V.—Modes of Infection and Spread.

From the history of the disease in this Colony, the salient points of which I have endeavoured to put before you as briefly as possible, the following conclusions may, I think, be drawn:—

1. That rats have, directly or indirectly, been the means of introducing the disease into the Ports of the Colony.

2. That rats have, directly or indirectly, been the means of spreading the infection from infected centres in the Colony to other centres.

3. That in the great majority of cases of the disease in man the infection has been more or less clearly traceable to infected rodents.

4. That rodents have been the chief cause of the persistence of the disease in infected localities.

Regarding the first and second of these points, a number of instances have been observed in which live rats have come ashore from vessels, or been carried long distances by rail or otherwise, in bales of forage or in "skeleton" or partially open cases or crates of goods, such as crockery, hardware and fruit, or other articles packed in straw or other similar packing. Sick rats are probably more likely to remain in a bale of forage or crate of merchandise during loading, unloading or transit than healthy ones. Again, a rat sick from plague may enter and die in a bale of forage or in a "skeleton" crate, and the carcase may be carried long distances by sea or rail. We know from laboratory experiments that such carcasses remain infectious for a considerable period—probably for several months—when covered up so that desiccation is retarded. On arrival of the bale or crate at its destination, local rats are likely to investigate its contents, perhaps devouring the carcase of the dead rat, and thus becoming infected. Or again, if merchandise such as that referred to be stored where there are plague-infected rodents it is likely to be contaminated by their naso-oral discharges and excreta, and, if subsequently removed to another locality—unless the conditions and lapse of time allow of complete devitalisation of the infection by desiccation—is liable to transmit the infec-
tion to the rat population of the latter. There can be no reasonable
doubt that plague has been introduced into Cape Town, Simon's
Town, Port Elizabeth, East London, Mossel Bay, and Knysna,
and from one or other of these Ports carried—by rail, except in
the case of Seymour—to King William's Town, Graaff-Reinet,
Burghersdorp, Kei Road, Imvani, Queenstown and Thomas River,
in one or other of these three ways, viz., either by plague-infected
live rats, the carcass of rats dead from plague, or by merchandise
or articles contaminated by the discharges of infected rodents.
There is, further, little doubt that the infection was introduced to
Durban, conveyed from Durban to Maritzburg, and conveyed to
Johannesburg from either Durban, East London or Port Elizabeth
in one or other of these ways.

In connection with the first point—the causes of infection in
human cases—of the 534 cases which have occurred in the Colony
up to the 15th ultimo—exclusive of Cape Town cases, the records
of which on this particular point are, as already stated, imperfect—
the adjudged sources of infection were as follows: Infected rats,
347 or 64'98 per cent.; infected cats, 3 or '56 per cent.; fomites
(infected clothing, &c.), 10 or 1'87 per cent.; pre-existing human
cases, 62 or 11'61 per cent.; whilst in 112 or 20'97 per cent. the
source is doubtful. In a large proportion of the latter, however,
there is a strong presumption in favour of rats as a source of
infection. It is noteworthy that of the 87 purely pneumonic
cases, in 24 or 27'59 per cent. the adjudged source of infection was
a pre-existing case in man. In one of the Cape Town cases—not
included in the foregoing figures—there was a clear history of
infection by a plague-infected cat; in another, that of the Chaplain
to the Plague Hospital, the evidence, though not conclusive, was
in favour of a similar cause.

Without going in any detail into the much discussed question
of the mode of spread of the infection amongst rats, and of its
transmission from rats to man, I may mention that in numerous
experiments with guinea-pigs, rats and rabbits placed in wire
cages side by side with flea-infested and plague-infected animals,
no case of the transmission of the disease to a healthy animal has
occurred. The view has recently been advanced, more especially
by Dr. Hunter of Hong Kong, that plague infection does not as
a rule enter the system through the skin, even in bubonic cases,
but that the disease is always a septicæmia ab initio. The con-
siderations put forward in favour of this view are briefly: (1) that
plague bacilli are demonstrable in the blood in a large percentage,
probably, in the majority of bubonic cases, in the early stages of the disease; (2) that the bubo frequently appears some time, perhaps several days, after the onset of the illness; (3) that where infection does occur in a skin area draining to a certain group of lymphatic glands, a bubo in an altogether different group of glands may result; (4) that multiple buboes frequently develop simultaneously; (5) that plague bacilli are usually present in pustules, carbuncles, extravasations and similar lesions, even in the early stages of the disease, and are also frequently demonstrable in the excreta.

In the bubonic cases which have occurred in this Colony primary buboes have almost invariably appeared at a very early stage of the illness; also in the comparatively small number of cases in which the place of entrance of the infection could be ascertained with reasonable certainty, the primary bubo developed in the group of glands draining the place of infection, though in some cases buboes developed in other groups of glands subsequently. The following instances may be quoted:

(1) Dr. J. C. Dunlop. Scratched left little finger during a post-mortem examination on a case of pneumonic plague on March 23rd, 1901, ill March 26th, bubo in outer group of glands in left axilla. No reaction took place at the site of the scratch, which was almost quite healed on admission to hospital on March 27th. The attack terminated fatally.

(2) European, male, aged 18. On or about March 6th, 1901, struck a man on the mouth with his left fist, thereby receiving a small wound on the knuckle of the left middle finger. Became ill on March 13th and was admitted to hospital two days later with a bubo in the outer group of glands in the left axilla. The wound over the left knuckle was inflamed and suppurating, B. pestis being found in the discharge. Two deep cervical glands, one on each side of the neck, subsequently enlarged. The man whose tooth had caused the wound on the patient's knuckle was healthy at the time of the assault and remained so.

(3) European, male, aged 34, labourer, employed on the Removal Staff of the Plague Department. On April 14th, 1901, had his right hand cut by the edge of a pail over which he was holding a child who was suffering from plague. The child passed a loose motion over the wounded hand. An open veldt sore on the other hand was soiled with faces. The patient became ill on April 18th, and on the following day a bubo developed in each axilla. Before admission to hospital on April 21st, buboes had also developed in each groin.
and in both sides of the neck. There was a slight local reaction in the wounds on the hands, but no plague bacilli were to be found in the discharges.

(4) Native, female, aged 25. Had been nursing her infant who died on March 12th, 1901, a post-mortem diagnosis of pneumonic plague being made. Admitted to Contact Camp, Uitvlugt, on March 13th, transferred to hospital on the following day with the general symptoms of plague and a bubo immediately above the right clavicle. On the day after admission to hospital a second bubo developed in the "pectoral" chain of glands in the left axilla. The situation of the first-mentioned bubo was unusual; it seems highly probable that the infection reached one or both the infected glands by absorption from the nipple.

(5) European, female, aged 19. Had assisted in nursing and had frequently kissed a patient, her fiancé, who was discovered to be suffering from pneumonic plague on the evening of March 29th, 1901, and died on the following morning. She was admitted to the Contact Camp, Uitvlugt, on April 1st, and transferred to an Observation Ward on the following day. On April 5th a deeply-seated bubo developed at the angle of the jaw on the right side and she was transferred to a Plague Ward.

Broadly speaking, experience in this Colony would appear to lend support to the view that in the majority of cases of the bubonic type infection enters by way of the skin—or, in the case of cervical buboes, through the buccal mucosa—and that the first local symptoms usually make their appearance in the lymphatic glands to which the place of entrance drains, but that infection becomes to a greater or less extent systemic at an early stage of the disease, perhaps in some cases before local glandular symptoms have developed sufficiently to attract attention.

VI.—Transmission of Infection from Man to Rodents.

The question may be asked, can the infection of plague be transmitted from man to rats, and if so, what are the risks of such an occurrence? Is the introduction of a case in man into a place with a large rodent population likely to lead to the infection of the latter? Experience in this Colony goes to show that the risks of such transmission are small. In no instance has an exported case of plague in man given rise to a fresh epidemic, though in several instances one or more cases in immediate contacts of the exported case have occurred. Plague-infected rats have been found on two occasions at the Plague Hospital at Port Elizabeth, but as the
hospital is less than half a mile distant from the town, the infection may have been derived from the latter. Although there was a considerable number of rats about the Cape Town Plague Hospital at Maitland during the 1901 epidemic they remained healthy.

The only instance which has been observed in this Colony in which there seems a distinct probability that the infection was transmitted from man to rats recently occurred at East London, for particulars of which I am indebted to Dr. E. N. Thornton, Government Plague Officer there. The greater part of the town of East London is situated on the East Bank of the Buffalo River. On the West Bank is a small township of about 100 houses with several stores and other buildings, and about half a mile distant from this is a small native location. Communication between the two banks of the river is by boat and pontoon. Up to the occurrence now referred to the West Bank had remained free from indigenous plague. In June last two native children were found dead of plague in a hut in this location after an illness of three and four days respectively, infection being clearly traceable to the East Bank Location, where the children had a few days before been spending the night; shortly after another case of plague occurred amongst the inmates of the hut they had slept in. The disease in both cases was of the acute pneumonic type, with profuse discharge of infectious sputum. The hut in the East Bank Location, which was disinfected on June 19th, showed recent indications of infestation, but only one live rat, which was healthy, was found. On July 4th, another case of plague occurred in a hut about twenty yards distant from that first mentioned, and in this latter hut four rats, recently dead of plague, were found. A careful inspection of the remainder of the location, the West Bank Township and the pontoon and vessels in the river, failed to reveal any further evidence of plague infection.

VII.—Persistence of Infection.

The question of the causes of the persistence of infection in infected localities is one of very great practical importance. Experience in this Colony tends to show that infection may persist for a considerable time—possibly for a couple of months or longer—in burrows and under-floor spaces in buildings which are believed to have been cleared of rodents. It is, however (generally), impossible to make quite certain of the complete absence of rats and also that infection has not been re-introduced. According to granary experiments carried out in Natal and published in a Report by
Dr. Hill, Health Officer for Natal, issued in 1904, in stores and similar buildings infested by plague rodents infection persisted for more than a month but for less than two months after the removal of all infected rodents and carcases.

The infection probably persists in burrows, nesting and rubbish contaminated by infectious excreta, though here again the ubiquitous flea may play a part.

Whilst rats undoubtedly play the major rôle in this continuance of infection, there is no doubt that mice also play a part. It is a matter of common knowledge that rats and mice are rarely found living together and on amicable terms, the reason being that rats are apt to make a meal off any young mice they may come across. It has been observed that after a store or an area has been cleared of rats, mice multiply rapidly. They do not migrate or roam about to anything like the same extent as rats do, consequently plague diffuses slowly among them, and in this way the infection may be unobtrusively kept going.

VIII.—MEASURES TAKEN FOR DEALING WITH OUTBREAKS.

I may now review the measures which have been taken for combating the disease, passing very briefly over such as have not an important bearing on the aspect of the subject dealt with in this paper.

The administration of all matters relating to plague has, up to the present, been carried out by the Government, with the Medical Officer of Health for the Colony as Director of Plague Administration. This arrangement has many advantages, but it also has certain disadvantages, chief of which is the difficulty of securing and retaining the active co-operation of Local Health Authorities. This disadvantage has been partly, but by no means fully, removed by the formation of Local Plague Boards, with advisory and consulting functions, at places where considerable outbreaks of the disease have taken place.

(1) MEASURES FOR THE PROMPT DISCOVERY OF THE OCCURRENCE OF PLAGUE.

(a) Man.—Plague is a notifiable disease under the Public Health Acts, and, as such, cases are required to be notified to the Local Authority by the medical practitioner, householder, or other person becoming aware of their occurrence. Notices describing the symptoms of the disease have been distributed broadcast. During periods of epidemic prevalence, employers of labour are, by circular,
requested to report any unaccountable absence from work on the part of their coloured, native, or Asiatic employees.

(b) Animals.—At the commencement of the invasion the public were, by notices and posters, requested to report the occurrence of any suspicious sickness or mortality amongst rats, mice or other animals liable to contract plague, coming to their notice. In August, 1903, notification of such occurrences was, by Regulation framed under the Public Health Amendment Act, made compulsory. Weekly reports as to the prevalence of rats and mice on railway premises, the numbers destroyed, and the occurrence of any suspicious sickness or mortality amongst them, are rendered by all station masters throughout the Colony. Travelling rat-catchers are also employed on the principal railway systems, their duties being not only to catch and destroy rodents on railway premises, but to promptly discover the occurrence of any suspicious disease amongst them.

Facilities for bacteriological diagnosis have been provided, and directions for forwarding specimens for examination published widely.

In this country of enormous distances and sparse European population, the difficulties in the way of the prompt discovery and notification of cases of the disease in man are considerable, yet the system has on the whole worked satisfactorily. Amongst the native, coloured and Asiatic sections of the population attempts at concealment have, however, been by no means uncommon. It is much more difficult to secure early information of the occurrence of the disease amongst rodents. Storemen and others, fearing the inconvenience entailed by disinfection, not infrequently fail to report. The system of railway rat-catchers and of reports by railway officials has on several occasions proved of the greatest value, leading to the discovery of outbreaks whilst infection was localised to the railway premises or their immediate vicinity.

(2) Measures in Infected Centres.

Cases in Man.—All cases have on discovery been immediately removed to a plague hospital or other suitable place, and isolated.

Contacts.—During the first year or so of the invasion all immediate contacts of cases were removed to an isolation camp, and kept there under surveillance for twelve days. During the Cape Town outbreak, 5,383 contacts were removed and isolated in this way, and of these only 64, or 1.19 per cent., developed plague. The administrative difficulties and expense entailed were very great,
Bubonic Plague in Cape Colony

and the system was very unpopular, especially amongst the educated classes. Gradually this system has been revised, and for a considerable time past only contacts who have been specially exposed to infection, as, for instance, persons who have been closely associated with or nursing pneumonic cases, or who cannot be relied upon to remain under surveillance, as in the case of lower class Asiatics or native "boys" who have come to the towns to work, are removed to the contact camps; all others are merely kept under daily surveillance for a period of twelve days from the date of last exposure to infection.

Inoculation.—During the Cape Town outbreak in 1901, and subsequently at Port Elizabeth, East London, and other infected centres, inoculation with Haffkine's plague prophylactic was extensively practised. In Cape Town practically the entire native population, numbering over 5,000, was inoculated simultaneously with their removal from Cape Town to the new location at Maitland. Only a few dropping cases occurred amongst them subsequently, but it is impossible to arrive at any conclusion as to how much, or how little, of this result should be credited to Haffkinine. At Port Elizabeth an attempt was made on the first outbreak of plague there to secure the wholesale inoculation of the native and coloured population. A general strike resulted and the attempt had to be abandoned. Apart from the general inoculation carried out at Maitland, and an inoculation campaign in Kaffraria in the same year, during which some 5,000 natives voluntarily presented themselves for inoculation, the great majority of inoculations have been performed on coloured persons, natives or Asiatics leaving infected centres by rail, the production of an inoculation certificate being, by regulation under the Health Acts, made a condition precedent to the issue of a railway ticket to persons of this class. The measure has always been a very unpopular one, and has in several cases given rise to a degree of irritation amongst the class principally affected which has materially increased the difficulties of the general conduct of plague administration and operations. Furthermore, it is generally admitted that the measure of protection afforded by Haffkine persists only for about six months at most, so that after this period inoculation should be repeated. In practice it has been found impossible, except in a very few instances, to secure re-inoculation. So far as has been practicable all persons on the plague staff and exposed to infection have been inoculated, the operation being repeated every five or six months. Up to the present, in round numbers, 33,000 persons have been inoculated.
with Haffkinine since the first outbreak of plague in the Colony. In 67 cases of plague the fact of previous inoculation has been ascertained; of these 34 recovered and 33 died, equal to a case mortality rate of 49.25 per cent., as compared with the average case mortality rate for all cases of 50.9 per cent.

During the past year or two the measures for enforcing inoculation have been considerably relaxed and comparatively few persons have been inoculated. The medical inoculator, together with the lay inspector of the type who goes round and makes polite enquiries, has to a very large extent been replaced by the rat-catcher and the disinfecting ganger with his two or three labourers equipped with disinfectant, spade, pick, trowel and cement, tools for exploring under floors and taking off iron sheeting, and billy-can for rats killed or carcasses found.

Regarding the protective value of inoculation with Haffkinine, no very definite opinion can be arrived at from experience in this Colony.

Yersin's anti-plague serum has been used on a considerable number of occasions as a prophylactic on persons who had recently been exposed to plague infection. The number of such cases is, however, too small to admit of any conclusions being drawn as to its protective value.

The Prevention of overcrowding and the Improvement or Evacuation of Insanitary Dwellings or Areas.—As a result of the plague invasion the native population of Cape Town, except the small proportion of educated or civilised natives, have been removed to a location situated outside the town and under Government control. Similar measures have been taken at Port Elizabeth. Extensive sanitary improvements of a permanent kind have been effected at both places; similar improvements have been prosecuted at the other infected centres. In the larger centres where outbreaks have occurred the effect of these improvements on the prevalence of filth diseases and on the general death-rate has been marked.

Rodents.—In the case of all the outbreaks determined efforts have been made to destroy or materially reduce the rat population. Traps, dogs, ferrets, poisons of various kinds and plaster of Paris have been tried, rewards of up to 6d. per rat destroyed have been offered, so-called expert rat-catchers have been specially imported, Danyz' virus has been given a very thorough trial, but it must be confessed that the results have in all cases been disappointing. Shortly after the commencement of the Cape Town epidemic cultures of Danyz' bacillus were procured from the Pasteur
Bubonic Plague in Cape Colony

Institute, but on arrival here they were found to be practically inert. A special laboratory was established under the charge of Dr. R. W. Dodgson, who succeeded in devising a method of raising the virulence of the organism to such a degree as to be uniformly fatal to inoculated rats. Pieces of bread which had been soaked in this virulent culture were distributed in very large quantities in Cape Town, and at Port Elizabeth, East London and Mossel Bay. A certain number of rats undoubtedly died from eating this infected bread, but nothing approaching an epizootic resulted, indeed, in certain stores in Cape Town where large quantities were regularly laid for a period of several months, the rats appeared to have acquired an immunity to the infection and to thrive and multiply on the supply of bread provided. There is one serious drawback to the use of this virus in a plague-infected locality—it is often impossible without careful bacteriological examination to say whether rodents found dead have died from it or from plague. If the carcasses are only discovered when decomposition is advanced the differentiation may be impossible without lengthy investigation; thus the difficulties of following the course of and dealing with the plague epizootic are greatly increased. A similar objection applies to its use in places to which plague infection is liable to be at any time introduced. Attempts to destroy rats by means of Danyz' virus were discontinued in this Colony after July, 1902.

Experience has shown that even where efforts to reduce the rat population have been attended with considerable success, such reduction, in the absence of other measures, is likely to be of only temporary duration. Thus in the village of Knysna during the last three months of 1903, a total of 10,661 rats and 3,010 mice were accounted for, mostly through the agency of an army of local small boys working under the incentive of a reward of 6d. per rat and 3d. per mouse, and yet within a month from the latter date the rodent population of the locality was reported to be as numerous as ever. As our experience widened efforts came to be directed, not so much to the mere destruction of rats and mice as to measures of a permanent kind calculated to prevent the survival or development of a large rodent population, especially under conditions of close association with man. Chief of these measures are the alteration of existing buildings and the construction of new buildings—and more especially of stores, stables and similar structures where grain, forage or other articles of a kind likely to attract or harbour rats are kept—so as to prevent the harbourage of and be as far as possible inaccessible to rats, the storing of what may
be termed "rat edibles" in such a way as to prevent infestation by rats, the prevention of accumulations of rubbish or other materials liable to harbour rats, and the carrying out of proper scavenging with a view to preventing rats from gaining access to waste foodstuffs and garbage.

Disinfection.—During the early stages of the Cape Town epidemic, and largely no doubt as a result of Indian plague literature and experience, disinfecting operations were for the most part confined to the dwellings of persons affected: these were most thoroughly and minutely dealt with. When the significance of the discovery, in a large proportion of infected houses, of rats and mice sick from or dead of plague began to be recognised, operations were extended (except in cases where there was no reason to suspect rodent infection), to the adjoining premises, and later on to the entire blocks of buildings in which the case occurred, the conduct of the operations being guided in the main by the occurrence of human cases. As the importance of the part played by the rat in the spread of the disease became increasingly apparent, the system of disinfection—apart from the disinfection of residences of patients—came to be based on an increasing extent, and ultimately almost entirely, on the progress and course of the rodent infection, the object aimed at being to promptly deal with any extension of this infection to a particular area, and so prevent the occurrence of cases in man. Since then the conduct of all disinfecting operations has been based on these principles. The chief considerations kept in view in carrying out the disinfection of any particular locality are the number and distribution of the rodent population, the amount and virulence of the plague infection amongst them, the routes by which this infection has reached and is spreading from the area, the most expeditious and effective means of eradicating it and of preventing its further spread, of preventing the infection of persons residing or working in the locality and of destroying its rodent population. The rat-catchers devote as much or even more attention to the discovery of disease amongst the rodent population as to the destruction of rats; they are, so to speak, the scouts of the disinfecting staff. Premises or blocks of premises in which the amount of infection is greatest, or in which there is the greatest risk of the occurrence of human cases, or of further spread, are dealt with first, and from these centres the work is extended in an ever widening zone as far as may be considered necessary to completely eradicate the infection. Every endeavour is made to confine and destroy the rodent population in each set or block of buildings, and so prevent their migration.
The disadvantages of this system of picking out and dealing with infected blocks or circumscribed areas in a town are, firstly, that even when extensive operations are carried out around known foci, one can never be quite certain that the whole of the infected area has been dealt with. If infection remains—perhaps in burrows or rat-runs whose occupants have previously succumbed to plague—in a month or two the rodents again infest the area and the infection is rekindled. In the second place, notwithstanding every precaution, including, where practicable, the use of rat-proof fencing, wire netting and similar devices, it is in many cases impossible to prevent rats—some of whom would usually be infected—from migrating and dispersing as a result of the disinfecting operations, and thus spreading the infection over a still wider area. This objection can only be removed in one way, viz., by carrying out the systematic disinfection of the entire infected town or area, beginning at one end and going right through to the other, devoting special attention to places where active infection is discovered or known to exist, but also dealing with every place where there is any risk of the persistence of infection. With a view to testing the efficacy and practicability of a measure of this kind, a scheme of systematic disinfection on these lines was carried out in Graaff-Reinet from April to May, 1903. The results were entirely satisfactory, the expense was not excessive, and plague infection was completely eradicated. During the three months following another and considerably larger infected centre—King William's Town—was dealt with in the same way and with equally satisfactory results. After the completion of the scheme and the subsequent period of three months' close inspection, no plague infection in man or animals was discovered in King William's Town until after the re-introduction of the disease from East London in March, 1905.

Subsequently, in September, 1903, a similar scheme was devised and carried out in the still larger centre of East London. Here the difficulties—apart from the greater size of the town—were much greater than any previously met with. An extensive fire had occurred some months previously and had destroyed a number of large stores, and as a result of this and of the block in goods traffic which, after the end of the war, followed on the disposal of the surplus military stores, the stores in East London were densely packed with goods. The Harbour Board Area, a strip of ground about a mile in length along the east bank of the Buffalo River—which had been badly plague-rat-infested from the commencement
of the outbreak—consists of "made-up" ground with huge boulders and spaces intervening below; these were swarming with rats, many of whom were plague-infected, and rats dead of plague were constantly being found. There were other considerable areas of "made-up" ground in the town, upon which wood-and-iron store buildings had been erected; these were also badly plague-rat-infested. In King William's Town store-owners and the mercantile community generally had, with very few exceptions, actively and cordially co-operated with the Plague Staff in carrying out the work of disinfection, but in East London such co-operation and assistance was in many instances not forthcoming and, indeed, a good deal of obstruction was met with. The systematic cleansing work was begun on September 26th, 1903, and completed in the beginning of April, 1904. Unfortunately, the Disinfecting Officer, Mr. W. C. Winshaw, who had been in immediate charge of the carrying out of the similar schemes at Graaff-Reinet and King William's Town, himself contracted plague shortly before the completion of the scheme, which had, therefore, to be completed by another Officer. In Mr. Winshaw's case infection was in all probability conveyed by the dusty atmosphere of a plague-rat-infested store. The attack terminated in recovery.

From the completion of these operations no further discoveries of plague-infected rodents were made in East London until the end of July following. On this latter date, however, a mortality amongst rats was discovered to be occurring in the neighbourhood of the Municipal rubbish-depositing site and in a store area adjoining, and on investigation it was found that the infection had already extended over a considerable area. Every effort was made to confine it but without success, and as a result the rodent population of the town was once again re-infected; concurrently with this recrudescence a number of cases occurred in man.

In November, 1904, a systematic cleansing scheme for Port Elizabeth was devised and entered upon, the work being carried out under the immediate direction of Dr. D. C. Rees, Government Plague Officer, and Mr. Winshaw. The difficulties were much greater than any of those previously experienced, owing mainly to the large extent of the town, the enormous number of large stores, and the prolonged infection. The scheme was completed in April last. Since then plague-infected rodents have continued to be found at intervals, and seven cases in man have occurred. These recrudescences would, however, appear to be of a purely local character, and there is still a reasonable hope of the complete
eradication of the infection during the course of the next few months.

In addition to the places above mentioned, the systematic cleansing of two small centres, viz., Kei Road and Lady Grey Bridge, have been carried out, and in both instances with complete success. There can be no question that this system is most effective for small centres; for large centres success in completely eradicating the infection is by no means certain, and the cost is heavy.

Time does not permit of my entering into any detail regarding this system of cleansing, but its salient features may be summarised as follows:—

(1) A careful inspection of the area to be dealt with is first made, and what may be termed a general “plan of campaign” decided on. It is known that the rats are apt to retreat before the advancing operations; where practicable these are arranged so as to constitute a series of “drives,” each drive converging on some place adapted for hemming in and destroying them.

(2) Estimates of disinfecting materials, equipment, and all articles likely to be required are drawn up and supplies arranged for, so as to obviate any delay during the progress of the work.

(3) A disinfecting staff, sufficient to carry through the scheme expeditiously, is organised, preference being given to foremen, gangers, and labourers who have previous experience of similar work. Arrangements are also made for the prompt carrying out of bacteriological examinations. Work is not commenced until all arrangements are complete and everything in readiness.

(4) In carrying out the work the lines already sketched are closely followed. All rat burrows, under-floor spaces, double partitions, and enclosed spaces in walls and buildings—every place that is likely to harbour rats, or to have been contaminated by infected rodents—is explored and disinfected. Expedition is a great desideratum—the aim is to carry out the work so as to entail the least possible expenditure of time and labour consistent with efficiency. Every effort is made to occasion as little inconvenience as possible to owners and occupiers of property and to avoid damage to property or goods; nothing is destroyed. The bona fide claims for compensation arising out of the general cleansing schemes at East London and Port Elizabeth have been quite trifling. Occupiers of stores and business premises are expected to assist where large quantities of goods have to be moved or other extensive work of a like kind carried out.
Concurrently with the disinfection of grain and produce stores and other buildings of a similar kind, the contents are re-stacked on dunnage twelve to eighteen inches above the floor level, and with a passage all round. It has been found that rats do not infest goods so stacked, especially if one or two cats be kept on the premises; they have to "break cover" every time they leave to get water—which they probably require once every twenty-four hours or thereabouts. This arrangement of the goods also greatly facilitates subsequent inspections. Permanent improvements in the direction of making the stores or buildings inaccessible to rats are at the same time carried out. Minor alterations of this nature are usually effected by the Plague Staff; more extensive alterations are required to be carried out by the owner or occupier.

The disinfectant principally used is an acid solution of perchloride of mercury of a strength of 1—750 or 1—1,000. The ideal disinfectant for the purpose should destroy all infection with which it comes in contact, and also prevent the return of rats to the premises until sufficient time has elapsed to allow of the devitalisation by desiccation of any infection which may have escaped destruction. With the exception of mercurial solutions, none of the commonly-used disinfecting solutions appeared to have any effect in this latter direction. In a series of experiments carried out by Mr. Winshaw, of the Plague Staff, and Dr. Coutts, of the Bacteriological Institute, Grahamstown, where rats were kept in cages floored with layers of soil saturated with various disinfectants, the rats in the cages the floors of which had been treated with phenol disinfecting solutions remained healthy, whilst none survived for a longer period than fourteen days on the mercurialised floors. No distinct pathological lesion was discovered in the latter, but a trace of mercury was discovered in their bodies on chemical analysis. In practice, rats rarely return to burrows or under-floor spaces treated with perchloride of mercury solution until several weeks after disinfection. Unfortunately, however, the use of this solution has very little effect in preventing the return of rodents to spaces and runs in woodwork, under roofs and so forth. Chloride of lime has been used for this purpose, but its action is evanescent. A disinfectant or other substance which would effectively prevent for a period of two or three months the return of rats to buildings and premises treated with it, would be of inestimable value in connection with plague disinfection.

(5) As the work of systematic disinfection of the area proceeds, some of the foremen or more intelligent gangers who have been
employed on the work, and who in consequence know all the nooks, crannies and rat haunts in their respective sections, are left behind to keep the area under surveillance with a view to the prompt detection of any return of rats or rekindling of infection. Experience, more especially at Port Elizabeth and East London, shows that isolated recrudescences of this kind are to be expected even when every care in the conduct of the disinfecting operations has been exercised, and unless they are effectively dealt with there is always grave danger of the re-infection of the entire area. As already mentioned, such an occurrence took place at East London; Port Elizabeth is at present in the stage of inspection after systematic cleansing, and isolated foci of persistent infection continue to be discovered at intervals. In most of these recrudescences the cause of the persistence of the infection can be ascertained. In several cases at Port Elizabeth it has resulted from rat burrows under concrete floors without foundations, which had escaped detection and disinfection. In a number of other cases it has been due to previously undiscovered rat-runs or enclosed spaces in walls or between buildings.

IX.—Prevention of spread of plague from infected centres.

(1) Man.—During the early stages of the invasion of the Colony a system of medical examination, and the issuing of medical certificates to all persons leaving infected centres by land, was carried out, measures being taken to prevent the departure of those not in possession of such certificates. The expenditure entailed was very considerable, and although every effort was made to minimise inconvenience to persons travelling, much public irritation resulted. Although the system in its complete form was in operation during the first three years or so of the invasion, only three cases of plague were discovered in persons desiring to leave; the measure probably had, however, a certain influence in preventing infected persons from attempting to escape from infected areas. As our knowledge of the modes of spread of the disease increased, and as it became evident that even where a case of the disease had been exported to a previously uninfected centre, there was little or no risk of any considerable extension, the system was gradually relaxed. During periods of epidemic prevalence of the disease arrangements are sometimes made for the medical examination of natives, coloured persons and Asiatics leaving by rail, largely in order to allay the
apprehensions of Local Authorities at the places of destination of passengers of this class. Passengers leaving infected ports are medically examined before departure, as provided for by the International Health Conventions.

(2) Personal Baggage.—Personal baggage was also at first similarly examined, and, in the case of natives, coloured persons and Asians, required to be disinfected before removal from plague-infected centres. This measure has for a considerable time past been discontinued, except under very special circumstances, or where required under the International Health Conventions.

(3) By Merchandise and Rodents.—Of immeasurably greater importance than either of the foregoing is the prevention of the spread of plague infection by the agency of merchandise and goods contaminated by infection or harbouring infected rodents or their carcases. The problem is a most difficult one, and up to the present no really effective solution of it has been evolved. With the enormous quantities of merchandise and goods leaving the larger ports by rail for places up-country, a thorough system of inspection cannot be enforced without causing serious inconvenience to the mercantile community, and, possibly, dislocation of trade. Sulphur fumigation by means of an apparatus designed on the lines of the Clayton Disinfector has been suggested. This might be practicable where the quantity to be dealt with is small—indeed, during the Mossel Bay outbreak in 1901 the fumigation of all goods likely to be contaminated with plague infection, or to harbour rats, was carried out before such goods were allowed to be sent out of the town—but in the case of places such as Cape Town, Port Elizabeth and East London, I cannot see at present how such a scheme could be carried into practical effect. The measures which have been found practicable are the careful surveillance of all stores and business premises from which goods likely to be contaminated with infection, or to harbour rats, are exported, and the inspection of all such goods before despatch. The history of the disease in the Colony shows that the measures taken have not in all cases been attended with success.

X.—Special Measures at Ports.

Before any vessel is granted pratique, certificates of the usual nature, regarding the occurrence of infectious diseases in man, must be signed by the master and also by the ship’s surgeon, if there be one. Up to the time of the “Nevassa” incident, already referred to, no certificate was required regarding the existence of rats on
board or the occurrence of suspicious disease amongst them; port health officers, however, had instructions to make careful enquiries on this point, especially in the case of vessels which had recently visited plague-infected ports. Under the regulation already referred to, making compulsory the notification of any sickness or mortality amongst rats or other animals liable to contract plague occurring within the Colony or in its territorial waters, a certificate as to the state of infestation of the vessel by rodents, the finding of any dead or sick rodents, or other circumstance pointing to the occurrence of sickness or mortality amongst them, is now required to be signed by the master of every arriving vessel before pratique is granted. This certificate has been in use since September, 1903.

Rat-catching staffs are employed at the larger ports, and arriving vessels searched for evidence of infection amongst rats, or for goods damaged or contaminated by rats; in the case of vessels which have recently visited plague-infected ports, this search is, if possible, carried out before the vessel comes alongside the quay. The Clayton Sulphur Disinfecting Apparatus has been provided at the port of Cape Town, but, except in one instance, has so far been used only for disinfecting infected vessels. Experiments which have been carried out by Dr. G. W. Robertson, Bacteriologist to the Government Public Health Department, show that the apparatus provides an effective means of destroying insects, rodents and disease infections. The heavy cost of working and the effects of the sulphur fumes on certain articles of cargo—such as seeds, the germinating power of which is destroyed, flour, which does not "rise" satisfactorily after treatment with the gas, and dyed silks, which are apt to be discoloured—are serious drawbacks. For empty vessels, vessels in ballast, or vessels with cargo of a kind not liable to be damaged by the gas, the Clayton System of Disinfection would appear to be both convenient and effective.

A good deal of attention has been directed to the question of preventing the migration of rats to or from vessels. During the first two or three years of the invasion of the Colony circular shields or bell-shaped discs were affixed to all mooring chains or cables, whilst gangways and other communications with the shore were tarred daily, so as to keep a strip of tarred surface, at least two feet broad, at all times in a sticky condition. As the efficacy of these measures appeared somewhat doubtful, arrangements were made to test them experimentally. A large tank was procured, a piece of cable stretched across it and rat cages fixed to the tank at each end of the cable. It was found that the forms of shields in
use were quite ineffective for preventing the passage of rats. A strip of recently applied tar was found to be equally ineffective. A considerable amount of ingenuity has since been expended by the Officers of the Department in devising a means of effectively preventing this migration. Many forms of shield have been devised, but all have proved ineffective. The only device which has proved at all effective is a metal tube some eighteen inches long, smeared thickly with bird-lime and adapted for fixing over cables. Although when chased a certain proportion of the rats experimented with succeeded in safely crossing this obstruction, it has been found that when not so chased they are, if the bird-lime and rats be fairly dry, invariably either caught in the bird-lime or else they fall into the water more or less entangled with bird-lime and usually drown. Gangways can be similarly protected by laying across them bird-limed boards about eighteen inches broad. The great defect of this plan is that it is only effective when both the bird-lime and the rats are fairly dry; in the open during wet weather it would be ineffective. The ideal arrangement for preventing this migration should not only effectively prevent rats from traversing cables between vessels and the shore but should catch all rats making the attempt, so that they could be subsequently examined; it should also be cheap and of simple construction. Such an apparatus has yet to be devised.

XI.—Concluding Remarks.

Before suggesting any extended application of the results of experience of plague in this Colony it may be well to enquire how that experience compares with the history of the disease in other countries which have recently been invaded. On tracing the history of the present pandemic—which commenced at Canton in 1894—it will be seen that in a very large proportion of the sea-port towns which have become infected, there is clear evidence of the introduction of the disease either by infected rats or by forage, grain, sacking, or articles of a similar kind contaminated by infected rats; I know of no instance where any considerable outbreak of plague occurring at a sea-port has been definitely traced to infection introduced by persons suffering from the disease.

Regarding the mode of spread of the disease in coastal towns, the experience of Hong-Kong, Asuncion, Pisco, Callao, Sydney, Brisbane and Durban has been similar to that of the Cape Colonial Ports. In each of these outbreaks cases of the disease in man
have followed in the wake of a rodent epizootic. Up to the present India and South Africa are the only countries which, during the present pandemic, have had any considerable experience of the spread of the infection inland. In this Colony, with the exception of the Izeli outbreak—in which the disease remained for a considerable time undetected—in every instance where the disease has gained a footing in an inland centre the transmission has been due directly or indirectly to rodents. In India, on the other hand, human intercourse has all along been regarded as the principal mode of spread of the infection to fresh localities, the infection being conveyed from place to place by human cases—frequently of the "ambulant" type—the rodent population being, it is said, almost always infected secondarily. Furthermore, human intercourse has been regarded, both by the Indian Plague Commission, and by most, if not all, subsequent writers on plague in India, as by far the more frequent mode of transmission of the infection to man. The Indian Plague Commission's Report of 1901 attributes epidemic plague principally to direct contact with persons suffering from the disease, or with infected articles; it, however, states that rats take plague and that rats and man may be reciprocally infective, but that an epidemic sometimes precedes and sometimes follows an epizootic, and that sometimes each runs its course independent of the other. From what has already been said it will be seen that the history of the disease in South Africa is radically different from this; indeed, no parallel can be found in the history of the present pandemic. It seems incredible that so many competent observers of plague in India should have been mistaken either in their observations or deductions. It may be that the native population of India is exceptionally susceptible to plague, or that the strain of infection has greater powers of diffusion by human agency than it has in other countries; possibly both these causes may operate. In the history of the present pandemic of plague the experience of India is clearly exceptional, whereas that of all other invaded countries is analogous to experience here. It is therefore, I think, justifiable to urge that the lessons taught by plague in this Colony are of very general applicability. The history of the past few years has shown that at the present time no country is safe from invasion by plague. It would appear that in Europe human intercourse is still regarded as the principal mode of the spread and introduction of the disease in man—the great danger to be guarded against. The International Health Convention, drawn up at Paris in 1903, makes careful provision for the inspection of passengers
leaving or arriving from infected ports, and for the inter-State notification of the occurrence of human cases of the disease, but no such notification of plague in rodents is required to be made unless or until cases of the disease in man have also been discovered. No one who has had experience of the usual mode of spread of the infection can regard this omission otherwise than as a vital defect. Again, while the Convention provides for the quarantining of vessels with human cases on board, vessels with infected rats, but without cases in man, on board cannot under the Convention be so dealt with. Since August, 1902, every discovery of plague in rodents or other animals in this Colony has been included in the weekly plague bulletins issued by the Government, an example which New South Wales and Natal have since followed.

There would seem to be a fairly general feeling that a European town, administered on modern sanitary principles, has little to fear from plague, and that, even were the infection introduced, it could be speedily eradicated by the application of the general sanitary measures ordinarily taken for combating outbreaks of infectious disease. Judging by experience of the disease in South Africa, this is a dangerous fallacy. Poverty, overcrowding, want of sunlight, bad ventilation and their concomitants, undoubtedly have their effect in fostering plague, as they have, for instance, in the case of small-pox. An attempt to combat a plague outbreak without taking measures against rats would be comparable to attempting to eradicate small-pox without enforcing vaccination. Little or no danger need be apprehended from the occasional introduction of cases of the disease in man; the real danger is the risk of infection of the rodent population, and it is against this that coastal precautions should be principally directed. No doubt, in a well-built European town, a rodent epizootic could be combated much more effectively than is possible in towns such as those of this Colony, they could more easily be divided up into what may be termed "rat-tight compartments." Yet should plague once gain a thorough hold on the enormous rat population of, for instance, one of the larger ports of Great Britain, such as London, Liverpool or Glasgow, and were it to have the same power of diffusibility amongst rats and the same transmissibility from rats to man as have been observed here, the results might be very serious. It is sincerely to be hoped that the resources of modern sanitary science will succeed in averting such an eventuality.