(*b*) *Housing Conditions.*—As general diet and hygienic conditions are fairly stable throughout the compounds, an obvious factor left to consider is the influence of the number of occupants per room upon the distribution of incidence of P.T.B. This number varies from 2 to over 100. If tuberculosis were appreciably infective, then a contact should experience greater liability to contract the disease than a non-contact, and larger rooms should exhibit a significantly higher rate of incidence than smaller rooms. To throw some light upon this problem, the Research Committee asked mine medical officers to keep compound spot maps of their recorded cases. On some mines this was not possible ; while many maps were unusable for statistical purposes. One medical officer had, on his own initiative, been keeping excellent spot-maps since the inauguration of the Research Committee, and his data, embracing 404 rooms with a capacity of over 20,000 Natives, and covering an experience of 33 months, are here dealt with separately. Of the others only 10 were ultimately found satisfactory ; they cover an experience of 17 months and deal with 1,194 rooms with a population of over 38,000.

TABLE 24 (*a*).

DATA REGARDING NUMBER OF OCCUPANTS PER ROOM.

5 Compounds—33 Months' Experience.

Room Capacity	No. of Rooms.	No. of Occupants.	Number of Cases per Room.									Total Cases.	Incidence Rate per 1,000
			0	1	2	3	4	5	6	7	8		
1– 20	17	226	12	5	—	—	—	—	—	—	—	5	22·1
21– 40	89	3,141	45	21	19	3	1	—	—	—	—	72	22·9
41– 60	232	12,023	95	75	38	14	7	2	1	—	—	237	19·7
61– 80	52	3,527	14	17	15	5	1	—	—	—	—	66	18·7
81–100	8	730	1	2	2	2	1	—	—	—	—	16	21·9
101–120	6	635	—	—	1	1	—	2	—	1	1	30	47·2
Totals	404	20,282	167	120	75	25	10	4	1	1	1	426	21·0

TABLE 24 (*b*).

DATA REGARDING NUMBER OF OCCUPANTS PER ROOM.

10 Compounds—17 Months' Experience.

Room Capacity.	No. of Rooms.	No. of Occupants.	Number of Cases per Room.							Total Cases.	Incidence Rate per 1,000
			0	1	2	3	4	5	6		
1– 20	495	6,726	422	65	7	1	—	—	—	82	12·2
21– 40	272	8,513	205	55	10	2	—	—	—	81	9·5
41– 60	392	20,370	243	108	33	5	3	—	—	201	9·9
61– 80	22	1,513	6	13	2	—	1	—	—	21	13·9
81–100	6	550	2	3	1	—	—	—	—	5	9·1
101–120	7	739	1	1	3	—	1	—	1	17	23·0
Totals ...	1,194	38,411	879	245	56	8	5	—	1	407	10·6

The incidence rates here computed are for the whole experience. A proportional reduction to one year does not render them comparable with the mean annual rates used in Table 18, on account of the turnover of the occupants. An assumed annual turnover of 90 per cent. brings them fairly close to the mean of the recorded rates for each group.

With the exception of rooms of capacity over 100, these incidence rates offer no grounds for suspecting any definite influence of the size of a room upon the number of cases occurring in it. The matter may be definitely tested by means of Pearson's well-known " Goodness of Fit " criterion.[57] If we assume that there is no bias in the risk either for individuals or for rooms, and that the probability of the occurrence of a tuberculosis case in any room is in no way affected by the previous occurrence of a case in the same room, then the distribution of cases amongst the rooms should follow the well-known Poisson Law.

Taking, therefore, the mean probability of the occurrence, of a case in the two experiences as $\frac{426}{20282}$ and $\frac{407}{38411}$ respectively, we find, on the assumptions just made, the following expected distributions :—

TABLE 25 (*a*).

POISSON DISTRIBUTION—33 MONTHS' EXPERIENCE.

Room Capacity.	No. of Rooms.	Number of Cases per Room.						Expected No. of Cases.
		0	1	2	3	4	5+	
1– 20	17	12·86	4·14					4·75
21– 40	89	42·41	31·44	11·65	3·50			65·97
41– 60	232	78·12	85·03	46·28	16·79	4·57	1·21	252·53
61– 80	52	12·51	17·82	12·70	6·03	2·94		74·08
81–100	8	1·18	2·26	2·16	1·38	1·02		15·33
101–120	6		2·09	1·61	1·19	1·11		13·34

TABLE 25 (*b*).

POISSON DISTRIBUTION—17 MONTHS' EXPERIENCE.

Room Capacity.	No. of Rooms.	Number of Cases per Room.				Expected No. of Cases.
		0	1	2	3+	
1– 20	495	428·62	61·71	4·67		71·27
21– 40	272	195·23	64·74	10·73	1·30	90·20
41– 60	392	226·03	124·45	34·26	7·26	215·84
61– 80	22	10·62	7·29	2·82	1·27	16·03
81–100	6	2·27	2·21	1·52		5·83
101–120	7	2·29	2·56	2·15		7·83

In these theoretical distributions the end classes have been grouped so that no frequency-cell contains less than a unit. The number of frequency-cells filled is 26 in 25 (*a*) and 21 in 25 (*b*). If E is the expected

frequency from Table 25 and O the corresponding observed frequency from Table 24, then the total variance is given by $\Sigma\ (E-O)^2/E$ where the summation is over all the cells. In the first case, the variance is found to be 31·58, and in the second 21·33. Now, in each case, the marginal totals of rooms are fixed, and furthermore the total number of cases in the theoretical distribution is also fixed by the experience. These restrictions necessitate the removal of seven degrees of freedom, and therefore the number of cells which may be filled arbitrarily is 19 in (*a*) and 14 in (*b*). For these values of χ^2 we find P = ·04 and ·09 respectively. That is to say, random sampling would lead to a worse fit with hypothesis in 4 per cent. and 9 per cent. trials respectively, and we therefore conclude that the evidence of the compound spot-maps discloses no grounds for belief that the number of inhabitants per room is a factor affecting the variations in the incidence rate of pulmonary tuberculosis.

The quest for an explanation of the differences in tuberculosis incidence between mine and mine is taken up also by Dr. Mavrogordato in a communication published as an Appendix to this Report (Appendix No. 5, p. 332).

In this communication he has set up like a row of ninepins the various tentative explanations which have been put forward from time to time and has then proceeded systematically to bowl them over one by one.

The only logical conclusions would appear to be either (*a*) that we have still not found the one factor accounting for the differences or (*b*) that there is no such one adverse factor in operation, but that the same influences operate all along the Reef, only varying in degree and in their combinations from mine to mine

7. Relation of Incidence to Age.

No large series of figures is available showing the relationship between tuberculosis incidence and age-distribution, because the age of the employees is not a matter *per se* that the mining companies concern themselves with, nor is it anybody else's business to keep record of them. We are dependent upon the series of post-mortem reports collected by this Committee for some definite information on this point. These are probably fairly representative, but it must be borne in mind that, for reasons given earlier in this section, ages are often only approximations and not exactitudes. Graph 1 deals with these figures.

The figures obtained from the series of 788 consecutive autopsies on mine Natives who had died of tuberculosis show that 245 cases were under 25 years of age. This represents 31·1 per cent. of the deaths occurring in 20 per cent. of the complement, and a death-rate of 6·4 per 1,000. In Natives aged between 25 years and 40 years there were 312 deaths ; this represents 39·6 per cent. of the deaths occurring in

70 per cent. of the complement and a death-rate of 2·3 per 1,000. There were 231 deaths in boys of over 40 years of age, *i.e.*, 29·3 per cent. of the deaths occurring in 10 per cent. of the complement, a death-rate of 12 per 1,000.

The incidence of tuberculosis in relation to age shows a striking similarity to the incidence in relation to length of service, viz., a " clumping " at the extremes, with comparatively few cases in the intermediate years ; or, in other words, tuberculosis abundant in the first year of service or in ages under 25, infrequent in the second to fifth year of service or in ages between 25 and 40, and again abundant in Natives with total service of over five years or in ages over 40.

Is age or length of service the important factor in determining this incidence ? There can be little doubt that it is length of service and not age.

The numbers of Natives starting mining work for the first time when they are already " elderly " are too few to test on a statistical basis whether they show a similarly high incidence in the first year of their service, but the fact brought out in the Pathological Section of this Report (see p. 169) that in Natives over 40 years of age, apart from the influence of silicosis, tuberculosis tends to become generalized practically just as much as in the younger Natives, would indicate that age *per se* has little influence on the power of resistance and therefore on the incidence.

8. Relation of Incidence to Length of Mining Service.

The first of what have been called transient factors which calls for investigation is the influence upon the incidence rates of the constitution of the mine complements with respect to previous contact with mining conditions. Unfortunately, data are not available for the previous history of all working Natives ; but two specially undertaken enquiries throw some light upon the problem.

The first of these was a census in respect of past service of the Native employees of eight mines. The total mean annual complement of these mines is about 75,000, and the samples covered by the census embraced 64,000 Natives.

This should be representative of the whole mine complement in each case. The years of service enumerated were years spent on any Witwatersrand gold mine, and not merely the years of employment on the mine on which the census was taken. The two terminal groups are here designated N.R (*i. e.*, new recruits of under one year of service) and L.S. (*i.e.*, long-service Natives of over five years' experience) respectively. How far the census figures obtained may be considered to reflect the average constitution of the complement of each mine during the year in which it was taken is not by any means certain, but in all probability they are substantially representative. The data are given in Table 26

TABLE 26.

EIGHT WITWATERSRAND GOLD MINES.

CONSTITUTION OF COMPLEMENT AND INCIDENCE RATES.

1928-29.

Mine Index No.	Total Complement in thousands	% of New Recruits.	% of Long Service.	Incidence Rates per 1,000.			
				P.T.B.	T.B.S.	S.S.	O.T.B.
2	9	16·84	15·47	3·49	3·04	0·563	1·58
4	16	21·14	16·65	2·73	2·92	1·366	2·17
6	11	31·53	8·41	6·52	2·06	0·687	1·12
14	4	17·58	8·87	1·39	1·86	1·625	0·46
16	4	16·23	11·67	2·12	1·18	1·884	0·94
18	8	22·19	6·07	1·92	1·15	0·638	0·13
21	17	25·76	6·23	2·63	1·70	0·527	4·04
28	5	27·23	9·33	5·45	3·86	0·454	0·68

From these the following correlations were obtained :—

TABLE 27.

EIGHT WITWATERSRAND GOLD MINES.

CORRELATIONS BETWEEN EXPERIENCE AND INCIDENCE.

	P.T.B.	T.B.S.	S.S.	O.T.B.
% N.R.	$+0·72 \pm 0·12$	$-0·46 \pm 0·20$	$-0·52 \pm 0·19$	$+0·17 \pm 0·25$
% L.S.	$-0·02 \pm 0·25$	$+0·69 \pm 0·13$	$+0·52 \pm 0·19$	$-0·12 \pm 0·25$

On account of the meagreness of the data upon which they are based, the probable errors of these coefficients are high. Nevertheless, the conclusion is legitimate that pulmonary tuberculosis and the two silicosis categories tend to be selective in their incidence ; the former attacks the new recruit more readily than the experienced Native, while the latter, depending, as they do, upon a continued inhalation of quartz-dust, can only appear, as a rule, in the Natives who have had at least a few years' service. Granting, therefore, that the various mines differ amongst themselves in respect of the experience of their Native complements, part, at least, of the hypernormality disclosed in Table 18 is accounted for in these three categories.

In so far as the present data are concerned, there is no evidence that experience of mining conditions influences in any way the incidence of tuberculosis other than pulmonary.

The second special enquiry directed towards the elucidation of the influence of previous experience upon the incidence of pulmonary tuberculosis involved Mines Nos. 2 and 4, with mean complements of

about 9,000 and 16,000 respectively. Over the period January, 1927, to June, 1928, the total number of shifts worked on any Witwatersrand gold mine was recorded for each case. (Mine No. 2 returned the information for P.T.B., T.B.S. and S.S. cases together; No. 4 for P.T.B. and T.B.S. together.) From these returns, in conjunction with the special census of service respecting these mines, relative incidence-rates for various durations of service have been obtained. As the previous histories are in terms of "shifts worked," while the census of service is in terms of years, the former have been converted into years on the approximate basis of one year service=300 shifts worked. This gives the following distribution :—

TABLE 28.

SERVICE DISTRIBUTION OF CASES, January, 1927, to June, 1928.

Mine Index No.	Category.	Years of Total Service.						Total No. of Cases.
		0–1	1–2	2–3	3–4	4–5	over 5	
2	P.T.B., T.B.S., S.S.	33	12	9	10	3	18	85
4	P.T.B., T.B.S. ...	77	19	14	8	6	17	141

To obtain annual incidence rates, a hypothetical complement (100,000) is assigned to each mine, and the hypothetical cases are obtained from the appropriate rates of the 1927-8 standard returns. These cases are now distributed amongst the years of service in the proportions disclosed by Table 28, while the hypothetical complement is likewise distributed in accordance with the proportions disclosed by the "census of service."

TABLE 29.

VARIATION OF INCIDENCE RATE WITH YEARS OF SERVICE.

Mine No. 2.—Hypothetical Complement, 100,000.

Recorded Rate: P.T.B.+T.B.S.+S.S. 7·60 per 1,000 per annum. Equivalent Cases: 760.

Years of Service.	0–1	1–2	2–3	3–4	4–5	Over 5	Totals.
Percentage of Cases (Table 28) ...	38·8	14·1	10·6	11·8	3·5	21·2	100
Percentage of Complement (Census)	16·8	24·2	19·7	14·7	9·1	15·5	100
Distributed Cases ...	295	107	80	90	27	161	760
Rate per 1,000 P.T.B. T.B.S., S.S. ...	17·6	4·42	4·06	6·12	2·97	10·39	7·60

Mine No. 4.—Hypothetical Complement, 100,000.

Recorded Rate: P.T.B.+T.B.S. 6·84 per cent. per annum. Equivalent Cases: 684.

Years of Service.	0–1	1–2	2–3	3–4	4–5	Over 5	Totals.
Percentage of Cases (Table 28.) ...	54·6	13·5	9·9	5·7	4·3	12·0	100
Percentage of Complement (Census)	21·1	24·1	16·6	13·2	8·3	16·7	100
Distributed Cases ...	374	92	68	39	29	82	684
Rate per 1,000 P.T.B. T.B.S.	17·7	3·82	4·10	2·95	3·49	4·91	6·84

These rates are exhibited on the next page in Graph 7, in which, for graphical purposes, the terminal group "over five years" is arbitrarily centred around the year 8-9. The results strengthen the conclusions based upon the correlations of Table 27. The incidence-rate in the first year of service is much greater than in any subsequent year. After that critical year is passed, the incidence rate drops abruptly, and remains moderately steady for a few years. In the later years the inclusion of silicosis cases causes the rate to rise again, the sharper rise in Mine No. 2 being a good deal due to the inclusion in its returns of simple silicosis cases, which are omitted in the returns from Mine No. 4.

The influence of length of service on tuberculosis prevalence is further discussed by Dr. Mavrogordato in Appendix No. 5, p. 348.

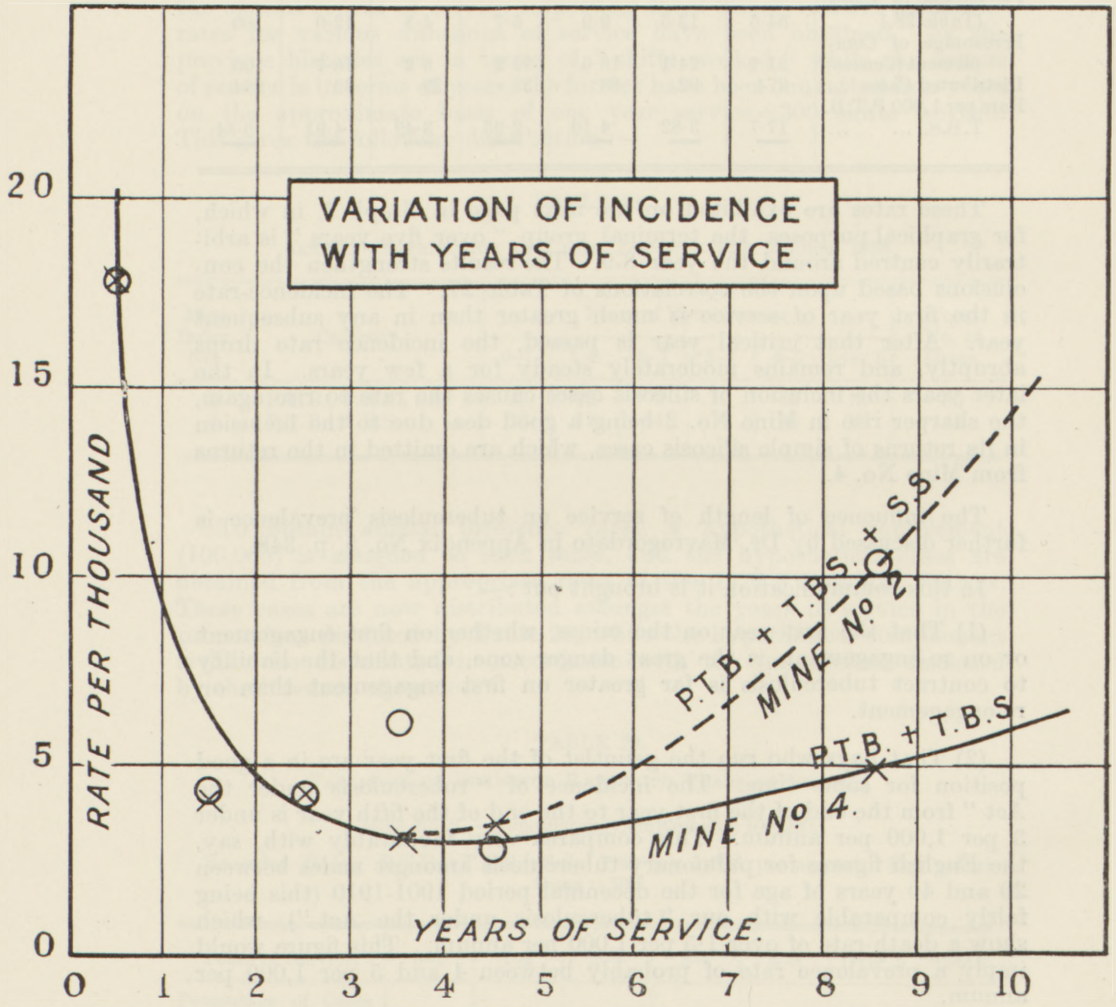
In this communication it is brought out :—

(1) That the first year on the mines, whether on first engagement or on re-engagement, is the great danger zone, and that the liability to contract tuberculosis is far greater on first engagement than on re-engagement.

(2) That boys who run the gauntlet of the first year are in a good position for some time. The incidence of "tuberculosis under the Act" from the end of the first year to the end of the fifth year is under 3 per 1,000 per annum. This compares very favourably with, say, the English figures for pulmonary tuberculosis amongst males between 20 and 40 years of age for the decennial period 1901-1910 (this being fairly comparable with our "tuberculosis under the Act"), which show a death-rate of over 1·5 per 1,000 per annum. This figure would imply a prevalence rate of probably between 4 and 5 per 1,000 per annum.

(3) After the close of the fifth year, the tuberculosis rate starts to rise as the baneful effects of duration of exposure to mining conditions overcome the beneficial effects of acclimatization to these conditions. The silicotic element plays a large part in the rise of the tuberculosis rate after the close of the fifth year.

Graph 7.



○=Incidence rates on Mine No. 2.
×=Incidence rates on Mine No. 4.

9. RELATION OF INCIDENCE TO TRIBAL IDIOSYNCRASY.

Owing to lack of data, it has not been possible to analyze tribe by tribe the influence, if any, of the tribal factor on the incidence rate.

A customary dichotomy, however, divides the Native labour force into East Coast and British South African Natives, and the opinion has been generally held that the former are more susceptible to tuberculosis than the latter.

An attempt has been made to investigate this supposed differential susceptibility on the basis of data supplied by the W.N.L.A. These data were obtained from their records of cases repatriated and cases compensated during the four years 1927-30.

An analysis of these records is shown in Table 30.

TABLE 30.

EAST COAST AND B.S.A. CASES REPATRIATED OR COMPENSATED.

Year.	P.T.B.			T.B.S.			S.S.		
	E.C.	B.S.A.	Total.	E.C.	B.S.A.	Total.	E. C.	B.S.A.	Total.
1927	369	330	699	217	75	292	127	38	165
1928	272	214	486	293	89	382	167	44	211
1929	260	307	567	259	105	364	136	52	188
1930	241	285	526	173	85	258	186	91	277
Total	1,142	1,136	2,278	942	354	1,296	616	225	841

The Chamber of Mines figures for the total Native complement for the four years under consideration were as shown in Table 31.

TABLE 31.

TOTAL NATIVE COMPLEMENT.

Year.	E.C.	B.S.A.	Total.
1927	82,163	103,258	185,421
1928	90,811	104,350	195,161
1929	85,771	106,358	192,129
1930	78,056	122,578	200,634
Average ...	84,200	109,136	193,336

For the four years under review, therefore, these figures yield the following mean incidence rates (Table 32) :—

TABLE 32.

MEAN INCIDENCE RATES PER 1,000 (1927-1930).

	P.T.B.	T.B.S.	S.S.
E.C.	3·39	2·80	1·83
B.S.A.	2·61	0·81	0·52
Total ...	2·95	1·68	1·09

It will be seen that these total rates differ to some extent from those deduced from the standardized returns of the mine medical officers (see Table 18). The difference cannot be accounted for by the fact that the returns cover slightly different periods of time. A re-grouping of the standardized monthly returns into calendar years shows that the numerical content of their P.T.B. category is invariably higher than that of the W.N.L.A. figures, while their silicosis categories are almost always lower.

The explanation lies in the fact that the two sets of figures deal to some extent with different cases, although many cases are common to both sets. The standardized returns contain a considerable number of cases of Natives dying in the mine hospitals who do not figure in the W.N.L.A. returns. Many of these, as the pathological records show, are cases of acute pulmonary tuberculosis ; they therefore go to swell the P.T.B. column in the standardized returns. The W.N.L.A. figures, on the other hand, contain a fair number of cases which do not appear in the standardized returns ; these being Natives with previous mining service who turn up at the W.N.L.A. either through having been detected when applying for re-engagement or through definite application for compensation. Such cases tend to swell the silicosis categories of the W.N.L.A. returns.

It was necessary to take the W.N.L.A. figures for the purpose in hand instead of using the standardized returns because the latter were not sufficiently complete in detailing the tribes of the cases.

Table 32 shows that in each of the three categories here considered there is a higher incidence rate for East Coast than for British South African Natives. The important question, then, is—how far may these differential susceptibilities be regarded as statistically significant ?

There can be no doubt regarding the significance of the difference in the two silicosis categories, for the observed difference is from eight to nine times its standard error in each case. But although the difference is significant, one is not justified in deducing therefrom a higher degree of susceptibility in East Coast Natives. Silicosis is a cumulative disease and its presence is not normally apparent until after the passage of some years of mining service. It is well known that a large proportion of the long-service Natives are East Coast boys, and the observed differences between the incidence rates in the two silicosis categories are in all probability secular phenomena, and not due to tribal idiosyncrasy.

In the pulmonary tuberculosis category, the difference between the rates of incidence for East Coast and for B.S.A. Natives is just over three times the standard error of that difference, so that the level of significance is here considerably lower than in the two silicosis categories. The relative distribution table for the four years' experience of P.T.B. is shown in Table 33.

TABLE 33.

	Not Attacked.	Attacked.	Total.
B.S.A.	0·563019	0·001469	0·564488
E.C.	0·434035	0·001477	0·435512
Total ...	0·997054	0·002946	1·000000

The mean annual complement is 193,000 and the tetrachoric correlation coefficient with its approximate probable error is therefore $0{\cdot}055 \pm {\cdot}012$. Hence the observed association is slight, but possibly significant.

Tribal idiosyncrasy receives some consideration in the Pathological Section of this chapter, the indication given there being that within the B.S.A. group the Basuto are more susceptible than the other tribes among which recruitment takes place.

In Appendix 5, Dr. Mavrogordato attempted to correlate the differences of tuberculosis incidence on various mines with the varying proportions of East Coast and B.S.A. Natives in their complements, but was unable to find that the proportion had any bearing on the mine's tuberculosis rate. He arrives at the interesting conclusion that within the East Coast group there is probably a section (not definitely identified) of " more susceptibles " than the group as a whole. This would be comparable with the Basutos among the B.S.A. group.

The greater susceptibility of the Basutos and the unidentified section of the East Coasters is probably to be linked up with a greater degree of isolation from outside civilization.

10. SUMMARY OF STATISTICAL SECTION.

(1) The statistics available are of unequal value ; the difficulties concerning them have been stated plainly and it is made clear where interpretations must be treated with some reserve.

(2) The general incidence rate of " tuberculosis, all forms," in the Natives employed upon the Witwatersrand gold mines has been falling during the past 16 years, and is now in the neighbourhood of 7 per 1,000 per annum. This rate is calculated in terms of average complement engaged, and when it is remembered that this complement changes at a rate of over 90 per cent. per annum it will be realized that this is making the most of the rate of incidence.

(3) Many European countries and countries inhabited by European stocks have a prevalence rate of tuberculosis no lower than that obtaining among our mine Natives for the same age-group.

(4) On the other hand, taken over the last ten years, our Native incidence-rate for simple tuberculosis is fully twice that of the White miners employed on the Witwatersrand, but the incidence of "tuberculosis under the Act," which includes silicotic cases in addition to simple tuberculosis is only about one-quarter of that in the European.

(5) Mine Natives running the gauntlet of their first contract have a lower tuberculosis prevalence for the next four years than obtains for the general male population in Europe of the same age. The employment risk is shown by the marked rise in the rate after five years of completed service.

(6) The two unhappy features of our mine Natives' tuberculosis are (*a*) the really high prevalence rate that obtains for the first contract worked on these mines and (*b*) the fact that, taken over two years' duration, the mortality is 70 per cent. of the morbidity owing to the severe form which tuberculosis takes in the Natives.

(7) There is evidence of a definite seasonal oscillation in the tuberculosis incidence on the gold mines, the peak coming in the summer months, and it is suggested that this may be due, in part, at least, to the inciting influence of the prevalent influenza in the spring months.

(8) There are marked differences in the incidence rate between mine and mine. No one factor has been found to account for these differences. It is suggested that the same factors operate on all the mines along the Reef but that they vary from mine to mine in their degree and in their combinations.

(9) There is evidence suggesting that certain groups of Natives coming from parts most isolated from outside contacts with civilization are more susceptible than the others.

Section E.—Pathology of Tuberculosis on the Witwatersrand.

1. Bacteriology.

Bacteriological investigations on the subject of tuberculosis on the Witwatersrand gold mines have been conducted on two main lines :— (1) The type of tubercle bacilli associated with tuberculosis among the Native mine labourers, and (2) a search for tubercle bacilli in samples of mine air, dust and mud, and in specimens of sputum collected underground.

(1) *Type of Bacilli associated with Tuberculosis in South African Natives.*—It has generally been taken for granted that the tuberculosis of Natives in South Africa is due mainly, if not entirely, to bacilli of human type. The following statement taken from the "Report upon the Work of the Miners' Phthisis Medical Bureau for the 12 months ended July 31st, 1925," by Dr. Watkins-Pitchford, indicates the grounds for this belief in so far as the Native mine labourers are concerned : "The form in which the disease is encountered on the mines

indicates that it is due to infection with the human type of the bacillus, since tuberculous disease of the skin, joints and bones—which characterize infections with the bovine bacillus—are practically never seen. In a recent publication (Bigger, *Handbook of Bacteriology*, 1925, p. 299) it is stated that the human adult is almost completely resistant against infection with the bovine type of *B. tuberculosis* and, moreover, tuberculosis is very rarely encountered amongst cows in the Transvaal, nor is cows' milk supplied to the Native labourers. These considerations point to the conclusion, not only that the disease is due to the bacillus of human type, but also that it is communicated directly by infection from one individual to another."

Tuberculosis among Animals in South Africa.—The situation at the present time as regards the prevalence of tuberculosis among cattle and other animals in South Africa may be gathered from the following extracts :—

Viljoen[58] states that until about ten years ago tuberculosis in cattle was almost confined to dairy herds in the western districts of the Cape Province, but more recently it has become increasingly prevalent in dairy herds in other parts of the Union. Exact statistics are not available for the northern provinces, but it is believed that not more than 10 per cent. of the dairy cows are affected. More definite statistics are obtainable for slaughter cattle. In the Durban export abattoir 0·05 per cent. were found to be tuberculous, out of 62,000 head. Pigs showed a heavier incidence—9 per cent. out of 6,500—but it was not determined whether their infections were of bovine, human or avian type. It is known, however, that many of the pigs came from dairy farms, and it is also known that avian tuberculosis is fairly common in some parts of Natal, so that there is a likelihood of bovine and avian types predominating.

In the report of the Johannesburg Municipal Abattoir for the period 1st July, 1926, to 30th June, 1927, A. C. Kirkpatrick, M.R.C.V.S., Acting Director for that period, reports that out of 112,495 head of cattle slaughtered there were 29 cases of tuberculosis (0·025 per cent.), 1 bull, 7 oxen and 21 cows. Among 72,059 pigs there were 267 cases (0·37 per cent.).

No information is obtainable as to the incidence of tuberculosis among the cattle belonging to Natives living in their own reserves. That it might exist is suggested by a recent observation recorded by Paine and Martinaglia.[59] They have found cases of tuberculosis occurring in wild buck living under natural conditions in the Albany district of the Cape. Two species (Kudu, *Strepsiceros strepsiceros*, and Cape Duiker, *Sylviacapra grimmi*) have been found so infected, the organisms isolated in every case being of characteristic bovine type. The infection must presumably have been derived from cattle, although the incidence among cattle in that district appears to be very low. Statistics from the Grahamstown abattoir show only 2 cases for the last 5½ years out of 17,263 cattle slaughtered, and 1 of these cases was a cow recently introduced from the Western Cape area.

On the whole, therefore, the evidence goes to show that tuberculosis is rare among cattle kept in the open, although it appears to be becoming more rife among stall-fed dairy cows. The risk of bovine infection occurring in humans is probably, therefore, greater among children in towns than it is among the Natives in their own kraals.

Some further information about the prevalence of tuberculosis in domestic animals is given in Appendix 10, p. 422.

The Present Investigation.—Although there was no real reason to doubt the generally accepted belief that the tuberculosis of the Native was due mainly, indeed, almost entirely, to the human type of bacillus, it appeared advisable to put this belief upon the surer basis of direct observation, hence the undertaking of the present investigation.

The details of the work—source of material from which the cultures were obtained, technique, etc.—are given in Appendix 6, p. 357.

The main finding of the investigation can be stated very briefly, viz., that the generally accepted belief was justified by the facts, for of the 100 cultures of tubercle bacilli isolated from various sources in Natives not a single one turned out to be other than human type.

Tuberculosis on the Rand gold mines and, seeing that it has been established that a big proportion of the Natives come to the mines already infected, tuberculosis of the South African Natives generally, must, therefore, be accepted as practically entirely a disease due to the human type of bacillus and spread from individual to individual.

The infection, as will be seen from the following report on the pathological anatomy of the disease, is largely air-borne, entering by the respiratory tract, although a small proportion of cases are infected through the alimentary tract.

As many cases as possible where the route of infection appeared to be *via* the alimentary tract were included in this investigation, so as to increase the chances of finding bovine types, but despite this loading of the dice in their favour no bovine types were found.

It may be noted that in four cases a growth was obtained from tissues of acid-fast organisms other than tubercle bacilli. These growths were always scanty, single colonies usually, and there was nothing to suggest that the organisms were in any way pathogenic. Three of the cases had characteristically tuberculous lesions, although tubercle bacilli were not obtained in culture ; the fourth case had no tuberculosis. The presence of these living acid-fast bacilli in organs is of some interest, especially when taken in conjunction with the fact of their common occurrence in the water and soil of the mines. Whatever their significance may be, their recovery in culture serves as a reminder that not every acid-fast bacillus found in tissues, even in tuberculous tissues, is necessarily a tubercle bacillus.

(2) *Tubercle Bacilli in Mine Soil and Air and in Samples of Sputum Collected Underground.*—The examination of mine soil, air, etc., was undertaken at the suggestion of Prof. Lyle Cummins as an endeavour to find out, if possible, to what extent the mines themselves were infective.

It is obvious that if cases of open tuberculosis cough or expectorate underground, there are considerable possibilities of mine air, dust and soil becoming infected, and it is likely that in the absence of sunshine and the presence of abundant warmth and moisture, tubercle bacilli might have a long life in the conditions prevailing underground. If this could be definitely established for any particular place or type of place in the mines, direct disinfecting methods of treating such places would be indicated, always provided that such methods could be devised.

That infection with tuberculosis can occur underground had already been shown by Mavrogordato.[60] He found tuberculosis in 8 out of 46 rats kept underground for varying periods, but in no instance for more than 18 months.

These considerations suggested to Professor Lyle Cummins that it might be of value to undertake a series of systematic examinations of mine soil, dust and air to see whether direct evidence could be obtained of their being infective.

It was realized that too much was not to be expected from such examinations, as the size of the samples that it was practicable to examine could at most only be but an infinitesimal fraction of a mine area. Negative results were therefore expected to predominate, but in accordance with the general rule applicable to such cases, it will be realized that failure to find tubercle bacilli in samples of mud or dust from a mine does not prove that that mine is necessarily free from tubercle bacilli.

The known frequency of acid-fast bacilli in mine soil and water made it essential that the identification of tubercle bacilli should be by biological methods and not merely by bacterioscopic examination. As a matter of fact, a quite cursory (by no means prolonged or exhaustive) examination of smears of the various samples obtained showed the presence of acid-fast bacilli in 48 out of the 100 samples of soil, etc., examined and in 3 out of the 14 samples of air examined.

The examination of specimens of sputum collected underground was considered advisable on account of the findings reported by Dr. Watkins-Pitchford.[37] He found 15·2 per cent. of sputa from underground workings to be tuberculous, but the diagnosis was based merely on bacterioscopic findings. In view of our later acquired knowledge that non-pathogenic acid-fast bacilli are common in mine soil, it seemed possible that his inference that the sputa were tuberculous might be in part, at least, incorrect, and that it would be advisable to have fresh observations made in which the diagnoses were based on a biological test. Unfortunately, for reasons given in detail in Appendix No. 6, it was only practicable to examine 33 such specimens of sputum. Amongst these 33 direct bacterioscopic examination showed the presence of acid-fast bacilli in 7 (20 per cent.), so that if dependence had been

put on the microscope alone a diagnosis of tuberculous sputum would have been given in even a higher percentage of cases than by Dr. Watkins-Pitchford.

The details of the examination of these various underground materials are given in Appendix 6. The results and conclusions drawn from them are as follows :—

(*a*) *Mine Dust and Soil.*—Although 48 samples out of the 100 examined showed the presence of acid-fast bacilli the biological tests were in every instance negative for tubercle bacilli.

Seeing that the samples with which it was possible to deal represent but such very minute portions of the whole mines, it cannot be inferred from this that mine dust is entirely non-infective, but keeping in view the fact that most of the samples came from picked spots where tubercle bacilli might reasonably have been expected to have lodged, it seems not unreasonable to infer that the dust and soil of the mines cannot be regarded as highly infective.

Tubercle bacilli must, of course, frequently be expectorated underground, and the question arises what becomes of them.

It is possible that those which lodge in dry dust become non-infective, as they have been shown by various writers (see, for example, Calmette[14]) to do in other similar situations. Probably, also, the frequent lime-washing of the walls which is carried out on the mines in the vicinity of all waiting-places is an important factor in the immobilization or destruction of tubercle bacilli. In moister situations the bacilli may either be diluted in numbers to such an extent as to be harmless, or they may be swept away altogether.

Inferentially, if the mine dust is regarded as not of much importance as the infective agent, only " droplet infection " remains as an important factor in the spread of tuberculosis.

(*b*) *Mine Air.*—Tubercle bacilli were not isolated from any of the 14 samples of air examined, but this is scarcely to be wondered at, as it would only have been by the merest chance if they had been.

Acid-fast bacilli were found present along with the dust filtered out of the air in 3 of the 14 samples. This is not without significance, as it indicates that, in addition to the possibility of tubercle bacilli being sprayed directly into the air by coughing, bacilli deposited on the soil or dust in sputum might again find their way into the atmosphere and so be inhaled. If their return to the air took place soon after their original deposition they might quite well be infective.

Although the direct examination of dust and soil indicates that these factors cannot be regarded as of much importance in the spread of tuberculosis, this finding suggests that they cannot be entirely ignored in this respect.

(c) *Specimens of Sputum from Underground Workings.*—Although 7 of the 33 specimens examined showed the presence of acid-fast bacilli the biological test for tuberculosis was positive in only 1.

In view of this finding, the figures reported by Dr. Watkins-Pitchford in 1916 can only be accepted with reservation as his purely bacterioscopic diagnosis cannot be regarded as definite proof that the acid-fast bacilli in the sputa were tubercle bacilli.

2. PATHOLOGICAL ANATOMY.

The data upon which the following section is based are given in Appendix 7, p. 374.

It should be borne in mind that the Report only deals with Native mine labourers, an exclusively male population mostly aged between 20 and 40, with extremes at, say, 17 and 60. Further, it only deals with approximately one-sixth of the total number of cases of tuberculosis and/or silicosis diagnosed in this population, viz., those cases which die on the Rand. The other five-sixths are repatriated and practically no pathological information is available regarding them. From Dr. Allan's work in the Transkei, however, it is known that although many of the repatriates die within comparatively short periods of their return home, others live for long periods and some even return to the mines and are passed for work there. It would seem to be a fairly safe assumption, therefore, that amongst the repatriates there are cases of a more chronic type than the majority of those which figure in this Report, although what proportion of these would fall amongst the group with pure tuberculosis, and what proportion are associated with silicosis, is unknown.

In considering tuberculosis among the Native mine labourers, two other features have to be kept in mind.

(1) The industry is a dust-producing one and an association of tuberculosis with a pneumonoconiosis (silicosis) is therefore common.

(2) The service of the Native mine labourer is as a rule not continuous but broken. It does sometimes happen that a Native "signs on" again whenever his contract is finished, so that cases with 10, 20 or even 30 years' continuous service are met with, but in a big proportion of cases, after 9 months or so of service, he has a spell at his kraal, but he may return to mining work again and again.

The 600 *Cases.*—The 600 cases reported in Appendix 7 include 338 "acute" cases—Groups C and D—in which the cause of death was uncomplicated tuberculosis; 200 "chronic" cases—Group B—in which the cause of death was also tuberculosis, but in which that disease was associated with silicosis; and 62 cases—Group A—in which tuberculous lesions were present but death was not actually due to tuberculosis. Of these 62 cases, 29 showed silicotic lesions in addition to tuberculosis, 26 had tuberculosis without silicosis, and in a more or less active form, 7 had only what seemed to be completely-healed lesions.

If we consider the question of susceptibility to tuberculosis of the different tribes of Natives employed, we find that, broadly speaking, there is very little difference between the two sections " East Coast " and " B.S.A. " Natives. We started this investigation with the general impression that the East Coasters would probably be found to furnish the bigger proportion of cases of the " natural tuberculosis " of virgin soil, but this has not proved to be the case. Indeed, if any one tribe can be said to show a bigger proportion of this type of tuberculosis than any other, it is unquestionably the Basuto. This is brought out by the figures in Table III of Appendix 7, and this feature may be correlated with the fact that Basutoland is not open to European settlement. The Basuto have probably, therefore, less previous tuberculization than any of the other tribes and are more nearly virgin soil when they come first to the Rand. Unfortunately, there is no extensive record of tuberculin tests among newly-recruited Basutoland labourers for comparison with the records in the East Coast recruits, but the small series of tests made by Dr. Allan, showing a lower percentage of positives than other tribes, is in harmony with this finding.

(*a*) *Acute Tuberculosis.*—Let us consider, firstly, the 338 cases put under the heading of " Acute Tuberculosis," although sub-divided into Group C of 241 cases in which the lesions were mainly thoracic, and Group D of 97 cases in which the lesions were mainly extra-thoracic.

It will be seen from Tables VIII-XI of Appendix 7 that considerably more than half of the deaths in these groups occur in boys under the age of 30 and that almost exactly half occur within the first year of mining service.

Table 34 shows the *percentage* of these cases in which the various organs and structures tabulated were the seat of tuberculous lesions.

It should be pointed out that these are minimal figures, based very largely on naked-eye examination only. Microscopic examination of some doubtful lesions and of some tissues in which tuberculosis was not even suspected established the presence of that disease, so that if microscopic examination of every organ had been systematically made there can be little doubt but that some of these figures would have been somewhat higher. Also, it should be stated that the head was only opened when there was a history of cerebral symptoms, so that the figure for the brain and meninges might well have been higher had head examinations been made in every case.

Comparisons may be drawn between tuberculosis as seen in this series of 338 cases and tuberculosis as it appears in other populations.

Through the co-operation of Professor Lyle Cummins and the kindness of the (British) Medical Research Council and of Dr. Roodhouse Gloyne, we obtained 200 post-mortem records completed at the City of London Hospital for Diseases of the Heart and Lungs, Victoria Park, London. These records were made on forms similar to those employed by this Committee.