Correspondence.

Mr. Browne

Mr. A. FLEMING BROWNE asked what the temperature of the air leaving the electric heating-batteries was. Also whether any tempering heating-coils or elements were provided to warm the air before it entered the air-washer, or whether means were provided for warming the water used for the sprays in the air-washer. Some such method for regulating the humidity of the air was generally found necessary in modern plenum plants, as objection to plenum systems of heating and ventilation had often been made on the score that the air was too dry for comfort. It would be interesting to learn, therefore, whether the Author had made provision for humidity-control.

Mr. Butterfield.

Mr. W. J. A. BUTTERFIELD remarked that he appreciated the great value of the information given in the Paper, but in regard to the grounds on which the Author dismissed alternative methods of heating such a building, he considered that the information given was inconclusive. The grounds of rejection of solid fuel were obviously adequate; but as regarded oil and gas it was not so clear why preference had been given to electricity. Fuel-oil was readily handled by pumping and involved no great fire-risks if reasonable precautions were taken. As regarded gas, the only grounds stated by the Author for dismissing it were that it would be dangerous to bring the large quantity required into such a building, and that its products of combustion might contaminate the air-supply. The danger of gaseous fuel, if greater than that of electrical heating, would be reflected in an increased premium for the insurance of the premises against risks of fire; and it would be interesting to know whether a reduction of premium had been obtained on the ground that electricity was being used for heating instead of gas. The 20,000 cubic feet of waste gases per hour was a smaller volume than that from solid fuel used very generally for heating premises of the same cubic content (though not necessarily in one occupation), and there was no difficulty in discharging such products so that they would not affect the purity of the air at a very slightly lower level. There would appear to be no obstacle to arranging for the gas-flues to discharge, say, 20 feet above the level of the air-intakes on the roof of those premises. The question of the advantage of drawing the air-supply from the highest available point had been considered in connection with other buildings, for example, the Houses of Parliament. In the course of investigations which he

Mr. Butterfield.

made in collaboration with Dr. Graham Smith in 1902 on the ventilation of the House of Commons, the relative purity of the air in respect of micro-organisms was determined for the air-intake on the terrace, and half-way up, and at the top of, the clock-tower. The Committee for which the investigations were made decided that the difference in the content of micro-organisms at the level of the terrace and at the higher levels of the clock-tower was not sufficient to warrant the placing of the intake near the top of the clock-tower instead of on the terrace. It was true that the air at the ground-level of Oxford street was very different from the air on the terrace of the House of Commons in respect of its content of micro-organisms; and further, since 1902 the quantity of suspended dust in the air at pavement-level had been greatly increased through the higher speed of traffic. It did not follow, however, that, because the pavement level was not the best from which to draw the air-supply for a building, the best alternative was to take it from the roof-level of a lofty building. Even though products of combustion might not be discharged from the building itself, it was impossible to escape the effect of the products of combustion discharged at the roof-level from neighbouring premises. There was no doubt that air less vitiated and more nearly free from dust occurred at about two-thirds of the height of an ordinary building, and he suggested that it would have been preferable in the present instance to arrange the air-intakes 20 to 30 feet below the roof-level. The Author did not state at what level the vitiated air from the kitchens and lavatories was discharged, and what means were taken to prevent it from passing to the air-intake of the building, or causing complaints of effluvium from the occupiers of adjacent premises. He had occasion a few years ago to advise as to the best means of avoiding complaints of effluvium when the air extracted by evacuation from some large kitchens near Oxford street was discharged from a vent at roof-level. The occupiers of blocks of offices on the opposite side of the street legitimately complained of effluvium when the wind carried the effluent air in their direction. Chemical treatment of the outflowing air had been tried, and ozonizing it had been considered, but he advised that the best method of overcoming the complaints was to pass the air exhausted from the kitchens into the oil-burning furnace of a boiler on the premises. The air from the kitchens was thus discharged, after heating in the furnace, together with the furnace-gases, at a slightly higher level than previously, and all complaints of effluvium from it ceased. He suggested that if gas heating had been adopted by the Author, the vitiated air from the kitchens and the lavatories could

Mr. Butterfield. properly have been evacuated with the products of combustion of the gas. The recirculation of air vitiated to the extent indicated by the presence of 7·5 to 9·0 volumes of CO_2 per 10,000 volumes of air appeared to be very unhygienic. The proportion of CO_2 named, when derived solely from respiration, indicated that the air was so highly vitiated that it should be forthwith discharged into the open. To recirculate any part of it through the building exposed those within to great risk of infection from colds and other respiratory diseases carried by other persons within the building. The recirculation of the air, in order to economize in heating, had grave hygienic disadvantages to those using the premises. It would appear as though the scheme had been conceived more in the interests of the goods displayed and stored in the premises than in the interests of the health of the 5,000 employees and of the customers.

Mr. Ellis. Mr. S. J. Ellis observed that the Author discussed all too briefly the question of using solid fuel, or oil, gas, or electrical power for heating purposes, and stated that electrical power entailed a considerably lower net cost than any of the other methods. It was stated in the Paper that 20,000 cubic feet of gas would have been required per hour, and that figure enabled a somewhat rough estimate to be made of the fuel-cost per hour for heating by coal and gas, and also for electricity. Gas having a calorific value of 475 B.Th.U. per cubic foot and costing 5*d.* per therm would cost 39*s.* 7*d.* per hour. Electrical power would require 2,780 kilowatts, giving, at $\frac{3}{8}$*d.* per unit, a cost of 86*s.* 10*d.* per hour. In the case of steam heating, if each pound of steam gave 1,000 B.Th.U., 9,500 lbs. per hour would have to be supplied. Taking the cost of coal at 26*s.* per ton, and an evaporation of 5 lbs. of water per pound of coal, a fuel cost of 22*s.* per hour was obtained. Further calculation showed that, if heating was carried out for 2,000 hours per annum, the saving in the cost of coal over electrical power was about £6,490, sufficient to pay interest upon considerable capital outlay. These figures were by themselves quite inadequate for a decision to be made as to the economy of any one system without taking other considerations into account. They were put forward in the hope that the Author would demonstrate the economy of electrical power for heating. On the surface it would appear impossible for a power-station having an over-all efficiency as high as 23 per cent. to supply heat in the form of electrical power at a price to compete with a coal-fired installation. The lighting and power requirements of a building such as that described must be considerable, and it would be of interest to know if any arrangement of back-pressure or pass-out engine supplying power and heating-steam had been considered.

Colonel Sir Gordon Hearn.

Colonel Sir GORDON HEARN was interested in the Paper because he had contemplated the ventilation and cooling of headquarter offices and workshops in India. The Indian could not maintain output in excessive heat. Indian clerks made no difficulty about attending at the office on holidays if they were able to work under fans instead of remaining in their hot houses. He had paid a visit to Messrs. Bourne and Hollingsworth's building on a cold morning—not perhaps so cold as some immediately preceding. His experience was not convincing as to the adequacy of the heating-arrangements, and several of the staff were patronizing the local electric heaters. The building was far from filled, so that body heat for warming the air was mainly supplied by employees. He assumed that the temperature was about 60° F., but it gave less comfort than a temperature of 58° F. in the reading-room of The Institution. The air was pure and sweet, and probably, if cooled to that temperature in summer, would prove an attraction to customers. He noticed no mention in the Paper of means for varying the humidity of the air. That was an important factor, for, he understood, it was possible by increasing the humidity to make a temperature of 45° F. perfectly comfortable. Washing the air added a certain humidity, but apparently that was insufficient, even after a further washing of recirculated air. He suggested that point should be considered, as a means of reducing the cost of heating and circulating, which, he calculated, might rise to £5 an hour, perhaps to £1,000 a month, in such a winter as that of 1929–30, since it appeared that 1,000 units might be consumed per hour. The changing of the air once in 5 minutes in cold weather appeared to be unnecessary, unless the building was well filled. In a fairly large workshop at Jamrud, during the building of the Khyber Railway, the temperature did not rise excessively, even though it was open on all sides and unprovided with windows or doors in the openings designed for them, and although the roof was of corrugated iron, but ventilated on the "saw-tooth" principle. The air outside had a temperature of 120° F. or more during the day, but it was very dry, except in July, when there were usually cases of heat-stroke at Peshawar. Near Calcutta the humidity was very high, although the temperature outside the workshop there seldom exceeded 85° F., and electric fans produced hardly any cooling effect. The air was exhausted by fans so that it was continually changing and surcharging the humidity. By circulating the incoming air over coolers and precipitating moisture, an amelioration of conditions might have been expected. It might be possible to add moisture in the form of steam to the air in the Oxford street building, but perhaps condensation in cold ducts and above the false ceilings

Colonel Sir Gordon Hearn. would be a difficulty. A greater degree of recirculation might have the same effect, depending on the numbers in the building instead of temperature alone. It was difficult to see how these numbers could be ascertained in the control-chamber. He would be interested to learn on what basis it had been decided to change a million cubic feet of air twelve times an hour. In his experience 4,000 cubic feet of air was ample for one person in an office, with occasional visitors, for 6 or more hours, without appreciable rise of temperature or foul air. Assuming, however, that 2,000 cubic feet per hour was allowed for each person, the 12 million cubic feet changed per hour contemplated an attendance continuously of 6,000 persons (customers and staff). Such a number was not apparent on the day of his visit, and indeed appeared to be a very high estimate.

Mr. Lintern. Mr. H. R. Lintern observed that the Author's reference (p. 12) to the anti-vibrating springs used under the two 60-HP. ammonia-compressors appeared to indicate that the device adopted was entirely successful in eliminating both noise and vibration due to the compressors. It was to be expected that the vibration would be very considerably absorbed by the arrangement shown in the elevation of *Figs. 5*, with a consequent reduction of part of the noise due to the compressors; but the anti-vibrators appeared to have given more satisfactory results than could be obtained from other methods of isolation, and it would be useful if the Author would give fuller details of their design, and particulars of the number of cylinders and arrangement of the cranks of the compressors, and of the method of fixing adopted. He thought that, if the compressors had not been mounted on the anti-vibrators, the noise due to their operation would still have been small, because, although such devices were useful for the absorption of vibration, and the mechanical efficiency of the compressors might be high, the amount of energy which was normally converted into noise was so small that its prevention could not usually be attained with complete success. He would have expected that to install such machines under such circumstances it would have been essential to isolate the room acoustically and to provide in the compressor-chamber a large sound-absorbing surface; and it was interesting to note that such precautions were not found to be necessary.

The Author. The Author, in reply, observed that the temperature of the air leaving the heating-batteries was normally 65° F. The water for the sprays could be pre-heated in cold weather by an element in the supply-pipe. This provision, however, had not been found necessary, because arrangements could be made during cold weather to allow some of the heated air to escape from the heater into the

The Author.

heater-chamber, and to draw a large part of the inlet air from the heater-chamber itself, which maintained the inlet air temperature above 32° F. even in the coldest weather. It had not been found necessary to provide any means for automatically maintaining the humidity of the air at a constant value.

Some of Mr. Butterfield's questions had been answered in the reply to the Discussion. The building was so high that no projection of any kind above a certain limited height would be permitted on the roof by the authorities. Therefore it would have been necessary, if fuel had been used, to discharge all products of combustion at the same level as the roof intake. As gas was also largely used in the building, no ground could be advanced for a reduction of insurance premium. The decision to draw fresh air from the highest level had been practically unavoidable, because there was no other place from which it could be taken without disfiguring the building. In point of fact, at least half the air was taken from the bottom of the light well, at the ceiling level of the ground floor. The vitiated air from the kitchens and lavatories was discharged at one side of the building, at a great distance from the inlet. Even in cases where a contrary wind was experienced, the distance was so great and the vitiated air was so diluted that if any of it did find its way into the inlet it would be inoffensive. No such vitiation had been detected. The ventilation of the kitchen and water-closets was so ample that even near the outlet it was difficult to detect any unpleasant smell from the water-closets, and there was only a slight smell from the kitchen. Recirculation of air was used in the early morning when there were very few persons in the shops. It was undesirable when the building was full, and in those conditions it was not attempted. There could be no question that electrical power was expensive when the net cost of the energy alone was considered. The other considerations, however, which he had already dealt with (p. 30), far outweighed the difference in cost. The absence of assistants due to ill health had been reduced by 60 per cent. since the new system was installed.

The use of local electric radiators had been contemplated from the first as a definite part of the scheme. It was difficult to ensure that all the corners of a large building ventilated by warm air would be thoroughly swept by warm air in proportion to the rate of heat-loss. Electrical radiators were therefore provided in all corners where a relatively low temperature was likely. The appearance of a glowing radiator was attractive, and for that reason alone their use was justified. Attention had been called to the fact that the temperature actually maintained in the severest weather was

The Author. exactly that which had been calculated. For the sake of economy, however, heating was not begun early enough to raise the temperature fully during the early hours when very few customers were present. There were frequently 10,000 persons in the building at one time. The figure given in the Paper for the capacity of the fans was the maximum, which was not excessive when the building was full—indeed, it was rather less than what he had wished for.

He had designed de-humidifying schemes for buildings in the Far East, which had been carried out, but which he had never seen. He was informed that they were perfectly satisfactory. The de-humidification of the air had a wonderful cooling effect, even when the dry-bulb temperature was not lowered at all by refrigeration.

The anti-vibrating springs referred to by Mr. Lintern were the product of Messrs. Christie and Gray. There was no isolation or sound-suppressing covering. Without the springs the noise would have been transmitted all over the building.