METHODS OF DISINFECTION.

AT the request of the State Board of Health of Louisiana, that a test be made of the efficiency of the modes of disinfection employed by that board, Dr. Hamilton, surgeon-general of the Marine Hospital Service, detailed Assistant Surgeon J. J. Kinyown, last spring, to make the investigation. Dr. Kinyown's full report is published in the *Weekly Abstract* for June 29, and is so interesting and important that copious extracts from it are given below.

After describing the quarantine station and hospital below New Orleans, at which he arrived May 6, Dr. Kinyown makes full quotations from the brochure of Dr. Joseph Holt, ex-president of the Louisiana Board of Health, entitled 'The Quarantine System of Louisiana: Methods of Disinfection Practised,' to show the manner in which *it is claimed* that the germs of disease are destroyed in the baggage of passengers and crew of vessels, the cabin, deck, hold, and cargo. It is unnecessary even to make an abstract of these passages, since the modes of disinfection used are sufficiently indicated by Dr. Kinyown's own remarks and the reports of the experiments he conducted. It is sufficient to say that three methods of disinfection are described, — that by the application of bichloride of mercury, fumigation with sulphurous oxide, and by applications of dry and moist heat.

"Testing the efficacy of the methods practised and materials used in the disinfection of ships, cargo, and baggage," etc., says Dr. Kinyown, "was with special reference to the germicidal powers for which it is claimed.

"Accordingly, before leaving New York, a large number of cultivation-tubes were prepared, containing blood-serum, peptone gelatine, agar-agar, and rags. A large number of these were inoculated from pure cultivations of the micro-organisms here mentioned; viz., spirillum choleræ Asiaticæ, spirillum Finkler-Prior, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis (Hueppe), bacillus murissepticus, bacillus pneumoniæ (Friedlander), bacterium of yellow-fever (Finlay), staphylococcus pyogenes albus, staphylococcus pyogenes aureus, streptococcus erysipelatus.

"Several of the series of above-named micro-organisms were obtained of Dr. T. M. Prudden; also one specimen of the micro-organism claimed to be the cause of yellow-fever, by Dr. Finlay of Havana, Cuba; another of the same organism was furnished by Dr. S. T. Armstrong, who had only a few days prior to my departure received it from Dr. Finlay.

"Whether the organism referred to *is* the cause of yellow-fever, we leave for others to confirm or disprove.

"In carrying out the following series of experiments, it was intended to show whether the process of disinfection applied to such vessels was sufficient to destroy the growth of these micro-organisms; and in but few instances was the process varied or the time lengthened from that which is practised from opening of the quarantine season to June 1, when the time is lengthened to five days. It was also for the purpose of deciding whether the time imposed on vessels prior to June 1 was sufficient for the prevention of epidemic disease.

"In carrying out these experiments, several classes were conducted at the same time, and, to have them correspond with the description of the machinery, etc., the same order will be followed.

"Since the opening of the season, vessels engaged in the fruit-trade, and plying between ports subject to quarantine, are not subjected to the same treatment as others. Should they have any passengers aboard who have with them any baggage or articles of clothing save what they wear, they are compelled to stop at the upper station, where the baggage of passengers, crew, ship's linen, etc., are subjected to the steaming process, while the cabin and deck are washed down with bichloride solution.

"If no baggage is aboard, they are given pratique to the city, where the cargo is discharged, and vessel cleansed by washing the deck and burning sulphur in the hold. The quantity of sulphur used was not learned.

"Whenever practicable, all the surfaces inside the hold of the vessel and between-decks are wetted by a simple ¾-inch hose with nozzle, the rose being dispensed with, as it is claimed that there can be a more thorough wetting accomplished than by its use. This is invariably done before the vessel is treated to sulphur dioxide, in order to delay it as little as possible.

"The flat surfaces of the decks are thoroughly washed with a rose sprinkler, but around among the corners, hatches, or perchance hogsheads of sugar that are sometimes on deck, the process is defective, because a great many places are not reached. The same can be said of the disinfection of the cabin, lockers, etc.: only a partial disinfection is accomplished; for, to wet all surfaces, with the present arrangements it would be necessary to almost submerge them with the solution. The carpets, rugs, rubber and leather goods, trunks, and valises are sprinkled with the same bichloride solution.

"Several experiments were made upon the goods, clothing, and surfaces thus treated; and it was found that the solution did not cover all the surface, for portions of carpets, scrapings from floor and under side of the forecastle, deck, etc., when placed upon sterilized nutrient media, showed evidences of germ-development. No apparent difference could be noticed between portions removed from the floor of the forecastle after being saturated for one hour with the bichloride, and other portions of the same that had not been reached by the solution. The last can be explained by the fact that the forecastle was in an extremely filthy condition, and, there being such an abundance of organic matter, the bichloride was rendered inert.

"For the general application of this solution to the ship, especially to cabin, carpets, etc., we suggested that a spraying apparatus be substituted, made by leading a rubber hose from the boiler of the tug, and connecting it with the supply-pipe of the bichloride solution in such a manner as to make a 'Richardson's spray-producer' on a large scale, so that by its use all surfaces, cracks, etc., can be thoroughly and evenly wetted.

"Former experience teaches that placing dirty and greasy clothing in the heating-chamber is not a safe procedure with the present apparatus, for to them have been traced the cause of fires breaking out during the steaming process. They are now left on deck and sprinkled with bichloride of mercury, in the following manner: One attendant stands ready with hose in hand, while another places the clothing to be thoroughly wetted down on the deck, turning them over from time to time, while the other plays a stream of bichloride upon them.

"The car upon which the clothing, bedding, goods, etc., is placed for the purpose of transporting them to the steam-heating chamber is not disinfected before the goods are placed upon it to be taken back to the ship."

Seven tables are given for the purpose of showing the variations of temperature obtained in the heating-chamber, and Dr. Kinyown then proceeds to give detailed reports of the experiments he made. The first series was for testing the applications of dry and moist heat. He says: —

"I was informed by Dr. Aby that his instructions from the board of health were to the effect that clothing, bedding, etc., after being placed within the chamber, should be raised to a temperature of 85° C., after which the steam should be turned on, and kept for twenty minutes after the thermometer indicates 100° C. This manner renders fire less imminent. The time of exposure of micro-organisms to the heating process was not varied from the prescribed rules, save in two instances.

"Cultivations of micro-organisms on various substances were placed, in each of the following experiments, in positions where the minimum heat was to be expected.

"EXPERIMENT NO. 1. — Cultivation-tubes of peptone agar-agar inoculated with spirillum choleræ Asiaticæ, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, bacterium of yellow-fever (?), were placed in a wire basket and hung in the compartment most distant from the boiler, and upon which but little clothing was hung. In sixteen minutes the temperature (dry heat) reached 79.4°, when steam was turned on and kept twenty minutes, cultivations removed, and inoculations made therefrom, the temperature being ascertained by placing a self-registering thermometer upon the surface of agar-agar within the cultivation-tubes. Repeated examinations show all growths to have been killed.

"EXPERIMENT NO. 2. — Cultivations of spirillum choleræ Asi-

aticæ on blood-serum, bacillus anthracis on agar-agar, bacillus typhi abdominalis on agar-agar, bacillus coli communis on agar-agar, bacillus pneumoniæ on agar-agar, bacterium yellow-fever (?) on agar-agar, staphylococcus pyogenes albus on blood-serum, staphylococcus pyogenes aureus on blood-serum, were suspended in among blankets and mattresses in a compartment near the boiler. A quarantine thermometer registered 88.8° dry heat in central chamber. Steam turned on, and kept forty-three minutes. Temperature among blankets fell to 82.5°. Inoculations made from these cultivations into peptone gelatine showed the bacillus anthracis and bacterium yellow-fever alive: all others were dead. The temperature was taken on the outside of the cultivation-tubes.

"EXPERIMENT NO. 3. — Chamber filled with goods, consisting chiefly of bedding and clothing of the crew. The articles were not hung closely together, as the chamber was filled to only three-quarters of its capacity. Cultivations of spirillum choleræ Asiaticæ, spirillum Finkler-Prior, bacillus anthracis, bacillus pneumoniæ, bacillus typhi abdominalis, bacillus coli communis, bacterium yellow-fever (?), staphylococcus pyogenes albus, staphylococcus pyogenes aureus, were placed in a basket and arranged upon and between mattresses. Thermometers being placed among cultivations, temperature registered 85.5° C. dry heat in centre chamber. Steam turned on, and allowed to remain twenty-seven minutes. All micro-organisms dead except those of bacillus anthracis and bacterium yellow-fever. Thermometer among cultivations indicated 95.5° C.

"EXPERIMENT NO. 4. — Chamber partially filled, compartment containing principally the mattresses and clothing of the crew. A hair mattress was opened, and tubes containing cultivations of spirillum choleræ Asiaticæ, spirillum Finkler-Prior, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, bacterium yellow-fever, bacillus murissepticus, staphylococcus pyogenes albus, staphylococcus pyogenes aureus, were placed within, and exposed to moist heat for twenty-five minutes. A self-registering thermometer placed among tubes indicated 75°. Examination of growths showed those of bacillus anthracis, bacillus murissepticus, and bacterium yellow-fever to be alive: all others were killed.

"EXPERIMENT NO. 5. — Chamber well charged with goods. A series of cultivation-tubes containing rags (both cotton and woollen) that had been inoculated with bacillus anthracis, bacillus typhi abdominalis, bacillus pneumoniæ, staphylococcus pyogenes albus, staphylococcus pyogenes aureus, were placed in among mattresses and blankets, and exposed for twenty minutes to moist heat. Temperature indicated, 62.5° C. Examination showed all growths dead save that of anthrax.

"EXPERIMENT NO. 6. — Clothing and bedding of steamship 'Saturnina,' from Cuba to New Orleans, placed in heating-chamber; all compartments filled. Owing to the uncleanness of the crew's bedding, we suggested that a longer time be given in the steaming process. Cultivations on agar-agar of spirillum choleræ Asiaticæ, spirillum Finkler-Prior, bacillus anthracis, bacillus typhi abdominalis, bacillus pneumoniæ, bacillus coli communis, staphylococcus pyogenes albus, staphylococcus pyogenes aureus, were placed in the compartment, arranged on mattresses, and surrounded by pillows. Temperature of middle chamber (quarantine thermometer), 76.6° C. Left for fifty-five minutes. Thermometer among cultivations indicated 67°. Inoculations show all killed except bacillus coli communis and bacillus anthracis.

"EXPERIMENT NO. 7. — Chamber was lightly charged, several panels in each compartment being empty. Cultivations made upon rags of the following: spirillum choleræ Asiaticæ, bacillus typhi abdominalis, bacterium yellow-fever, staphylococcus pyogenes albus, staphylococcus pyogenes aureus. These were suspended among clothing, chiefly underwear, and allowed to remain forty minutes. A thermometer placed in a tube containing similar media registered 99°. Inoculations from the tubes show that all have been killed except the bacterium of yellow-fever.

"EXPERIMENT NO. 8. — Chamber filled with goods, — bedding and clothing. Cultivations of spirillum choleræ Asiaticæ, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, bacterium yellow-fever, staphylococcus pyogenes albus, were placed in heating-chamber, in its centre, arranged upon blankets and clothing. These were subjected to moist heat for forty minutes. Temperature indicated near cultivations was 69°. The bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, and staphylococcus pyogenes albus were found to be alive.

"The quantity of sulphur consumed in the fumigation of each vessel is from 100 to 400 pounds, according to the size of the vessel. Those arriving at quarantine during our stay at the station varied from 100 to 2,000 tons burden. About 100 pounds of sulphur are consumed in an hour, and form about 1,170 cubic feet of sulphur dioxide. If, as is claimed, 180,000 cubic feet of air per hour be driven into the hold or compartment of a vessel, the strength of the gas would be approximately .6 per cent.

"That that quantity of air is not driven into the hold is proven by the fact that in quite a number of volumetric analyses, made on various vessels at the close of fumigation (for the purpose of determining the quantity of sulphur dioxide present), it was shown that there are from 2 to 6 per cent to the 100 pounds of sulphur, the capacity of the compartments being about the same, viz., 20,000 cubic feet. This does not represent the full amount of the gas generated, for in all vessels there is constantly present a certain amount of moisture, which absorbs the gas.

"In the generation of the sulphur dioxide there is formed in the 'battery' a certain amount of nitrous oxide, and, the gas being quite hot (130°) as it enters the vessel, every factor is present for the rapid production of sulphuric acid. The greatest percentage of gas was found in holds containing coffee, still less in sugar, and least in those vessels that had been treated with the bichloride solution previous to fumigation. In these the percentage was notably diminished (2 per cent), the gas being absorbed by the wetted surfaces, also uniting with the mercuric salt, forming a compound which impairs germicidal power of both, and destroys penetrating properties of the gas.

"We were informed that it was the custom formerly to put the exhaust-fan in operation for an hour before, driving pure air into the hold, thus aerating the vessel and cargo before fumigation was commenced. This was not put in practice during our stay. Vessels hailing from ports known to be infected are treated to a larger quantity of gas, 200 pounds or more of sulphur being used to each compartment.

"In testing the germicidal power of the fumigating process it was for determining whether the short time of detention practised prior to June 1 was of sufficient duration to insure complete disinfection of vessel and cargo.

"Where the compartments are empty or communicating with the engine-room or chain-locker, the hatches are not sealed by the customs authorities, and there is no assurance that the sulphur fumes remain longer than a short time after the disinfection is finished.

"It was noticed in several instances where the forward hatch communicated with the chain-locker or engine-room, that the hatches were removed immediately after fumigation, and a wind-sail put in place for the purpose of driving out the fumes, so as to enable the vessel to leave for New Orleans as soon as possible.

"Vessels having their hatches sealed are insured of at least fifteen hours' disinfection. The forecastle, after being thoroughly wetted with bichloride solution, is treated to the 'pot plan,' the longest period of time being three hours, after which it was immediately permitted to be thrown open by the crew. The following experiments were made: —

"EXPERIMENT NO. 1. — Spanish bark 'Pedro,' from Havana to New Orleans. Thoroughly wetted down with bichloride solution. A basket containing cultivations on agar-agar that had been inoculated fifteen days previously with spirillum Finkler-Prior, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, bacterium yellow-fever, was placed about sixty feet from the hatch, where the fumigating-pipe enters. The cotton plugs were removed from the test-tubes. These were left for a period of ninety minutes, the time occupied in the fumigation. One hundred and fifty pounds of sulphur were used. Inoculations made from time to time from these tubes show that all the growths were not influenced by the exposure.

"EXPERIMENT NO. 2, SO_2. — Steamship 'Morgan.' Rear hold compartment filled with sugar in sacks. A basket containing cultivations prepared for exposure was placed in the hold about six-

teen feet distant from the hose leading into the compartment; tubes containing spirillum Finkler-Prior, bacillus anthracis, bacillus pneumoniæ, bacillus murissepticus, bacterium yellow-fever (?), staphylococcus pyogenes albus, staphylococcus pyogenes aureus. Time of exposure, two hours and twenty minutes. One hundred and fifty pounds of sulphur used. Owing to the character of cargo, no bichloride solution was used. Inoculations made from growth of each micro-organism show no effect upon them.

"EXPERIMENT NO. 3, SO_2. — Two baskets were prepared for placing in the forward hold of steamship 'Morgan;' capacity, 101 tons; cargo of sugar in bags; basket No. 1 containing cultivations of spirillum choleræ Asiaticæ on blood-serum and rags, bacillus coli communis on agar-agar, streptococcus erysipelatus on blood-serum; basket No. 2, spirillum Finkler-Prior, bacillus anthracis, bacillus coli communis, bacillus pneumoniæ, bacterium yellow-fever (?).

"Basket No. 1 placed fifteen feet from pipe; basket No. 2, thirty feet from pipe. Cultivations exposed for one hour and twenty minutes; fumigation lasted one hour. About 100 pounds of sulphur used. Cultivations had to be removed, as the vessel was ready to leave the dock; forward hatch was not sealed. All cultivations alive; no inhibitory effect noted.

"EXPERIMENT NO. 4. — Steamship 'Floridian,' from Colon to New Orleans, having but little freight; several compartments empty. Cultivations of spirillum choleræ Asiaticæ on blood-serum, spirillum Finkler-Prior on blood-serum, bacillus anthracis on agar-agar, bacillus typhi abdominalis on agar-agar, bacillus murissepticus on blood-serum, bacillus cholera nostras on agar-agar, staphylococcus pyogenes albus on agar-agar, staphylococcus pyogenes aureus on agar-agar, were placed in forward compartment (empty). Compartment fumigated for two hours, and allowed to remain for eight hours and thirty minutes. Inoculations were made from time to time, and it was found that those of choleræ Asiaticæ, Finkler-Prior, staphylococcus pyogenes alba and aureus, and bacillus murissepticus, were dead. No effect was noted in any way upon anthrax, typhoid, and cholera nostras.

"EXPERIMENT NO. 5. — Cultivations prepared by placing a small quantity of sterilized cotton in test-tubes, and moistening it with a small quantity of distilled water. The cotton was then infected with several growths of the following: spirillum choleræ Asiaticæ, spirillum Finkler-Prior, bacillus anthracis, bacillus coli communis, bacterium yellow-fever (?), staphylococcus pyogenes albus, staphylococcus pyogenes aureus.

"These were placed in an empty compartment that had been thoroughly washed down with the bichloride solution. About 125 pounds of sulphur used. Volumetric examination of gas shows 8 per cent. Time cultivations were exposed, three hours and fifty minutes. Only that of choleræ Asiaticæ was killed.

"EXPERIMENT NO. 6. — Cultivations on agar-agar, made only twenty-four hours before, of spirillum choleræ Asiaticæ (2), spirillum Finkler-Prior, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, bacillus pneumoniæ, bacterium yellow-fever (?), staphylococcus pyogenes albus, staphylococcus pyogenes aureus; also cultivations on cotton and woollen rags of spirillum Finkler-Prior, bacillus coli communis, bacillus pneumoniæ, bacillus typhi abdominalis, bacillus murissepticus, staphylococcus pyogenes aureus, streptococcus erysipelatus.

"Both series were placed in the forward compartment of steamship 'Lizzie Henderson,' a small steamer plying between Tampa and New Orleans. After fumigation the hatch was battened down, and the cultivations left until the vessel arrived in New Orleans, when they were taken out and inoculations made therefrom into fresh agar-agar. Time of exposure, twenty-four hours. Of the growths upon agar-agar, those of bacillus pneumoniæ, Finkler-Prior, and choleræ Asiaticæ were killed. None of those on rags affected.

"EXPERIMENT NO. 7. — Cultivations made twenty-four hours before, upon the surface of agar-agar, of spirillum Finkler-Prior, spirillum choleræ Asiaticæ, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, bacillus pneumoniæ, bacterium yellow-fever (?), placed in forward hold of steamship 'Hutchinson,' down under bags of sugar. Fumigation for one hour and twenty minutes; then hatch closed. Fifteen hours later, while proceeding to the city, the hatch was thrown open; and nine hours thereafter, on arrival in New Orleans, the basket was removed. All germs found living.

"EXPERIMENT NO. 8. — Potato placed in large test-tubes, and inoculated with spirillum choleræ Asiaticæ, spirillum Finkler-Prior, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, bacillus pneumoniæ, bacterium yellow-fever (?), staphylococcus pyogenes aureus.

"These were placed in a basket, and wrapped in an old mattress, which was lowered into an empty compartment of the steamship 'Saturnina.' Fumigated for two hours. 200 pounds of sulphur used. The mattress was taken out four hours after. All growths dead except anthrax, typhi abdominalis, staphylococcus pyogenes aureus, cholera nostras, and yellow-fever. Test-tubes containing agar-agar and gelatine show that the gas in the above-mentioned time penetrates to the depth of three-quarters of an inch. Percentage of gas, 6 per cent. Hatch sealed by customs-officer.

"EXPERIMENT NO. 9. — Recent cultivation on agar-agar, of spirillum choleræ Asiaticæ, spirillum Finkler-Prior, bacillus anthracis, bacillus coli communis, bacterium yellow-fever (?), staphylococcus pyogenes albus, were placed in hold of bark 'Antonio Georgio,' in ballast, from Havana to New Orleans. Ballast and interior of hold well washed down with bichloride solution. Fumigation, an hour and a half. 150 pounds of sulphur used. Time of exposure, two hours. No effect on the organisms.

"EXPERIMENT NO. 10. — A basket containing surface cultivations on agar-agar, of spirillum choleræ Asiaticæ, bacillus anthracis, bacillus typhi abdominalis, bacillus coli communis, bacillus murissepticus, staphylococcus pyogenes albus, bacterium yellow-fever, was placed in forward compartment of steamship 'Inventor,' down under bags of coffee, being well covered up. Fumigation lasted four hours. 275 pounds of sulphur consumed. Hatch was then closed for seven hours, when it became necessary, on account of the chain-locker communicating with the compartment, to open the hatch and place wind-sail in position, in order to drive out the gas, so that anchor could be raised. The basket was removed on arrival in New Orleans, twenty hours after, at which time the fumes were still quite strong. Examination showed all cultivations to be alive, though slight inhibitory effect was noticed.

"Cultivation-tubes containing agar-agar and gelatine that were exposed at the same time to SO_2 completely inhibited the growth of all micro-organisms tested.

"EXPERIMENT NO. 11. — Cultivations on agar-agar, of spirillum choleræ Asiaticæ, bacillus anthracis, bacillus typhi abdominalis, bacillus murissepticus, staphylococcus pyogenes albus, placed in rear compartment of steamship 'Inventor,' at a point farthest from the entrance of SO_2. Cargo, sugar. Fumigation for four hours and thirty minutes. 300 pounds sulphur used; hatch then sealed. On arrival in New Orleans, twenty-two hours later, the hatch was opened and an attempt made to remove the basket, but the fumes of the gas were so strong that this could not be accomplished for two hours and a half. Examination of the cultivations showed that all micro-organisms were dead except that of anthrax.

"Cultivation-tubes containing agar-agar and gelatine showed the same inhibitory power as in the preceding experiment.

"EXPERIMENT NO. 12. — A litre of air was collected in sterilized vessels before and after the application of sulphur dioxide. Examination was made for the purpose of determining whether or not the gas exercised a germicidal effect on the micro-organisms of the air in the ship's hold.

"A series was collected that had been exposed one, two, four, and eight hours respectively, samples having been collected previous to application of the gas for the purpose of making control observations. None of the series showed diminution in number.

"EXPERIMENT NO. 13. — Cultivation-tubes containing peptonized agar-agar, gelatine, and rags, exposed for one, two, and four hours, show a decided inhibitory effect on all micro-organisms that were tested. Those exposed for six, eight, and twenty hours to sulphur dioxide killed all non-spore-bearing germs.

"It has been our intention to show by the foregoing observations upon the methods practised in carrying out the present system of quarantine at this station whether or not it is efficient; if not, to show its defects, and how remedied.

"In the evolution of such an establishment, the many difficulties that must have stood in the way of such an undertaking, due credit must be given to those gentlemen who formulated the theory and put in practical operation the present system of disinfection.

"From the series of observations made in determining the temperature of the chamber for the application of dry and moist heat, it is clearly shown that the time prescribed is entirely too short when the chamber is filled with goods; more especially is this noticed when the chamber is filled with such goods as blankets, mattresses, and cushions. Unless a longer period of time is given to each charge, it is certain that only a partial disinfection is accomplished.

"It was suggested to Drs. Wilkinson and Aby that the defects of the present style of steaming-apparatus could be best overcome by adopting the application of dry and moist heat under a pressure of from ten to twenty pounds. To accomplish this it would be necessary to have new machinery, — instead of the steaming-chamber now in use, to have constructed a large chamber of boiler-iron, capable of standing at least twenty-five pounds pressure to the square inch, and provided with one bulk-head door that could be properly secured to make it steam-tight, being provided with suitable appliances for ascertaining the temperature in any part of the chamber. In this manner the disinfection by steam and dry heat could be thoroughly accomplished, and much more speedily than at present. Lighter articles, such as clothing, etc., when not too much crowded, received sufficient heat to disinfect them.

"We are informed by the president of the board, Dr. Wilkinson, that the matter was laid before the health board, and it was by resolution decided to remove the present location of the quarantine station to a place farther down the river, in order that there could be complete isolation; and, guided by the result of the experiments undertaken, a heating-chamber capable of sustaining sufficient pressure from within will be erected, thus insuring an equal distribution of heat and the possibility of attaining and maintaining a much higher temperature than at present; also that an order would be given to the resident physician to the effect that the steaming-chamber should not be so heavily charged, and the time of exposure be extended to a sufficient limit to insure a proper degree of heat.

"It is believed that if, before the application of sulphur dioxide to the holds and cargoes of vessels, the holds be thoroughly aerated by means of the exhaust-fan and the use of a greater quantity of sulphur, confining the gas in the vessel, say, a period of not less than thirty-six hours, then the application of the bichloride solution to the hold and between-decks will accomplish a thorough disinfection of the surfaces of vessel and cargo.

"It is shown that in the short process of fumigation prior to June 1 the gas does not penetrate to any depth in such cargoes as coffee, sugar, etc. After June 1, the time of detention being five days, there is insured a thorough application of the gas in its greatest germicidal power.

"The following conclusions may be drawn: —

"1st, That the application of bichloride solution to interior of the cabin, carpets, rugs, trunks, valises, rubber and leather goods, should be made in such manner as to insure the moistening of all surfaces.

"2d, The chamber should not be charged to more than half its capacity, and the time lengthened to at least one hour.

"3d, That the time imposed on vessels that have undergone the fumigating process prior to June 1 should be longer, and the application of bichloride to the interior of the hold should be done after the gas has been confined at least thirty-six hours.

"4th, That the establishment of the present style of apparatus is a great stride in the right direction, and has demonstrated its feasibility and the correctness of the principles involved.

"The president, Dr. C. J. Wilkinson, asserts, that, whatever degree of heat has been obtained, it is certain that no case of yellow-fever has developed on any vessel that has been subjected to this process; a fact, however, which was not uncommon under previous methods."

IT is announced that in October, 1889, the second triennial session of the International Congress of Hydrology and Climatology will be held in Paris.

PROTECTION OF BUILDINGS FROM LIGHTNING.

FROM the time that Franklin flew his kite at Philadelphia, and ascertained beyond cavil the true nature of lightning — from that time to the present, the protection of buildings and ships from its destructive agency has been mainly a matter of detail, and application of the laws of electricity so far as they were known.

For a long time the erection of lightning-conductors was opposed by the religious world as heretical and impious. But first in some Protestant provinces in Germany, and later in France and England, the use of the heretical rods gradually extended.

At some recent meetings of the London Society of Arts, Prof. Oliver J. Lodge has delivered a series of lectures on protection from lightning, in which he has summarized the prevailing opinions of scientific men.

The two main destructive aspects of a lightning-flash are (1) its disruptive, or expanding, or exploding violence; (2) its heat. The heating effect is more to be dreaded when the flash is slow and much resisted; the bursting effect, when conducted well, except at a few places. A noteworthy though obvious thing is, that the energy of the discharge must be got rid of somehow. The question is, how best to distribute it.

That conductors often fail is undeniable. It is customary to say they are not properly made, or that there was a faulty joint, or that there was a bad earth. A bad earth is the favorite excuse. A good earth is a good thing undoubtedly, and one cannot well have too much of it; but for a flash to leave a fine thick copper conductor on a tall chimney while still high up, and begin knocking holes in the brickwork in order to make use of the soot, or the smoke, or some bolts or other miserable conductors of that sort, because it is not satisfied with the moderate allowance of earth provided for it at the bottom, is evidence either of simple perverseness, or else of something more deep-seated and not yet properly called attention to.

If the earth is bad, the flash can show its displeasure when it gets there by tossing it about, and boring holes into it, and breaking water and gas mains; but at least it might leave the top and middle of the chimney alone, it might wait till it got to the badly conducting place before doing the damage. Yet it is notorious that on high chimneys a flash often refuses to follow a thoroughly good conductor more than a quarter or half way down, but takes every opportunity of jumping out of it and doing damage.

It may be said that the effect of the bad earth is to make the whole path so highly resisting that the discharge necessarily declines to take it. Well, if that were so, it need not have come into the conductor at all. It is supposed with one breath to strike the conductor, because it affords an easy path to earth; and with the next it is said to leave the conductor, because, after all, it finds it a bad one.

Besides, it need not be so very particular about a little resistance. It has already come through, say, half a mile of clear air: it might manage a few feet of dry soil. It strikes violently through the air, enters the conductor, and begins to go quietly. Why does it not continue to go quietly till it gets to the bottom of the good conductor, and then begin displaying its vigor by boring holes below, as it has done above? Why should one end have to be so persistently cockered up? Why not insist upon having not only a good 'earth,' but also a good 'sky'?

The old and amusing political controversy between knobs and points has disappeared. Points to the sky are recognized as correct; only Professor Lodge would advocate more of them, any number of them, rows of them, like barbed wire — not necessarily at all prominent — along ridges and eaves. For a point has not a very great discharging capacity. It takes several points to discharge readily all the electricity set in motion by a moderately sized Voss or Wimshurst machine: hence, if you want to neutralize a thunder-cloud, three points are not so effective as three thousand.

An earth is necessary, or you will have your foundations knocked about and your garden ploughed up. A good earth is desirable. A few tons of coke, with the conductor coiled up among it, is a well-known and satisfactory plan if the soil be permanently damp. A bag of salt might, perhaps, be buried with it to keep it damp throughout, or rain-water may be led there. Often, however, the most