated from a large room, in which the public came and went, by a glass partition. This

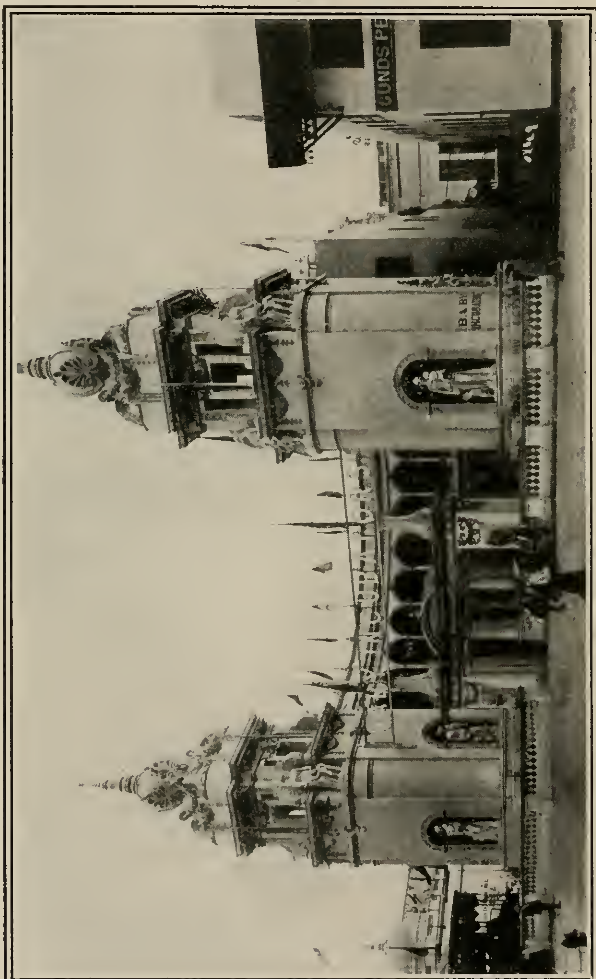


FIG. 1.—The Baby Incubator Building.

partition was built about the middle of the season on recommendation of the committee appointed by the Board of Health; previous to this the incubators were separated from the public only by an iron railing. Not only were the nurses constantly annoyed by questions from the interested visitors, but the air became surcharged at times with carbon dioxid and obnoxious effluvia from thousands of sight-seers. Hence, I deem it of the utmost importance that the room in which the incubators stand be entirely separated from the public; for the air of a room, no matter how thoroughly ventilated, in which many people congregate is unfit for young infants. Every time the door of an incubator is opened this foul air enters the baby's resting place. There is no easier way to induce the symptom complex of hospitalism. (Fig. 3).

Therefore the air in the visiting room had no connection whatever with the incubator ward, and the air supply, outlet and inlet, was entirely separate. For, to place the incubators in the public room subjects the little ones to grave dangers of intoxication and infection every time the door of the incubator is opened.

The incubator room received the air supply by a large opening in the ceiling at one end, while at the opposite end two large electric exhaust fans continually emptied the atmospheric contents. While the narrow room was, theoretically, too small, practically with this forced ventilation the air remained perfectly pure. During the cold weather the room was heated by a wood-burning stove at one end of the room, almost immediately beneath the opening for the entrance of air. An effort was made to keep the temperature of the air about 75°F., or a little higher. At this end also was a door which opened into the nursery, a corner of which was walled off for a diet kitchen and dressing room. This door remained closed most of the time so that the air from the nursery could not enter the incubator room.

THE DIET KITCHEN.

The diet kitchen and dressing room was made from a corner of the nursery, walled off by a thin partition from the nursery and ventilated by an opening in the ceiling and an outlet shaft extending from a few inches from the floor upward and constantly emptied by an electric exhaust fan. The sterilization of the bottles, heating of the thermophores, warming of the milk, etc., was done on a gas stove. The objectionable odor of gas was obviated by having a large hood with a flue running to the top of the building. This removed the hot air and combustion products. A trial was made with electric

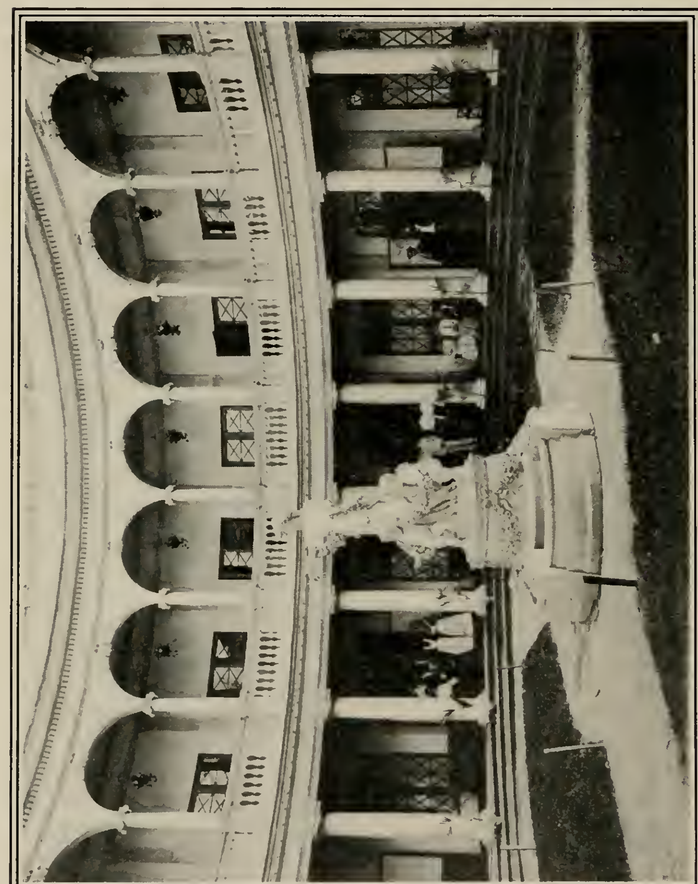


FIG. 2.—The Interior Court.

heaters but were found impracticable, since the heating of large quantities of water was too slow. The heat from the gas stove kept the diet kitchen at a temperature of 75 to 85°F. During the cold weather the temperature was kept up by a wood-burning stove which stood near the door of the diet kitchen.

For the purpose of dressing the babies, shelves were attached to each side of the kitchen. Pads of cotton covered with sterilized gauze were laid upon them. Underneath these pads were electrotherms which could be heated if for any rea-

FIG. 3. The Incubators. Photograph taken before the Glass Partition was Erected.

son a premature infant with feeble heating power had to remain in the dressing room for a short time.

Altogether the objectionable features of having the diet kitchen and dressing room together were minimized, but in all such institutions separate rooms should be provided.

THE NURSERY.

The nursery also was separated from the public by large glass windows. It was ventilated by doors and numerous windows, and heated, during part of October and November, by two wood-buring stcves. The floor was covered with linoleum which was thoroughly cleaned every day.

FIG. 4. – Showing Cylinder where Heat is Applied.

THE INCUBATORS.

The incubators used were manufactured by the Kny–Scheerer Company of New York. It is a modification of the Lion incubator. The principal improvement consists in the use of a thermophore placed in a metal drawer in the lower part of the incubator; an improvement probably adopted from the suggestion of L. Furst and others (*Berliner Klin. Woch.*, November 20, 1899). This thermophore is rectangular metal box which contains crystals of some salt (sodium acetate?) which when placed in boiling water liquify. The process of recrystalization going on slowly, the metal box radiates heat for several hours. The principal heating of the incubator is accomplished by means of a coil of metal tubing which contains water. The water pipe extends to the outside of the incubator where it enters a cylinder lined with fire-clay. Within this it a gas flame which heats the water. For most purposes an ordinary Bunsen burner is sufficient. In a few incubators a larger gas heater was employed. (Fig. 4).

The products of combustion from these heaters were carried off by means of a tin pipe running from the top of the heating cylinder through the ceiling of the incubator room. The incubator is made entirely of nickel plated iron, glass and tin. The two sides have large glass windows and the double doors in front are made entirely of glass except a narrow framework. The size of the incubator chamber is—length, 56 cm; breadth, 46 cm.; heighth, 46 cm. It might with benefit be made a little wider, for a larger chamber would be preferable on account of the greater ease in attending to the baby, and the heating capacity would be more stable. Then, again, the flow of the ventilation would need be less swift.

About 10 cm. above the water coil is a platform made of plated steel wire on which the infant lies, but separated from it by a pad of cotton covered with rubber cloth over which fresh sterilized gauze was placed daily.

The air enters the incubator below the water coil and strikes a flange within the coil which spreads the air current. It rises on all sides of the infant and where the pad is not impervious may pass through the frame. On the top of the chamber is a circular opening for the egress of air. This has a pipe attached in the upper end of which is a small metal fan (anemometer) which by the rapidity of rotation indicates the velocity of outflow. A thermometer is attached on a level of the infant to the side of the incubator walls. A hygrometer is also one of the valuable instruments in each incubator.

THE AIR SUPPLY.

The air supply was received through a large tin pipe (diameter, 24 cm.) which extended from the roof of the building through the ceiling and emptied into a similar pipe which ran horizontally the whole length of the incubator room. From this horizontal pipe smaller tubes (diameter, 7 cm.) carried the air to the incubators. The air was forced through these pipes by an electric fan at the opening of the large pipe on the roof. The opening of the pipe was made vertical to preclude water entering the pipe and was covered by a double layer of gauze in order to keep out any large particles which might enter. Immediately below the fan an electric resistance coil heated the air during the cold weather.

FIG. 5.—Showing Metal Box attached to the side of the Incubator into which the Air enters.

The air was again filtered immediately on entering the incubator in a little metal box attached to the side of the incubator. In spreading out under the bedding it passed slowly over the hot water coil and was heated before rising to pass around the baby. The moisture required was obtained principally from an open vessel placed in the same drawer with the thermophore, An additional moisture was received when necessary from a beaker glass in the small side box. (Fig. 5). An opening which could be closed is found immediately below the thermophore.

ADDITIONAL HEATERS.

As mentioned, additional heaters were provided in the shape of electrotherms. These were pads covered with rubber cloth in the center of which an electric resistance coil gave heat. During the time of dressing very young infants they were laid upon these electrotherms and thus received an additional amount of heat. Sick infants who have to be removed from the incubator can be placed on the electric heaters.

THE FILTRATION OF THE AIR.

As mentioned, at the opening of the supply pipe, a double thickness of ordinary gauze was stretched and this was changed at intervals. The principal filtration, however, was done in the small metal box at the side of the incubator which had a lid and through which the air passed before it entered the incubator (Fig. 5). A wad of cotton in the pipe or even in the box was uncertain for if well packed it seriously interfered with the ingress of air. I finally decided on a thin layer of cotton which, between two layers of gauze, was placed over the opening of the box that led the air into the incubator. This gauze filter was held in place by strips of adhesive plaster and this was changed every other day; on very warm days when the air supply was poor this filter had to be removed during the heat of the day.

A very thorough filtration of the air is impossible without using considerable force back of the air current and we can not depend on ordinary filtration to remove bacteria, hence it is the more important that the source of the air be from the outside.

THE REGULATION OF HEAT.

The heat supply was controlled by a thermoregulator in the upper rear corner of the incubator chamber. A hollow tin disk filled with ether pressed upon an iron pin which passed through a soft rubber disk into the opening which admitted the gas (Fig. 6). As the incubator became warmer the disk expanded and forced the point of the pin into the opening and thus shut off the gas supply. Theoretically it seemed a very

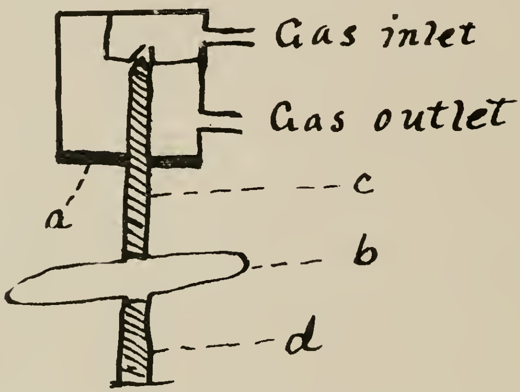


FIG. 6.—Diagram illustrating the mechanism of the Thermoregulator. *a*, soft rubber disk; *b*, hollow disk filled with ether, the expansion of which pushes upward the pin *c*, which closes the opening in the gas inlet and shuts off the gas; *d*, is a screw, by turning which the disk and its attached pin may be raised or lowered, thus making the regulator more or less sensitive to the heat.

simple and ideal thermostat, but practically the stability of the whole heating apparatus had much to be desired. We were not able to dispense with constant intelligent supervision of the heating apparatus, although the thermoregulators could be depended upon to turn down the gas flame when the incubators became too warm. The causes which forced us to supervise the heating and air supply will be discussed below.

THE PRACTICAL DIFFICULTIES OF THE AIR SUPPLY.

The air supply, although forced downward by a fan, was by no means constant. There was a marked variation in the velocity with which it flowed through the incubators. On cool days, when the ratio of the atmospheric temperature and the incubator was 1 to 2 or 1 to 3, the anemometers rotated at a furious rate, but when the ratio rose to 3 to 4 or even 4 to 4, the circulation became poor. The hottest incubator had the most rapid circulation. When the outside air became warmer than the incubator the fan did not seem to be sufficiently powerful.

These difficulties were met in various ways. A too rapid circulation of air was moderated by increasing the thickness of the filtering gauze by a layer of cotton; sometimes the supply pipe was plugged in addition with a loose wad of absorbent cotton. When the air circulated too freely the difficulty of maintaining a constant high temperature was incurred; hence, as the external temperature fell near or below 40° some resistance to the intake of air was necessary in certain incubators.

When the outside air was very warm and the circulation of air correspondingly poor, all internal resistance to the flow of air had to be removed. On very warm days even a double layer of ordinary gauze could not be used for filtration purposes. Filtration of the air in the incubators had to be entirely discontinued on certain days, and the air supply of incubators not in use was shut off by tightly plugging the supply pipe; in this way the air supply in the incubators in use was correspondingly enlarged and the little fans were kept whirling at a rapid rate. The rapidity of the inflow was indicated by these fans, and our rule was that the fans should rotate just sufficiently rapid so that the individual blades of the fans were barely discerned and not so rapid as to make it appear as a single disk.

Another difficulty arose from the fact that the electricity for some reason had to be shut off during the night for a short time, but with the exception of a few very warm nights the circulation was sufficient. This defect of having the power shut off at night was finally remedied.

Theoretically it seems proper to get the air supply from the roof, but as this makes a long shaft which has great "drawing" power difficulties will arise. It takes a tremendous power to force hot air downward, and when the air is cold it is forced downward by its own weight, displacing the hot air. The long vertical pipe, therefore, is very objectionable. It is better to obtain the air from the outside at a level or very little above the top of the incubator; in this way there will be less trouble with the velocity of air through the supply pipes.

DIFFICULTIES IN HEAT REGULATION.

The importance of having the incubators always at the temperature desired or at least at a constant temperature is self-evident, but even with the elaborate mechanism employed the incubators required intelligent supervision. Our nurses could not go to sleep for three hours and be awakened by the watchman as they seemed to have done in London.

In the first place the gas pressure in the supply pipes was very inconstant, so that on different days or different periods in the day the flames in the Bunsen burner were different in size. Especially in the evening when the many restaurants and other places using gas for heating and other purposes had all their burners in use, the gas pressure became so low that the flames with the gas turned on to its fullest extent were too small to keep the water in the heating coil near the boiling point, which would often be necessary in the evening. Many attempts were made to rectify this deficiency in the gas pressure. The Concession Company even purchased an expensive gas pump, which proved unsuccessful because it failed to work at times and, therefore, had to be cast aside. Fortunately the gas company in the last two months in some way increased the general gas pressure which remedied the defect during our coldest weather (October and November). Again, when the air outside was near the freezing point the air would enter too rapidly and cool the incubator; this was remedied by increasing the filtration cotton. When the gas flames were too small alcohol lamps had to be used to raise the temperature of the water in the heating coil; or water was boiled on the gas stove and the boiling water poured into the coil. Most valuable, however, in overcoming these deficiencies of heat was the thermophore. Whenever an incubator began to go down in temperature in spite of the gas turned on full, a thermophore, several of which were always ready in boiling water, was placed in the compartment beneath the baby. This is an admirable way in making up the deficiencies in heat.

But we had trouble in another way. In hot weather the incubators would get too hot. This was no fault of the thermoregulator but must be charged to the extreme fluctuations in temperature of the outside air. In a climate like St. Louis where the terrestial temperature may vary 20° in a few hours, and the air is taken from the outside, no thermoregulator ever invented can be adequate. I need give only one example: The outside temperature one morning was 70°F. At noon the thermometer registered 95° in the shade. In the morning heat had to be applied to the incubators, and about 11 o'clock the thermoregulators turned the gas down, and it was turned entirely off by the nurses. At 12 o'clock noon, in spite of the fact that there had been no artificial heat for an hour, the temperature in the incubators was exceeding the prescribed upper limit, and the hot water was taken out of the coils; but the temperature still went up and iced water had to be poured into the heating coils of some of the incubators. To prescribe a temperature of 84° and to have the air streaming in at 95° gives the opportunity of making a refrigerator out of an incubator. This opportunity arose several times last summer.

It will be seen that the difficulties were such as to necessitate a constant supervision, and I feel that no sort of a machine can replace intelligent watchfulness when it comes to rearing premature infants. This supervision is furthermore necessary because the incubator's temperature was often changed according to the needs of the infant.

There can be no doubt that the principal cause of the variation in heat is the inflow of air from the outside. In a changeable climate it seems best not to obtain the air directly from the outside, but it should first pass through a large chamber in which its abnormal condition is modified.

THE HUMIDITY.

We tried to maintain the humidity at about 60 per cent, but the variations were extreme in spite of care. In warm weather with rain outside it often rose to 90 per cent; when the air was dry and cold outside it would fall as low as 10 per cent. The pan of water in the drawer is situated below the water coil and therefore its evaporation is too slow. By placing wet cotton or twisted gauze in a beaker in the side box an additional moisture could be obtained, but all this was insufficient in cold weather.

The best way to raise the humidity rapidly is to pour hot water in the evaporating pan, but as soon as the water cooled the humidity dropped again.

The trouble with the humidity again depended on the fact that the air was received from the outside.

Considerable relief was obtained when the electric coil in the large inlet pipe was hot and moistened cotton was put in the small air box at the side of the incubator. I do not see how an incubator could be constructed to remedy this entirely.

HOSPITALISM.

In a restricted sense, the term hospitalism is applied to a species of intoxication found in infant asylums and characterized by fatal malnutrition, atrophy and death. In another sense it has been used to designate the poor resisting power of such infants to all infectious processes. In a wider sense it signifies the aggregate of etiological factors which cause such an enormous death-rate in all infant asylums and hospitals. It is in this wider sense that the term is here used.

It is well known that the death-rate in foundling asylums ranges from 35 to 80 per cent, enormously exceeding the mortality of infants in homes. The causes which lead to this are various but, as a rule, the high death-rate is principally attributable to the introduction of some pathogenic organism and its dissemination among the infants. Now, the same factors which cause this morbidity and mortality in foundling asylums are very prone to be operative in an incubator institute. Hence, to whatever difficulties may be encountered in rearing the babies on account of their premature birth, are added the great dangers of keeping many babies together and nursed by the same individuals.

The death-rate, therefore, in such an institution will always be much higher than the death-rate of such babies in private practice. So that I am not at all convinced that such institutions are a blessing. There are death-dealing causes connected with such an institution that are extremely difficult to overcome.

It was hospitalism that made the mortality so high before I took charge, and it was operative for some time even after radical changes were made in the management. Its inception began with a very sick baby which was obtained from a foundling home. Following its arrival the mortality rapidly increased. Some blunder in the milk supply added another infection and enteritis and marasmus carried the infants off. It is rather significant that the symptom of hospitalism arose after a baby was obtained from a foundling home.

The prevention of hospitalism then is the first duty of an incubator institute and it takes money, great care and well-trained nursing to accomplish this.

In the first place no infant should be admitted that is several days old and shows some gastrointestinal or any other infection. I consider the admission of a sick baby from a foundling home several days old as the greatest mistake of the former management.

In the second place, only mother's milk should be fed to incubator babies, and even "graduates" must obtain a mixed feeding. At least mother's milk confers an immunity to infection on young babies which can not be supplied by any modification of cows' milk.

The most rigid asepsis must be practiced in regard to everything that enters the mouth of the infant. Sterilization and cleanliness are absolutely necessary. No nurse who takes care of an infected baby, however mild it seems, should at the same time care for a well baby.

A recent valuable contribution on the subject of the arrangement of an infant hospital is by Klautsch.—*Archiv Kinderheilkunde*, Vol. 39.

Disinfection of the Incubators.

The frequent disinfection of the incubators has been especially insisted upon by Budin. The Kny-Scheerer incubator is well made for thorough disinfection. It can be washed and an antiseptic applied; as to the antiseptic to be used little is found in literature. After Bertin insisted that incubators may serve as a source of infection and must be so constructed in order that they may be disinfected, Lion fulfilled the requirements, and an incubator was constructed that could be sterilized by dry heat or steam; but this can not be done very often unless special provisions for this has been made. Hence, I had to select antiseptics. I rejected formaldehyd for the simple reason that the irritating fumes which emanate from the disinfected surfaces might prove injurious to the inmate. While its occasional application to an incubator in which the infected infant happens to be placed, may be recommended, as a disinfectant for daily use it has serious objections. For a different reason corrosive sublimate could not be used, since its corrosive effect on nickel plate and iron is too well known. On the other hand, carbolic acid or tricresol have not these disadvantages, but as some of these antiseptics must adhere to the crevices and be gradually evaporated it might prove deleterious. Most of the ordinary antiseptics proving objectionable, alcohol in a strength of 70 per cent was chosen as the safest disinfectant; this seemed ideal, especially as Harrington's recent experiments were fresh in mind. Each day everything was removed from the incubators and the inside given a thorough wiping with a moist cloth. This was followed every other day by a careful sponging of all metallic and glass surfaces with 70 per cent alcohol; a few minute's airing sufficed to get rid of the alcoholic vapor. No infection was traced to the incubators during my service.

As to the attempt of disinfecting the air, here and there hinted at in literature, it is only mentioned to be pronounced ridiculous. The use of sulphuric acid to dry and cleanse the incoming air also is useless and not devoid of danger.

THE PREVENTION OF INFECTION.

The most iron rules must be laid down to prevent microbic infection. Each infant must have its own thermometer, bottle and clothing. For various reasons this rule could not always be followed; but the thermometers were kept in a sublimate solution and rinced immediately before using. The bottles and nipples were thoroughly boiled between each feeding and an additional supply constantly kept on hand in a solution of boric acid, and were washed in sterile water before using. No diaper was used a second time. For the same reason it is dangerous to apply several babies in succession to the same wet nurse; the disinfection of the nipple is by no means easy. Thrush and mild gastrointestinal infection can arise in this way. The wet-nurses' nipples were disinfected with dilute alcohol or boric acid solution.

The most dangerous and, as it proved, the most certain means of conveying infection is the nurse's finger; without conscientious, trained nurses, accidents will happen. With each baby there is a possibility of introducing some new pathogenic micro-organism, and sometimes even before it is recognized another baby may be infected from this. Every newcomer must be carefully watched for several days as to the appearance of infected eyes, mouth or umbilicus.

By our means an infection was practically excluded. One baby developed furuncles; the same trouble appeared in others, and when I took charge, by rigid isolation of all clothing a further spread was checked and healing took place under treatment. The mouth was the most common seat of infection and our attention must be especially laid upon this port of entry.

In all such institutions the well must in every way be entirely separated from the sick and provisions for this separation must be supplied.

Clothing.

There seems no good reason why a premature infants should not be clad as other infants; they should be warmly clad even in an incubator. It is a mistake to depend entirely on superheated air to prevent the loss of heat. The inhalation of such hot air neither stimulates respiration or metabolism and favors infection; hence, we should depend in a great measure on good clothing to lessen heat radiation from the body. Too much clothing in the very feeble necessitates too much manipulation, and still we adhered to the old custom of wrapping them in cotton, but this was adhered to for a short time only (one or two weeks), when the ordinary clothing of infants was placed upon them.

The subjoined halftone (Fig. 7) illustrates the articles of clothing for a premature infant: A soft woolen shirt, a diaper, flannel band, cotton and a covering of gauze in which the body is wrapped. Eross was probably correct in attributing little warmth to these envelops of cotton—loose cotton is not warm. A soft light woolen blanket would really seem preferable in private practice, or lamb's wool should be used instead of cotton.

FIG 7.—The first clothes of a Premature Infant, consisting of a flannel shirt, flannel band, diaper of cotton and gauze, and cotton and gauze envelop.

We recall one instance where a father brought a premature infant safely to the incubators which had been wrapped in absorbent cotton and then enveloped in several thicknesses of a blanket. It would seem safer to substitute some thick woolen goods for the gauze to be used over the cotton. The diaper in all cases consisted of a layer of absorbent cotton and sterilized gauze (Fig. 8). Every morning and evening enough of these diapers were made for half a day. As soon as they were wet or soiled they were discarded and burned. When it is known that we used about $5.00 worth of sterilized gauze daily just to make napkins it will be seen what expense is found in such an institution. In no case was it permissible to change the diaper of one baby for that of another when slightly wet and then dried.

Fig. 8.—The aseptic diaper.

Long knit socks or stockings were put on all infants which were pinned to the diaper in the usual way.

Light.

Ballentine (*British Medical Journal*, May 17, 1902), Rotch and others declare that premature babies should be kept in darkness. On the contrary, our babies were kept constantly in the light; for, as mentioned, light was necessary to show the incubators and at night it was necessary to permit of their care. While the light was much subdued after 11 p.m. the infants were never in darkness. I was unable to discover any harmful effect of this light.

EXERCISE.

Even the youngest infants should have their arms out so that it can move them; this permits a little motion and assists the respiration and circulation.

BATHING.

The question of bathing like so many questions concerning premature infants is considered from a different standpoint by each author. Some interdict bathing for the first week or ten days, while others recommend its daily use. Rotch says that the premature infant should not be bathed but should be rapidly covered with warm sweet oil and wrapped up in absorbent cotton; this is changed only every forty-eight hours, when the infant is again covered with oil. Voorhees gives very similar directions. Monti recommends that premature infants be bathed at once after birth in water at a temperature of 29 to 30°R. (about 98°F.). He furthermore believes that sponging the baby once or twice daily is very advantageous as a circulatory stimulant. Parts of the infant are successively exposed and washed with sterilized cotton dipped in warm water; a mild soap can be used. This stimulates the function of the skin and prevents infection. Blair also finds daily repeated baths helpful to stimulate the circulation and the skin. Budin is an ardent advocate of daily bathing in warm water, but he finds it especially of service in those infants whose temperature remains below normal. Finkelstein has likewise corroborated the value of bathing.

For the purpose of increasing the rectal temperature Budin advises two procedures: Where a rapid elevation of the temperature is desired the infant is plunged into a bath at a temperature of 37°C. and remains there until its temperature is normal. However, he finds that if the infant is placed in the bath at a temperature of 1° above the infant's rectal temperature and then gradually raised during fifteen or twenty minutes until it reaches 37°C. the infant's rectal temperature will remain normal much longer than it will when raised rapidly by the former method. The temperature of the water is elevated by the addition of warm water which should be poured into a funnel to which a tube is attached which reaches below the surface of the water in the bath tub. If the water is gently poured into the tub the warmer water has a tendency to float on top and does not mix with the cooler water.

We followed Rotch's directions in the main. The infant was rubbed with oil and placed at once in the incubator. The baby was not bathed for several days, when a daily sponge was begun ; this was done with sterilized cotton, one part after another being exposed; after this it was given an oil rub. In several instances a warm bath was given when the infant's temperature fell below 96°F. For rapid elevation of the rectal temperature the warm bath is the ideal method and should always be resorted to.

I shall have to obtain more evidence than I possess at present to believe that this frequent bathing is necessary. Of course, when the temperature of the incubator is kept too high, as Blair's figures evidently are, or if the incubator temperature is kept too low as Budin evidently does, at least for infants weighing less than 1200 grams, these baths must be absolutely necessary; in the one case to cool the infant and in the other case to heat the infant. But if the infant's rectal temperature is maintained between 97 and 98°F., bathing will be found unnecessary. A daily sponge and afterward a good rub with oil will usually be found sufficient. If the baby's temperature is below 96.5° or above 100°F., the bath should be given.

There is, however, one possible advantage of frequent bathing during the first few days of life and that is that the skin has an opportunity to imbibe water, for usually an insufficient supply of water is given during the first few days. Still, as it will be found easier to give the same amount of water by the stomach or rectum this advantage is not worth considering.

The Oil Rub.

Many authors do not mention the oil rub. Some seem to think it unnecessary, others believe it is a mistake to use it, still others recommend it. It is difficult to conceive any serious objections to it. As massage is so helpful it is really necessary to have some emollient for massage on the dry tender skin. Furthermore it protects the sensitive skin somewhat from irritation, and as a means of cleansing it should by no means be dispised. Then there are two specific reasons which, therapeutically at least, should be given due consideration :

First, the oiled skin prevents a too rapid heat loss, the oil acting as a non-conductor, and, finally, the oil prevents to some extent the evaporation of water, which in a warm incubator should always receive attention. In fact, the rapid loss in water is one of the most serious menaces to the life of the infant.

Just what oil should be used is somewhat indefinite. Probably any non-irritating oil will answer. We used olive oil, Rotch recommends sweet oil. An animal fat would seem to be preferable, so that fresh lard or fresh butter might be used; the tendency of the latter to become rancid will, no doubt, be a serious objection. Cocoanut butter should also be permissible. The odor of cod-liver oil makes it objectionable. The oil should be sterilized by heating for several minutes and placed in sterilized bottles; it should be applied with sterilized cotton or a thoroughly disinfected hand.

EXERCISE–MASSAGE.

All authorities agree that massage and passive movements are beneficial. The infant's limbs should be free so that movements are possible. Complete swaddling, therefore, is unwise. It was our custom to massage the infant every morning after the bath. The loose clothing permitted active movement. A good cry several times a day is helpful in that it removes atelectasis and increases oxygenation.

III.

THE NURSES.

It is unnecessary to discuss the propriety of having only well-trained nurses to take care of premature infants. When the danger of sepsis to these little ones is considered, especially in an incubator institution, only those trained in the principles of medical and surgical asepsis should be permitted to serve. The wet-nurses should have nothing to do with the incubators or their inmates.

As to the number of nurses necessary, the exigencies of different periods must decide. We had fourteen well-trained nurses. They worked in three shifts, each eight hours long; hence, there were four or five nurses on duty all the time. These nurses cared for twelve to fifteen babies, nearly half of which were "graduates," that is, babies out of the incubators. It will be seen that each nurse had under her care from three to five babies. As a rule, there was such a division of the work that the nurse having the care of a very delicate infant, which demanded much attention, at the same time supplied the needs of older babies who needed less care.

It is a recognized rule in institutional nursing that the nurses who feed the babies should not handle the napkins or bathe the babies. This rule we did not follow, since rigid asepsis rendered it unnecessary and it was found more satisfactory that individual nurses look after all the wants of the infant.

The Transportation of the Infant.

The extreme susceptibility of the premature infant to atmospheric changes in temperature make the problem of heat supply one of the most important in their care. The protection of the newly-born from the loss of heat is so generally recognized that the family physician or midwife usually makes some provision for its prevention. It is a mistake to assume that these babies always die from temperature reduction In a few instances, when our physician arrived, the premature infant had been kept so warm that its temperature a short time after birth was over 100°.

Recognizing that the prevention of the initial heat-loss is most important the management early made provisions to minimize this danger. An ambulance and driver were provided which could be called upon day or night. A receptacle, in the nature of a small portable incubator, was utilized to keep the baby warm. The house physician and one of the nurses were usually dispatched to get the infant when a telephone message was received. Occasionally, due to a variety of causes, the infant could not be reached for three or four hours, but most commonly our physician, nurse and ambulance reached the premature infant in less than two hours, nevertheless, the number of infants for whom we were asked to send and who had expired on arrival of the ambulance was very large. It is true that after it became generally known that the Incubator Institute was caring for all premature babies free of charge, physicians, midwives and parents would send for the baby ambulance for miscarriages of $4^1/_2$ to 6 months. Anything that moved was considered a sufficient subject to send to the incubators. But we gladly made an effort even in the most hopeless cases. One infant died on the way, many others which were in a hopeless prematurity arrived in fair condition to die a few hours later. During the three months of my service we received four infants each weighing less than 900 grams in very good condition, but who died shortly afterward.

As soon as the infant was reached, the rectal temperature was taken and it was quickly examined as to evidence of dis ease. It was then wrapped in cotton wool and placed into the portable incubator, a description of which follows, for which I am indebted to Dr. Gordon:

PORTABLE INCUBATOR.

"This was designed for use in the ambulance and was made of enameled tin with a glass top. It is 12 inches wide, 18 long and 16 inches high. At the bottom is a sliding drawer which is pulled out by means of a handle. This is the bed and is composed of a strong wire netting held in a frame; a thick layer of cotton is put next to the wire netting, next a layer of several hot water bottles, next a still thicker layer of absorbent cotton upon which the baby, well rolled in cotton, lies. A thermometer lies beside the child. About 4 inches of the top is composed of the enameled tin through which are two holes 1 inch in diameter for the exit of air. The rest of the top is composed of a sliding glass door with a handle. The inlet of air was allowed for by opening the bottom drawer a trifle. Around the entire incubator goes an ordinary trunk strap which serves the double purpose of a handle and to hold the drawer and top in place.

In the ambulance the incubator rested not on the floor but on a shelf suspended by springs and straps from the center of the roof of the ambulance. Near the front end of this shelf was an opening 3 inches in diameter; the open end of the sliding drawer was put just over this hole in the shelf, so that there could be a free ingress of air. On a trip the temperature of the incubator was maintained, approximately at 92 to 94°."

The distance which the babies had to be carried was important. A long ride always had a pernicious influence, even when carried in our portable incubator. For example, Henry, gestation $7^1/_2$ months, weight 1733 grams, was brought six miles at night over very rough, unpaved streets and on arrival exhibited multitudinous hemorrhages from the skin and mucous membrane.

Quite a large number of premature infants came from places outside of St. Louis. Many times telegrams were received that Mr. —— had started with an infant, asking us to meet him at the station, and although the ambulance never failed to be at the station only once out of perhaps six or eight such calls did the baby arrive. Most commonly the infant died after a short time and the parent would stop at the first station and return home.

A few infants were brought to the incubator in fair condition, wrapped in blankets, and during the warm weather such a method is practicable.

We found it inexpedient to encourage physicians outside of St. Louis to send babies to the institute.

The Rectal Temperature on Arrival.

As soon as the infant arrived its rectal temperature was taken and if this was below 96.5° a warm bath at 98° was given to restore the loss of heat, otherwise it was rubbed with warm oil, dressed and placed in the incubator.

Budin has laid great stress on the prevention of the initial loss of heat, and claims that of infants under 1500 grams with a temperature less than 32°C., 98 per cent die. Most of our infants arrived in good condition as regards the body temperature. The accompanying Table I, shows this.

It will be seen that three infants arrived with a temperature above normal; in all three instances the cause of this must have been the overheating of the portable incubator, although one of these had a temperature above normal when taken from home.

Rectal Temperature on Admission.

Name	Weight Grams.	Rectal Temp.	Remarks.
Dederick	852	93.4	Died in one day.
Edward	1932	102.6	Portable Incubator too warm.
Walter	1100	100	Portable Incubator too warm.
Marion	3182	95.4	Asphyxia neonatorum; died in a few hours.
Nickerson	724	88	Brought by father long distance.
Charles	909	95	
Henry	1733	9766	
Ella	810	95.2	Died in a few hours.
St. Louis	1385	98.4	
J. Henry	1790	101	
Galvin	2456	96.6	
Pearl	1769	97	
Omega	2158	97.6	
Margaret	1783	96.4	

TABLE I.

From all this I must conclude that the portable incubator should have a temperature of 90 to 94° for infants under 1800 grams, and 86 to 90° for infants weighing more than this. Of course, the temperature of the baby when first seen, the thickness of the clothing of the infant and the distance through which it is to be conveyed must all be considered.

The Temperature of the Incubator.

In spite of much that has been written on this subject there is no unanimity as to the temperature at which the incubator should be kept. Heubner, in his recent text-book states that it has been found that a temperature of 30°C. (86°F.) is the proper temperature for premature infants, but such a general statement is insufficient for practical guidance. No doubt some of the differences in opinion may be attributed to the experience of physicians with infants of different ages. Probably, too, the variable amount of clothing used may partially account for these differences.

Finkelstein (*Ther. d. Gegen.*, 1900) recommends 95° for very feeble and puny infants, in ordinary cases he uses 90° as the standard. This is much higher than some authorities. Voorhees claims that 86 to 92° is about correct. Rotch placed one infant, gestation 30 weeks, weight 2850 grams in the incubator at 94° and another weighing 2040 grams in the incubator at 90°.

All these figures, however, are outclassed by Blair (*St. Louis Medical Review*, May 21, 1904) who often starts with a temperature of 100°. He recommends a temperature of 93 to 97° for infants of 6 or 7 months' gestation. For 8 months' gestation he gives 88 to 95° as the proper temperature. Even for 9th month he uses as high 90°. These figures are certainly higher than those given by most authorities and contrast strikingly with the temperature recommended by Budin and Rothschild.

Before stating the temperature of the incubator approved by Budin, it is well to point out that Monti erroneously declares that Budin keeps all his cases in the incubator at about 35°C. (*Kinderheilkunde*, Vol. III, page 635). This error induced me to try a higher temperature in one or two cases with results not encouraging.

Professor Budin has probably had more experience than any living authority and his results are so superior to others reported that his judgment in regard to any point regarding premature infants must receive the most respectful attention.

Budin (*Le Nourrisson*, 1900, page 18), in answer to the question concerning the proper temperature for the incubator, recites his experience: It had been the custom at the Charite to keep the incubators at a temperature of 30°C. (86°F.), but he observed that the babies were very restless, cried and perspired easily; he concluded that the temperature was too high. Further experience only corroborated this surmise and he adopted the rule to keep the incubators at a temperature of 25 to 26°C. (77 to 79°F.). This was used in nearly every case except in a very few instances when the infant weighed less than 1000 grams. This is so much lower than what is generally given as the proper temperature that one might readily believe it to be an error if it were not repeated. A similar statement is found in the article by Perrett (*Rev. d'Hygiene et de Med. Infant*, Vol. II, No. 2, 1903, page 123) which is incorporated in the recent treatise by Rothschild.

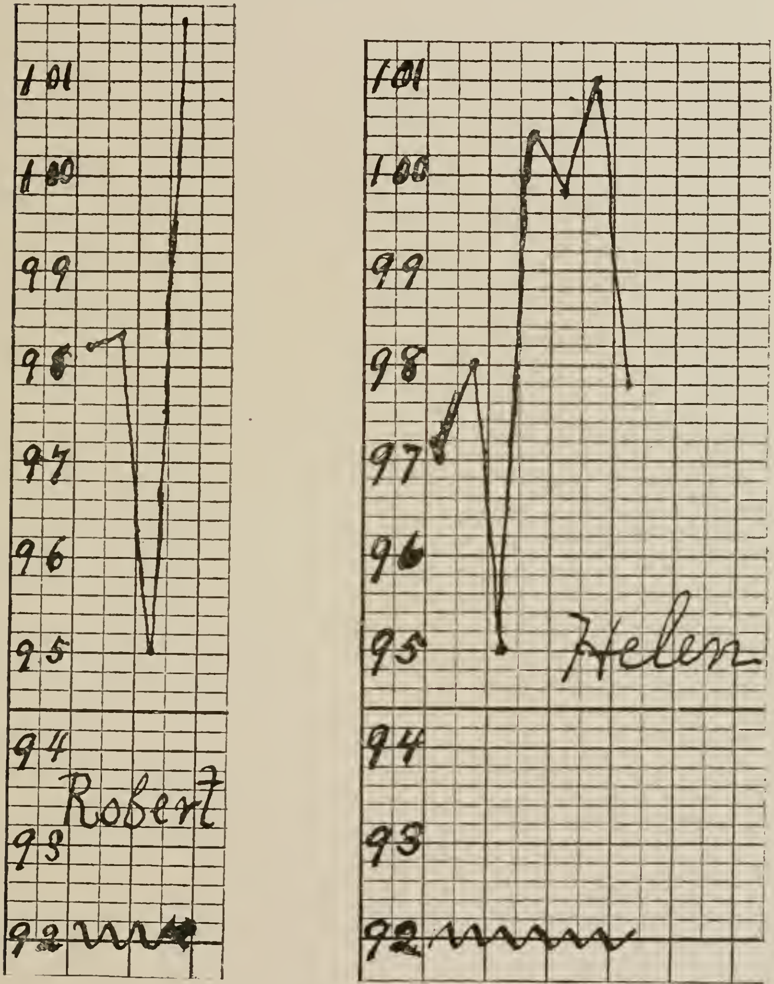
It is obvious that the extremes—77° of Budin and 95° by Blair, show that this subject needs further investigation, or else we will have to conclude that the premature infant can survive a very wide range of atmospheric temperature. Now, what is the proper temperature?

The answer to this question is by no means as easy as would seem at first sight. It would be almost as difficult to give the proper temperature for the child or adult, and yet it is necessary to reach some sort of conclusion from the conflicting data.

Without attempting to draw any definite figures from the experience of the different authors, it is safe to assume that, partially at least, their different views are based on the practical results obtained in treating infants of different weight and age. Then, too, the bath treatment as practiced by Budin materially alters the danger of heat loss even with the incubator at the low temperature. But to use a uniform temperature of 77 to 79° for all cases, as he recommends, scarcely seems rational, as the metabolic activity in premature infants varies.

In the earlier months of this institution my predecessors used a much higher temperature for the incubators. Probably their practice was based on the experience of Rotch and the recommendations of Blair, whose paper had just appeared.

We maintained a lower temperature of the incubators during my service and it may be instructive to study the results more carefully. It is an undisputed axiom that the incubator should



CHARTS 1 and 2.

be kept no higher than what is necessary for the individual infant. The heat in the incubator must be adjusted to the needs of the individual.

But how do we ascertain the needs of the infant; or, in other words, what are the criteria on which to base the temperature adjustment?

The final test, of course, is the number of recoveries, but the immediate indications are—1, the rectal temperature; 2, the warmth of the extremities; 3, cyanosis; 4, loss in weight; 5, restlessness, and 6, perspiration.

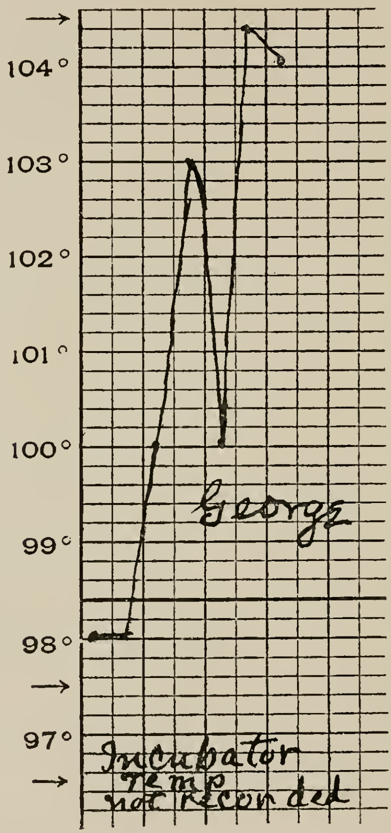


CHART 3.

1. What is the proper rectal temperature? Several authorities (Monti, Budin) expect a subnormal temperature for a few days. Finkelstein warns us that overheating harms the babies and cites some experience. The experience of Rotch and Adriance also reveals the fact that the rectal temperature may readily be forced above normal by an overheated incubator and to the detriment of the infant.

Contrary to this, Blair states that he never permits the rectal temperature of a premature infant to fall below 99.5°, and declares that the rectal temperature may be safely maintained at 100 to 102°.

I.—INFANTS WEIGHING LESS THAN 1000 GRAMS.

First Series.

Name Gest. Weeks.	Weight Grams.	Age Days.	Incubator Temp.	Extremes Rectal Temp.	Remarks.
Mary 26	900	1	98	102 -104	Lived 20 hours.
Helen 26	1000	1	92	97 - 98	
		2	92	95 -100.4	Incubator
		3	92	99.8-101	below 92
		4		97.8	Died.
Esther 22	530	1	98	102.4-104	
		2	95	99.6-100	
		3	92	97.3- 98	
		4		97	Lived 9 days.
Ernest 30	900	1	90	103.4	Lived 1 day. Infected?
Doris 26	1000		92	97.8-100.4	
			92	98.4- 99	Died.

TABLE 2.

Second Series.

Name Gest. Weeks.	Weight Grams.	Age Days.	Incubator Temp.	Extremes Rectal Temp.	Remarks.
Robert 26	1000	1	90-92	98.2- 98.3	
		2	90-92	95 -101.6	Died.
Charles 26	909	1	90	95	
		2	93	94. -.96.4	
		3	93	94.2- 97	Died.
Ella 20	810	1	93	96	Died.
Dederick 24	852	1	92	95 - 95.4	Died.

TABLE 3.

I tried to keep the rectal temperature between 97 and 99°. A temperature of over 100° or below 96.5° indicated that something was wrong. The temperature of the incubator at first was, as seen from the subjoined tables, from 88 to 92°. I repeat that I had to use a much higher temperature than I desired because the infants were clad very lightly.

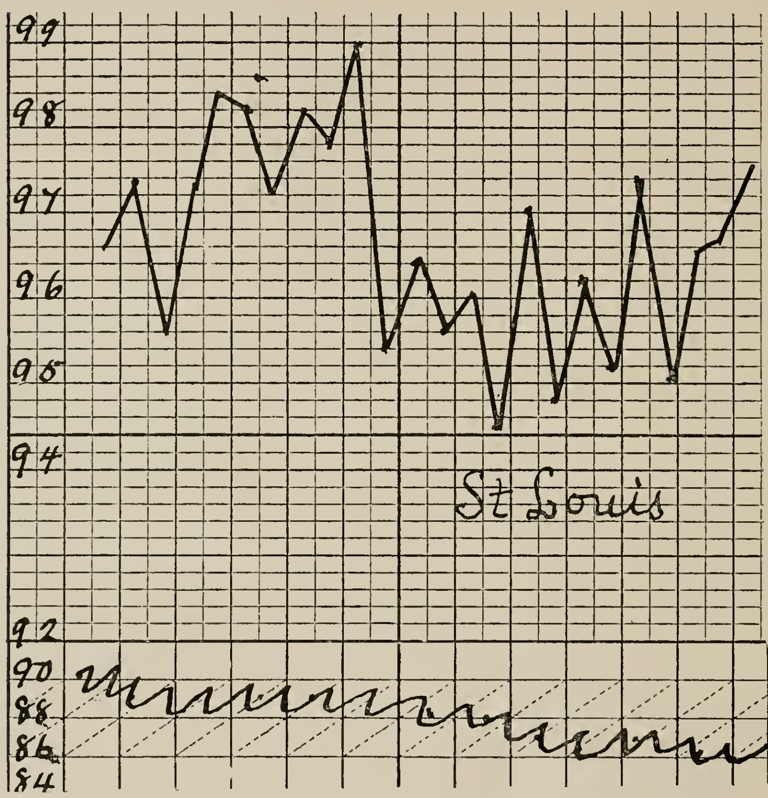


CHART 4.

For the purpose of proper study I have divided the infants into two series—the first series being under the medical management of my predecessor (May to August) the second series were under my own direction (September—December). The first study is what effect has the temperature of the incubator on the rectal temperature (Tables 2 and 7).

Infants weighing between 1000 and 1500 grams.

		First Series.		
Name Gest. Weeks.	Weight Grams.	Age Days.	Extremes Rectal Temp.	Remarks.
Warden 28	1360	1	100 -103	
		2	98.6-102	
		3	97.6- 99	Lived,
		4	98.4-101	21 days.
George 28	1300	1	98 -	
		2	100 -103	
		3	100 -104.4	Lived
		4	104	5 days.
Louise	1360	1	101.4	
		2	102 -103	Died.
Leonore	1340	1	97 - 98.6	
		2	98	
		3	98	Recovered.
		4	97 -100	

Incubator Temperature not recorded.

TABLE 4.

Second Series.

Name Gest. Weeks.	Weight Grams.	Age Days.	Incubator Temp.	Extremes Rectal Temp.	Remarks.
St. Louis 28	1385	1	90	96.6-	Arrived-
		2	89	97.4-95.6	rectal temp.
		3	89	97.3-98.4	98.4
		4	89	98.2-97	
		5	88	98.2-97.8	
		6	88	99 -95.4	
		7	88	96.4-95.4	
		8	88	96 -94.4	
		9	86	97. -94.8	Indigestion.
		10	86	96.2-95	
		11	86	97.4-95	Baby final-
		12	86	96.5-96.5	ly graduated.
		13	86	97.6-96.4	
		14	86	95.2-96.8	
Walter	1100	1	88	98.2	Arrived-
		2	90	96 -95.6	rectal temp
		3	92	94.6-99	100.
					Lived 3 days.

TABLE 5.

It will be seen that the higher incubator temperatures of the first series usually resulted in fever in the infant. In the second series the temperatures were kept more normal. In both series all the babies died;[1] the causes of death will be discussed later. In the first series the baby's temperature averaged about 5° above the surrounding temperature although there were, no doubt, feeble efforts on the part of the infant to keep its own normal temperature. (Tables 2 and 3).

Infants weighing between 1500 and 2000 grams.

First Series.					
Name Gest. Weeks.	Weight Grams.	Age Days.	Incubator Temp.	Extremes Rectal Temp.	Remarks.
Mildred 30	1900	1	96	102.4-104.4	
		2		103.4-106	
		3		103.4-102.4	
		4		100 -101	
		5	(?)	98.6-101	Cyanosis
		6		97.4-100	
		7		98 -100.2	Ultimately developed severe atrophy-but lived..
		8		98.2-101	
		9		99 -101	
		10		97.2-100.1	

TABLE 6.

In the second series, with one exception, the difference also is about 4 or 5°. What feeble metabolism must that be which can not raise its temperature only 2° above the surrounding temperature?

From this it would appear that premature babies should be allowed from 5 to 6°, the difference between its temperature desired ond the incubator. Hence the incubator should not be more than 92°. If the baby's temperature still falls, more clothing should be used, or warm baths should be given according to the method of Budin.

It was observed that the infants with an elevation of temperature were very restless, nervous and showed marked irri-

[1] This refers to infants weighing less than 1000 grams.

tability. Two cases in the first series (not recorded in the table) had convulsions with the high temperature. I believe that these babies may be safely kept at 90° if well protected with clothing and a cap (Tables 4 and 5).

It is unfortunate that I find no records of the incubator temperature in the first series,[1] but I have been assured that the babies were kept very warm (about 94°). Nearly all of them had fever and consequently did not do well.

In the second series, in spite of the fact that the incubators were kept at a much higher temperature than demanded by Budin, the infants' rectal temperature fell below the minimum point permissible (97°). (Tables 6 and 7).

Second Series.

Name Gest. Weeks.	Weight Grams.	Age Days.	Incubator Temp.	Extremes Rectal Temp.	Remarks.
Pearl 28	1769	1	94	98	
		2	90	97 - 99.2	
		3	90	100.6-100.4	
		4	88	98.8- 97	
		5	88	98 - 99	
		6	87	99.8- 97.4	
John H.	1790	1	90	99.4- 97.6	Admitted with temp. of 101.
		2	90	99.1- 97	
		3	88	98 - 96	
		4	88	98 - 96.4	
		5	86	96.2- 97.6	
		6	86	97 - 97	
Margaret	1783	1	92	98 -100	
		2	90	96 - 98	
		3	90	99 - 97.6	
		4	90-92	97.2- 97.4	
		5	90-92	97.3- 98.2	
		6	90-92	98 -100	

Table 7.

A high temperature of the incubator and its results is exemplified in the case of Mildred of the first series (see chart 5). Owing to the incomplete data I have not tabulated additional cases. This case illustrates very forcibly the harmful effects of fever in the early stages. Even in the second series,

[1] Infants weighing 1500 to 2000 grams.

in all instances there was a tendency to febrile movement, probably due to overheated incubators. Great precaution to

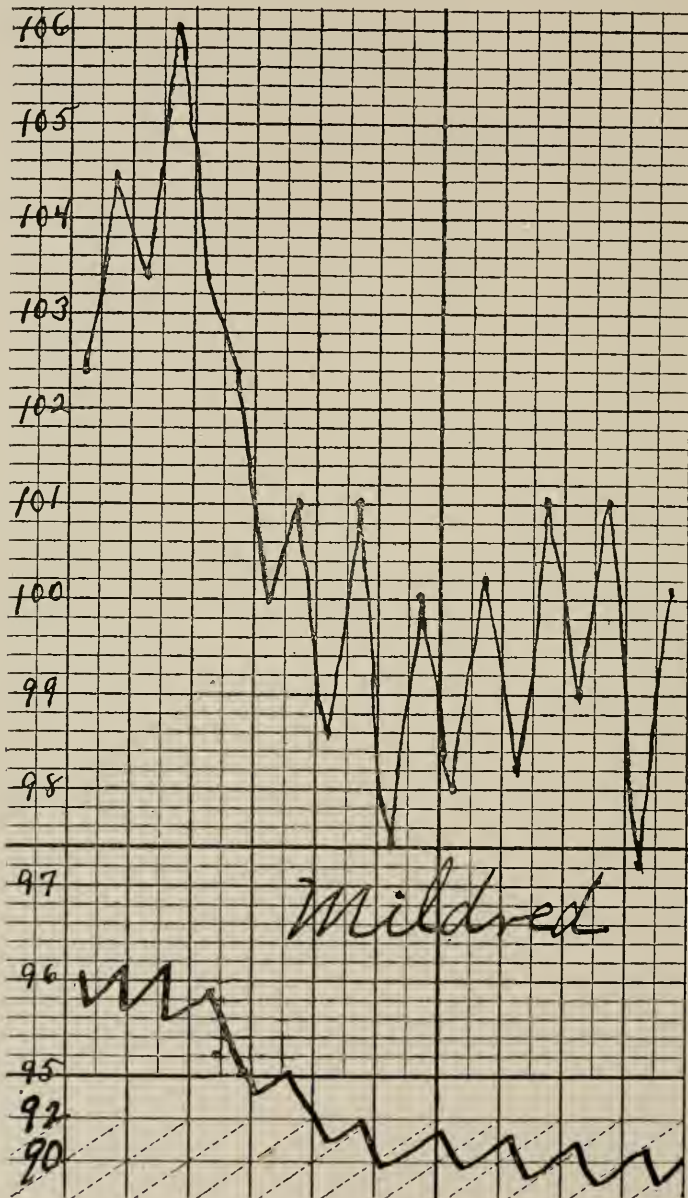
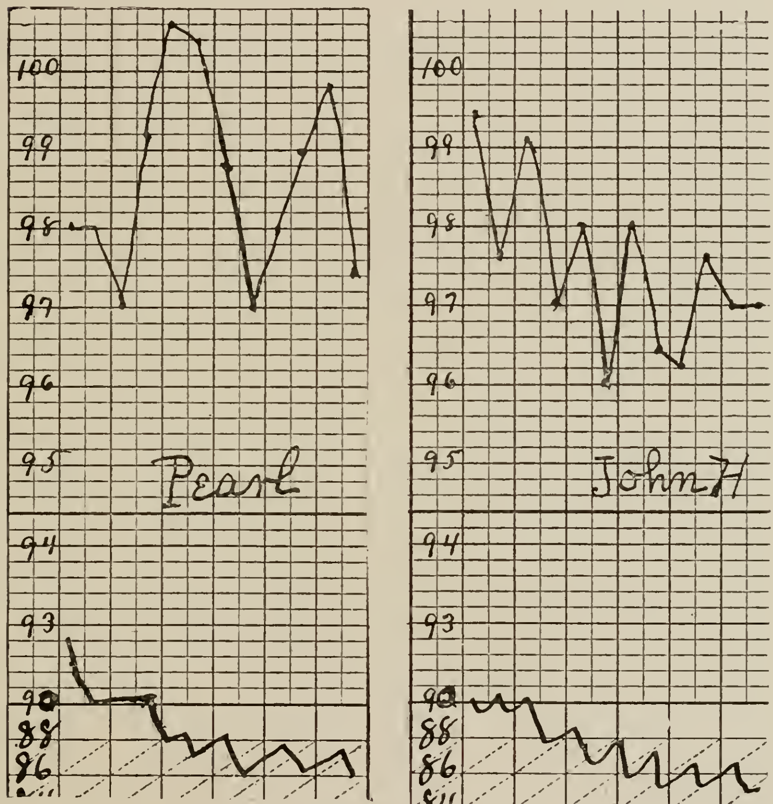


CHART 5.

prevent subnormal temperatures and consequent cyanosis suggested the temperatures (90—92°); yet, with the exception of the first few hours, this was too high, as evidenced by restlessness and perspiration.



CHARTS 6 and 7.

Charts 1 to 7 illustrate the relation of the incubator and rectal temperatures in geometric curves. The upper curve gives the rectal temperature twice daily, while the lower zigzag line illustrates approximately the temperature of the incubator. A complete correspondence is not seen, other factors enter into the augmentation of the temperature, such as the food supply, digestion, etc.

Judging from my own and the experience of the authorities mentioned above, the following conclusions may be offered:

1. The rectal temperature of the premature infant should be maintained at a temperature of 97 to 99°.

2. If the rectal temperature deviates from this standard it should be considered abnormal and measures taken to restore the normal heat.

3. Infants weighing less than 1000 grams should at first be placed in a temperature of 90 to 94°. However it is better to wrap the infant in a blanket and put on a cap; then an incubator temperature of 88 to 90° may be sufficient. Subnormal temperatures should be treated by warm baths according to the method of Budin.

4. Infants weighing from 1000 to 1500 grams (6 to 7 months gestation) should be kept at a temperature of 88 to 90°. If little clothing is placed upon them a temperature of 92° will often be necessary.

5. Infants weighing more than 1500 (1500 to 2000 grams) show greater vitality and can safely be kept at 86°, if warmly clad.

6. All infants weighing more than 2000 grams (7 to 9 months gestation) should be warmly clad and kept at a temperature of 80 to 84°.

7. In all cases it is expedient to maintain the incubator temperature at the lowest point which the infant can comfortably bear. Higher temperature predispose to indigestion, poor katabolism and cyanosis.

8. Attacks of cyanosis lead to depression of the body heat and should be treated by warm baths rather than an elevation of the incubator temperature.

Perspiration, sudamina, restlessness, and cutaneous hyperesthesia are indications of too much heat. The thermoregulating apparatus of the infant, however feeble it may be, is severely strained when the temperature is too high. Better results follow the lower temperatures. Excess of heat leads to a higher death-rate.

OTHER INDICATIONS.

While the rectal temperature must remain the most reliable criterion of the proper incubator temperature, it is by no means always accurate. The infant has a thermo-regulating mechanism, however feeble it may be in some, which controls to a certain extent the internal temperature. Thus, the lessened flow of the blood to the extremities results in cold hands, which can be touched by the nurse at every feeding. Cold hands and feet may mean insufficient oxygenation, feeble circulation or an insufficiently heated incubator.

On the other hand, thermotaxis is strained by an incubator that is too warm, and perspiration may be found on the forehead of the feeblest infant. It is a sharp reproof that too much heat has been used. Often the perspiration in a warm incubator is not sensible, since the warm air favors rapid evaporation, and the activity of the sudoriferous glands is manifest by the appearance of sudamina and miliaria. Thus, in the case of St. Louis, who on account of a severe indigestion, had a subnormal temperature, the incubator heat was elevated to 92°, and on two or three occasions a very intense erythematous blush appeared, on the edges of which were typical sudamina and miliaria maculopapules. Yet this infant had suffered from hypothermia, with the incubator at 90°, for several days, caused by indigestion. When the incubator was elevated to 92 to 93°, the skin lesions appeared, without an abnormal rise in temperature, showing the adjustment of the organism to the increased heat supply.

It is obvious that the adjustment of the incubator temperature to the needs of the infant presents many difficulties. Different observers will regard the several indications with a varying importance, and hence, the great differences in opinion. There can be no question that the baby should be warm and comfortable. Some will feel most comfortable with a rectal temperature of 97°, others will need 99°, or even a fraction more. I shall refer to other phases of this in treating of special diseases.

While it was the rule to take the rectal temperature from two to four times daily, in every case of cyanosis the temperature was taken as an additional precaution (see Cyanosis). Repeated vomiting also should suggest a more careful watch. A very rapid loss in weight, when no other cause can be assigned, demands inquiry into the heat supply. Somnolence or cutaneous hyperesthesia are indications for inquiry into the bodily temperature. A convulsion may be the first sign of overheating.

IV.

THE FOOD.

While Rotch and Morse have had very good results in feeding premature infants on modified cows' milk, and in private practice it may at times be impossible to obtain a wet nurse, in an institution human milk is alone permissible. The advantages are so many that it does not seem worth the while to make comparisons. Rotch's argument that cows' milk can be accurately modified to the needs of the infant does not hold, since the human milk may also be modified. But the comparative sterile nature, the easier digestibility and the immunity-conferring properties of human milk are sufficient to counterbalance any possible advantage derived from an accurate control of the composition. Hence, wet-nurses must be obtained. We had five wet nurses who, with their infants, slept in another part of the building. They furnished the milk but had nothing to do with the care of the incubator babies.

THE WET-NURSES.

In the selection of wet-nurses I was guided by different principles than are usually expressed, since the assumption that a proper wet-nurse for such an infant is its mother or a wet-nurse whose infant is very young does not stand a critical analysis. It is a well-known clinical observation that young infants during the first few weeks of lactation are subject to a variety of dyspeptic disturbances, attributable to deleterious changes in the composition of mothers' milk. Reference to diarrhea, colitis, vomiting and flatulent colic is all that is necessary. Then, again, we know from the researches of Soldner and Camerer, Pfeiffer and others that human milk is strongest in the early days of lactation and gradually becomes weaker in proteids as the period advances. In a series of analyses they found the following averages (*Zeitschr. f. Biologie*, Band xxxiii):

Time of lactation, day.	Nitrogenous substances.	Solids.
5	2.95	11. 7
8 to 11	2.53	12.25
20 to 40	1.78	12.35
70 to 120	1.43	11.44
170	1.08	10 85

Obviously, a wet-nurse whose infant is at least three months old, is most suitable for the premature baby.

Naturally, the general health of the wet-nurse must be carefully investigated, but local disease of any kind (nose, throat, skin, etc.) must also receive consideration. A small, well protuberant mammilla is desirable.

Our nurses had all passed the third month of lactation, and as far as could be ascertained, except in one instance, the milk was in every way suitable.

Another question is concerning the number of wet-nurses required. A wet-nurse should be able to supply the needs of two or three premature infants. Budin found that under proper feeding and increased demands of repeated nursing the milk gradually increased in quantity up to a certain limit.

MILK—HOW OBTAINED?

Infants weighing less than 1800 grams are generally too feeble to nurse the breast and must be fed some other way, hence it was our custom to have the milk drawn and the prescribed quantity fed in other ways. The milk was occasionally drawn from the breast by means of the breast pump; generally the milk was drawn by manipulation, that is, a process of milking. It is really surprising, after a few days of practice, how readily the wet-nurse can "draw" her milk from her breast by "milking." The milk was drawn into sterilized glasses, poured into other sterilized glasses and kept in the ice box. This "milking" took place four or five times a day. In addition, the older infants were placed directly to the breast.

COMPOSITION OF THE MILK.

No chemical analysis was made of the milk; in our work, I assumed that the milk of the five nurses at different periods would average a composition as follows: Proteids 1.50, sugar 6.50, and fat 3.75. This gives a caloric value of 670 large calories to the liter, or about 21 calories to the fluidounce. The calories were obtained in the usual way—by regarding the heat value of fat as 9.3 to each gram; proteids and sugar each were calculated as 4.1 calories to to the gram.

For practical purposes the assumption of an average composition must be regarded as sufficient, as the daily variations are such that chemical analysis is almost impossible except in isolated cases where much milk is to spare.

Heubner considers the caloric value of mothers' milk as varying between 614 and 724 large calories (*Kinderheilkunde*, Vol. I) to the liter, and regards 650 calories as a fair average. I took a slightly higher average based on the analyses of American women (Rotch, Holt, etc.)

METHODS OF FEEDING.

The methods of feeding varied with the needs of the patient. Very small infants—under 1200 grams, were usually fed with the ordinary medicine dropper. The nurse fed the milk by dropping one drop after another on the tongue. In many cases the Breck feeder (see "Rotch's Text-Book") was used with good results. If the infant was very feeble, would swallow with difficulty or would readily become cyanotic, gavage was employed. When the baby became more vigorous a small rubber nipple on a small bottle gave excellent satisfaction. A small nipple may easily be made by perforating the rubber cot on an ordinary medicine dropper. Later the infant was placed to the breast.

NASAL FEEDING.

Monti recommends nasal feeding in premature infants. The milk is poured gradually into the nose by means of a small funnel. Finkelstein has also given his sanction to this method. Some writers, *e.g.*, Batten, *Lancet*, 1899, have found nasal feeding very advantageous in persistent vomiting of the newly-born.

In older children—after 2 years, this method is a well-recognized procedure, but in the premature the meatus is so narrow that it is exceedingly difficult to pass a catheter, while to permit its passage through the nose by gravity, subjects the infant to the dangers of an acute rhinitis from decomposed milk. It is impossible to cleanse the nose properly after feeding. In the nasopharynx, especially, particles of milk are likely to cling and by decomposition cause irritation, and a toxemia, more or less severe, may be a consequence.

The principal objection to nasal feeding is that it interferes with the respiratory tube. I have again and again observed cyanosis, even fatal, in very small infants result from milk running into the nasopharynx and nose when the head was kept down in oral feeding. These babies can not breathe through their mouth and anything that tends to obstruct the nose jeopardizes its life.

GAVAGE.

For the reasons mentioned nasal feeding was not employed, but in all cases where swallowing could be done only with difficulty, feeding was accomplished by pouring the required amount of milk into the stomach through a catheter.

While this does not seem to disturb these infants, in spite of care, regurgitation with its attendant evils frequently follows the withdrawal of the tube. The milk should not be forced, but should be permitted to flow into the stomach slowly by the force of gravity. A too rapid flow is resented by the stomach. The infant should be held upright when the tube is introduced, since the recumbent position favors the flow of the regurgitated milk into the nasopharynx. Still, in very feeble, cyanotic infants the recumbent position only may be feasible. In withdrawing the tube great care should be taken that a drop does not fall into the larynx, which may cause fatal cyanosis.

From our experience I can not help but feel that gavage should be the preferable method of feeding in infants weighing less than 1200 grams (22 to 26 weeks gestation). In fact, in these cases it should be used at once without trying the drop method. As will be seen these feeble infants will become cyanotic on the slightest provocation, even the act of swallowing inhibiting the respiratory center. Deglutition is a dangerous act in these infants.

WHEN TO COMMENCE FEEDING.

While it is the custom with infants born at term to give them very little food until the milk secretion is established, it is a safer rule in premature infants to begin administering water and milk a few hours after birth. Then life depends entirely on the reception of food, since there is little stored in the tissues.

THE DAILY AMOUNT.

Before estimating the quantity to be given at each feeding and the interval between the feedings, it is best to decide how much milk is to be given in the twenty-four hours. This is a most important matter, since insufficient nourishment is followed by rapid loss in weight, hypothermia, cyanosis and death. On the other hand, overfeeding brings on disastrous results from indigestion, intestinal putrefaction, somnolence, loss in weight, and fatal atrophy. It is the duty of the physician, therefore, to adjust the amount of milk to the digestive power and the needs of the individual infant. The digestive ability is judged from the condition of the digestive tract, the character of the stools, the presence or absence of vomiting, and the approximate amount of urine passed. The needs of the infant is estimated from its weight, its appetite, and the rectal temperature.

Most authors find it sufficient to give the quantity at a feeding and the intervals. Budin, however, lays down definite rules, and from his large experience these rules must be considered most precise and extremely practicable. It should be remembered, however, that this physician only considers infants weighing more than 1200 grams at birth.

Because time must be allowed for a certain degree of adaptation of the digestive apparatus to the milk, it is evident that during the first few days proportionately less nourishment must be administered; hence, Budin distinguishes two periods in the food adjustment:

1. During the first ten days of life.
2. After ten days.

The first division he again divides into three classes:
a. Infants weighing less than 1800 (1350 to 1800) grams.
b. Infants weighing from 1800 to 2200 grams.
c. Infants weighing more than 2200 grams.

	I. Weight 1350 to 1800 grams.		II. Weight 1800 to 2200 grams.		III. Weight 2200 to 2500 grams.	
Day of life.	Amt. milk, grams.	Calories.	Amt. milk, grams.	Calories.	Amt. milk, grams.	Calories.
2	115	76	128	83	180	118
3	160	105	175	115	236	145
4	210	140	226	150	295	195
5	225	150	308	207	335	220
6	250	165	324	218	370	244
7	280	185	335	225	375	246
8	285	188	350	230	385	250
9	310	205	380	250	415	272
10	320	210	410	270	425	278

TABLE 8.

In the accompanying Table 8, I reproduce the average amount of milk which he gives during the first ten days of life, but have taken the liberty to annex the caloric value, based on an average composition (650 calories to the kilogram).

While the amount in these tables seem somewhat arbitrary, it should be remembered that these figures are averages in quite a number of cases. It is obvious that the quantity of milk is progressively increased, so that the infant takes about three times as much on the tenth day as on the second day. If we calculate the energy quotient in these quantities with reference to the average weight (assuming 650 calories to 1000 grams of milk) the figures indicated in Table 9 are obtained.

THE AMOUNT AFTER TEN DAYS.—BUDIN'S RULE.

Budin gives a very clear rule by which the proper amount of milk to be given after ten days' of life may be determined.

It may be stated as follows: Take one-fifth of the weight of the infant, this gives the quantity of human milk to be given to the premature infant in twenty-four hours. Or, multiply the infant's weight by two and take one-tenth.

	I. Weight 1500 grams.	II. Weight 2000 grams.	III. Weight 2500 grams.
Day of life.	Energy-quotient.	Energy-quotient.	Energy-quotient.
2	50	40	45
3	70	55	60
4	90	75	80
5	100	100	90
6	110	105	100
7	120	110	100
8	125	115	100
9	130	125	110
10	140	135	110

TABLE 9.—Showing energy quotient in the amount of milk, as recommended by Budin, for premature infants during the first ten days of life.

I shall have occasion to refer to this table again.

If we assume any weight of an infant as N, one-fifth of this would be $N \div 5$, which is the quantity of milk to be given to any premature infant. Then $1000 \div N \div 5 \times 650$=the number of daily calories ingested, and $N \div 1000$=the number of kilograms in the infant's weight.

Hence, the energy quotient is 130, that is, 130 calories are given for each kilogram of weight in twenty-four hours. As I shall discuss the caloric needs at length later on, it is only necessary to state that this is approximately the proper amount, as has been demonstrated clinically in many ways. If there is an error at all, it is on the side of liberality. As we shall see, my own experience teaches that this energy quotient at ten days is too high, since indigestion is the rule if the food is given in such large quantities.

We shall next examine some records of the amounts given during my service (Table 10).

Daily Quantity of Milk Ingested in cc.

I.- Weight, 1350 to 1800 grams.

Day of life.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
St.Louis.	25[1]	60[1]	60	90	140	180	180	180	200[3]	200[3]	200[3]	200[3]	180	180
John H.	28	45	60	140	180	190	210	190	215	215	210	240	215	215
Pearl.	28[2]	80[2]	90	90	105	120	135	135	135	180	220	270	290	315
Margaret		90[2]	95	150	150	180	210	250	225	210	210	210	240	240

II.- Weight, 1800 to 2200 grams.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
John M.	90	210	240	300	300	300	300	300	300	300	300	300	300	330
Omega.	24[2]	90	180	225	270	315	315	240	240	300	300	300	240	300
Bernice		90	90	130	120	200	240	270	270	240	180	180	180	180

III.-Weight, 2200 to 2500 grams

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Annie.		90	200	220	240	300	310	320	300	300	360	330	360	360

TABLE 10.

[1]Three per cent sugar solution.
[2]One-half of this sugar solution.
[3]One-fifth sugar solution.

If these figures are compared with those of Budin (Table 8), it will be seen that the quantities we gave were considerably less for the corresponding period. And yet, vomiting and indigestion occurred in several cases. Thus, about the eighth day, St. Louis showed indigestion as shown by the character of the stools. On the twelfth day John H. had to have his food reduced for a similar cause. In the case of John M. there was in the beginning a too rapid increase, so that a subsequent increase could not be made for many days. In the case of Bernice, who commenced to vomit on the ninth day, the reduction in quantity was probably too great, since she cried with hunger after every feeding.

Perhaps, I was too cautious, but the previous poor results with overfeeding forced me to go to the other extreme. I shall give only three examples, and this is not with a view of criticising but rather to assist in arriving at a satisfactory conclusion as to the proper quantity to give (Table 11).

Daily Amount of Human Milk in cc.
First Series.—Weight 1530 to 1800 grams.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mildred.		150	100	120	120	130	90	90	120	135	135	130	126	126
Leonore.		40	50	75	75	70	70	80	120	120	110	90		
George.	4	35	45	45	50	60								
Alice.	60	60	90	85	100	100	100	120	150	105	110	120	120	130

TABLE 11.

From this Table it is seen that that the quanty given, with the exception of the first baby, was less than the averages laid down by Budin. Still most of these were near 1350 grams in weight. Mildred was overfed the first day and, consequently, showed marked dyspeptic symptoms lasting for many days, in spite of the reduction in the daily quantity.

I refrain from giving any more figures from the first series for the simple reason that the larger infants had to be put on mixed feeding. Altogether, from this study the conclusion is justifiable that Budin's figures in regard to the daily quanty of milk are somewhat high for feeble infants, while for those weighing more than 1800 grams his averages, no doubt, are correct. Still I would prefer to make the daily increment less large so that at least two weeks would elapse before the infant gets one-fifth of its body weight in milk for twenty-four hours.

During the latter part of the season I was enabled to draw a definite formula based on the caloric needs. This gives us a general rule for the feeding of those babies, which is eminently practical and, when properly controlled by noting the digestive functions of the infant, will lead to excellent results. Hence, I offer the following rules for the feeding of premature infants, and reserve the following Section (V) for discussing its value and practicability:

RULES FOR FEEDING PREMATURE INFANTS.

1. During the first day of life the premature infant should receive sufficient human milk diluted with an equal quantity of water, or 3 per cent sugar solution, so that the energy quotient shall be thirty calories. Any fractional part of the first day should receive a proportionate part of the energy quotient.

2. On the following days the energy quotient should receive an increment of ten every day, so that an energy quotient of one hundred and twenty calories is reached by the tenth day. The quantities are represented in Table 12.

Day of life.	Energy-quotient.	Day of life.	Energy-quotient.
1	30	6	80
2	40	7	90
3	50	8	100
4	60	9	110
5	70	10	120

TABLE 12.

3. In many cases it is best to increase more gradually, especially if slight dyspeptic symptoms appear. It will be found more safe to keep the energy quotient the same for two or three days after reaching eighty, as indicated in Table 13.

Day of life.	Energy-quotient.	Day of life.	Energy-quotient.
1	30	8	90
2	40	9	90
3	50	10	100
4	60	11	100
5	70	12	100
6	80	13	110
7	80	14	120

TABLE 13.

4. After two weeks the energy quotient should be maintained near one hundred and twenty calories.

5. In all cases the stools must be watched for signs of indigestion. When the stools become greenish, or contain undigested curds it is best not to increase the energy quotient over eighty until these symptoms disappear.

The practice of making the energy quotient the basis of infant feeding is entirely rational, and its value has, as yet, been scarcely appreciated. While it is true that the length of gestation must also be considered, the weight must be the most practical guide.

I will give two examples of this method of feeding:

Day.	Milk, cc.	Calories.	Day.	Milk, cc.	Calories.
1	15	10	8	170	112
2	75	50	9	170	112
3	90	62	10	185	125
4	110	75	11	185	125
5	130	87	12	185	125
6	150	100	13	200	137
7	150	100	14	225	150

TABLE 14.

Baby A, arrived at 4 p.m.; weight, 1250 grams. Since its weight was one and one-fourth kilos, its daily amount of milk must be one and one-fourth times its energy quotient in calories. And since there are 670 calories (21 in an ounce) in a liter, the calculation is easily made, as follows (Table 14).

Of course, all these figures are given in round numbers; I can not claim that extreme accuracy is necessary. It should also be noticed that this is a hypothetical case, calculated on the basis of birth-weight; but as the weight decreases during the first week the figures are somewhat too large. Each time the baby is weighed, and as we shall see, it should be weighed every day, the quantity of food for the next twenty four hours should be calculated. Now, while this may seem very complex, in a given case a more simple rule can be followed, but this rule should remain the standard by which other milk schedules may be judged. Here is an example from actual life at the Baby Incubators (Table 15) and illustrates the harmful results of trying to feed too much.

I cite the case of Omega to illustrate how one may begin by adhering to the rule, but because the vigorous baby seemed so hungry on the fourth day the food was increased beyond the prescribed limits and in three days, as marked dyspeptic symptoms appeared, the food had to be reduced in amount.

Omega.—Weight 2123 grams.

Day.	Weight.	Milk, cc.	Calories.	E. Q.
1	2123	60	61	28
2		95	82	38
3	2094	135	103	49
4	2087	240	177	85
5	2094	275	198	94
6	2084	320	230	110
7	2108	320	230	109
8	2108	240	174	82
9	2080	240	168	80
10	2108	300	230	108
11	2094	300	230	109
12	2094	300	230	109

TABLE 15.

NOTE.—The first few days the total calories were increased by giving sugar-water. Where a discrepency between the milk and calories appears it is due to the calculated calories in the 5 per cent sugar water.

From a study of Budin's figures and my own experience, I am convinced that the schedule given is about correct.

Now, since there is a gradual increase of daily allowance of milk, and the amount the first day is represented by an energy quotient of 30, the daily increment is 10 calories. Moreover, since there are 670 calories in one liter, any quantity of milk is found by taking one and one-half times the calories wanted. Hence, to obtain the quantity desired for any day (during the first ten days) we have the following algebraic equation:

$$x=3w\div 2000\ [30+10\,(a-1)]$$
$$\text{Whence, } x=3w\div 200\ (2+a)$$

Where w stand for the weight of the infant, and a represents the day of life.

Therefore, I offer the following practical rules to those who do not wish to calculate the amount of daily feeding on the basis of the energy quotient:

1. Before the tenth day.—*Divide the weight of the infant by seventy* (70) *and multiply the quotient by the age plus two* (2).

2. After the tenth day.—*Divide the body weight by five* (5).

These are simple and practical rules,—the second rule is that of Budin.

THE AMOUNT AT EACH FEEDING.

It is curious how different physicians take different means of determining the capacity of the stomach. Rotch has depended mostly on post-mortem examination of the premature stomach; he reports three cases. One was a fetus, seven and a half month's gestation, weighing 1930 grams and having a gastric capacity of 18 cc. In another case, eight month's gestation, while the fetus weighed only 1230 grams, the stomach could hold 22 cc.. In the third case, gestation thirty-two weeks, weight 1440 grams, the size of the stomach was much smaller, holding only 8 cc. (2 drams).

Voorhees also recommends that the first quantities should be 1 to 2 drams (4 to 8 cc.) and gradually increased.

Perret states that having determined the quantity of milk (method of Budin) it is easy to decide the quantity at each feeding by dividing it by the number of feedings daily. He regards ten feedings as the proper number. Hence, the total quantity divided by ten will give the amount at each feeding. Budin has a very similar rule.

Monti recommends quantities from 20 to 40 grams.

We followed Voorhees' directions mainly, beginning with one-half to two drams (2 to 8 cc.) at a feeding and rapidly increasing. Efforts at larger quantities frequently resulted in vomiting, which is dangerous in such infants.

As there is still so much uncertainty concerning the size of the stomach, considerable latitude must be allowed. I still believe that having decided the total quantity to be given, we best decide on the number of feedings daily and divide the quantity of the milk by this. This is a very practical rule.

THE INTERVAL.

As to the interval, no definite rule exists. Rotch and Voorhees feed every hour. Perrett, Budin and Monti insist on two hour intervals. In fact, Monti finds the hourly feedings of Passini wrong (theoretically?), an infant should not be fed so often and so much. In artificially-fed infants he recommends three hour intervals. How he can get enough food into a premature infant in these intervals is a mystery. Our rule was about as follows:

Infants weighing less than 1500 grams were fed every hour in day time, sometimes less often at night—(20 to 22 feedings daily).

Infants weighing 1500 to 2500 grams received their food every one and one-half hours—(14 to 16 feedings daily).

Babies weighing more than 2500 grams can receive their food at two hour intervals.

Of course, the age of the patient must always be considered.

AN EXAMPLE.

The infant weighs 1350 grams (about 3 pounds), 28 week's gestation. How much food should it receive on the third day of life?

Twenty feedings daily. Energy quotient 50, daily calories 66. This equals 100 cc. of milk—each feeding 5 cc.

ADDITIONAL FEEDING.

For the infants taken out of the incubators additional feeding was necessary; since our supply of wet nurses was limited these babies had to thrive on mixed feeding. During the service of my predecessor certain proprietary foods had been given, for which he had been criticised, probably unjustly so, since the basis of his feeding was cows' milk. I determined at once to discontinue the use of the proprietary foods for reasons well known to pediatrists. Only cows' milk, properly modified, was used. Walker-Gordon modifications were rejected for the simple reason that these mixtures are twenty-four hours old before delivery. Old milk can hardly be found satisfactory with these feeble infants. Hence, I decided on a home modification of the cleanest, freshest milk that could be obtained. Milk was finally obtained from the Walker-Gordon Laboratory. The unchanged milk was sent out to the Incubators by a special messenger. Milk that was drawn the night before reached us about noon; it was, of course, kept cold until delivered. It was allowed to stand on ice for three hours and the lower half removed in the usual way. The top milk was used diluted with whey made from the lower half. In other words, the babies were fed on a whey and milk mixture, as has been advocated by Rotch and Morse in this country, and Monti and others in Europe. The mixtures were usually Pasteurized. Several times we had vomiting and occasionally diarrhea from these mixtures, but in all cases it could be referred to a high bacterial contamination of the milk. During the hot months, especially in times of hot weather and low barometer, the rapid change of milk is too well known to need especial study here.

The following formulæ give the directions for mixing and the approximate composition of some of these mixtures. Subjoined is also found the approximate calculated caloric value of the food, on which the quantity of feeding was based.

FORMULA I.

Directions:		Composition:	
Whey,	fl.℥ 8	Proteids,	0 95
Top milk,	" 2	Lactalbumin,	0.60
Limewater,	" 1	Caseinogen,	0 35
Water,	" 5	Fat,	0.87
Lactose,	ʒ 4	Sugar,	6.

Caloric value, 11 to each fluidounce.

FORMULA III.

Directions:		Composition:	
Whey,	fl.℥ 8	Proteids,	1.40
Top milk,	" 4	Lactalbumin,	.70
Limewater,	" 1	Caseinogen,	.70
Water,	" 3	Fat,	1.75
Lactose,	ʒ 4	Sugar,	6.50

Caloric value, 15 to each fluidounce.

FORMULA V.

Directions:		Composition:	
Whey,	fl.℥ 4	Proteids,	1.60
Top milk,	" 6	Lactalbumin,	.55
Limewater.	" 1	Caseinogen,	1.05
Water,	" 5	Fat,	2.60
Lactose,	ʒ 4½	Sugar,	6.50

Caloric value, 17.70 to each fluidounce.

It would be superfluous to give additional formulæ. Altogether we had nine such mixtures, but those given were used mostly. In calculating the composition, the proteids are regarded in the strength of 3.6 per cent, while the fat (one half of all the milk) was computed as 7 per cent. In two mixtures (7 and 8) we employed top milk containing one-third of the whole and which we calculated the fat as 10 per cent in the mixture. The caloric value was calculated from the ordinary rule that each gram of proteid or sugar yields 4.1 large calories, and that each gram of fat gives 9.3 calories.

In feeding these older babies we were again guided by the energy quotient, which, of course, had to be controlled by the digestive power of the infant. It is very difficult to maintain a constant energy quotient when the change is made from human milk (calories, 21 to each ounce) to a milk mixture with only about one-half its caloric strength. It was no wonder, therefore, that most infants lost in weight when this change was made, even though the food was digested perfectly.

While the whey and milk modifications were satisfactory as a food for the older infants, especially when supplemented by one or two breast feedings, it is difficult to understand how such a mixture could be preferred to human milk. To give the infant a proper caloric strength in such dilute foods necessitates the administration of large quantities. I imagine it would be very hard to give a ten-days old baby an energy quotient of 100 in a formula like No. I.

V.

THE CALORIC NEEDS OF THE PREMATURE INFANT.

Heubner has laid down the rule that the food of the infant should have a energy quotient of 100 calories. A quotient of energy which is less than 70 calories is insufficient to sustain the needs of the normal infant. Artificially-fed babies require an alimentation whose energy quotient is 120 calories. Schlossmann believes that a higher energy quotient (110 calories) is necessary.[1]

The subject is comprehensively discussed in an article by J. L. Morse (*American Journal Medical Sciences*, March, 1904), to which I must refer for more extended reference to the literature.

While it may be admitted that the figures of Heubner are rather too high for large infants, for premature infants their value must stand, since it is a well-known law that the small bodies lose proportionately more heat than large ones. It has, therefore, been assumed that premature infants require more calories per kilo than those born at term. The cases of Beuthner and Schlossman leave the matter still in doubt, although they found a higher energy quotient necessary (113, 119). Morse from his interesting study also reaches the conclusion that the caloric need of premature infants is relatively greater than that of full term infants.

A further corroboration of this need is found in the very successful method of feeding adopted by Budin, who, calculating on even a low basis of calories in human milk, uses an energy quotient of 120 to 130 calories in alimentation.

I offer this additional evidence of the caloric needs of the premature infant. While I recognize that, as the milk of the wet nurses was not analyzed quantitatively, and an average

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[1] The energy quotient signifies the number of calories in the food given to each kilogram of the infant's weight.

John Henry.							
Age, days	W'ght	Loss or Gain	E.Q.	Age, days	W'ght	Loss or Gain	E.Q.
2	1615		25	32	1590	+ 7	80
3	1548	−67	35	33	1610	+ 20	82
4	1550	00	60	34	1633	+ 23	85
5	1548	00	86	35	1625	− 8	95
6	1520	− 28	97	36	1653	+ 28	95
7	1512	− 8	100	37	1682	+ 29	95
8	1498	− 14	98	38	1690	+ 8	100
9	1490	− 8	98	39	1704	+ 14	110
10	1490	0	102	40	1718	+ 14	105
11	1476	− 14	100	41	1732	+ 14	100
12	1483	+ 7	110	42	1740	+ 8	100
13	1476	− 7	110	43	1760	+ 20	97
14	1483	+ 7	120	44	1790	+ 30	100
15	1470	− 13	106	45	1804	+ 14	114
16	1477	+ 8	105	46	1812	+ 8	120
17	1484	+ 7	60	47	1825	+ 13	135
18	1470	− 14	60	48	1867	+ 42	134
19	1476	+ 6	60	49	1867	00	134
20	1512	+ 36	70	50	1860	− 7	135
21	1520	+ 8	60	51	1867	+ 7	135
22	1505	− 15	60	52	1896	+ 29	135
23	1526	+ 21	75	53	1910	+ 14	132
24	1526	00	75	54	1910	00	132
25	1526	00	75	55	1931	+ 21	135
26	1526	00	75	56	1924	− 7	131
27	1520	− 6	75	57	1924	00	131
28	1526	+ 6	75	58	1924	00	131
29	1543	+ 16	75	59	1938	+ 14	130
30	1583	+ 40	75	60	1931	− 7	120
31	1583	00	78	61	1952	+ 19	125

TABLE 16.

composition was assumed, these figures are by no means absolutely correct. Yet, it is the method usually adopted to calculate the caloric needs. Morse is certainly rather severe in criticising results based on this estimate, when he states that figures based on such an average caloric value per liter of of milk can not be of great value. It would be an almost impossible task to analyze each separate food supply of the infant, since it is known that the milk varies in composition on different days and even on different periods of the day. Then it would make a marked difference whether the infant obtained its milk when the breast was overfilled or nearly empty. It will be seen, therefore, that nearly all calculations in regard to the need of the energy quotient when human milk is used must be based on an average caloric value.

We had five wet nurses who furnished the milk, and their milk was emptied into a bottle whence it was fed to the babies. It was often mixed, that is to say, one baby would receive milk from more than one wet nurse on the same day. I feel, therefore, that we are perfectly justified in using an average composition in making calculations.

Then, again, the present purpose is not so much to establish a maximum or minimum line, but to find a practical average which can be used by physicians in the feeding of premature infants. The rule has already been given in the previous section, it remains now to study the individual cases and see if the proper needs have been formulated in the rules for feeding.

It took some little time after I took charge to get the daily weights and quantities sufficiently exact, so that the figures given are the results after September 18th.

In analyzing the record of the food and weight of John Henry (Table 16) several interesting facts may be noticed. In the first place, in trying to increase the milk in the first two weeks as rapidly as Budin directs, a severe attack of indigestion was induced. On the fourteenth day with the alimentation having a quotient energy of 120 calories, about what his rule of feeding would give, our patient had frequent green stools showing undigested food. Moreover, he had several attacks of cyanosis and subnormal temperature. On the seventeenth day the food had to be decreased and an additional supply of water given. The dyspeptic symptoms disappeared in about ten days, and he began to have a good daily gain on a quotient energy of about 75 calories. It will be observed that during the ten days (27th to 37th day of life) he gained 162 grams, or an average of 16 grams a day. This record rather supports the assertion of Czerny and Keller (*Des Kinder Ernahrung*, page 385) that some infants gain 15 grams daily on an energy quotient of 70 calories. During another period (46th to 56th day of life), with an energy quotient of 130 calories, he gained only 112 grams, or an average of 11 grams daily. Of course, the first period was immediately after a period of indigestion and loss in weight; the gain may be probably accounted for by a storing of water. Another period when the quotient energy was near 100 calories (35th to 45th day) gave a daily gain of 18 grams. A much higher quotient energy gave no higher gain. Even later, when on account of supplying his hunger, or putting him to the breast he took a still larger quantity of milk his gain was no greater. Table 17 gives a brief résumé of his subsequent history.

Day of life	W'ght	Gain or Loss	E.Q.
70	2144	+192	145
80	2279	+135	160
86	2293	+114	130

Table 17.

In the case of Bernice (Table 18—Chart 8) I feel sure that our method of feeding was rather too cautious at the beginning. In her case the method of feeding based on the energy quotient had not as yet been adopted. Notice the sharp rise in weight on September 22d, when the energy quotient on the previous day was near 100 calories. She certainly corroborated the view of Heubner that an infant can not gain on an energy quotient of 70 calories or less. The first good gains are reached when the energy quotient is over 80 calories.

BERNICE.

Date	W'ght	Calories	E.Q.	Date	W'ght	Calories	E. Q.
9/14	1995	Entered		10/24	2066	252	121
15				25	2101	252	119
16				26	2130	252	113
17				27	2137	252	113
18	1966	84	42	28	2186	232	106
19	1952	126	64	29	2186	212	96
20	1938	147	75	30	2222	212	95
21	1938	189	97	31	2222	227	102
22	1974	157.5	79	11/1	2229	281	126
23	1974	168	85	2	2293	277	120
24	1974	120.75	61	3	2307	304	131
25	1966	100	50	4	2314	303	131
26	1966	126	64	5	2392	277	115
27	1966	126	64	6	2435	277	113
28	1952	110	56	7	2413	277	115
29	1966	105	53	8	2413	315	130
30	1966	120.75	61	9	2463	265	107
10/1	1959	120.75		10	2498	288	115
2	1952	126	64	11	2527	253	100
3	1952	115.5	59	12	2548	285	111
4	1938	126	65	13	2598	251	96
5	1945	126	64	14	2598	285	109
6	1952	136.5	69	15	2634	298	113
7	1966	147	74	16	2627	342	130
8	1966	147	74	17	2655	351	132
9	1966	147	74	18	2683	342	127
10	1966	147	74	19	2662	331	124
11	1981	168	84	20	2676	332	139
12	2002	252	125	21	2691	342	127
13	2009	252	125	22	2698	294	108
14	2030	189	93	23	2719	313	115
15	2023	189	93	24	2691	267	99
16	2023	189	93	25	2655	315	118
17	2038	189	92	26	2733	360	131
18	2059	168	81	27	2740	198	72
19	2073	194	93	28	2726	269	98
20	2038	225	110	29	2719	219	80
21	2052	190	92	30	2676	210	78.67
22	2045	252	123	12/1	2740		
23	2059	252	122				

TABLE 18.

During the period of October 11th to 21st (energy quotient near 90 calories) she gained on an average of 6 grams daily. During the period of October 22d to November 1st, with an

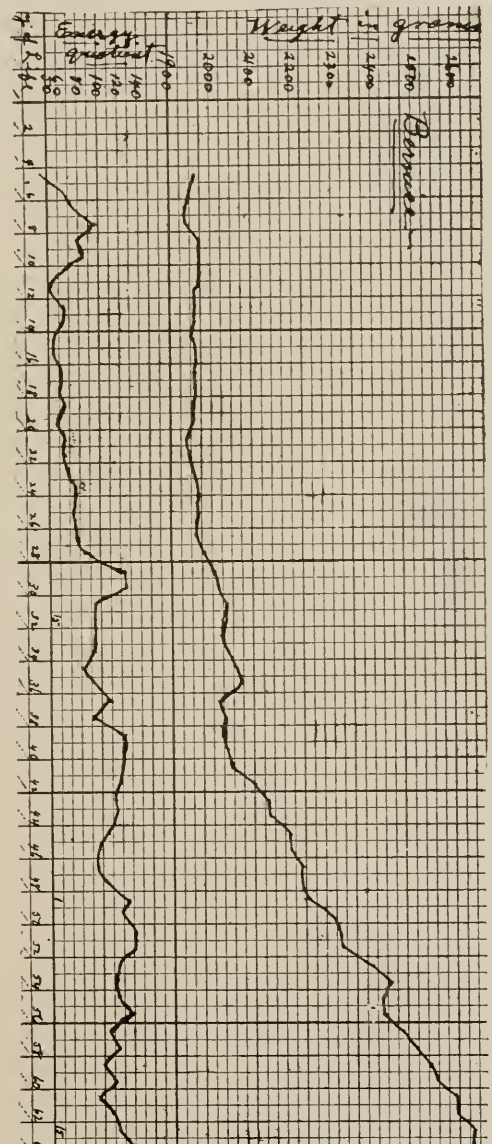


CHART 8.

energy quotient of about 110 calories, she gained 8 grams daily. On the following period of ten days the average gain was 29 grams daily, with an energy quotient of nearly 115 calories.

Pearl.							
Age, days	W'ght	Loss or Gain	E.Q.	Age, days	W'ght	Loss or Gain	E.Q.
2	1705		37	16	1591	+ 8	105
3	1626	— 79	38	17	1598	+ 7	105
4	1598	—28	39	18	1633	+35	103
5	1576	— 22	67	19	1640	+ 7	102
6	1583	+ 7	66	20	1654	+14	101
7	1561	—22	61	21	1676	+12	100
8	1561	00	64	22	1697	+21	100
9	1561	00	64	23	1697	00	100
10	1568	+ 7	64	24	1705	+ 8	99
11	1568	00	110	25	1733	+27	97
12	1568	00	120	26	1726	— 7	97
13	1583	+15	140	27	1726	00	97
14	1605	+22	140	28	1755	+29	96
15	1583	— 22	140	29	1755	00	96
				30	1783	+28	95

TABLE 19.

In the case of Pearl (Table 19) the alimentation had to be reduced on the fifteenth day as dyspeptic symptoms appeared. From the fifteenth to the twenty-fifth day with an energy quotient near 100 calories the average daily gain was about 15 grams. Following this period the food quantity was relatively less and the gain in weight was correspondingly less.

Omega (Table 20—Chart 9) was a large baby and we should expect a larger gain on the same energy quotient, but as a matter of fact we find no great difference. The first period of ten days (15th to 25th day) with an energy quotient of 100 to 130 calories the average daily gain was only about 15 grams. On the following ten days, with a lessened food supply, the gain was about 4 grams daily. This was caused also by slight indigestion superinduced by excessive feeding (17th to 24th day). It only emphasizes the fact that it is dangerous to give an alimentation that exceeds an energy quotient of 120 calories during the first few weeks.

Omega.

Age, days	W'ght	Loss or Gain	E.Q.	Age, days	W'ght	Loss or Gain	E.Q.
				18	2137	00	135
2	2133		29	19	2151	+14	135
3	2123	00	39	20	2157	+28	135
4	2094	−29	50	21	2165	−14	135
5	2087	−7	85	22	2194	+29	134
6	2094	+7	95	23	2215	+21	132
7	2080	−14	110	24	2186	−29	134
8	2108	+28	109	25	2222	+36	132
9	2108	00	82	26	2208	−14	118
10	2080	−28	80	27	2222	+14	118
11	2108	+28	108	28	2250	+28	112
12	2094	−14	109	29	2236	−14	112
13	2094	00	109	30	2208	−28	116
14	2066	−28	87	31	2272	+64	120
15	2101	+35	109	32	2257	−15	111
16	2137	+36	108	33	2222	−35	127
17	2137	00	135	34	2257	+35	95

TABLE 20.

The rapid increase in the food in the case of Margaret (Table 21) did not succeed in producing a rapid gain. Time must always be allowed for the weak digestive apparatus to adapt itself even to mother's milk. She did not stay with us long enough to determine her digestive power any further as the Institute closed and she was sent home in good condition.

The history of St. Louis (Table 22) is exceedingly instructive. By the rapid increase of the food to an energy quotient of 100 calories on the sixth day the initial loss in weight was checked, but an indigestion followed which was treated by a reduction in food, and for twenty days there was

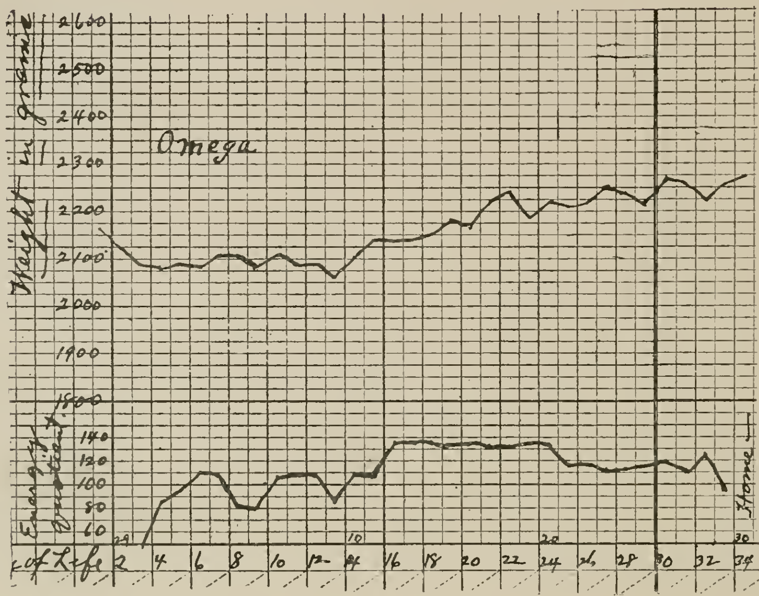


CHART 9.

Margaret.							
Age, days	W'ght	Gain or Loss	E.Q.	Age, days	W'ght	Gain or Loss	E.Q.
				9	1540	— 14	102
2	1726		22	10	1533	— 7	95
3	1640	— 86	41	11	1533	0	95
4	1561	— 79	67	12	1533	0	95
5	1533	— 27	68	13	1547	+ 14	108
6	1547	+ 12	81	14	1561	+ 14	107
7	1540	— 7	95	15	1547	— 14	108
8	1554	+ 14	114	16	1547	0	108

TABLE 21.

no gain in weight. On the twenty-seventh day there was a great improvement in stools and the food was increased to an energy quotient of 100 calories. But pushing the food beyond

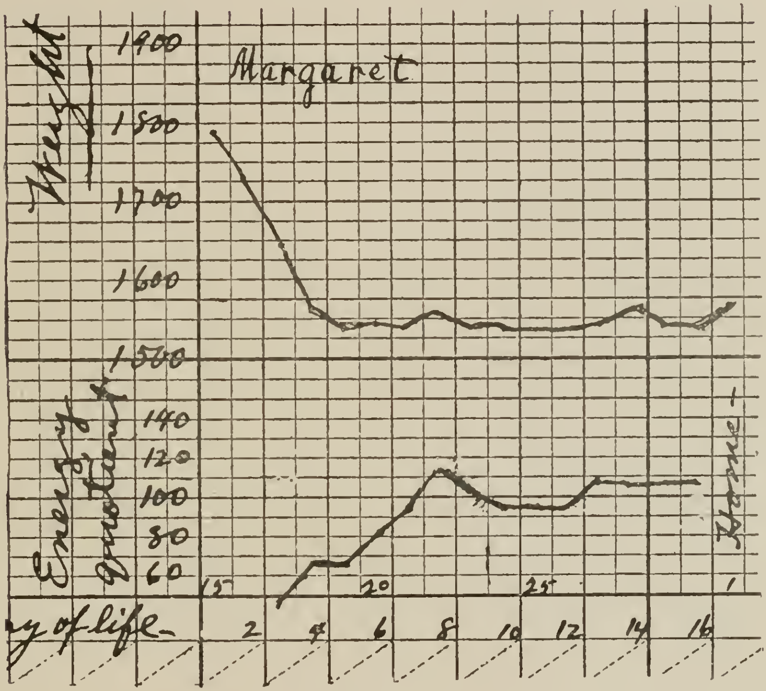


CHART 10.

that again brought on greenish stools. On the forty first day the infant had not yet regained its original weight, and the stools having improved a forced alimentation was tried, gavage being used at times. Mother's milk was given in increasing quantities so that its energy quotient on the fifty fourth day reached 195 calories. Probably this was overfeeding—yet the infant gradually became accustomed to this food and on the following twelve days (48th to 60th day) gained on an average of 19 grams daily. On the following ten days (not shown in the table) he gained 10 grams daily on an energy quotient of 130 calories. His history will be more specifically discussed under "Indigestion."

St. Louis.							
Age, days	W'ght	Gain or Loss	E.Q.	Age, days	W'ght	Gain or Loss	E.Q.
	1385			31	1300	00	85
2	1356	—29	20	32	1272	—28	98
3	1264	—92	27	33	1286	+14	98
4	1228	—36	48	34	1293	+ 7	113
5	1235	+ 7	64	35	1280	—13	115
6	1250	+15	100	36	1266	—14	71
7	1257	+ 7	100	37	1285	+21	86
8	1279	+22	88	38	1278	— 7	68
9	1272	— 7	80	39	1285	+ 7	61
10	1250	—22	72	40	1300	+15	82
11	1243	— 7	73	41	1300	00	112
12	1230	—13	90	42	1342	+42	125
13	1237	+ 7	73	43	1413	+71	126
14	1250	+13	80	44	1413	00	148
15	1250	00	86	45	1385	—28	150
16	1236	—14	82	46	1349	—36	155
17	1230	— 6	90	47	1385	+36	153
18	1228	— 2	88	48	1378	— 7	180
19	1250	+22	90	49	1413	+35	178
20	1243	— 7	80	50	1427	+14	147
21	1243	00	67	51	1434	+ 7	145
22	1250	+ 7	58	52	1448	+14	159
23	1257	+ 7	68	53	1476	+28	190
24	1221	—36	74	54	1490	+14	195
25	1228	+ 7	74	55	1519	+29	193
26	1243	+15	75	56	1512	— 7	194
27	1280	+37	100	57	1533	+21	191
28	1293	+13	100	58	1540	+ 7	190
29	1300	+ 7	100	59	1568	+28	160
30	1300	00	100	60	1605	+37	130

TABLE 22.

Annie (Chart 11) illustrates the gradual increase of food, and how the loss in weight is checked when an energy quotient of 70 calories is reached. She gained nicely on an alimentation having an energy quotient of 95 to 100 calories. Chart 12 shows how a larger increase of food does not increase the gain in weight but slightly. An energy quotient of 150 calories was too large. She gained very rapidly (30 grams daily) on a food having an energy quotient of 120 to 130 calories (58th to 64th day). She was a large baby to begin with and her growth was uninterrupted.

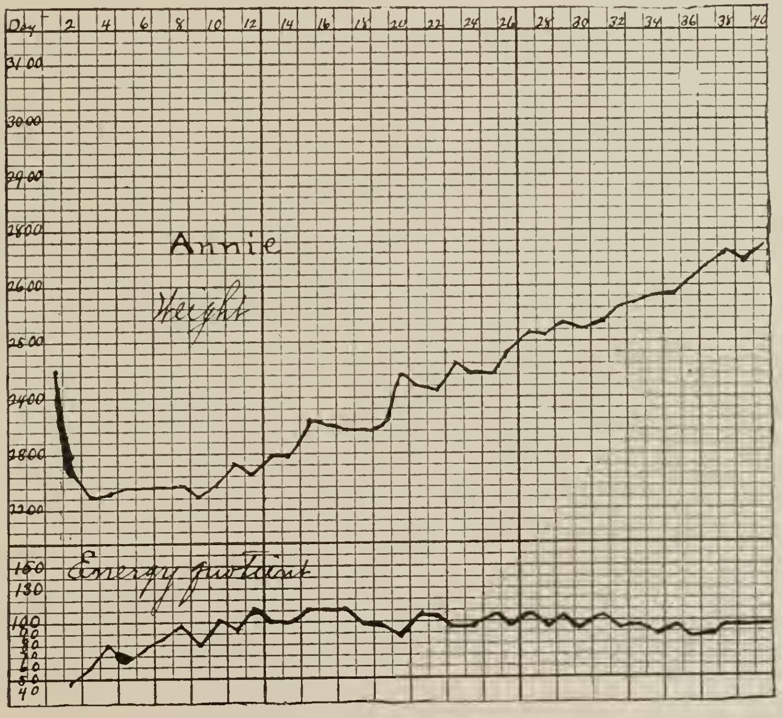


CHART 11.

Charts 13, 14 and 15 (Leonore, Mag. and Donald) illustrate the growth on mixed feeding. These were graduates, and the curves show their food and weight during certain periods of their life. Again, we notice that an energy quotient of

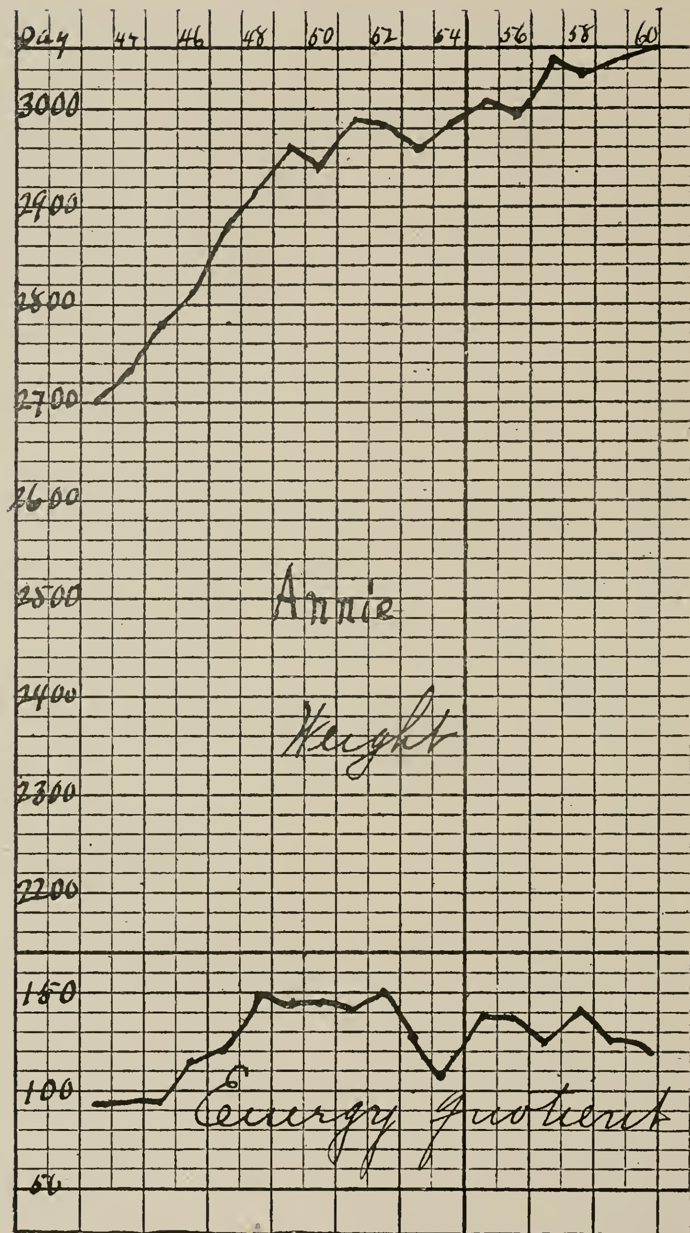

Day
44
46
48
50
52
54
56
58
60
3000
2900
2800
2700
2600
2500
2400
2300
2200
Annie
Weight
150
100
50
Energy Quotient

CHART 12.

about 120 to 130 calories is most satisfactory. Higher quantities give rise to indigestion. When the energy quotient is the same, and digestion is perfect it is impossible to draw any distinction between modified cows' milk and human milk in these older babies.

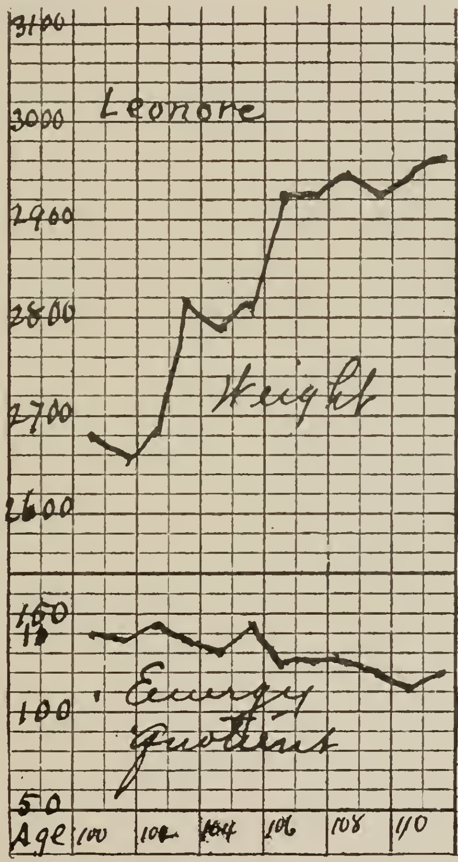


CHART 13.

DEDUCTIONS.

1. The use of the energy quotient as a basis of infant feeding is entirely practicable.

2. An energy quotient of 70 calories should be considered the minimum for maintaining the metabolic equilibrium. In

many cases a steady growth may be obtained on this alimentation.

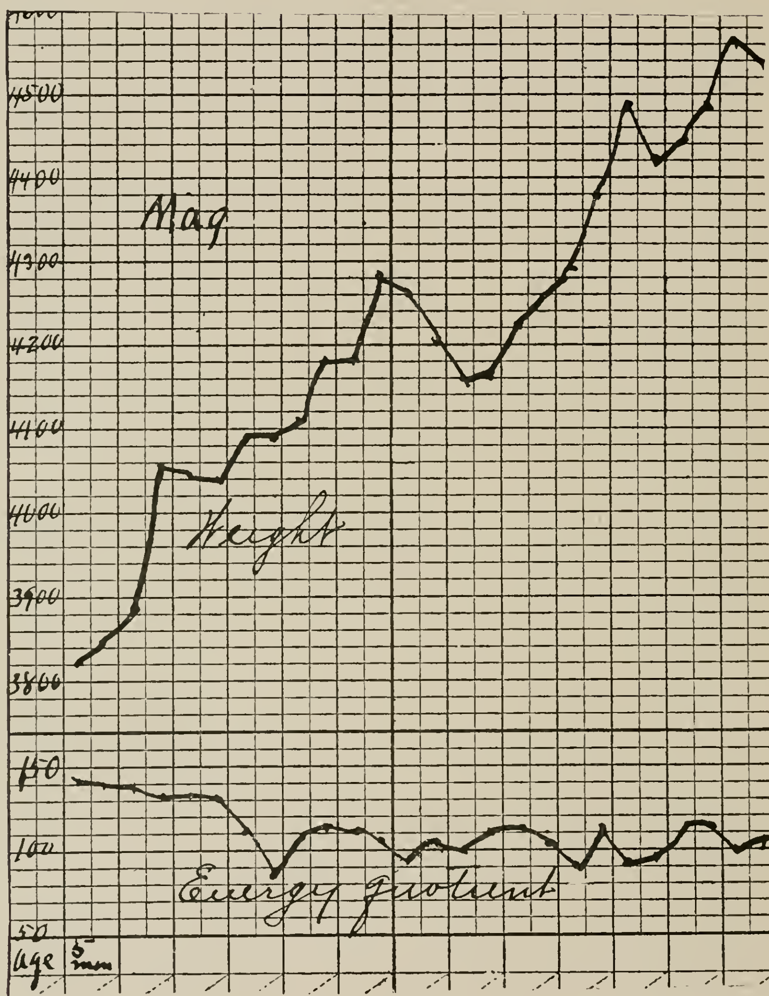


CHART 14.

3. Most premature infants require human milk having an energy quotient of 100 to 120 calories in order to insure a steady gain in weight.

4. Quantities of human milk having an energy quotient

of more than 135 calories should only exceptionally be given, as this favors indigestion and subsequent loss in weight.

5. In older infants there is little difference in growth when human or bovine milk is used, provided the digestion is perfect and the energy quotient the same.

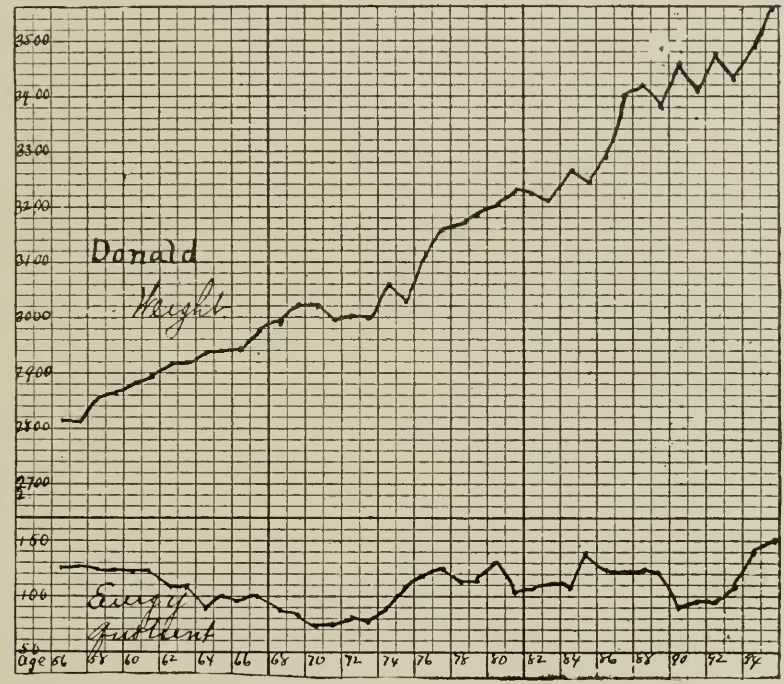


CHART 15.

THE QUANTITY OF WATER NEEDED.

Before dismissing the general subject of feeding it is necessary to point out that since the infants are kept constantly in a very warm, and often dry air, evaporation of water is very rapid; consequently, an additional quantity of water must be supplied, especially during the first few days. The consequences of an insufficient water supply will be studied under a different topic. This water is best supplied by diluting the milk given with a 3 to 5 per cent sugar solution. Equal parts of mother's milk and the sugar solution is a very good mixture with which to begin. An additional supply of sterilized water can be given per rectum. It is well to try to give as much water (including that given in the milk) as is represented by one-sixth of the body weight. Thus, if an infant weighing 1500 grams is given 65 cc. of milk on the second day, he should receive sufficient water so that the total fluid is near 250 cc. By doing this all tendency to inanition fever or other complications may be avoided. If the milk has been diluted and this infant takes 130 cc. of liquid by the mouth, an additional 120 cc. must be given by the rectum in two or three injections. It is unnecessary to state that this water must be at a temperature of about 99°.

VI.

THE MORBIDITY.

While we attempt to formulate general rules which will obviate all evils, the rearing of premature infants is such a complex problem that special pains must be taken in each individual to prevent diseases and symptomatic disorders. The physician's work consists in preventing these disorders and, if they arise in spite of care, in alleviating them. The premature baby is most susceptible to a variety of influences which only exceptionally impress the healthy infant born at term; hence, their diseases require special study. Congenital malformations need not be discussed here.

The functional derangements which need special study, since they are most frequently connected with the mortality, may be classified under four heads:

1. The Respiration.
2. The Temperature.
3. The Digestion.
4. The Nutrition.

What additional light has our study at the Baby Incubators on the "Pike" thrown on these subjects?

CYANOSIS, APNEA, ASPHYXIA.

The most formidable derangement of the respiratory function is the failure to breathe, or apnea, and is characterized by cyanosis of the skin and mucous membrane. The appearance of severe cyanosis always signifies that the infant does not make sufficient inspiratory efforts. I will use the term apnea to signify absence of respiration due to insufficient excitation of the respiratory nerve centers. Asphyxia is more properly applied to those cases in which some obstruction to the ingress of air exists. However, I do not wish here to enter on any controversial points relative to the proper use of these terms. This tendency to cyanosis depends partly on the atelectasis present, but more especially on the feebleness of the respiratory muscles and, above all, on the lessened irritability of the nerve centers.

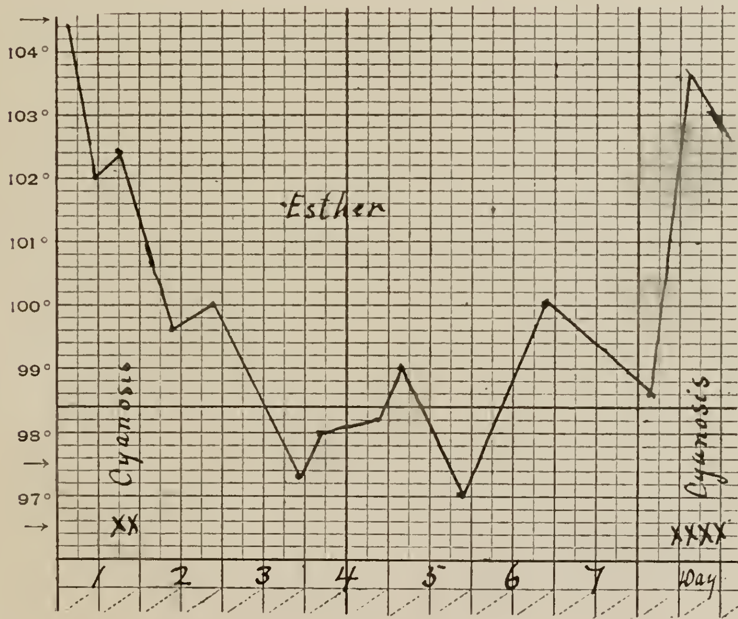


Chart 16.

Cyanosis is the principal cause of death among infants weighing less than 1200 grams. All the infants under this weight, during my service, died of a single or repeated attacks of cyanosis. This derangement, then, merits the most careful attention.

It is astonishing what feeble respiratory movements on the part of the infant is sufficient to insure an adequate supply of oxygen. When these movements stop the infant which has a very red appearance shows, after a few moments, a dusky red color, this gradually deepens into a bluish red, dark blue and, finally, almost black color. If the asphyxia persists pallor supervenes, which usually means death, that is a failure of the heart also. What brings on these attacks after an infant has breathed very well? Budin has very clearly laid this down (*Le Nourrisson*, page 29).

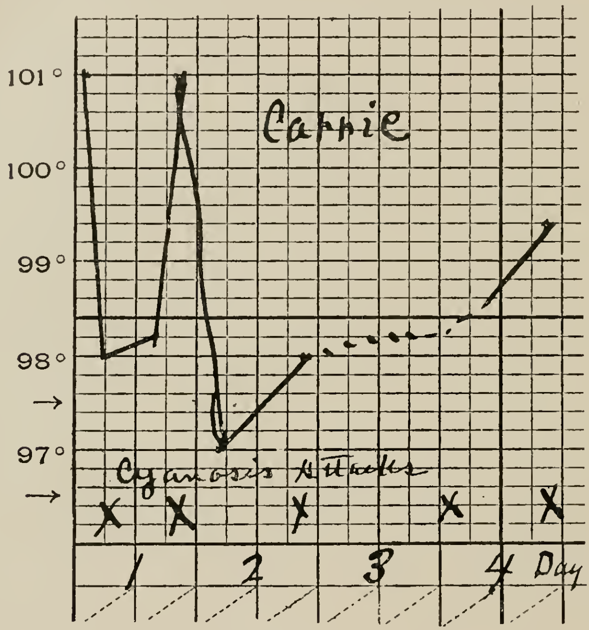


CHART 17.

Besides the reduction of temperature an insufficient quantity of nourishment is given as a principal cause. Perrett also gives the reduction of the body temperature and insufficient alimentation as the principal causes of cyanosis. Little else on this subject is to be found in literature.

From the study of our records the etiological factors of cyanosis appear to be many. In the first place the birth weight of the infant has a marked influence. Infants weighing less than 1200 grams are almost invariably attacked. So. also a gestation of less than 28 weeks seem to endow so little breathing capacity that cyanosis would almost invariably appear. Most infants do not die of one attack; very commonly several attacks preceded death. Cyanosis, especially if the attacks would be prolonged or frequently repeated, was invariably accompanied by a reduction of the rectal temperature, even when the baby was not removed from the incubator. The suspension of respiration leads to a lessened tissue oxydation, and thus predisposes to other attacks

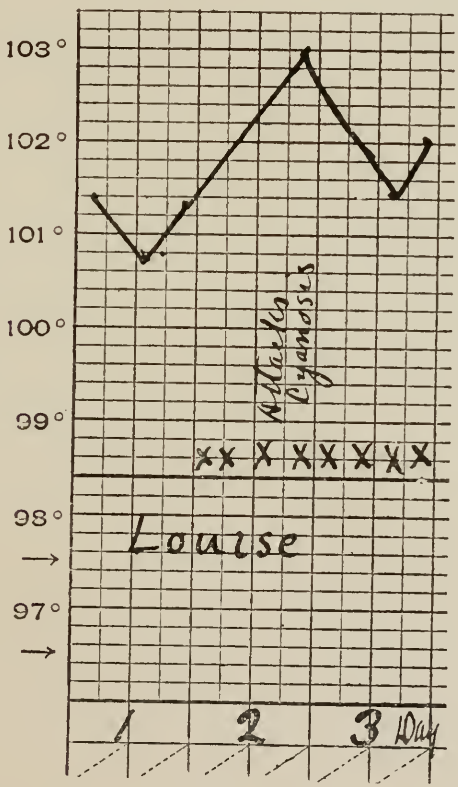


CHART 18.

The next question to be answered is what relation has the rectal temperature to the appearance of cyanosis? Budin gives the cooling of the body as a cause, and no doubt he is correct. On the other hand, it must not be forgotten that the cooling of the skin is one of the most powerful stimulants to respiration (see Knapp, *Scheintod der Neugeborenen*, for a discussion of this subject). Furthermore, an elevation of temperature also endangers life by causing the appearance of cyanosis. This is well exemplified by a long series of cases (First Series) in which the incubator was kept at a relatively high temperature (94 to 98°). See the relation of the high temperature and cyanosis in Charts 16 to 21. Especially in the case of Esther (Chart 16) the cyanotic attacks indicated by the sign X, were manifest only when the rectal temperature was over 102°. Hence, an elevation of temperature over 102° predisposes to cyanosis. This is another reason why the incubator should not be kept too high. But even when the temperature is perfectly normal (Chart 21), as in the case of Robert, repeated attacks of cyanosis may appear.

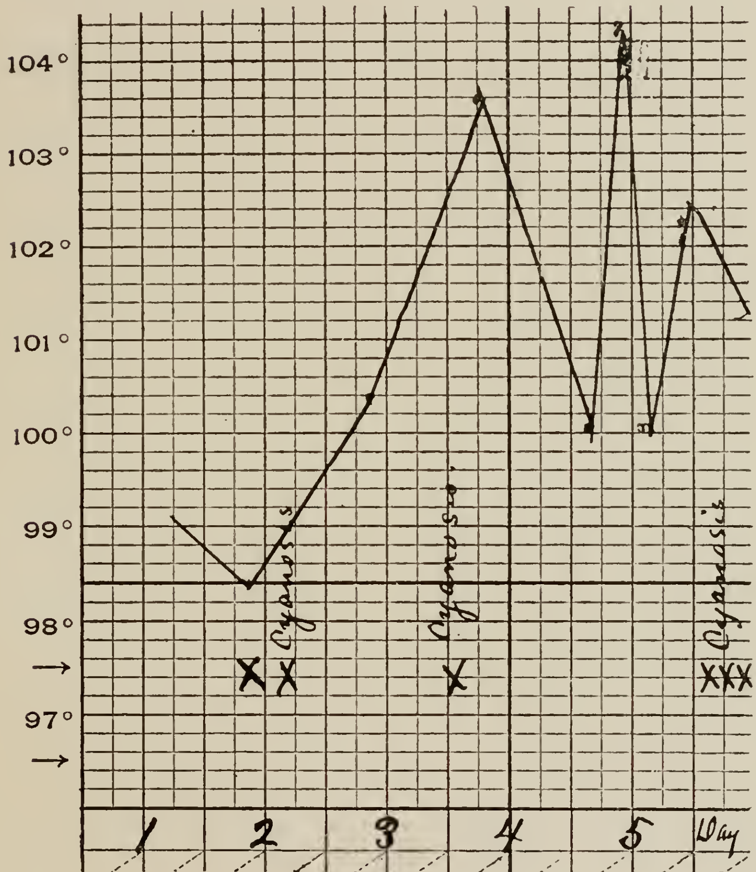
An inquiry into the other direction is less definite. Many infants weighing more than 1200 grams had a rectal temperature of 95.3° without the appearance of cyanosis. Yet it can not be denied that cyanosis is the dangerous symptom of too great loss of heat, but it could not be determined at what temperature it is likely to appear. Two infants who were admitted with a temperature of 93° did not show this symptom. As in elevations of temperature it is often impossible to decide whether it is the reduction in temperature or the cause back of this reduction that is responsible for the respiratory cessation. To be more specific, a few cases may be cited:

CASE 43.—Deaderick, gestation 24 weeks, weight 825 grams. Admitted with a rectal temperature of 93.4°. Placed in incubator at 94 to 96°. Lived 18 hours. Rectal temperature never exceded 95.4°. Had three attacks of cyanosis.

CASE 48.—W. K., gestation 24 weeks, weight 1100 grams. Admitted with a temperature of 100°. Incubator temperature 90°. Rectal temperature dropped to 96° in nine hours, but rose to 99° when the incubator was 92°; again dropped to 93° (incubator 90°), yet had no attack of cyanosis until immediately before death, third day, with a rectal temperature of 96° (incubator 93°).

CASE 51.—C. K., gestation 28 weeks, weight 909 grams.

Admitted with a rectal temperature of 95°. Placed in incubator at 93°. Rectal temperature the first day was between 94 and 96 4°. Third day became cyanotic with a rectal temperature of 97°.

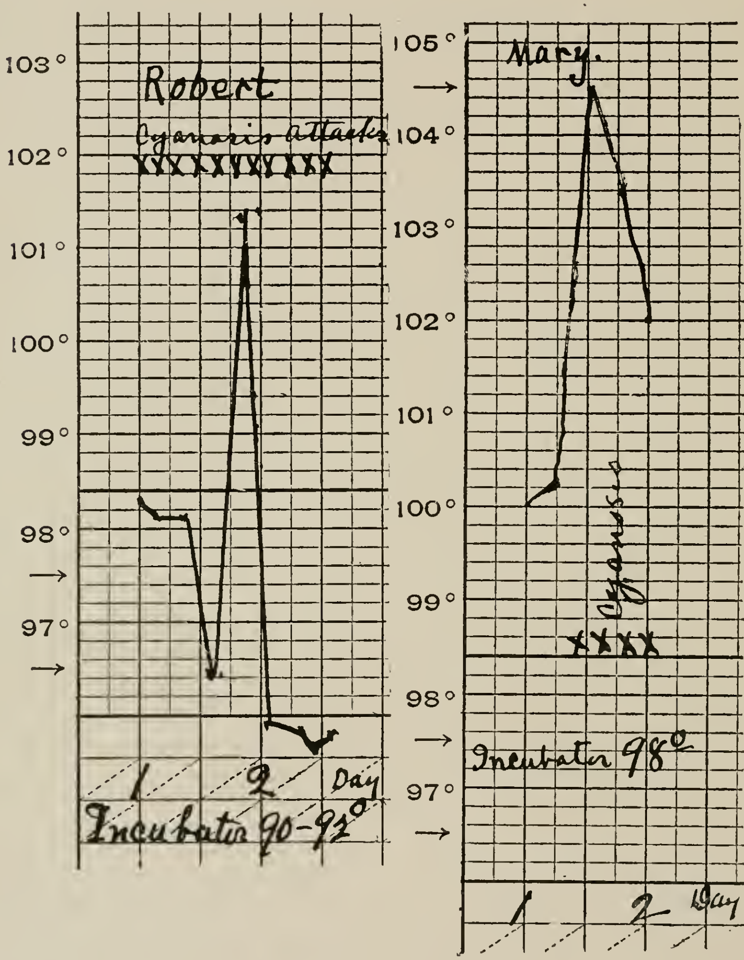


GEORGE.

CHART 19.

It will be seen, therefore, that subnormal temperatures by no means lead to repeated attacks of cyanosis. Altogether I can not consider a rectal temperature of 96° very dangerous. A temperature even below this does not mean an immediate attack of apnea.

The respiratory movements, however feebly they seem, must be relatively vigorous when there is much atelectasis, and to supply this energy, food is necessary. Budin is undoubtedly correct in assigning an inadequate food supply as a principal cause of cyanosis.



CHARTS 20 and 21.

The infants, after a few hours or days, die from exhaustion, that is, an insufficient fuel has reached the tissues and the respiratory muscles and nerve centers give way first. In seven cases analyzed from the First and Second Series, that is, infants weighing less than 1200 grams, the food during the first forty-eigth hours had an energy quotient of less than 20 calories, and even part of this was rejected by the stomach. To prevent cyanosis, then, the most careful attention should be given to the food.

There is, however, one other danger, and that is over-feeding. Too much food inevitably leads to indigestion and this to cyanosis. Thus, in the baby Alice (Case 36, First Series), weight 1364 grams, the energy quotient on the second day was 150 calories with indigestion and repeated attacks of cyanosis resulting. Again, in that of Doris (Case 38) the food quantity represented by an energy quotient of 140 calories on the first day resulted in death in two days, with the temperature practically normal. Again, Henry (Case 42), on the fourteenth day, with an energy quotient of 120 calories, but showing marked dyspeptic symptoms had several attacks of cyanosis. With these paroxysms the rectal temperature fell.

Cyanosis is also a symptom of inanition fever, or more properly, a disturbance caused by an insufficient supply of water. In the infants Pearl, Margaret, etc. (Cases 53–56), in addition to diluting the milk, rectal injections of a physiologic salt solution were resorted to in order to supply the necessary water. As mentioned previously, the rapid evaporation in such superheated air (88–94°) must always be considered, and careful attention to the rules laid down for the administration of water will often prevent cyanosis.

While food is absolutely necessary to prevent cyanosis, it can not be denied that the act of feeding in infants weighing less than 1200 grams is one of the principal causes of cyanosis. Paradoxical as it may seem, feeding is dangerous to these infants. Most of the attacks of cyanosis arise during or immediately after feeding. In the first place, the very act of deglutition in certain infants will in some way stop the respirations. I have noticed this particularly even before this experience. Then, again, a few drops of milk may lodge in the mouth and incite no deglutition but stop the breathing.

The milk may enter the larynx during deglutition or from vomiting afterward. If the head of the infant is kept down, as is often done to increase the blood supply in the brain, and the infant is fed, the milk may run into the nasopharynx and occlude the respiratory tube, resulting in cyanosis.

During vomiting, also, the food often regurgitates through the nose and fatal cyanosis may follow. Vomiting is very dangerous in these feeble infants. I may better illustrate the difficulties and dangers of feeding by reciting an experience:

Robert, weight 1000 grams, gestation 26 weeks, arrived with a rectal temperature of 98.8°. While being dressed for the incubator his first cyanotic attack appeared, which was relieved by oxygen inhalations and artificial respiration. In spite of his temperature being near normal constantly, and even above normal, with nearly every feeding cyanosis would become manifest. For the first nine hours nothing was fed except a few drams of 3 per cent sugar solution. This feeding was certainly inadequate. It is necessary to begin feeding as soon as possible. In the following twenty-four hours food representing an energy quotient of 24 calories was administered but much of this was not retained.

After twelve hours' trial of feeding with a dropper, gavage was resorted to, with no change as to the number of attacks of cyanosis. Vomiting was frequent after gavage, many times the milk was regurgitated through the nose. Altogether he was a promising baby and yet in spite of most careful work for two days, the cyanotic attacks did not diminish (Chart 20).

In this little patient, the fact was demonstrated that even with the best of care, infants of not more than 26 or 28 weeks' gestation and weighing less than 1200 grams, life will become extinct.

Finally, fatal attacks of cyanosis, with or without a rise of temperature, occurring after the second day, indicates a local or general infection. This may occur in any premature infants (Chart 16). The history of one case will suffice:

CASE 45.—E. H., male, gestation 7 months, weight 1930 grams. Admitted, after a ride of seven miles over rough roads, in fair condition. He had two attacks of cyanosis on the way. Rectal temperature, on admission, 102.6°. Placed in the incubator at a temperature of 88°. Rectal temperature the first day 98 to 100°, second day 99 to 101.2°. On the afternoon of the third day the temperature suddenly rose to 102.8°. Small cutaneous hemorrhages appeared in various parts of the body. Diagnosis: Hemorrhagic disease caused by some infection.

Food supply, mother's milk in quantities of 4 cc. every hour, increased to 6 and 8 cc. The alimentation gave the following energy quotient: First day, 30 colories; second day, 35 colories; third day, 40 colories. Additional water was given by the rectum after the second day. A slight attack of cyanosis cccurred on the evening of the second day, with a temperature of 100°. Twice on the following morning the infant became blue, with a rectal temperature of 100.2°. In the morning of the third day the rectal temperature rose to 102.8°, and frequent attacks of cyanosis ended fatally.

Many additional cases could be cited from the First Series, but this will illustrate the statement that fatal cyanosis occurs on account of an infection.

The treatment of cyanosis is to ascertain the cause and remove it. For the attacks, artificial respiration takes first place. During feeding the nurse must watch the breathing and if the slightest cyanosis appears, must stop the feeding and restore the breathing. Pinching the baby often restores this function. Tapping on the head with the finger will remind the nervous system to act. When these methods are insufficient, artificial respiration, to initiate the respiratory function, must be employed. Before doing this one must be sure that the upper respiratory tube is clear of milk or mucus. The baby is rolled on its face and the head lowered. Milk will then flow out of the larynx or pharynx. It can then be wiped away.

As to the method of artificial respiration, the exigencies of the case must decide. Undoubtedly, Schultze's method is the most effective, but has the great objection that the swinging rapidly cools the infant. If the rectal temperature is high, this method can be used. When the temperature is subnormal other methods should be chosen. Marshall Hall's method is applicable in the incubator. Silvester's method will more generally be found serviceable and can be used in the incubator or bath. The infant should at once be placed in a warm bath (temperature 100°F.) if the rectal temperature is below 36°C.

It is well to have several methods of artificial respiration in mind, as different conditions necessitate the choice of different procedures. The methods of Pacini, Bain or Behm can be used in the incubator. Prochownick's method (suspension by the feet and compression of the chest) can be used advantageously if the cessation of the respiration is caused by milk or mucus in the upper respiratory tube. The method of Harvie does not necessitate exposure so much as Schultze's procedure.

Simple suspension alone will often initiate respiration. The method of Laborde was used in one case unsuccessfully.

One or two attempts at blowing air into the trachea were unsuccessful. It was our custom in many cases to place one drop of a 1/1000 solution of nitroglycerin on the tongue of these babies. Often it seemed very helpful. Oxygen inhalations were constantly used. I am not very sure as to its value. Oxygen can not initiate the respiratory function. When the breathing has started, oxygen hastens the oxygenation of the blood and dispels cyanosis.

Altogether the problem of cyanosis is one of the principal tasks awaiting solution. With skill and great care its dangers may be obviated, but in infants weighing less than 1200 grams, it is only rarely that cyanosis will not appear.

HYPOTHERMIA.

A rectal temperature below 36°C. (96.8°F.) should be considered an indication for employing warming measures. It is not sufficient to raise the temperature of the incubator only; it is necessary to inquire into the cause of the reduction in temperature. In the first place, there is the post natal hypothermia which resulted from too great exposure after birth. A fall in temperature will also occur even if the infant is placed at once in the incubator. The observation of Perrett is instructive in this connection :

A premature infant, weight at birth, 950 grams, had a rectal temperature of 36.1°C. It was immediately placed in an incubator at 32°C. The temperature taken every two hours thereafter gave these results—35.6, 34.2, 34, 35.2, 35.9, 36 9°C.

In other words, the temperature dropped to 34°C. in spite of the incubator; then, after six hours, it gradually rose to normal. Even Lepine, more than forty years ago, asserted that the temperature of the premature infant at the room temperature may drop to 33°C., but, as Budin remarks, the return to normal is not so easy as he indicated.

Evaporation and radiation from the translucent congested skin, causes a rapid loss of heat, and the incubator is designed to prevent this. It is questionable, however, if the incubator should be used to supply heat to the infant. Warm air is a slow method of heating the infant. For the initial drop in temperature the warm bath should be resorted to. When the infant's temperature is normal it must be thoroughly dried and placed at once in the incubator. These warm baths can be frequently repeated.

Repeated attacks of cyanosis usually result in a fall of the rectal temperature. Warm baths and careful attention to diet are necessary.

Very serious is the reduction in temperature following attacks of indigestion. When there are symptoms of colic, green, undigested stools, some of which contain mucus, the question of treatment offers many problems. Blair has been very successful in these cases by heating the incubator up to 96 to 98° and keeping the rectal temperature slightly above normal. In addition he employs bathing. Personally, I feel that the bathing and careful dieting witout the incubator being so high will be found equally successful. In private practice it not infrequently happens that after the premature infant is a few days old, and has been overfed, dyspeptic symptoms appear and the infant has hypothermia. The careful treatment of the indigestion and the employment of warm baths are the rational indications and may be absolutely necessary.

Here again I must insist that attention to clothing should be given in just such cases. There is no better way to stop heat loss from a radiating body than to envelop it in non-conducting (woolen) clothing or blankets. Frequently, a reduction in temperature may be checked by enveloping the infant in a soft woolen blanket. Even its head may be thus enveloped and radiation checked.

Our experience shows that infants weighing even less than 1000 grams should be allowed a difference of 4° between their own and the atmospheric temperature. When, even with additional clothing, hypothermia ensues, attention to the food supply and nutrition is necessary.

Finally, a sudden hypothermia may be caused by some infectious process and rapidly end fatally. Altogether, the prompt and careful management of hypothermia is one of the problems of premature infants.

FEVER.

Fever results from an insufficent water supply, an overheated incubator or some infection. Occasionally, constipation seems to be the only cause present. It is remarkable how the temperature of the premature infant fluctuates, being disturbed by sligh causes. An elevation of temperature up to 38°C. (100.4°F.) has no significance. A temperature higher than this demands attention. Fever was a very common condition of the infants of the First Series. As I have incomplete data, a report of the cases would be unprofitable. In the Second Series the only two infants having a temperature of more than 102° were infected.

The treatment of fever in the premature infant does not differ from that of older infants. As a rule, it is best to remove the infants from the incubator if the temperature rises above 102°. Often this is all that is necessary, besides the treatment directed to the underlying pathological condition.

INDIGESTION.

Under this head may be grouped a class of disturbances which are brought about by functional derangement of digestion. It ranks with cyanosis as one of the disorders which causes great anxiety to the attendants. The symptoms do not differ from those in older infants and yet a few symptoms are more pronounced. The most usual cause of indigestion is overfeeding. I have already, in the Sections on Feeding, referred to this cause. If, during the first few days, the milk is given in too large quantities, or later, when the quantity of food given represents more than 130 calories (energy quotient), symptoms of indigestion are liable to appear. In the first week severe indigestion is likely to be fatal; in fact, the impossibility of digesting a sufficient quantity of milk is probably the principal cause of death in infants weighing less than 1000 grams.

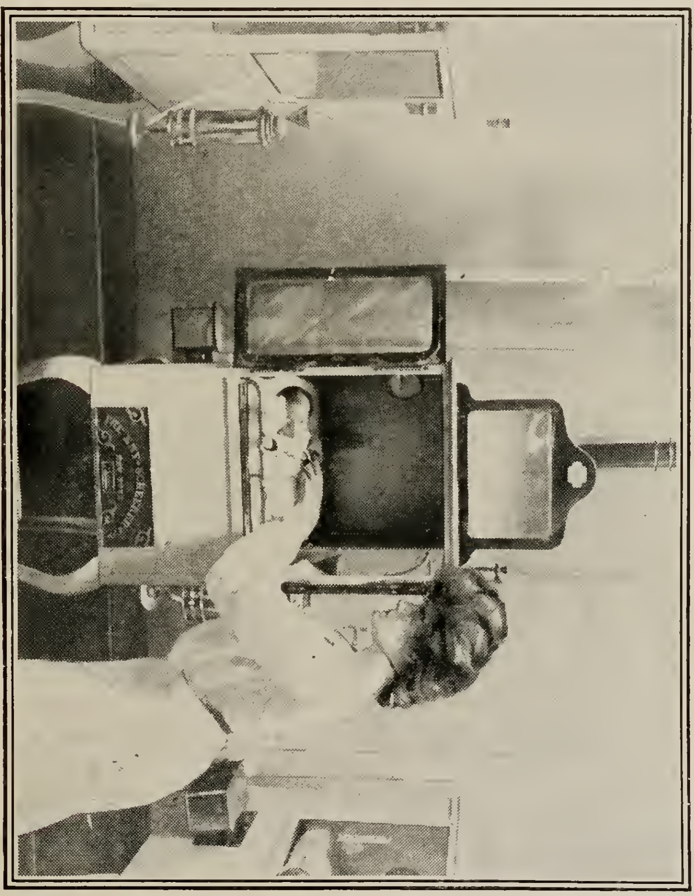


FIG. 9 - Feeding the Infant, the Doors of the Incubator Being Open.

Another cause of indigestion is insufficient ventilation. In foundling homes, as Routh, long ago pointed out, bad air gives rise to severe dyspeptic symptoms. Premature infants, also, will lose their appetite, and digest food poorly, when the air is impure. Not only must the most rigid rules for ventilation be enforced as regards the incubator, but the room in which the incubator stands must be thoroughly ventilated. When an infant is fed, the door of the incubator is opened for a short time and the cooler air from the room flows rapidly into the incubator and displaces the warm air (Fig. 9). In a show incubator, therefore, it will not do to have the incubators stand in the same room with the visitors. The incubator room must be tightly separated from the visiting room by glass partitions. (Fig. 10).

FIG 10.—The Incubator Room with the Glass Partition which Separated the Incubators from the Visitors.

How far mild infections contribute to indigestion is uncertain as it is often impossible to distinguish digestive disturbances arising from overfeeding or a primary infection.

By what symptoms do we recognize the onset of digestive disturbances? As these infants are usually constipated it will not be sufficient to depend on inspection of the stools except as a corroborative sign. The diagnosis must be tentatively made without seeing the passage.

The symptoms which will direct our attention to the digestion are as follows: Somnolence, anorexia, loss in weight, drop in the rectal temperature, cold extremities and cyanosis. Furthermore, the infant may have repeated attacks of crying and other indications of colic. Vomiting also is very significant, but by no means a very instructive symptom. That form of indigestion which induces colic seems to be less serious, although the colicky attacks may be followed by stupor and death.

Several problems suggest themselves in this connection and it may be instructive to inquire into some of them.

As to the quantity of food sufficient has already been told in the Section on Feeding. Another question that demands consideration is the relation of the incubator and the rectal temperature to the powers of digestion?

I again make two divisions—First Series and Second Series, the first under the management of my predecessor. For want of space I can give only a few histories.

First Series.

Case 30.—Louise, weight 1360 grams, gestation 7 months. Admitted a few hours after birth with a rectal temperature of 101.4°. First day, food 60 calories energy quotient; several stools in the evening, temperature above 101°. Second day, gavage several times, part of the first day, food was given having an energy quotient of about 80 calories, but stools were frequent, several attacks of cyanosis appeared and food was reduced to 20 calories. The temperature remained high (Chart 18). Several baths were given. The stools improved when several enemata were employed. The bowel movements remained free and contained undigested food. The third day the food was reduced too much, only about 12 cc. being given in eighteen hours. Death from repeated attacks of cyanosis.

As the quantity of food was too large the first day it is difficult to state whether the indigestion was caused by this or by the high incubator temperature.

The same remarks may apply to Earnest (Case 26), an infant of about the same weight as the preceding, who was given a mixed feeding, was given more than 6 ounces of food in the first eighteen hours and when he would not take it gavage was employed. There was vomiting, great crying with pain and on the third day several attacks of convulsions, and death. As I have not the complete data at hand, the cause of all this is not clear. The temperature was over 101° all the time.

In the case of Warden (Case 14), who soon after admission had a temperature of 104°, the vomiting of mucus suggested that mucus is not always the result of cold, but rather to overfeeding and high temperature of the incubator.

Celeste (Case 15), gestation 7 months, weight 1460 grams, was placed in the incubator at 94°, when the rectal temperature rose to 102°, it was reduced to 90°. On the following four days the rectal temperature was about normal (97 to 99.6°). A few hours after admission with a temperature of 102°, she vomited several times mucus and curds. Otherwise no dyspeptic symptoms appeared. Water was administered freely. Food given was mother's milk diluted 1 in 4 parts— and the baby did not receive sufficient food. Energy quotient third day 25 calories. She died suddenly on the fifth day. I place this case among the others to illustrate how great care will avoid indigestion, but the infant may die suddenly from exhaustion.

Two more cases of the First Series will be noticed:

Mildred (Case 35, see Chart 5), gestation 7 months, had fever (101 to 104.4°) during the first few days of life. Weight at birth 1930 grams She was fed on mother's milk. Her alimentation daily was as follows: In calories (E. Q) second day, 20; third day, 30; fourth day, 35; fifth day, 50.

It will be seen that during this time she had fever, probably from the incubator being too high (96°). She received no excess of food, and yet she developed marked indigestion. She had foamy stools, with curds and the stools did not become yellowish, but remained green. The stools also contained mucus.

I will have occasion to refer to this case again under the heading, Inanition. Altogether, the high temperature inhibited the digestion.

In the case of Leonore (Case 21), though a smaller infant, the rectal temperature did not go over 100°, and no dyspeptic symptoms appeared in the first week.

SECOND SERIES.

Case from the Second Series need not here be repeated, suffice it to state that a subnormal temperature (below 97°) also inhibits the digestive functions as it appears from the records of several babies. I must conclude, therefore, that maintaining the temperature of the incubator too high or too low predisposes to indigestion.

The treatment of indigestion resolves itself into measures that evacuate the bowels and careful feeding. A dose of castor oil should be given and the quantity of food reduced. As a rule, it is safer to lengthen the intervals and leave the quantity the same when the stomach is not very irritable, while stopping the food altogether for a few hours may be necessary, if there is not much vomititing. Yet, in very small infants the stopping of the feeding is dangerous, as cyanosis may appear.

In all cases of indigestion the food should be reduced to an amount which represents an energy quotient of 70 to 80 calories and should be maintained there until dyspeptic symptoms disappear. In larger infants (more than 1800 grams) it is often advisable to reduce the food to a quantity that represents 60 calories (E. Q.)

I used various methods in order to increase the digestion. Budin has had remarkable results with pepsin, and in a few cases pepsin in the form of Fairchild's essence of pepsin was administered. In these cases I could not find the striking results which Budin obtained, yet in those cases characterized by colic, or evidences of proteid indigestion it should be given.

Further observations on the subject of indigestion will be given under the headings, Loss in Weight, and Inanition.

ANOREXIA.

Not infrequently premature infants become somnolent and show no disposition to nurse; occasionally a repugnance to food is manifested. These are symptoms of overfeeding, hypothermia or infection. A dose of castor oil should be given, less food administered, if too much has been given, and gavage employed. In several cases I used a physiological salt solution, *per os*. This supplies water and, after a few doses, induces a thirst, which causes the infant to drink its milk eagerly.

In fact, the stimulation of the appetite is very necessary in many cases. Since Pawlow found meat extracts as powerful stimulants of the digestive juices, the employment of meat broths seems rational. In fact, we used small doses of mutton broth in many cases (see Inanition). Wine of cod liver oil (Merck) was also employed as a digestive stimulant.

CONSTIPATION.

Several authorities draw attention to the fact that premature infants are subject to constipation. The muscular coat of the bowel either lacks the power, or the mucous membrane is less irritable. At any rate the evacuation of the bowels needs daily attention. As a rule, an enema of salt solution was employed. In several cases olive oil in half teaspoonful doses twice daily was used but not always successfully. Castor oil can be given, but has the well-known disadvantage of constipating afterward. All of our infants suffered from constipation when the diet was not excessive in quantity.

VII.

THE NUTRITION.

Several disorders may be properly classified under nutritive disturbances. At the outset, it may be profitable to observe normal and abnormal variations in the weight. All infants lose weight immediately after birth, but premature infants in incubators, especially, may lose, relatively, more than the infant at term. Thus, in the Second Series, the loss in weight is represented in Table 23.

This table illustrates the loss in weight of five of our infants who ultimate did very well. When it is recalled that the initial loss of the infant born at term is about 11 per cent of its body weight (Holt), simple calculation shows at once that these infants in the first five days lost as follows: John H. 9 per cent, Pearl 11 per cent, Omega 4 per cent, Margaret 14 per cent, St. Louis 12 per cent; the loss, therefore, was not more than the average infant at term, but it must be remembered that these infants are fed regularly after the first few hours, while the infant born at term gets very little until about the third day. Then this does not represent the total initial loss as most of our babies lost for one or two more weeks. The total initial loss was as follows: John H. had the lowest weight on the fifteenth day (Table 16), initial loss 13 per cent; Bernice, lowest weight on the twenty-first day, initial loss 3 per cent; Pearl, lowest weight on the ninth day, initial loss 11 per cent; Omega lowest weight on the fourteenth day, initial loss 5 per cent; Margaret, lowest weight on the twelfth day, initial loss 12 per cent; St. Louis, lowest weight on the eighteenth day, initial loss 12 per cent.

Loss in Weight (Grams), First Five Days.

Name.	2d Day.	3d Day.	4th Day.	5th Day.
John H.,	75	67	00	00
Pearl,	64	79	28	22
Omega,	25	10	29	7
Margaret,	57	86	79	27
St. Louis,	29	92	36	7

Table 23.

All of these infants, who lost more than 10 per cent suffered from indigestion, hence their loss should not be compared with those of healthy infants. There should be no extreme loss in weight in premature infants if the feeding and water supply is properly adjusted. No doubt the highly-heated incubator favors loss of weight by evaporation. Unfortunately, the records of the First Series on this point are incomplete. I, therefore, must refer to one little infant treated recently in private practice, who was kept at a warm room-temperature (75 to 78°F.) but clad warmly and a hot-water bottle usually applied to the body. The weight at birth was 1820 grams. The infant was put to the breast every two hours soon after birth and in addition pasteurized whey was given in quantities of 4 to 8 cc. every hour and a half. The lowest weight on the third day was 1760 grams. Hence, the initial loss was less than 4 per cent.

It remains to examine a few fatal cases:

C. G., weight on arrival at the incubator 910 grams, second day loss 84 grams, third day loss 30 grams, fourth day loss 58 grams. The initial loss was 19 per cent.

E. K., gestation 7 monts, weight on arrival 1930 grams, second day loss 67 grams, third day loss 38 grams, not weighed on day of death.

W. K., gestation 25 weeks, weight 1100 grams, second day loss 31 grams, third day loss 76 grams, total loss about 11 per cent. Slight edema occurred on the second day.

These cases demonstrate that, as a rule, infants who die in a few days lose weight relatively more rapid than those who survive. This again accentuates the importance of prompt and careful alimentation. The prevention of a rapid loss in weight is one of the difficult problems in the care of premature infants.

Persistent loss or stationary weight characterize inanition, malnutrition and marasmus.

In studying the gain in weight, it is obvious from the cases reported (Section IV) that one gram daily is a satisfactory increment of growth. A sudden gain of weight often signifies the appearance of edema. A rapid rise in weight in a very sick baby is often the precursor of death.

ANEMIA.

Nutritional disorders, obviously, can not entirely be classed among functional disorders, and yet there are a large group of peculiar appearances in the premature infant for which no other cause than the inherent defects of the premature birth can be assigned. One such condition is anemia.

Several writers have drawn attention to the peculiar tendency of the premature infant to become very anemic. Now, since the infant born at term, according to Bunge, has an excess of iron stored in the liver, the deficiency of iron in human milk is perfectly compensated, at least during the period of the first half year. However, if the baby is born before term, it has been assumed that there is no accumulation of iron in the liver; I am not sure that any comparative analyses have been made to establish this assumption. At any rate, the hypothesis that premature babies become very anemic because an inadequate supply of iron exists in the liver rests on a very shaky foundation. My own experience in private practice with several premature infants not kept in an incubator, fed on mother's milk, and digestion good, sustains the position that premature infants have no special tendency to become anemic.

Quite different results were obtained at the World's Fair Baby Incubators. The tendency to anemic condition was very strong. Practically, all the infants became very anemic after a few weeks, one or two extremely so. Thus, Mildred, examination October 1st, in incubator five weeks, showed a hemoglobin content of 45 per cent (Talquist); and Jack, who had been in the incubator somewhat longer, gave 65 per cent. It is true, however, that the older the infant the less liability to this anemia, *e.g.*, Annie (weight at birth, 2456 grams), after six weeks, 70 per cent; John H., weight 1790 grams, six weeks old, hemoglobin 65 per cent. One month later the hemoglobin of John H. had fallen to 40 per cent. There can be no doubt that severe indigestion predisposes to this anemia; in the case of St. Louis, for example, six weeks in the incubator caused the hemoglobin to fall to 60 per cent. Meanwhile the infant had severe indigestion which persisted, and one month later, while the baby was very much improved and had gained in weight, the hemoglobin had fallen to 35 per cent.

Ballantyne recommends the administration of the peptonate of iron and manganese to premature infants to prevent anemia. We used iron vitellin, giving 15 drops of the well-known solution to each infant three times a day. There was some benefit, but it did not altogether prevent the loss in hemoglobin. Omega, weight 2158 grams, hemoglobin on admission 100 per cent. was given iron vitellin three time a day, and yet in one month the hemoglobin had fallen to 85 per cent. In the case of Pearl, also, in spite of the addition of iron the hemoglobin fell 15 per cent in one month. The administration of broths in a few cases had no effect on the hemoglobin.

Only my general impressions can be given as to the actual cause of the anemia. The incubator seems to predispose, if not actually cause, a loss of hemoglobin. The following deductions seem fairly well established from my observations :

1. Premature infants reared in the room are less liable to anemia than those kept in the incubator.

2. Keeping the incubator very warm increases the loss of hemoglobin.

3. Indigestion increases the anemia.

4. The anemia increases as the stay in the incubator is prolonged.

5. The administration of iron can only partially diminish the loss of iron.

It is clear, then, to treat this anemia, in addition to the administration of iron, the infant should be removed from the incubator as soon as possible.

EDEMA.

Premature infants show a remarkable predisposition to the appearance of edema. It occurs especially in connection with anemia, but it may appear in those whose blood shows little diminution in hemoglobin. Indigestion and malnutrition favor its appearance in a marked degree. Several of such cases occurred among the babies on the " Pike." One observation made, appears to corroborate very forcibly the fact established by Widal, etc., that an excess of sodium chlorid in the blood favors the retention of serum in the tissues. In two cases, in which on account of an irritable stomach an insufficient supply of food was given and a 1 per cent solution of sodium chlorid was administered by the mouth and rectum, edema in a severe degree appeared. This disappeared promptly on the withdrawal of the salt.

Here I can not refrain from suggesting, parenthetically, that cases of obscure edema in infancy may be explicable on the ground that too much much salt has been added to broths or cereal decoctions.

We gave adrenalin chlorid for the edema without definite results. The treatment depends on the other conditions—indigestion and malnutrition.

INANITION, MARASMUS.

The artificial conditions under which the premature infant is reared predisposes to inanition and atrophy, even when the imperfect development of the digestive apparatus is not considered. When, in addition, premature infants are housed together in the same room and hospitalism has its full force, the occurrence of such cases are only to be expected. Still there can be little doubt that the careful supervision of the nutritive processes will entirely prevent this.

When I took charge of the incubators there were two extreme cases of atrophy in the incubators. Both recovered. Their records, briefly told, are given as contributions not only to the subject of premature infants but also to the general subject of infantile atrophy from a clinical and, especially, therapeutic standpoint.

CASE 5.—Jack, admitted May 9, 1904; age uncertain, but born several days before admission, gestation 30 weeks (doubtful), weight less than 1000 grams; received in atrophic condition; was placed in incubator at 35°C. Eight hours later, with the incubator at 36°C., the rectal temperature rose to 103°F. The infant showed signs of weakness and was given whisky (full dose). The food given was a modification of cows' milk (exact composition not recorded) in quantities of 8 to 15 cc. After twenty-four hours the incubator temperature was reduced to 30°C., when the rectal temperature fell to 97.2°F. The baby refused his food, gavage was employed, and the milk peptonized. On the third day the rectal temperature fell to 96°F. On the fourth day I find the following order: "Temperature of the incubator to be 36°C if the temperature of the body is below 100°F."

Evidently this was carrying out Blair's recommendation. (*Loc. cit.*). The rectal temperature then rose, but the incubator was again reduced. On May 13th, the rectal temperature dropped to 94°F. There were as yet no dyspeptic symptoms, but on the following day slight bloody stools appeared. A purulent ophthalmia also showed itself which was treated by applications of boric acid solution and some ointment. The stools showed no blood after the second day of illness, the temperature remained practically normal but the temperature of the incubator was not recorded.

May 17th the rectal temperature again fell to 94°F. On the following two days it varied between 95 aud 99 5°F. Gavage was usely employed. Food 15 cc. every two hours. On On May 24th the order reads to keep the incubator temperature not higher than 94°F.

May 30th the baby was receiving 15 to 30 cc. of milk mixture every two hours. Digestion fair; temperature not recorded. No weight has been recorded.

June 3d the rectal temperature 98 to 99°F. Incubator temperature 34 to 36°C. [It is remarkable what adaptation of the organism to high heat has occurred.]

June 5th the rectal temperatture 99.6 to 101.2°F. Incubator temperaturc 30 to 31°C. Stools showed signs of indigestion, because of this and slight growth, beef juice and panopepton were given.

June 9th the feeding was changed, 30 cc. of mother's milk were given at a feeding—eleven feedings daily; this represents about 230 calories. As the weight of the infant is not recorded the energy quotient can not even be approximated. But as the infant was still very small, the energy quotient must have been about 200. Food was slightly reduced on the following day. In spite of this the infant cried at times as if hungry. Modified cows' milk had to be substituted occasionally. Rectal temperature normal (between 97.6 and 99°F.), incubator temperature not recorded. The food a few days later was again reduced—mother's milk, 15 cc., eleven feedings daily.

June 25th the weight recorded was 1230 grams; is taking mother's milk having an equivalence of about 200 calories (E.Q.). Temperature normal, incubator temperature not recorded. On the following day the baby was put to breast several times, signs of indigestion were present, and the temperature dropped to 95°F. on one occasion. The baby was fed irregularly—put to breast, mother's milk from bottle and occasionally given a modification of cows' milk, panopepton as a tonic. Stools not loose, in fair condition. The supply of mother's milk giving out, the infant, in July, received cow's milk again.

July 19 he was placed on Eskay's food; he was given about 45 cc. every two hours. After a few feedings he refused to nurse and gavage was employed. He vomited several times and the stools became worse. Mother's milk had to be used ugain. A few days later he was again placed on Eskay's food, 30 cc. every two hours.

July 26th the infant was very weak; solution of glonoin and whisky were used. He revived again and seemed better after a few days, and was again placed on food in quantities varying from 30 to 60 cc.

About August 10th Eskay's food was increased to 60 cc., when the stools became very free and large. This continued for several days without improvement. Human milk had to be used again.

September 2. (I took charge). Found a small atrophic infant, skin appeared very pale, weight 1690 grams. The incubator was lowered to 84°F., this was agained lowered in a few days to 82°F. and in about two weeks to 80°F. Milk prescribed was human milk, 60 cc. every two or three hours, nine to ten feeding daily. In spite of this large quantity of human milk the infant did not gain. The stools were large and pasty and the temperature normal.

After a few days an attempt was made to stimulate absorption. The mother's milk was reduced to 30 cc every two hours, or about 200 calories daily, which still made the energy quotient fully 150. Since it has been shown that small quantities of peptone or albumose stimulates absorption, 3 grams of somatose were given with each feeding, commencing September 9th. The infant was also put to breast at times, and weighing showed that about 1 1/4 ounces was ingested. The somatose was continued for one week without any special gain in weight. Unfortunately, a modification of cows' milk (whey and cream mixture) had to be substituted frequently as human milk was deficient. This mixture was Formula 1, and had a caloric strength of only 11 to the ounce (see Section IV). On September 21st the milk was increased to to 45 cc., ten feedings daily, this give an energy quotient of nearly 200; but still there was little gain in weight. The use of wine of cod liver oil (Merck) in 20 drop doses had slight effect.

September 30th Dr. O'Neal made the following note: For the past week or two the head had a hydrocephalous aspect, the hair thin, rather inclined to be long, veins prominent over the parietal eminences; posterior half of the head large and full; forehead prominent but not protruding. Mouth breather.

On October 1st the milk was diminished to nine feedings daily, of 30 cc. each, representing an energy quotient of 120 calories. Some meat broth (4 cc. in 8 cc. of barley water) was given with each feeding as a tonic. The infant gained on this steadily. The baby was taken out of the incubator every day for at least two hours.

October 6th the head measurements were: Circumferences, occipitofrontal, 13 1/2 inches; parietofrontal, 13 inches; sub occipitobregmatic, 13 inches. For constipation 1/2 teaspoonful of olive oil twice daily.

October 12th, ovoferrin, 20 gtts, three time daily. The broths were discontinued. Gain in weight very slow.

October 15 the infant was put on a minimal diet for a few days. Energy quotient less than 80 calories. His gain was about the same. In the next ten days with an average quotient energy of about 120 calories he gained only 4 ounces. But in the next two weeks with an energy quotient of about 100 calories there was practically no gain. After that the gain was steady on an energy quotient of 110 to 120 calories. His weight on leaving, November 30th, was 2186 grams. He graduated from the incubator November 13th.

This infant would probably have done much better out of the incubator. The prolonged early heating seemed to diminish vital activity. Even on large quantities of food (200 calories energy quotient) he did not gain in weight. A minimal feeding had no remarkable result. His best gain was on a food whose value was 125 energy quotient. Broths and medicines had little effect. I understand the infant has done very well since being taken home.

CASE 35.—Mildred, gestation 30 weeks, admitted a few hours after birth in good condition, weigh 1475 grams. Date of admission August 17, 1904. Placed in incubator at 96°F. In another place (Section III) has already been told the result of the high incubator temperature (see Chart 5). Its effect on digestion has also been referred to. She was somewhat overfed the first week, became slightly cyanosed when nine days old, with a rectal temperature of 101.°F. She had green, undigested stools following the twelfth day of life. Her rectal temperature fluctuated from 96 to 101°F. When three weeks old she weighed 1360 grams. Her food was exclusively human milk, in quantities represented by 80 to 90 calories energy quotient.

On September 2d, when she came under my care she weighed 1200 grams. Why she had fallen off until she weighed so little I am still not able to determine. She was not greatly overfed, the only condition which I thought abnormal was the high incubator temperature in the early days. Probably, also, a mild infection had occured.

On September 3d I ordered an increase of the milk, 15 cc. every hour and a half in the day time and two hours at night; incubator temperature 86°F. The increase of food gave the infant 110 calories energy quotient. This caused a gradual increase in weight for a few days. In her case, also, the administration of somatose was tried, with no effect. On September 18th she weighed 1340 grams; in ten days her weight had dropped to 1135 grams and she seemed in a wretched condition. What caused this further drop? Possibly some infection, aided by overfeeding, for on September 20th for some reason she was given more milk (energy quotient, 170 calories). Vomiting and slight diarrhea ensued. The milk was at once brought down, and her rectum washed out daily with salt solution. For vomiting, solution of adrenalin was prescribed, which also acted as a stimulant.

On September 23d I had to reduce her to a minimal diet. For twenty-four hours the food represented energy quotient of 40 calories. This greatly lessed food quantity necessitated the raising of the incubator temperature again to 86°F. In spite of this great reduction in the food the digestive disturbance continued for days. Thin stools and tympanites were the principal symptoms and the infant became very weak. Whisky and nux vomica had to be administered.

September 25th 4 cc. salt solution were added to the milk and sugar solution, but the salt was continued for two days only. On the 28th the food was increased to 15 cc. every hour and a half and the baby commenced to gain slowly.

It was a terrific fight. Marasmus and enteritis in a premature infant. For several days it seemed our efforts would be in vain. I do not know what saved it. I attribute most to the practical starvation for a few days, when only 1 dram of mother's milk in 2 drams of sugar solution were given every hour and a half.

October 8th there had been a marked gain in weight—1310 grams, but it was found to be caused by edema. Even at this time the stools were still offensive. She was getting food representing an energy quotient of 130 calories.

October 9th this note was found: Several abrasions on the genitals; erythema on right side, abdomen and legs; edema lessened; whole body very white, pasty color; leaden hue to eyes and lips at times. Has been very weak for the last two weeks.

October 14.—Began the use of ovoferrin.

October 22.—Improvement has continued. Weight, 1445 grams.

October 29.—Weight, 1568 grams; food, 160 calories energy quotient.

November 5.—Weight, 1654; energy quotient 140 calories

November 12.—Weight, 1811 grams; E. Q. 140 calories.

November 19.—Weight, 1888 grams; food, 135 E. Q.

November 26.—Weight, 1938 grams; food, 146 E. Q.

The improvement continued. She did very well when she left the incubators, when she was fed entirely on a whey and cream mixture. Weight, on the day of leaving incubators, 2002 grams. She had been out of the incubator for three weeks.

This case only serves to emphasize the fact that the treatment of inanition and atrophy consists in the careful observation of infinite details in everything concerning hygiene and nutritrion. The practical lesson to be learned is that a high incubator temperature prediposes to atrophy. Several years ago ("Thermic Fever in Infants," *Pediatrics*, 1898) I called attention to the fact that atrophy is very liable to follow overheating in infants. My experience with incubators only confirms this statement. The forced pyrexia in the case of Mildred during the first week of life, was the principal cause of her subsequent inanition, even admitting that a mild infection occurred later

VIII.

THE INFECTIONS.

We have seen what immense difficulties are encountered in the regulation of heat and food supply, and this holds especially true when the infant weighs less than 1500 grams, but a still more important consideration is found in the infections. Infections spare none of the infants, the smallest and the largest may succumb. The "graduate" may go as rapidly as the new born. One of the objects concerned in the rearing of the premature infant is the prevention of infection, but every pediatrist will concur if I state that in any institution where many infants are placed together it is a most difficult problem.

What are the infections that kill premature infants?

They are the same that are encountered in every foundling asylum. One infant or an attendant acquires the disease on the outside and this forms the source of the epidemic. Infants in institutions die in epidemics; the high death-rate is the result of repeated catastrophes.

Inasmuch as any incubator institution taking care of more than one or two infants is practically a similar institution to a foundling asylum, the dangers of the latter are only accentuated in the former. A baby asylum is a success only when human milk can be fed, and the most rigid asepsis is enforced. This holds especially true for the incubator institute. Our experience on the "Pike" only accentuates well-know facts, that asepsis in all things must be rigidly enforced.

There are two portals of entry for the infection which should be especially considered—the respiratory tube and the alimentary canal. Hence, the food and air form the most common carriers of infection. The other carriers are those things which come in contact with the infant, namely, the nurses' hands, nipples, thermometers, clothing, napkins, etc.

THE AIR INFECTIONS.

The infants are very subject to influenzal and pneumococcic infections, resulting in inflammation of the respiratory tube. These infections arise from some one who has the disease. Fortunately, we had no respiratory infections, that were recognized clinically. Budin reports an epidemic among his premature babies ("Le Nourrison," page 105). I am very familiar with these epidemics in the Bethesda Foundling Home. The origin of these are visitors, most commonly the nurses or wet-nurses. Hence, the following rule must be adopted, especially in the colder months: No nurse must care for the premature infant, and no young mother must nurse an infant, who shows any signs of acute infection of the respiratory tract, that is, bad colds, angina, bronchitis, laryngitis, tracheitis. Nurses with a "bad cold" must be excluded until they are better.

GASTROINTESTINAL INFECTIONS.

The Incubator Institute on the "Pike" had a frightful experience with gastrointestinal infection. During the first part of the season, in charge of my predecessor, for a time mothers' milk was not procurable, and through some error an infected baby, an infant with gastroenteritis was placed in the nursery. Following this, an epidemic of gastroenteritis commenced, and until September 2d, it raged continuously. It was the catastrophe of hospitalism.

On September 1st, when I took general charge, the most rigid rules of asepsis were laid down and carried out and the epidemic subsided.

But how does this epidemic spread? In this epidemic, the data on hand are insufficient, but the epidemics spread mostly by the fingers of the nurse and the nipples. When the nurse cleanses the mouth of an infected infant, and without thoroughly disinfecting her fingers, another mouth is washed, the germs may be carried in this way. The nipples may be insufficiently boiled. Another common method is the thermometer when used in the rectum of the infected baby and, when not sufficiently disinfected, introduced into the rectum of a healthy infant. The diaper may serve as a source of infection, especially when only slightly wet it is dried and placed on another baby, Flies and insects may light on the lips of one baby and carry the infection to the mouth of another.

It must be conceded that part of this epidemic may have been due to the milk, although it was mostly sterilized.

More concerning this epidemic will be related in the next section.

Besides the gastroenteritis, there are several forms of septicemias that occur in the newly-born. The origin of the infection is probably in the food. I refer to the so-called hemorrhagic diseases. Again, occasionally, on the third or fifth day, there may be a sharp rise in the temperature with no hemorrhagic spots, but the infant rapidly succumbs. It has been shown that the mucous membranes of the newly-born are permeable to bacteria, and this probably holds true for the premature infant. Hence, a variety of septic infections, or septicemias, may occur without any local lesions. We had a few examples of this.

Infections of the conjunctiva are common in the newly-born, and even more so in the premature infants. It is a very easy matter to carry the infectious material from one eye to the other. Several cases of purulent conjunctivitis occurred among the babies.

One of the most difficult problems is the question of oral asepsis. As the secretion of the muciparous and salivary glands are scant in the premature baby, the retention of milk-particles somewhere in the mouth is the rule. It is absolutely necessary to cleanse the mouth several times a day with a physiological salt solution or some mild antiseptic, and yet this very cleansing process is dangerous. I saw cases of thrush transferred in this way. It is so easy for the nurse to convey the spores of the saccharomyces from one mouth to the other, Thrush, however, is a comparatively mild disease, when we consider other pathogenic micro-organisms; *e.g.*, the colon or Shiga bacilli, may be carried in the same way, the importance of this mode of infection is obvious. Nurses must be taught to disinfect their hands thoroughly. After washing the mouth of any baby, especially a sick one, the fingers must be dipped in 70 per cent alcohol for a few minutes before washing the mouth of another baby. It is, perhaps, unnecessary to state that the rubber nipples must be thoroughly boiled between each nursing.

The mammilla of the wet-nurses forms a most common conveyor of infection. Let the wet nurse give the breast to one infant with a sore mouth, or with some disease, and very soon nurse another infant, the pathogenic germs may thus be carried one to the other.

This is a most troublesome method to deal with. The thorough disinfection of the mammilla is practically impossible. Boric acid solution, of course, is unreliable, and stronger antiseptics cause the nipple to harden and crack. The rough surface of the mammilla can not be thoroughly cleansed; 70 per cent alcohol is about as safe and effective disinfectant for the nipple as any with which I am familiar. But great pains must be taken that the wet-nurse nurses only perfectly healthy infants. The sick infants should receive their human milk from a bottle, which can be completely sterilized. The real solution of the question is this: Every mother should nurse her own baby and not nurse any other. But when one wet-nurse gives her breast to several infants, you can expect trouble. Altogether, it is safer, in the very young, to have the wet-nurse "milk" herself and feed the milk to the premature infant from a bottle. Of course, the rule does not hold in private practice.

Another source of infection is decomposed milk in the nose or nasopharynx. The infant vomits and the milk passes through the nose, where particles cling and by decomposition causes irritation. After vomiting through the nose, the instillation of salt solution through the nostril will be found helpful.

The skin forms another route by which the infant may be infected. The most common lesions are impetigo and furunculosis. When I took charge I found several cases of furunculosis. Again the cases started by having received an infant in the nursery with a few small boils. The disease spread. I discovered that the infants with boils on their bodies were placed on the same pad, while being dressed, as the healthy babies. The deposition of a drop of pus, however minute, conveyed the infection to the skin of healthy infants. Hence, the pads on which the babies are laid may initiate a severe epidemic. When the order was given that all infants with sores or boils on them should be placed on a special pad, the cover of which was changed frequently, the furunculosis stopped its spread.

The diapers may serve as a source of contagion. For a time the diapers, when only slightly wet, were dried again and placed on a baby, but unfortunately the baby was not always the same. Hence, any gastrointestinal or skin infection could be carried thus. I ordered each diaper to be burned after having been taken off. This was rather an expensive but effective measure.

Each infant should have its own thermometer, otherwise the thermometer should be kept in strong sublimate solution and washed off before using. The umbilicus, of course, may be a source of infection. When properly dressed in the beginning it will rarely be troublesome. The cord drops off much slower in the premature infant, and its decomposition should be prevented by allowing it to dry thoroughly and using an antiseptic powder.

The skin and mucous membrane of the premature infant must be considered as a wound from a surgical standpoint, and no septic material must be allowed to enter. It is not remarkable that the high incubator temperature should enhance the activity ot the bacteria in the mouth, nose and skin, when it is recalled that pathogenic micro-organisms grow best at high temperatures.

In any institution where premature infants are kept, certain rules of isolation must be maintained and adequate provision must be made for this isolation. Four departments are necessary, these should be in five separate rooms and entirely separate as regards treatment.

1. The Room for the Incubators.—Each infant must have its own incubator, which should be disinfected at least every second day. No promiscuous intermingling of the infants in different incubators is permissible. Suggestions as to incubators have already been made.

2. The Nursery.—Here the healthy "graduates" reside. Infants taken from the incubator should be kept under observation for a few weeks to ascertain their resisting power in the varying conditions of a warm room.

3. Room for Cleaning, Bathing, and Preparation of Food of the Healthy Infant.—This room should be accessible to the incubators and contain everything necessary for the care of premature infants.

4. Another room for the bathing, cleaning and feeding of sick infants or infants showing some mild infection, as thrush, furunculosis, indigestion, and ophthalmia. The most rigid asepsis must be practiced in this apartment.

5. A Hospital Room for Sick Babies out of the Incubator.—Here all acute gastroenteric infections or acute respiratory disease, or any contagious disease is isolated. This room should be entirely separated from the other rooms.

It will be seen that the incubator institute should have four departments. Separate nurses for each department are absolutely necessary. Wet-nurses for each department should also be distinct. To repeat, the departments where everything must be separate, are as follows:

1. The nursery.

2. Incubators with healthy infants and their dressing room.

3. Incubators with slightly diseased infants and their dressing room.

4. The hospital for contagious diseases.

In the accompanying sketch (Fig. 11) the general plan of such an incubator institute may be readily seen.

I must admit that the building of the incubators on the "Pike" did not follow this plan, but insofar as it was deficient in carrying out these rules of isolation, its results were imperfect.

It need scarcely be mentioned that bottles, clothing, thermometers, etc., should never be taken from one department to the other.

The treatment of acute infectious diseases differs in no way in the premature infant from those at term. Of course, they can not do anything with gruels, yet, if dextrinized, they can be substituted for a short period for milk. We used liquid takadiastase for dextrinizing gruels. This was given to those infants who were sick with gastroenteric infection; a small quantity of human milk was gradually added. But the treatment of infectious diseases in premature infants must be mainly prophylactic.

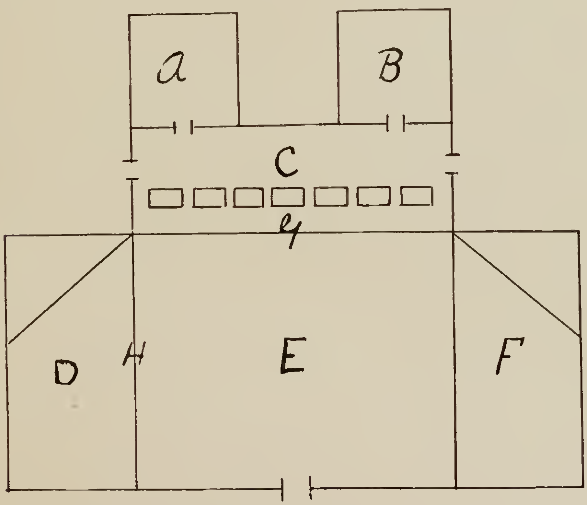


FIG. 11 —Diagram illustrating the ground plan of a public institution for Baby Incubators. *a*, Dressing room for healthy infants. *b*, Dressing room for infants showing some mild infection. *c*, Room for incubators. *d*, Nursery for healthy ' graduates." *e* Room for visitors, separated from *c* and *d* by glass partitions *g* and *h*. *f*, Baby hospital room for contagious diseases.

IX.

MORTALITY.

Statistics concerning the death rate of premature infants from several sources are available. Only a few of these need here be given, and these are among the most recent. Before the introduction of modern warming methods, and especially the aseptic methods, the results were very uncertain. Several modern writers confess they have little success with premature infants. Hecker and Trumpp give the mortality from 30 to 50 per cent, according to the initial weight of the infant. A few years ago Voorhees (*Archives of Pediatrics*, 1900) published some interesting figures on this subject. In the second edition of his "Infancy and Childhood," Holt compares Voorhees' death rate with those of Tarnier. With the increased length of gestation, the mortality drops. At 6 months, only 16 per cent were saved by Tarnier. Excluding cases which died within a short time after birth, Voorhees saved 66 per cent; at 6 1/2 months, only 22 per cent of all were saved, and at 7 months 41 per cent survived.

Altogether, it seems that the weight of the infant serves as a better basis for comparing the mortality. Budin's statistics are based on the weight. He gives two tables which are here reproduced (Tables 24 and 25).

It will be seen that the results at the Clinique Tarnier, in 1898 give a total mortality of 10 per cent only, which are truly remarkable figures; but, on looking at the table it will be seen that nearly all the infants weighed 1500 grams or more. The death rate in infants of less than 1500 and more than 1200 grams is 60 per cent.

But even more remarkable results were obtained at the Clinique Tarnier (Perrett, *Rev. de Hyg. et du Med. Inf.*, 1903; see also Rothschild, "Tratie de Hyg. et Path. du Nourrisson," 1893). He gives the death-rate in 1899 as 17.8 per cent; but in 1900, with 148 subjects, it fell to 7.4 per cent; and in 1901 the extraordinary small mortality of 4.8 per cent was obtained in 144 subjects. In a total of 579 premature infants during four years' service, Budin lost only 59, or 10.2 per cent.

Category.	Weight, Grams.	Infants.	Deaths, No.	Deaths, Per cent.	Living, No.	Living, Per cent.
1	less than 1200	40	38	95	2	5
2	1200—1499	146	124	85	22	15
3	1500—1999	432	265	61.3	167	38 6
4	2000 or more	212	69	32.5	143	67 5

TABLE 24.

Showing death-rate of Premature Infants at the Debiles de la Maternite, Paris, France, 1895, '96 and '97.—Budin.

Category.	Weight, Grams.	Infants.	Deaths, No.	Deaths, Per cent.	Living, No.	Living, Per cent.
1	less than 1200	1	1	100	0	0
2	1200—1499	5	3	60	2	40
3	1500—1999	30	4	13.3	26	86.7
4	2000 or more	108	7	6.4	101	93.6

TABLE 25.

Showing death-rate of Premature Infants at the Clinique Tarnier, Paris, France, 1898.—Budin.

It is no wonder, therefore, that we must call him master and be very slow to criticise his methods. Of course, although I have not the exact figures for the last three years, these infants mostly weighed near 2000 grams. Nevertheless, the results are remarkable, and he obtained these by insisting that the infant's temperature should not be allowed to fall too low after birth, that it should not be kept too warm, that it

GENERAL MORTALITY—BABY INCUBATORS.

	April—December.			September—December.		
	No.	Died.	Recoveries, Per cent.	No.	Died.	Recoveries, Per cent.
Sex,						
Boys,	24	15	37.5	12	5	58
Girls,	32	18	44	17	5	70
Total,	56	33	41	29	10	65
Gestation, Months,						
Under 6	2	2	0	1	1	0
6	6	6	0	4	4	0
7	16	4	75	13	2	85
8	5	3	40	3	1	66.6
8½	2	1	50	1	0	100
Weight, Grams,						
Under 1000	6	6	0	4	4	0
1000—1200	5	4	20	2	1	50
1200—1500	4	2	50	2	0	100
Over 1500	13	4	69	12	3	75
Admission,						
April	2	0	100			
May	9	3	66.6			
June	9	8	11			
July	12	8	33.3			
August	8	6	25			
September	8	3	62.5			
October	7	5	29.5			
November	1	0	100			

TABLE 26.

Compiled by Dr. F. N. Gordon.

should not be overfed but get food enough, and that it should not be infected.

Before discussing various factors that influence the death-rate I will give the death-rate of the infants at the Incubators on the "Pike." (Table 26)

On account of the imperfect data it will not be practicable to make a comparison of the mortality of the First Series —May to August inclusive, with the figures of Budin. The death-rate during September to November (Second Series), when placed in the categories suggested by Budin, is shown in Table 27.

Category.	Weight, Grams.	Infants.	Deaths, No.	Deaths, Per cent.	Living, No.	Living, Per cent.
1	less than 1200	6	5	83.3	1	16.6
2	1200—1499	2	0	0	2	100
3	1500—1999	6	1	16.3	5	83.3
4	2000 or more	5	1	20	4	80

TABLE 27.

Showing the death-rate of Premature Infants during the months of September to November, 1904, inclusive.

I must admit that this table is not entirely valid, since a few of these infants were turned over to me from the First Series in the incubators. One infant I have excluded from this table, it was an infant weighing 3182 grams and suffering with atelectasis. It died a few hours after it was received and was never in the incubator.

The two deaths of infants weighing more than 1500 grams are scarcely pardonable. One was clearly an infection, the other died from multiple hemorrhages after a very long drive in the ambulance. Excluding infants weighing less than

1200 grams, our mortality from September 1st to December 1st, 1904, of premature babies placed in the incubator was about 15 per cent.

What has our experience taught in regard to the weight of the infant and its likelihood of living?

Infants weighing less than 1200 grams at birth rarely live with any form of treatment. The cause of death is an inadequate food absorption, so that signs of exhaustion soon appear (cyanosis and hypothermia).

Literature, however, records a few infants who weigh less than this and still survive for many months. Occasionally an infant, as in the case of twins, will not be born until 8 months' gestation and still weigh less than 1300 grams and will, consequently, have more resisting power. Undoubtedly, infants born at 6 months' gestation, or less, weighing less than 1000 grams, may live in spite of its weakness.

Before dismissing the subject of the mortality, it is interesting to note that the inherent vitality of premature infants seems to differ; some apparently struggle through unhygienic surroundings and thrive with very little care on the part of the mother. The case reported by Oberwarth (*Berliner Klin. Woch.*, July 13, 1903) is instructive in this connection:

A male infant, prematurely born at 27 weeks' gestation, was wrapped in a newspaper and laid on a couch, where it remained for eight hours. It being still alive at that time it was placed in bed with its mother. Thereafter it was placed in a basket and surrounded by hot bottles. For nineteen days its skin was very cold. On the tenth day it weighed 1 pound (about 455 grams). It was fed on cows' milk, 1 part to 3 parts of water, with cane sugar added. It was too feeble to nurse, so it was fed with a spoon, receiving about two tablespoonfuls every two hours. On the twelfth day, in June, it was taken out of doors. When one month old it weighed 750 grams and was growing very well, in spite of a suppurative otitis that developed.

This infant was entirely under the care of the mother, only the midwife gave advice as to care and feeding. It received a daily bath.

In literature Oberwarth found seven cases of infants weighing less than 2 pounds (910 grams) who lived varying periods from 10 days to 11 years.

One remarkable example may be cited from our cases, First Series:

CASE 31.—Esther, born June 30th, gestation 5 1/2 months, weight 600 grams; entered with a rectal temperature of 104.4° (portable incubator too warm). Placed in incubator but the temperature was not recorded. She was fed on mother's milk in 20 drop doses every hour. Became cyanosed several times during the first twenty hours. Her rectal temperature remained above 102°. She was given whisky and oxygen for its cyanosis.

July 31,—Rectal temperature 99 to 100°. No cyanosis recorded. Mother's milk 20 to 25 drops every hour. This milk was given diluted with water.

August 1.—History about the same.

August 2.—Rectal temperature 98°; defecation only on saline enema.

August 3.—Rectal temperature 97 to 99°.

August 4.—Rectal temperature fell to 96°, but was again raised to 100°. Mother's milk increased to 2 cc. every hour.

August 7.—The infant suddenly became cyanosed, with a rectal temperature of 103.6° (infection or incubator too hot?), and died in a few hours.

This infant lived one week and its maintaining life so long gives hope that with greater care some may be saved who are even of less than 6 months' gestation.

With infants weighing more than 1500 grams the death-rate should be small. In the case of infants weighing more than 2000 grams the death-rate should approximate that of infants born at term.

As to the cause of death in our cases, little need be said. Infection played a most important part during the First Series, and even later was not entirely absent. As mentioned, the infants weighing less than 1200 grams usually died of cyanosis.

The time of death is important. If it lives as long as three days infection must always be considered as a possible cause. Of our babies who died:

The number of infants living less than one day,	8
Infants living more than one day but less than three days, - - - - - - - -	7
Infants living between three and ten days, -	3
Infants living more than ten days, - - -	10

This shows that the mortality is greatest during the first four or five days. If infants live as long as one week their chances are very good.

Budin finds that exposure immediately after birth with a reduction of the body temperature has a marked influence on the mortality. Infants whose rectal temperature has fallen below 93° have little prospect. On the other hand, overheating the premature infant so that its rectal temperature reaches 103° is also harmful.

It was the rule that premature infants brought a great distance on a train or in the ambulance invariably succumbed. It is, therefore, preferable to try to rear a baby at home, however poor its surroundings, than to ship it to a distant city for incubator treatment. No infant lived that came farther than five miles in the city. None lived which came from places outside of St. Louis.

In summer the gastroenteric infections are most to be dreaded. It was a curious fact that the death-rate of the nursery graduates was higher than that of the incubator babies during the epidemic which has been previously mentioned. This is accounted for by the fact that the former receive substitute feeding and were less isolated than the babies in the incubator. A catastrophe like this epidemic endangers all institutions and is the most powerful argument against baby asylums of any kind.

X.

How Long Should an Infant Remain in the Incubator?

An answer to this question can not be given, since it must vary with the condition of the infant. In institutions conducted for show purposes there is a great liability to permit the infants to remain in the incubator too long. If the circulation of the air is perfect and the incubator temperature very low (75 to 80°) there is really no harm in keeping infants weighing less than 2500 grams in the incubator longer than the immediate needs require. Yet, it is a good rule to keep the infants in the incubator only so long as is absolutely necessary.

A premature infant who has been kept in an incubator relatively warm, can not be brought out so soon as when the baby is at once accustomed to a lower temperature.

When the digestion is good and an increase of weight progressive, the temperature of the incubator may be lowered rapidly, and the infant removed in one or two weeks. On the other hand, very small infants with feeble digestive power and gain in weight may be kept in the incubator for one or two months. One of our infants remained in the incubator nearly six months. This was Jack, who suffered severely from gastrointestinal disturbance and infantile atrophy. It is a question, however, whether he would not have done better outside of the incubator. The incubator treatment of infantile atrophy, as has been suggested by some writers, can find little support from our experience.

Commonly, the rule as to the incubator is as follows :

Infants weighing less than 1200 grams should remain in the incubator about two months. Infants weighing between 1200 and 1500 grams should remain in the incubator six weeks. Infants weighing 1500 to 2000 grams should remain in the incubator three to five weeks.

WHAT INFANTS SHOULD BE PLACED IN THE INCUBATOR?

My own experience in private practice, as I shall mention again below, is that infants of more than 32 weeks' gestation and weighing more than 2000 grams (4 pounds) need no incubator. Hence, it should be a rule in any institution to receive infants only who weigh less than this. There is no lower limit as to weight, for, as mentioned, even the smallest infant, weighing as little as 500 grams and of less than 25 weeks' gestation, with a length of 10 inches, are very rarely saved. An effort should be made in all cases. It should be remembered, however, that no institution will have a good mortality record which accepts many infants weighing less than 1200 grams.

THE QUANTITY OF MILK TAKEN FROM THE BREAST.

Parenthetically, I desire to insert here a few observations made on the quantity of milk taken from the breast by premature infants. An accurate determination of the amount of milk nursed from the breast does not necessarily give a good index of the quantity actually required, since these young infants easily become fatigued and they do not possess the strength to draw the milk rapidly. A few of our babies were weighed before and after nursing and the gain in weight recorded as the actual amount of milk taken.

1. John, gestation 7 months, length of trunk 18.5 cm., age 2 months. At four different nursing took the following amounts: 23, 30, 16 and 24 grams.

2. Mildred, gestation 7 months, weight 1633 grams, age 3 months, length of trunk 17 cm., took at one nursing 75 grams.

3. Anna, gestation 8 months, weight 2988 grams, length of trunk 21 cm., took at two different nursings 38 and 46 grams respectively.

4. Edith, gestation 7 months, weight 4535 grams, age 6 months, took at two different nursings 185 and 140 grams respectively.

It was unfortunate that further observations were not made. As it is, the records are too few from which to draw any conclusions. It is interesting to note that one infant weighing less than 1800 grams took more than two ounces, and an infant, born premature, at 6 months of age could take as much from the breast as the average amount taken by an infant of the same age but born at term.

THE LENGTH OF PREMATURE INFANTS.

While the length of the infants were measured at various times, the figures are too irregular to be of any service. It seems much better to depend on the weight of the infant in estimating the food and the warmth required. In the preceding paragraph, no relation between the length of the trunk and the amount of breast milk taken could be made out. It is possible, however, that a certain approximate relationship of the length of the trunk and the capacity of the stomach may be discovered on further investigation. This might give us a practical guide as to the capacity of the premature infant's stomach.

THE VIABILITY OF THE FETUS.

I am not aware that any recent observation have been made on the viability of the fetus. There is little or no proof that the age of the viability has been reduced by modern treatment, when we define viability as the possibility to live. The age at which the fetus is viable must be maintained at about 24 weeks' gestation. The liability of surviving has been increased, however, by the incubator treatment, and in this sense it may be stated that the viability has been improved.

ICTERUS.

Premature infants are especially predisposed to physiological jaundice a few days after birth. In some this jaundice persists for weeks. Whether we adopt the theory of Hoffmeier as to the hematogenous origin of jaundice, or what seems more probable, that it has a hepatogenous source, it is true that during this period digestive disturbances are more apt to occur from a deficiency of intestinal juices. The feeding during this period must be carefully watched, and it will usually be found safer to give the increase in food every second or every third day.

Hemorrhages and infections of the skin are prone to occur during this icterus.

THE CHOICE OF THE INCUBATOR.

For show purposes, and even in institutions, the Lion Incubator or some of its modifications will be found most satisfactory. It is too ponderous for frequent transportation and perhaps too expensive for use in private practice. An incubator made after the plan of Rotch will be found very serviceable, but its objection, too, is that it is very expensive. A more simple apparatus is that of Blair, and no doubt is about all that is required when the attendants are well trained. Its simplicity is certainly a point in its favor, but it is also very heavy and its transportation by no means easy.

From its description, the incubator devised by Palano seems to fulfill the requirements of efficiency, compactness and cheapness.

The heating chambers of Ruhl and Denuce should by no means be despised, in fact, Blair's incubator follows this principle, that is, a chamber having double bottom and double walls between which warm water is poured.

The incubator modified by Hearson and introduced by Godson into England is a modification of the Tarnier apparatus and is probably very efficient. The incubator of Odile Martin will, however, be found more simple and less expensive. This may be briefly described as a box, length 82 cm., width 62 cm., height 45 cm., which rests upon a low stand. The cover is made of glass, the sides are hollow and made to contain water. The water is heated by an alcohol lamp. Except in size the principle is the same as the Blair incubator. The infant lies in a basket, which is surrounded by a wide space for the circulating air. A thermosyphon, or faucet for emptying the water, a funnel for pouring in the water, and a thermometer form other parts of the apparatus.

The incubator of Auvard is especially to be desired for simplicity and can be used in private practice. Yet its temperature requires constant supervision and unless a trained nurse or at least an intelligent attendant is always watching abrupt changes may take place in the heat or ventilation.

THE INCUBATOR CHAMBER.

Bosi and Guidi, in Venice, and Escherich, in Graz, have constructed large rooms which can be kept at a constant temperature, and which take the place of the incubators. No doubt, this has many advantages in institutional work, but it by no means prevents infection. Here is a brief description of the incubator room (Escherich Pfaundler):

The incubator chamber is situated on one side of a large room and is large enough and high enough for the nurses to enter. The frame work is made of iron and the two sides and top of glass. The floor of the room and incubator chamber are made of xylith. The heat is supplied by ordinary hot water tubes. The air is received from the outside and passes over the heating coils then over a vessel of water to give the required moisture. The air is filtered by a cotton filter. The heat is regulated by means of an increase or decrease of the ventilation. Electrical devices give warning that the temperature is going too high or too low

When two or three babies coming from a different source are housed together trouble can be expected. The incubator chamber of Escherich by no means prevents hospitalism.

The permanent warm bath, as recommended by Winkel, will never become very popular, since there are difficulties, which even his apparatus, can scarcely overcome. The frequent change of water necessitated by the excretions of the infant requires much work and care. The floating of the fecal material all over the body does not seem very hygienic. It is almost as difficult to keep water as air and iron radiant surfaces at a constant temperature, and the advantage of Winkel's permanent bath are more ideal than practical.

The Premature Infant in Private Practice.

Should the premature infant be sent to an institution? Unless the parents are very poor the answer will unhesitatingly be in the negative. No infant should be sent to a hospital or an asylum, when its need, though imperfect, can be fulfilled at home. This is likewise true of the premature infant. The results in private practice are much better than in an institution.

The practitioner should remember that the whole function of the incubator is to lessen the heat loss from the premature baby. Even some highly educated physicians erroneously seem to entertain the idea that the incubator in some obscure way aids vital activities and maintains the life of a feeble organism. Hence, any method adopted to meet the exigences of the case, according to the conditions present, which maintains the rectal temperature between 98 and 100° succeeds in doing all that an incubator can do.

In the first place infants weighing more than 2000 grams rarely need an incubator. Good clothing and a warm room, with an occasional hot water bottle will usually be found sufficient. In summer, when the terrestrial temperature is between 80 and 90°, even much smaller infants can be successfully reared out of the incubator. Thus, three years ago, in the case of an infant, weighing about 1250 grams, during the month of August, we had no difficulty in keeping the baby warm in a basket. He is a healthy boy now.

When the weather is colder other means can be devised. Placing the baby in a basket, five or six feet from a hot stove or steam radiator with a thermometer beside the baby may be all that is necessary. The old method of using hot water bottles around the baby in an open basket has the sanction of some of the best pediatrists. In warm weather this may be sufficient even for the smallest baby. For example, in a recent case, an infant weighing 2 pounds (900 grams), during the month of July, was placed in an open basket surrounded by hot bottles, and its temperature rose to 101°, so that the bottles had to be withdrawn. The hot bottles and weather accomplished all that was necessary.

Often an incubator can be improvised. Thus, for a recent case, during the cold weather, a box was lined with a blanket, a large opening made on one side, which was exposed to the heat of a steam radiator. Other openings in the upper and lower parts of the box provided for the entrance and exit of air. By placing the box nearer or further from the steam heater, the heat could be raised or lowered. A thermometer placed beside the baby indicated the temperature. With a little supervision this crude incubator worked very well.

Another practical incubator may be made on the order of Auvard. A box is divided into two compartments by a porous partition (wire screening, for example). In the lower compartment hot water bottles are placed through an opening made in the side of the box, which also admits air. This can be covered by a shuttle which serves to partially close the opening. In the upper compartment lies the baby on a blanket. A lid, with a large opening in it for the exit of the air may be used to cover the box. A thermometer reaches to the side of the baby by a small opening in the top or side of the box. The objection to these wooden apparatus is that they can not be properly cleaned. A good scrubbing inside and outside with strong soap occasionally, when the infant is taken out, will disinfect them sufficiently. After all, it is friction, soap and water that do the most effective cleansing even with the metal incubators.

When a good incubator can be obtained quickly there is certainly no reason that it should not be used, provided that intelligent people are in attendance. In fact, all premature babies should constantly have a trained nurse in attendance day and night.

I must repeat, the most difficult task in rearing premature infants, is not the prevention of heat loss but maintenance of a proper nutrition.

LITERATURE.

To those interested in a study of the premature infant the chapters on this subject in "Les Nourrison," by Pierre Budin, will be found especially valuable. Another valuable monograph is found in Volume III, "Monti's Kinderheilkunde." This article is especially valuable in the description of incubators. A very practical exposition of the subject is found in "Traite D'Hygiene et Pathologie du Nourrison," by Henri de Rothschild. Among American writers, Voorhees, in the "Reference Handbook of the Medical Sciences," has contributed a practical and valuable treatise. See also text-books by Rotch and Holt. A good list of the articles on the premature infant and incubators is appended to the article by Palano (*Munch. Klin. Woch.*, Volume I, page 1498, 1903).

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