less, and the fear of pricking the cord unfounded; even if it happens it is not harmful.

3. Medio-cervical puncture is useless and dangerous; mid-dorsal puncture is difficult and useless; superior dorsal puncture between the first and second dorsal vertebrae, and dorso-lumbar between the last dorsal and first lumbar vertebrae are easy, and suffice to obtain analgesia of all regions of the body.

4. The addition of neutral strychnine sulphate to the anaesthetic preserves the full antiseptic power of the solution and at the same time neutralizes its injurious action upon the bulb. Thanks to this addition, superior spinal analgesia can be performed without danger.

5. Among known anaesthetic substances, stovaine, tropacocaine, and novocain seem to be the best; any of them may be used with the addition of strychnine.

6. The strychnine and the anaesthetic substance need not be sterilized, a process which would destroy some of their properties.

7. The water used for making the solution must be sterilized but not distilled.

8. The injection should consist of 1 c.cm. of solution, the amount of strychnine and anaesthetic substance being varied.

9. The technique is simple, requiring only a Pravaz syringe and the usual needle for lumbar puncture.

10. There are no contraindications for general spinal anaesthesia, which always succeeds if the liquid penetrates into the arachnoid cavity and if the dose of the anaesthetic is sufficient.

11. General spinal anaesthesia is absolutely safe; it has never caused death, nor produced any important complications, early or late.

12. General spinal anaesthesia is infinitely superior to inhalation anaesthesia. Owing to its simplicity, it is within the reach of all, and as there is no contraindication it may be employed with any patient. As it can be performed by the surgeon himself it does away with the attendance of a person often inexperienced, and never responsible.

13. In operations on the face, or the throat, where analgesia by inhalation is difficult and often incomplete, spinal analgesia is a great resource. In laparotomies, owing to the "abdominal silence" it determines, it is very much superior to analgesia by inhalation.

14. The facts stated in this paper will prove how in science a condemnation *a priori* like that pronounced by Professors Bier and Rehn is precipitate and ill-founded.

15. I am firmly convinced that general spinal analgesia will be the analgesic method of the future.

REFERENCES.

¹ *Presse médicale*, Paris, May 1st, 1909. ² Gauthier, *Chimie biologique*, 1892.

THE DEPARTMENTAL COMMITTEE ON HUMIDITY AND VENTILATION IN HUMID COTTON- WEAVING SHEDS.

By COLONEL MATHEW D. O'CONNELL, M.D.

IN the Warrant of appointment of the Departmental Committee on Humidity and Ventilation in Cotton-Weaving Sheds, the Home Secretary asks the Committee to say: "At what degrees of heat and humidity combined definite bodily discomfort arises, under the conditions of the work carried on by the operatives, and what, if any, danger to health is involved by continuous work at those degrees."

Being for many years much interested in the question of the effect of combined heat and humidity in raising body temperature in warm and hot climates, I made some observations on a number of healthy men at rest, exposed within glass houses heated by 5-in. pipes, and, when it appeared, by the sun, and humidified by sprinkling the earthen floor with water at the natural temperature. The air within the glass houses was still. These houses are used for growing orchids, crotons, ferns, grapes, and tomatoes. The men during exposure wore their coats or not as they pleased. The body temperature was taken in the mouth. My object was not to ascertain how high body temperature can be raised by exposure to high

degrees of atmospheric heat and humidity, for this is known; but to ascertain, if possible, the lowest degrees of atmospheric heat and humidity combined at which body temperature begins to rise above the maximum normal limit—37.2° C. (99.0° F.).

In each observation I give the dry-bulb temperature, the wet-bulb temperature, the absolute and the relative humidity of the atmosphere; for there seems to be some uncertainty as to which of these atmospheric factors is the cause of body temperature rising. So I think it better to give all. The observations are as follows: The drying power of the air is given per 10 cubic feet, as this is approximately the bulk of an average man.

From my own sensations in the glass houses and in warm and hot climates, I would say that bodily discomfort begins as soon as the body temperature begins to rise above the maximum normal limit, 37.2° C. (99.0° F.), from impediment to heat loss from the body. When body temperature begins to rise above this normal limit from increased production of heat in the body, as from exercise in the open air, I have not noticed the same discomfort until the body temperature reaches nearly 37.7° C. (100.0° F.). But in this paper I am not concerned with rise of body temperature from increased production of heat, but only from impediment to heat loss.

In order to apportion the relative importance of each meteorological factor of the atmosphere within the glass houses in producing rise of body temperature by impeding heat loss from the body, it is necessary to remember that heat is lost from the body by radiation, by evaporation, by conduction and convection, and by the excreta.

Loss of Heat from the Body by the Excreta.

As no excretions were voided during the short exposures in the glass houses, this need not be further referred to.

Loss of Heat from the Body by Radiation.

The rate at which any radiating body gives off heat depends on the difference between its own temperature and that of the surrounding air. When the dry-bulb temperature of the surrounding air is the same as the normal temperature of man—36.8° C. (98.4° F.)—no heat is being lost from the human body by radiation. As the dry-bulb temperature of the surrounding air falls below the temperature of the body, loss of heat from the body by radiation increases. When the dry-bulb temperature of the air falls to 0.0° C. (32.0° F.), or over sixty degrees below the temperature of the body, loss of heat from the body by radiation must be considerable.

Loss of Heat from the Body by Evaporation.

The rate at which heat is being lost from the body by evaporation depends on the drying power of the surrounding air, that is, its capacity for taking up water vapour. The drying power of cold air is small. At 0.0° C. (32.0° F.), air can contain only 21 grains of water vapour per 10 cubic feet when saturated. As at such temperature air is always nearly saturated, the amount of vapour it can take up is very little. Consequently loss of heat from the body by evaporation is little. Thus in air having a dry-bulb temperature of 0.0° C. (32.0° F.), when loss of heat from the body by radiation is considerable, loss of heat by evaporation is inconsiderable.

As the dry-bulb temperature of the air rises the drying power of the air increases, and as the dry-bulb temperature falls the drying power of the air falls. Whilst air having a dry-bulb temperature of 0.0° C. (32.0° F.) can only contain 21 grains of water vapour per 10 cubic feet, at 10.0° C. (50.0° F.) it can contain 41 grains; at 21.1° C. (70° F.) it can contain 80 grains; and at 36.8° C. (98.4° F.)—that is, at the temperature of the human body—it can contain 193 grains per 10 cubic feet. Hence as the dry-bulb temperature of the air rises, and loss of heat from the body by radiation decreases, the drying power of the air and loss of heat from the body by evaporation increase. In like manner, as the dry-bulb temperature of the air falls and loss of heat from the body by radiation increases, the drying power of the air and loss of heat by evaporation decrease. Thus it seems that loss of heat from the body by radiation and loss of heat from the body by evaporation are usually complementary one of the other; and for this reason exposure to great extremes of atmospheric temperature can be borne without abnormal increase or

	Time.	Dry-Bulb Temperature, Degrees F.	Wet-Bulb Temperature, Degrees F.	Vapour in 10 cub. ft. of Air.	Vapour Required to Saturate 10 cub. ft. of Air.	Relative Humidity, per Cent.	Body Temperature, Degrees F.	
<i>April 20th, 1909.</i>								
First Observation :	p m.			gr.	gr.			
Outside glass house ...	3.5	56.0	50.0	33	17	65	98.2	
Entered glass house ...	3.22							
Inside glass house ...	4.0	77.0	69.0	63	37	63	99.6	Uncomfortable.
<i>Second Observation :</i>								
Outside glass house ...	3.12	56.0	50.0	33	17	65	98.8	
Entered glass house ...	3.12							
Inside glass house ...	3.40	79.0	72.5	74	32	69	99.5	Uncomfortable.
<i>April 21st, 1909.</i>								
Third Observation :								
Outside glass house ...	3.40	47.5	45.5	34	5	86	98.0	
Entered glass house ...	3.45							
Inside glass house ...	4.22	62.5	59.5	53	10	82	98.8	Comfortable.
<i>April 24th, 1909.</i>								
Fourth Observation :								
Outside glass house ...	2.4	57.0	52.0	37	15	70	98.0	
Entered glass house ...	2.10							
Inside glass house ...	2.45	78.0	75.0	87	16	84	99.6	Uncomfortable.
Fifth Observation :								
Outside glass house ...	2.4	57.0	52.0	37	15	70	98.0	
Entered glass house ...	2.10							
Inside glass house ...	2.45	78.0	75.0	87	16	84	99.6	Uncomfortable.
Sixth Observation :								
Outside glass house ...	2.4	57.0	52.0	37	15	70	97.6	A rather anaemic
Entered glass house ...	2.19							man.
Inside glass house ...	3.5	78.0	75.0	87	16	84	99.7	Uncomfortable.
<i>May 4th, 1909.</i>								
Seventh Observation :								
Outside glass house ...	3.15	64.0	53.0	32	34	48	97.8	
Entered glass house ...	3.15							
Inside glass house ...	3.40	82.0	68.5	54	63	46	99.4	Uncomfortable.
<i>May 7th, 1909.</i>								
Eighth Observation :								
Outside glass house ...	3.40	62.0	51.5	30	32	48	99.2	After ½-mile walk.
Entered glass house ...	3.40							
Inside glass house ...	4.5	86.0	78.0	85	47	64	100.0	Bodily discomfort.
<i>July 9th, 1909.</i>								
Ninth Observation :	a.m.							
Outside glass house ...	10.15	64.0	58.0	45	21	67	98.0	
Entered glass house ...	10.15							
Inside glass house ...	11.10	80.5	71.5	67	45	59	99.6	Uncomfortable.
<i>July 12th, 1909.</i>								
Tenth Observation :								
Outside glass house ...	11.30	62.0	56.5	42	20	70	98.9	
Entered glass house ...	11.30							
Inside glass house ...	12.0	87.0	78.0	83	53	61	99.6	Uncomfortable.
<i>July 13th, 1909.</i>								
Eleventh Observation :	p m.							
Outside glass house ...	3.30	66.0	61.0	51	19	73	98.6	
Entered glass house ...	3.35							
Inside glass house ...	4.0	78.0	73.0	78	25	75	99.7	Uncomfortable.
<i>July 14th, 1909.</i>								
Twelfth Observation :								
Outside glass house ...	4.7	65.0	59.0	46	22	68	98.4	
Entered glass house ...	4.7							
Inside glass house ...	4.25	67.5	65.0	63	11	85	98.8	Comfortable.
<i>July 19th, 1909.</i>								
Thirteenth Observation :	a.m.							
Outside glass house ...	11.30	62.0	55.0	39	23	62	98.4	
Entered glass house ...	11.30							
Inside glass house ...	11.55	78.0	71.5	71	32	69	99.2	Uncomfortable.
<i>July 20th, 1909.</i>								
Fourteenth Observation :	p.m.							
Outside glass house ...	2.5	63.0	60.0	52	12	82	98.4	
Entered glass house ...	2.10							
Inside glass house ...	2.38	77.5	72.0	74	30	73	99.2	Uncomfortable.
<i>July 21st, 1909.</i>								
Fifteenth Observation :								
Outside glass house ...	4.26	64.0	58.5	43	26	62	98.3	
Entered glass house ...	4.30							
Inside glass house ...	4.53	68.5	64.2	57	14	76	98.8	Comfortable.
<i>July 29th, 1909.</i>								
Sixteenth Observation :								
Outside glass house ...	4.0	62.0	57.0	44	18	72	98.0	
Entered glass house ...	4.0							
Inside glass house ...	4.20	68.0	65.5	64	11	83	98.9	Comfortable.
<i>July 30th, 1909.</i>								
Seventeenth Observation :								
Outside glass house ...	3.15	69.0	62.0	50	28	64	98.6	
Entered glass house ...	4.0							
Inside glass house ...	4.30	77.0	72.0	75	25	75	99.6	Uncomfortable.
<i>August 3rd, 1909.</i>								
Eighteenth Observation :								
Outside glass house ...	3.0	61.0	56.0	43	17	72	98.8	
Entered glass house ...	3.13							
Inside glass house ...	3.55	75.0	71.5	76.5	17.5	82.5	99.6	Uncomfortable.

decrease of body temperature. At high atmospheric temperatures loss of heat from the body by radiation is little or nothing; but loss of heat by evaporation is very great, and this prevents body temperature rising above normal. At low atmospheric temperatures, although heat loss by radiation is very great, heat loss by evaporation is little or nothing, and consequently body temperature does not fall below normal.

If, however, by natural or artificial humidification the drying power of warm or hot air is reduced, the complementary relationship between loss of heat by radiation and loss of heat by evaporation is upset, loss of heat by radiation is reduced by the high atmospheric temperature, and loss of heat by evaporation is impeded by the reduced drying power of the air, and therefore body temperature rises. On the other hand, if, by natural or artificial desiccation, the drying power of cold air is increased, loss of heat by radiation is increased by the low atmospheric temperature, and loss of heat by evaporation is increased by the increased drying power of the air, and body temperature falls.

Heat Loss by Conduction and Convection.

The rate at which heat is being lost from the body by conduction and convection depends on the rate of movement of the air, or, which has the same effect, of the body. Loss of heat from the body by conduction and convection is increased by movement and impeded by stagnancy of the air. Hence if air is stagnant as well as hot and damp, loss of heat by conduction and convection is impeded, as well as by radiation and evaporation, and body temperature must rise. Hence also if air is moving as well as cold and dry, loss of heat by conduction and convection is increased, as well as by radiation and evaporation, and body temperature must fall.

In my first observation the body temperature of a healthy man was raised from 36.7° C. (98.2° F.) to 37.5° C. (99.6° F.) in thirty-eight minutes by going from a moving atmosphere having a dry-bulb temperature of 56.0° F. and a drying power of 17 grains per 10 cub. ft. into a stagnant atmosphere having a dry-bulb temperature of 77.0° F. and a drying power of 37 grains per 10 cub. ft. In this observation heat loss from the body by conduction and convection was reduced by going from the moving atmosphere outside the glass house into the stagnant atmosphere inside. Heat loss by radiation was reduced by going from the outside atmosphere having a dry-bulb temperature of 56.0° F. into an atmosphere within the glass house having a dry-bulb temperature twenty degrees higher—namely, 77.0° F. The impediment to loss of heat by conduction, convection, and radiation produced by this hot stagnant atmosphere caused the body temperature to rise to 37.5° C. (99.6° F.) in thirty-eight minutes, notwithstanding the fact that the drying power of the air, and consequently loss of heat from the body by evaporation, was increased by 20 grains per 10 cub. ft. In other words, the reduction of heat loss by radiation and conduction and convection caused by the hot stagnant atmosphere was greater than the increase of heat loss by evaporation due to the greater drying power of the air within the glass house, and consequently body temperature rose 0.8° C. (or 1.4° F.) in thirty-eight minutes.

As previously stated, I think that bodily discomfort begins as soon as the body temperature begins to rise above 37.2° C. (99.0° F.), from impediment to heat loss. To say briefly what are the lowest degrees of heat and humidity combined which give rise to this bodily discomfort is not so easy. Professor Haldane's statement that body temperature begins to rise above normal when the atmospheric temperature, wet bulb, rises above 70.0° F. approaches nearest to an accurate answer. And yet I suppose he does not intend to convey that this always holds good. If he does, then residents in hot climates would suffer from pyrexia more frequently even than they are known to do. When the dry-bulb temperature is, say, above 90.0° F., would a wet-bulb temperature of 70.0° F. cause the body temperature to rise above 37.2° C. (99.0° F.)? I think not.

In order to formulate an answer to the Secretary of State's question, it seems to me that it would be necessary to take into consideration three factors of the atmospheric environment found within the cotton-weaving sheds. These are, first, the dry-bulb temperature of the air, for by

the difference between this and the normal temperature of the body is regulated the rate at which heat is being lost from the body by radiation. Secondly, the drying power of the air at such dry-bulb temperature, for by this is regulated the rate at which heat is being lost from the body by evaporation. The drying power of air can be ascertained from Glaisher's tables if the dry-bulb temperature, and either the wet-bulb temperature or the absolute or relative humidity of the air are also known. And, thirdly, the rate of movement of the air, for by this is regulated the rate at which heat is being lost from the body by conduction and convection.

It should be remembered that in my observations the men were at rest. If, like the weavers in the cotton sheds, they had been doing hard, continuous work during the exposure, it is to be presumed that body temperature would have risen still higher.

As regards the danger to health involved by continuous hard work in a hot, damp, stagnant atmosphere, I think it is sufficiently obvious. Any one who sees a body of men, women, and children who have been exposed to a hot damp atmosphere, natural or artificial, cannot but be impressed by their anaemic appearance. In a higher degree it may be observed in troops returning to England after a few years' service in a hot climate. In a lower degree it may be observed in the workers in certain industries, such as the cotton-weaving sheds, who carry on their work in a hot, damp atmosphere. There is only a difference in degree. The troops in hot climates live for many months of the year in a hot, damp atmosphere from which they cannot escape. The workers in the hot damp atmosphere of the humid cotton-weaving sheds escape from it from 6 o'clock p.m., when work ceases, until 8 o'clock a.m., when work begins, and at intervals during the day for meals, etc.

The anaemia produced by the hot damp atmosphere in which work is carried on in certain industries is described by Malden in the *Journal of Hygiene*, 1907. He examined the blood of many workers in the aniline and nitrobenzin compounds works, and describes the results as follows:

1. The specific gravity of such blood is below normal.
2. The haemoglobin is reduced from 5 per cent. to 50 per cent.
3. The colour index is low.
4. Diminished polymorphonuclears.
5. Increased number of lymphocytes.
6. Reduced number of red corpuscles, which also show signs of degeneration and of imperfect development.

Malden apparently attributes these changes to the poisonous action of the dyes, but is it not plainly the result of the hot damp atmosphere in which the men work. And is it not exactly the same change which is found in the blood of those who reside in hot damp climates? Nay, more, is it not malarial blood minus the parasite? (See *Journal of Tropical Medicine*, March 15th, 1909.)

CLASSIFICATION OF CASES OF PULMONARY TUBERCULOSIS.

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A SIMPLE and easily-worked clinical classification of cases of pulmonary tuberculosis according to their gravity has long been a desideratum. Statistics comparing the results of different methods of treatment are of value only in so far as they deal with disease of the same degree of severity. A praiseworthy effort to secure the necessary precision led to Turban's classification, which recognizes three stadia or stages, as follows:

1. Disease of slight severity, affecting at most one lobe or two half-lobes.
2. Disease of slight severity, more extensive than first, but affecting at most two lobes; or severe, and affecting at most one lobe.
3. All cases of greater extent and severity than second.

This classification has the radical defect of fixing attention on what is not the most important aspect of the case—on its extent—the intensity of the disease