

Description of a simple and efficient method of performing artificial respiration in the human subject especially in cases of drowning / by E. A. Shafer.

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DESCRIPTION
OF A
SIMPLE AND EFFICIENT METHOD
OF
PERFORMING ARTIFICIAL RESPIRATION
IN THE HUMAN SUBJECT
ESPECIALLY IN CASES OF DROWNING
TO WHICH IS APPENDED INSTRUCTIONS FOR THE TREATMENT
OF THE APPARENTLY DROWNED

SHARPEY-SCHÄFER BY
E. A. SCHÄFER, F.R.S.

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THE mechanical methods of performing artificial respiration in the human subject which have been most in use up to the present time are—

1. The Marshall Hall method, which consists in placing the subject in the prone position and rolling the body alternately into the lateral and prone position, making pressure upon the back when in the latter position.
2. The Silvester method, in which the capacity of the chest is increased by raising the arms above the head and thus dragging upon and elevating the ribs, the chest being emptied by placing the arms against the sides of

the chest and exerting lateral pressure on the thorax. The subject is throughout in the supine position.

3. The Howard method, which consists in emptying the thorax by forcibly compressing the lower part of the chest: on relaxing the pressure the chest again fills with air. The subject is throughout in the supine position.

It has been shown¹ that all these methods can be made to effect a sufficient intake of air in the human subject, but each one of them is attended by certain disadvantages, which become accentuated when the subject is in an asphyxiated condition, and especially when the asphyxia is due to drowning. For under these circumstances all the muscles are in a limp, relaxed condition: if the head is thrown back, as when the subject is supine, there is a tendency for the tongue to fall back into and to block the pharynx: there may be water in the air-passages, and an abundance of mucus is usually secreted, which, becoming churned up into a froth with the air and water, tends to block the bronchial tubes. There is also an enormous congestion and swelling of the liver, combined with and caused by great distension of the heart, especially of the right cavities. This last-named circumstance, viz. the congestion of the liver, renders the application of the Howard method extremely dangerous in cases of drowning, since forcible pressure upon the lower chest under these conditions is apt to produce rupture of the liver, an accident which occurred on several occasions in the dogs experimented upon by Dr. Herring and myself in our investigations into this subject for the Committee of the Royal Medical and Chirurgical Society.

The supine condition is strongly contra-indicated (1) on account of the tendency which there is in this position for the tongue to fall back, and (2) because this position does not facilitate but rather hinders the escape of the water, mucus, and froth from the air-passages, throat, and

¹ Report of Committee on Suspended Animation, 1903. The amount of exchange per unit of time was, however, not determined.

mouth. The Marshall Hall method has not these disadvantages, but it involves a considerable amount of physical labour, and the rolling of a heavy inert body over upon hard ground or upon the planks of a boat may easily produce bruising and superficial injuries which it should be our endeavour to avoid. The Silvester method, besides the objection that it involves the supine position, an objection which is peculiarly applicable to drowning cases, also demands a very large amount of physical exertion; and the dragging upon the humero-thoracic muscles tends to strain and otherwise to injure them. From the physiological point of view there is a fundamental difference between the Silvester method on the one hand, and the Howard method on the other, since the Silvester method is active in producing inspiration while expiration is passive, whilst in the Howard and other pressure methods, expiration is produced actively and inspiration is passive. Since the former appears more exactly to imitate the normal conditions of respiration, it might at first sight be supposed on that account to be preferable, but there is another element to take into consideration, viz. the part which is played by the nervous centre of respiration. For it has been shown (by Hering and Breuer, and by Head) that a main factor in exciting inspiration is the emptying and concomitant collapse of the lungs, so that if they are mechanically caused to collapse the inspiratory centre is stimulated through fibres of the vagus nerves distributed to the lungs, and, when the centre is acting, a normal inspiration is the result of such stimulation. On the other hand, mechanical inflation of the lungs has a tendency to inhibit inspiration and to depress the activity of the respiratory centre. During complete asphyxia the activity of that centre is in abeyance, but, as the subject begins to pass out of the asphyxial condition, it tends to resume its functions, and it is therefore clearly preferable to employ a method of artificial respiration which will stimulate the centre to activity rather than one which will depress its activity. Hence any pressure method is, on

physiological grounds, to be preferred to a traction method—apart altogether from the greater simplicity of manipulation. Further, for the reasons above given, the prone position is to be preferred to the supine, especially in cases of drowning.

The method about to be described presents none of the disadvantages which have been enumerated in considering the older methods. It is safe, efficient, and involves a minimum amount of labour on the part of the operator. It consists in laying the subject in the prone posture, preferably on the ground, with a thick folded garment underneath the chest and epigastrium. The operator puts himself in a position athwart or at the side of the subject, facing his head and kneeling upon one or both knees, and places his hands on each side over the lower part of the back (lowest ribs). He then slowly throws the weight of his body forward to bear upon his own arms, and thus presses upon the thorax of the subject and forces air out of the lungs. This being effected, he gradually relaxes the pressure by bringing his own body up again to a more erect position, but without moving the hands: as he does this, air is drawn, by the removal of pressure from the chest walls and by their elastic reaction, into the lungs. This process is repeated quite regularly and without manifest intervals between the movements not less often than twelve times a minute: it may be done somewhat more rapidly, but fifteen times a minute would, in any case, be sufficient. By this means it is easily possible in an average man to effect an exchange of fully 6500 cubic centimetres per minute¹—an amount which is more than enough to maintain complete aëration of the blood.

The advantages of this method may be thus enumerated:

¹ The data upon which this statement is made are given in a paper by the author presented to the Royal Society of Edinburgh, and published in the 'Proceedings' for 1903. The other methods all yielded far smaller results.

(1) The ease with which the physical operations necessary to carry on artificial respiration may be performed ; hardly any muscular exertion is required.

(2) The efficiency of the gaseous exchange produced by it between the outside air and the air in the lungs.

(3) The extreme simplicity of the procedure ; no complex manipulations are required.

(4) The impossibility of the air-passages being blocked by the falling back of the tongue into the pharynx.

(5) In cases of drowning the readiness with which water and mucus are expelled from the air-passages through the mouth and nostrils.

(6) It involves no risk of injury to the congested liver or to any other organ.

INSTRUCTIONS FOR THE TREATMENT OF THE APPARENTLY DROWNED.

Immediately on removal from the water, place the patient face downwards on the ground with a folded coat under the lower part of the chest. Not a moment must be lost in removing clothing. *If respiration has ceased, artificial respiration is to be commenced at once : every instant of delay is serious.*

To effect artificial respiration put yourself athwart or on one side of the patient's body in a kneeling posture and facing his head (see figure). Place your hands flat over the lower part of the back (on the lowest ribs), one on each side, and gradually throw the weight of your body forward on to them so as to produce firm pressure—which must not be violent—upon the patient's chest. By this means the air (and water, if there is any) is driven out of the patient's lungs. Immediately thereafter raise your body slowly so as to remove the pressure, but leaving your hands in position. Repeat this forward and backward movement (pressure and relaxation of pressure) every four or five seconds. In other words, sway your body slowly forwards and backwards upon your arms

twelve to fifteen times a minute, without any marked pause between the movements. This course must be pursued for at least half an hour, or until the natural respirations are resumed. If they are resumed and, as sometimes happens, again tend to fail, the process of artificial respiration must be again resorted to as before.

Whilst one person is carrying out artificial respiration in this way, others may, if there be opportunity, busy



Figure showing the position to be adopted for effecting artificial respiration in cases of drowning.

themselves with applying hot flannels to the body and limbs, and hot bottles to the feet ; but no attempt should be made to remove the wet clothing or to give any restoratives by the mouth until natural breathing has recommenced.

Hypodermic injections of atropine sulphate ($\frac{1}{100}$ th to $\frac{1}{50}$ th grain) and of supra-renal extract (either as adrenalin chloride or in any other form) may be used to assist recovery.

DISCUSSION.

The PRESIDENT, in introducing Professor Schäfer's communication, said that it contained the author's conclusions on the best method of carrying on artificial respiration in the apparently drowned. It was the outcome of a paper communicated to the Society a short time ago (1903) by Professor Schäfer, on behalf of the Committee on Suspended Animation appointed by the Society, and represented Professor Schäfer's own individual views.

Dr. BOWLES said that as he had so recently and so fully discussed the Report of the 1902 Committee, it would be unnecessary to do more than consider the method of resuscitation then proposed by Professor Schäfer as safe, simple, and sufficient. It was true that it was simple, and inasmuch as it was exactly and no more than the first movement in Dr. Bowles' own method, a copy of which he had sent to Professor Schäfer some time prior to the presentation of the Report, he (Dr. Bowles) agreed in principle with Professor Schäfer's method of introducing air into healthy lungs with diaphragm, respiratory muscles, ribs, and cartilages in their natural elastic condition, and air cells and lung tissue resilient and free from fluid or other obstructions; but in drowning Dr. Schäfer had again confirmed what Dr. Bowles had often found and reported during the last forty years in drowned human beings, that all the muscles were in a limp and relaxed condition, and that there was always a danger of the tongue falling back and adding to the asphyxia, and for fluids and mucus to be churned into froth, and so still further adding to the obstruction in the air-passages; the lungs too were sodden, hydræmic, and inelastic, and the chest walls much less elastic than in the healthy man.

It could not be expected, under the conditions existing in the drowned, that pressure on the back alone with the patient in the prone position could effect sufficient gaseous exchange between the outside air and the air in the lungs, as claimed by Professor Schäfer. Dr. Bowles had indeed as long ago as 1871 introduced two other movements, which he had found from experience of great use in obtaining real efficiency.

1st. The rolling the patient from the prone position on to the right side to increase chest expansion, and so introduce more air and relieve the heart and circulation from pressure, and at the same time allow the liver to rest, as it were, on the ground.

2nd. After a time—ten minutes or more,—when most of the froth and fluids had been removed from the surcharged lung, the patient's upper arm might be carried above the head, but with the patient on his right side, not on his back, as recommended by Dr. Sylvester.

The reasons for those movements were derived from his own experience, and that of other members of the profession, not only in drowning, but in comatose conditions generally, the mucous stertor of apoplexy, hæmoptysis, drunken stupor with vomited matter in the pharynx, bronchitis, and other maladies.

In his late speech on the Report, and especially in former papers, he had referred more in detail to such conditions, and he had still more recently dealt with it in his pamphlet on 'A Method for the Treatment of the Apparently Drowned.' It was clear that the Committee's Reports of 1862 and of 1902 were in practical agreement, and that they fully confirmed the soundness of the principles of the Marshall Hall method. Later experiences had, however, enabled Dr. Bowles to correct a few details in the application of those principles, so as to ensure complete efficiency in the method of treatment then submitted for the use of the public. The propriety of the application of warmth, of subcutaneous or rectal injections, of stimulants, or other medical means at particular moments could only be properly arrived at under medical supervision.

MR. WARRINGTON HAWARD thought the unprejudiced listener would see that both the methods alluded to in the discussion had advantages and disadvantages. But methods applicable to asphyxiated persons were not applicable to drowned persons. In the drowned the first necessity was to get rid of the fluid and froth from the lungs; hence the prone position is advisable in the early stages of the treatment. But something more than the measures recommended by Prof. Schäfer was required, and this, as Dr. Bowles had pointed out, was furnished by the rolling movement with a modification of the Silvester method by raising the free arm. It was also, no doubt, important to keep one lung clear by always keeping the patient on the same side. Thus it seemed to him that for the drowned the method of Dr. Bowles was superior to all the other methods—it combined their advantages, avoided their disadvantages, and added what was necessary to make them efficient. He suggested that the Society might now publish some definite pronouncement upon this matter.

DR. F. W. HEWITT endorsed the remarks of Mr. Warrington Haward. Dr. Bowles' method seemed the most likely to meet the generality of cases of asphyxia from drowning. He considered the prone method inadmissible because, at all events in the case of the deep unconsciousness produced by anæsthetics, the trunk weight was liable to interfere with or prevent that

elastic recoil of the parietes upon which lung expansion depended. He referred to a case of embarrassment of breathing in an anæsthetised infant from mucus in the air-passages, to whose chest he applied intermittent pressure, and it seemed that with each pressure less air was drawn into the chest, until at the fifth compression none entered, respiration coming to a standstill in the expiratory phase. Air was forced out, but the mucus seemed to act like a valve and prevent its entry. Fortunately respiration spontaneously recommenced after about two minutes' complete cessation, artificial respiration having failed to effect the entry of air. It was perhaps more important to provide for inspiration than for expiration, and the value of lung inflation must not be forgotten. He thought bleeding to relieve the right heart was probably a useful help to recovery.

Dr. F. P. WIGHTWICK also endorsed what Mr. Haward had said, especially as to the need for the Society formulating some authoritative rules. The Silvester method, although it was not certain that it was the best, was recommended everywhere, and advertised throughout the country. It was important that a definite instruction on the matter should be given by the Society.

Dr. M. S. PEMBREY, speaking from the physiological side, thought that the experiments by Hering and Breuer, quoted by Professor Schäfer, were not to the point, as the animals were under anæsthetics and were breathing, the nervous centres not being in abeyance as in drowning. Besides, impulses by the vagus were not essential to respiration; breathing went on after they were divided: absence of oxygen and excess of CO_2 were the important factors in the act. In regard to expiration or inspiration, it seemed to him that Dr. Bowles' method was the better, and one of the most important factors was to start the circulation so as to get oxygen to the medulla; this was helped by establishing negative pressure by the inspiratory movement, which was a part of both Dr. Bowles' and Dr. Silvester's methods. Similarly venesection was useful. This method of artificial respiration was absolutely useless in the case of a new-born infant, as the lungs were solid. Moreover, if, during even the first few days of life, the chest was opened, the lungs did not collapse, because they were not on the stretch as they were later owing to the chest growing more rapidly than the lungs. The old method practised by farmers in the lower animals of directly blowing air into the lungs was much to be preferred. The question of the rigidity of the thorax was also important, as in old persons no recoil was obtainable; the respiration in them was mainly abdominal, hence a combination of the methods was desirable. The importance of warmth was great, because it antagonised the depression of the nerve centres. As to fluid in the lungs, it was so rapidly absorbed that its presence was of

secondary importance. The Silvester method, he thought, did not meet all the requirements, but Dr. Bowles' combined method seemed adequate.

Dr. G. NEWTON PITT thought it would be desirable for any cases of rupture of the liver by the Howard method to be put on record; they were probably very few in the human subject.

Dr. HENRY R. SILVESTER said that the method advocated and described by the author as "simple and efficient" had the merit of being extremely ancient, having been practised in principle from time immemorial down to the middle of the eighteenth century, and might be called the simple compression method. Simple compression had been performed with varying details. Sometimes the patient was treated on the ground, but when possible the body was laid on a table with the head hanging over the edge, and pressure made on the back of the thorax by the hands of the operator. Before the importance of the function of respiration was fully appreciated it was probable that the object sought was the removal of the water from the body of the drowned person, which was believed to be the cause of danger, and there was no doubt that water when swallowed could be, by this simple means, removed from the stomach, although not from the lungs, which, as is well known, seldom or ever contain any large amount. Water in the stomach is usually vomited on recovery. During the eighteenth century the simple compression plan passed into the rolling method.

Dr. Silvester then quoted several of the earliest recorded cases in which the rolling method was used, with full details of the process, but this treatment was soon found to be "coarse, inefficient, and dangerous," and had to be discontinued. In the year 1774 the public were cautioned by the Royal Humane Society that "experience proves that this treatment is injurious, and often destroys the small remains of life;" and by the year 1862 all treatment by direct mechanical compression was rejected, and the directions issued by this society might be summed up in two words, "Apply warmth."

With regard to the means of restoring respiration in the apparently dead by drowning, Dr. Silvester stated that the instructions given by Professor Schäfer would be generally admitted to be faulty in principle, for it was sought by these instructions to make expiration precede inspiration, whereas in natural breathing expiration was always second in order, and not the primary act. In stillborn infants, whose lungs had never been inflated, forced expiration at first was, of course, impossible. A similar objection applied to the Marshall Hall rolling method. In most cases of asphyxia the chest was in a state of expiration, and therefore pressure on the thorax as directed by these instructions would not only aggravate this

existing evil, but would at the same time increase the passive congestion of the thoracic viscera.

Next with regard to the means to be employed to effect forced inspiration in the apparently drowned. After quoting the instructions given by Professor Schäfer, he said that in the unconscious person with the functions of the nervous system in complete abeyance, and the thorax in a condition of expiration, the expansion of the chest walls required for inspiration was dependent alone on the elasticity of the costal tissues, and consequently could take place only feebly and inefficiently unless receiving some active mechanical aid. But when the patient was lying prone, with the weight of his body resting on the most mobile part of his chest, and the diaphragm pressed up by the abdominal viscera against the lungs, and the vital capacity of the chest thereby diminished, he was placed under the most serious embarrassment so far as the entrance of air into his lungs was concerned. In order to obviate this evident disability, the plan of rolling very naturally superseded that of simple compression in the prone position, for, by rolling the body backwards, the natural resiliency of the ribs was allowed fuller play, though on one side of the chest only, and, in consequence, a limited amount of air could be drawn into the lungs. Any advantage possessed by the rolling method over simple compression was, however, neutralised by the danger of fracturing the cervical vertebræ, the fatigue of turning the almost lifeless body alternately on the chest and on the back fifteen times in a minute for some hours, and the employment of only one side of the chest at a time; also the congested condition of the heart and thoracic viscera rendered the pressure in the prone position dangerous in the treatment of cases of drowning; while the free elevation of the ribs on both sides of the chest, which is possible in the supine position of the body, and offered facilities for removing this state of congestion, was not taken advantage of.

The next point considered was what was the amount of air respired. It was ascertained by means of experiment that the amount of air inspired by this method was exceedingly small, and compared most unfavourably with the amount obtained in the Silvester method. The greater the amount of air inspired with each effort of the operator, the shorter would be the time required for recovery, and the better would be the prospect of resuscitation, for the greater would be the number of air-cells exposed to the revivifying influence of the oxygen admitted.

With regard to the amount of pressure likely to be exerted in following out the instructions given by Prof. Schäfer, when carried out by a seafaring population, he said that the pressure on the patient's chest would not be less than from thirty to forty

pounds. The weight exerted by the operator on the chest wall would probably be dangerous in the case of infants and the aged. He pointed out that another great objection to this form of treatment was that it could not be carried out in a hot bath; a similar objection applied to the Marshall Hall rolling method, and this would render impossible the universal adoption of either of these systems. The Silvester method was the only one which could be employed in a bath, and the hot bath was deemed by the Royal Humane Society of the greatest value in the treatment of the apparently drowned, and in all cases of absence of natural respiration.

The posture of the operator, "athwart the patient," as illustrated in the professor's paper, in respect of female patients was, moreover, undesirable.

The alleged injury to the humero-thoracic muscles was not substantiated in the actual use of the Silvester method, the elasticity of the thoracic parietes obviating such a result; and he stated that the plan he adopted when the operations had to be prolonged, or the subject unwieldy, was to place the hands in the axillæ of the patient, and draw up his shoulders towards his head for two seconds for inspiration, and to replace the arms by his side and press them for two seconds against his chest for expiration, the feet being secured. This entirely avoided fatigue.

The objections to Prof. Schäfer's suggested treatment were—first, that expiration was made to precede inspiration when the condition of the chest was already in a state of expiration; secondly, that inspiration was opposed by the weight of the patient resting on the front of his chest; thirdly, that pressure on the thorax was injurious when the heart and thoracic viscera were already in a state of congestion; fourthly, that pressure on the back in the prone position was objectionable, as the abdominal viscera by compressing the diaphragm limited the vital capacity of the chest, and for obvious reasons this form of treatment was often inappropriate in the case of female patients; fifthly, that the contents of the stomach were liable to pass into the windpipe; sixthly, that a dangerous amount of pressure might be exerted on the costal parietes; seventhly, that the amount of air inspired was much smaller than by other methods; eighthly, that the employment of the hot bath was impossible.

The PRESIDENT (in closing the discussion) said, in reply to Mr. Howard and Dr. Wightwick, that clearly the first duty of the Society was to have this subject investigated by a competent committee. This had now been done, and the results had been communicated to the Society. Now that Dr. Bowles and Dr. Silvester, whom he might call the champions of the Marshall Hall and the Silvester methods, admitted that there were not only good

features in both plans, but that each adopted in practice some part of the other's procedure. Again, as Professor Schäfer's method was the prone position of the Marshall Hall, with intermittent pressure in the place of rolling, it seemed as if the Society had reached the stage when they would be able to formulate a method for the treatment of the apparently drowned, and this was certainly very desirable.

APPENDIX.

Professor SCHÄFER, who was unable to be present either at the reading of his paper or at the subsequent discussion, appends the following remarks on the discussion :

A majority of the speakers have expressed opinions in favour of the Marshall Hall method, with the additions recommended by Dr. Bowles ; Dr. Silvester, as was perhaps natural, continues to hold the view that the only suitable means for effecting artificial respiration is that introduced by him and known by his name.

So far as I am aware, no one of those gentlemen who have expressed their opinion on this matter has made any measurements or comparative experiments as to the relative efficiency of the several methods which have been advocated, and especially as to their adequacy to maintain the air exchange of the living subject. It is not sufficient, in order to determine this adequacy, to measure the amount of air which can be exchanged in a single movement of artificial respiration ; but it is essential to be able by any given method to obtain an air exchange *per minute* equal (or nearly so) to that yielded by the ordinary respiration of the individual who is the subject of the experiment ; and not only so, but also to be able to maintain this air-exchange for half an hour or an hour with little inconvenience to the subject and without fatigue on the part of the operator. Dr. Silvester and Dr. Bowles both claim that their methods are more efficient than any other, and Dr. Silvester goes so far as to deny, on purely *a priori* grounds, that the prone-pressure method advocated in the paper under discussion *can* be efficient. These are, however, merely pious opinions, and require only the test of experiment to demonstrate their fallaciousness. I have myself again and again made the attempt by both methods (Silvester and Bowles) to maintain respiration in the living subject, and have entirely failed. In point of fact, after the space of about a minute the subject of the experiment can no longer remain passive ; he is compelled to breathe. And this is easily understood, for we find that by neither method is an

amount of air exchange per minute effected nearly as great as the air exchange of natural respiration. With the pressure methods, and especially with the prone-pressure method here described, it is far otherwise. In this method the amount of air exchange per minute can be experimentally demonstrated to be *greater than* the normal air exchange of the individual, so that by it respiration can be maintained artificially for an indefinite time without the subject having the least desire to breathe naturally: I have myself so maintained it in one individual during a full hour.

The experimental evidence (which I have given at length in the 'Proceedings of the Royal Society of Edinburgh,' and which is also stated briefly in an appendix to the Report of the Committee on Suspended Animation) leaves room for no uncertainty as to the relative efficiency of the several methods under discussion. Thus in one subject, a young man of twenty-three, whose natural respiration at the rate of thirteen per minute produced an air exchange per minute of 5850 c.c., the Silvester method gave only 2280 c.c.; the Marshall Hall method 3300 c.c.; the Howard method 4020 c.c.; and the prone-pressure method 6760 c.c., all being worked at the same rate as the natural respiration. The addition suggested by Dr. Bowles to the Marshall Hall method of raising one arm over the head has in my hands only rendered it still more difficult to obtain a sufficient amount of air exchange *per minute*, on account of the extra time occupied by this additional complication. It is therefore very evident to me that Mr. Warrington Haward and Dr. Hewitt have not had any personal experience of this method, which they think superior to others. Let them try and keep a man going by its means without any aid from his own muscular mechanisms, and they will soon be undeceived as to its adequacy.

With regard to the criticisms of Dr. Pembrey, in so far as they have not been dealt with in my remarks on those of the preceding speakers it will be found that they have been already anticipated and discussed in the paper itself: this is the case with that relating to the nervous mechanism of respiration during asphyxia. His remark that the prone-pressure method is not applicable to the new-born child, a remark repeated later by Dr. Silvester, is an obvious truism, for the only mechanical methods applicable in that case are inflation and Schultze's swinging method. As to old people, the prone-pressure method is probably as applicable as any other, but in them lack of mobility of the chest walls must operate against all methods alike. In so far, however, as it produces pressure upon the abdominal contents, the prone-pressure method is independent of this lack of mobility, which cannot be affirmed of any of the other methods advocated.

The objections Dr. Silvester has raised hardly require special comment. Many of them are based on an incorrect conception of the mechanical conditions of the chest wall, as the simplest experiment is sufficient to show ; and, for the rest, I have either answered them already in criticising the remarks of previous speakers, or the answer is too obvious for it to be necessary for me to prolong these remarks unduly. The special advantages of the prone-pressure method as against other methods hitherto in use are summarised in the paper (p. 5), and no single one of the statements there made has been seriously traversed in the above discussion.

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