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RESEARCH ORGANISATION

REPORT  
ON

THE HEAT STROKE POSITION AT THE END OF 1964

By

C. H. WYNDHAM

HUMAN SCIENCES LABORATORY

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## S U M M A R Y

### Aims

The aim of this study was to examine the heat stroke position at the end of 1964 in terms of the trends in the numbers of stopes and development ends and also in the "estimated" numbers of men in various class intervals of wet-bulb temperatures over the period 1957 to 1964.

### Results and conclusions

Between 1957 and 1961 there was a steady increase in the number of stopes and development ends and in the estimated number of men at wet-bulb temperatures above 80°F. The deterioration in the position was worse at the higher wet-bulb temperatures over this period, there was a 44% increase in the number of men in the class interval 84°-88°F W.B., a 48% increase in the class interval 88°-91°F W.B., and a 92% increase above 91°F W.B.

Since 1961 the position has improved. The number of stopes with the higher wet-bulb temperatures has decreased. Although the number of development ends has increased the net effect was that there were fewer men working at the higher wet-bulb temperatures in 1964 than in 1961.

These trends over the years 1957 to 1964 are summarised in the following table :-

Numbers of men at various wet-bulb temperatures

Class intervals of W.B.	<u>Y e a r s</u>		
	1957	1961	1964
Less than 80°F	82,130	69,688	70,992
80° - 83.9°F	32,306	39,647	45,207
84° - 87.9°F	28,482	42,022	39,359
88° - 90.9°F	13,502	18,366	15,368
91° - 92.9°F	2,378	4,811	2,831
Above 93°F	271	547	498

The improvement has not only been in the numbers of men working at high wet-bulb temperatures. An estimate has been made of the numbers of fatal and non-fatal cases that could have been expected in 1964. This is based upon the numbers of men working at various wet-bulb temperatures and from the incidences of fatal and non-fatal cases of heat stroke at various wet-bulb temperatures in the analysis of the 1957 to 1961 data (H.S.L. reports 5/61 and 1/64). On this basis 10 deaths and 31 non-fatal cases would have been expected.

Only 2 deaths and 20 non-fatal cases, however, occurred in 1964. This marked improvement in the number of fatal cases is attributed to the implementation of the recommendations, (contained in the two reports referred to) of the Human Sciences Laboratory and to the training of all European supervisors and African bossboys in the early recognition and treatment of heat stroke cases in working places with wet-bulb temperatures in excess of 84°F.

## 1. Introduction

An analysis of the causal factors in the heat stroke cases that occurred in the period June 1956 to July 1961 indicated that there had been a deterioration in the underground heat stroke position over that period (H.S.L. reports 1/64 and 5/61). This conclusion was based on the fact that the "estimated" numbers of men working at W.B. temperatures above 91°F, rose by 92% in that period. Above 88°F W.B. the number rose by 48% and above 84°F W.B. by 44%.

This increase in the numbers of men working in high W.B. temperatures showed that a potentially dangerous situation was developing and certain recommendations were made in the two reports referred to, which had as their object the reduction of the heat stroke hazard in other ways. One of the recommendations was that all European supervisors and Bantu bossboys in hot areas of the mines, i.e., in W.B. temperatures above 84°F, should be trained to recognise the early signs and symptoms of heat stroke, and to institute emergency treatment when these occurred. These recommendations have been implemented (H.S.L. report 4/64). Another proposal that was made in the reports was that a watching brief should be held on the situation in that the Chamber of Mines should annually collect and collate data on the numbers of Bantu working at various W.B. temperatures underground. Arrangements are in hand for this to be done.

This collection and collation of the data will, however, take some time. In the interim it is essential that the Industry should be given a picture of the present heat stroke position in terms of the trends in the numbers of development ends and stopes at various W.B. temperatures during the period 1957 to 1964. This has been done. An estimate will be given of the numbers of Bantu working at various W.B. temperatures underground during the same period and the trend in these figures will be compared with the trend in the numbers of heat stroke cases. A comparison will also be made between the numbers of fatal and non-fatal heat stroke cases that actually occurred in 1964, and the numbers that would have been predicted to occur. This comparison will be based on the curves derived from the 1956 - 1961 data (H.S.L. reports 1/64 and 5/61) relating the incidences of fatal and non-fatal cases - in cases per 1,000 - to W.B. temperatures.

## 2. Trends in the numbers of working places at various wet-bulb temperatures

Information on the numbers of stopes and development ends at various class intervals of W.B. temperatures is annually collected by the Group Ventilation Engineers and collated by the Chamber of Mines. This information is given in Table 1 for the years 1957 to 1964. The data are also plotted in Figures 1 and 2 respectively for stopes and development ends in the various class intervals of W.B. temperatures in which they are reported. The figures also contain the average velocity of air, in the case of stopes, and the average volume of air, in the case of development ends, for this period. From Figure 1 it is clear that between 1957 and 1961 there was a marked deterioration based on the increase in the numbers of stopes in the various class intervals of W.B.

/temperatures .....

temperatures above 84°F, but since 1961 the position has improved. There has also been an increase in the velocity of air in stopes with W.B. temperatures above 88°F. These recent improvements in the stopes have not been paralleled in the development ends (Figure 2.) There has been a steady increase in the numbers of development ends in all of the class intervals of W.B. temperatures above 80°F. Fortunately, since 1961 there has been an associated increase in the volumes of air ventilated into the development ends, except those with W.B. temperatures above 93°F.

These trends are shown in another way in Figures 3 and 4 where the numbers of stopes and development ends are respectively given for W.B. temperatures below 80°F and, for W.B. temperatures above 80°, 84°, 88°, 91° and 93°F. Figure 3 brings out very clearly the decrease since 1961 in the numbers of stopes operating at the higher W.B. temperatures. In the period 1961 to 1964 the total number of stopes above 80°F W.B. temperatures fell from 4,401 to 3,749 and the total above 91°F W.B. temperature fell from 239 to 97. By contrast, over the period 1957 to 1964 there was a steady increase in the numbers of development ends at the higher W.B. temperatures and this is shown in Figure 4. The total number of development ends rose from 3,562 to 4,940 in that period and the numbers above 91°F W.B. temperature rose from 149 to 210.

3. Trends in numbers of men at various wet-bulb temperatures and in fatal heat stroke cases.

There are in general more men in stopes than in development ends, and therefore in assessing the trends in the heat stroke situation in the mines it is important to make an estimate of the numbers of men in the various class intervals of W.B. temperatures in the period under review. This has been done by making use of the weighting factors proposed by the H.S.L. in reports 5/61 and 1/64 for calculating the "average" numbers of men in stopes and development ends. For most of the period the weighting factor for development ends was between 7 and 8 men per stope and for stopes it was about 17 men per stope. The "estimated" numbers of men in the various class intervals of W.B. temperatures are given in Table 2 and in Figure 5, and the "estimated" numbers below 80°F and above 80°, 84°, 88°, 91° and 93°F W.B. temperatures are also given in Table 2 and in Figure 6.

The trends over this period in the numbers of men at the various class intervals of W.B. temperatures are summarised in Table 3.

From this Table it is clear that the deterioration in the heat stroke position between 1957 and 1961 has been halted and to some extent reversed. In all of the class intervals above 84°F W.B. temperatures there has been a reduction in the numbers of men working. This is especially the case in the class interval 91°-92.9°F W.B. temperature.

/4. The .....



4. The heat stroke position in 1964

One way in which the heat stroke position in 1964 can be compared with that during the period 1957 to 1961 is to take the numbers of men working at the various W.B. temperatures in 1964 and estimate the numbers of heat stroke cases that could have been expected, using the curves relating the incidences of fatal and non-fatal heat stroke cases to W.B. temperatures from the 1957 to 1961 data (H.S.L. reports 5/61 and 1/64). These estimates can then be compared with the actual numbers of cases in 1964.

The manner in which these estimates are made is illustrated in Figure 7. In this Figure are given, firstly, the curves relating the incidence of fatal and non-fatal cases to W.B. temperatures for the period 1957 to 1961. (The data from which the curves were drawn are given in Table 4). In Figure 7 is also drawn, in histogram form, the numbers of men working in the various class intervals of W.B. temperatures for 1964. From the morbidity and mortality curves one could predict the non-fatal and fatal cases for 1964:

Class Intervals W.B. temperatures	Numbers of Men	Predicted number of cases for 1964	
		Non-fatal	Fatal
80° - 83.9°F	45,207	2	0
84° - 87.9°F	39,359	10	3
88° - 90.9°F	15,368	11	3
91° - 92.9°F	2,831	5	2
Above 93°F	498	3	2
		31	10

In actual fact there were 20 non-fatal cases and only 2 fatal cases in 1964. One fatal case occurred in the class interval 84° to 87.9°F W.B. temperature and 1 fatal case in the class interval 88° to 90.9°F W.B. temperature. There were no fatal cases above 91°F W.B. temperature, while 8 non-fatal and 4 fatal cases were predicted.

5. Discussion and conclusions

5.1 Trends in the numbers of working places and men at various wet-bulb temperatures

There has been a reduction in the numbers of stopes at the higher W.B. temperatures and also an increase in the velocity of air in the stopes. There has, however, been a concomitant increase in the numbers of development ends at the higher W.B. temperatures, but greater volumes of air were sent into these areas, except above 93°F W.B. temperature.

There were about twice as many men in stopes as in development ends and the net effect therefore was a reduction in the numbers of men "estimated" to be working in the higher W.B. temperatures during the period 1961 to 1964. It is clear from these results that there has been a marked improvement in the heat stroke position since 1961.

/5.2 Comparison .....

5.2 Comparison of the actual numbers of heat stroke cases with those predicted for 1964

Even though there had been a marked reduction in the numbers of men working at the higher W.B. temperatures during the period 1961 to 1964, ten fatal and 31 non-fatal cases would have been predicted for 1964. This estimate is based on the mortality and morbidity figures at various W.B. temperatures, based on the data for the period 1957 to 1961. In actual fact there were only 2 deaths and 20 non-fatal cases in 1964.

Too much should not be placed upon the results in one year. However, the great reduction in mortality rate of only 2 fatal cases in 1964, might be due to the fact that the main recommendations made in the H.S.L. reports 5/61 and 1/64 were introduced in 1963. A check was made in the early part of 1964 and this showed that, in most mines, European supervisors and Bantu bossboys in production areas had received some training in the recognition and treatment of heat stroke cases. A point in favour of the possibility that these measures led to the reduction in fatal cases of heat stroke is contained in the fact, firstly, that not one fatal case of heat stroke occurred at W.B. temperatures above 91°F, where it had been predicted that there would be 4 fatal cases in the 3,500 men working in these conditions. At W.B. temperatures of 88°-90.9°F there was only 1 fatal case instead of the expected 3 fatal cases, and at the W.B. temperatures of 84°-87.9°F there was also only 1 fatal case instead of the expected 3 fatal cases. Secondly, this reduction in fatal cases is not due to the elimination of heat stroke cases. There were still 20 non-fatal cases. These two facts allow one to conclude that the reduction in fatal cases is probably due, in the main, to the early recognition and proper treatment of heat stroke cases by underground officials trained in these procedures.

Greater improvement can still be expected. The training of European supervisors and Bantu bossboys in the early recognition and treatment of heat stroke cases has not yet been put upon a systematic basis in the Industry, as is the case with the acclimatization procedures where the training and examination of acclimatization supervisors is under the control of the H.S.L. It can be proposed therefore that if heat stroke deaths are not eliminated in the next few years, then further efforts should be concentrated upon the better training of the European supervisors and Bantu bossboys in this regard. This training should be under the control of the H.S.L.

TABLE 1

S T O P E S

	1957	1958	1959	1960	1961	1962	1963	1964
Less than 80°F	4296	3054	3008	2943	2843	2790	2638	2846
80 - 83.9°F	1665	1424	1554	1682	1640	1788	1742	1739
84 - 87.9°F	1419	1417	1456	1606	1708	1626	1542	1407
88 - 90.9°F	652	774	809	767	764	637	587	506
91 - 92.9°F	114	114	148	166	225	152	103	87
Above 93°F	5	4	5	4	14	7	7	10

DEVELOPMENT ENDS

Less than 80°F	3456	2867	3163	3015	3064	3422	3211	2822
80 - 83.9°F	1407	1280	1362	1444	1578	1764	1915	1955
84 - 87.9°F	1334	1407	1607	1709	1862	1799	1903	1930
88 - 90.9°F	672	739	761	864	774	775	818	845
91 - 92.9°F	120	186	146	182	146	184	189	169
Above 93°F	29	47	31	41	43	42	54	41

TABLE 2

## NUMBERS OF MEN WORKING AT VARIOUS W.B. TEMPERATURES

	1957	1958	1959	1960	1961	1962	1963	1964
Less than 80°F	82,130	69,787	75,476	70,864	69,688	74,808	70,534	70,992
80 - 83.9°F	32,306	32,117	36,870	37,687	39,647	44,508	44,934	45,203
84 - 87.9°F	28,482	32,900	37,054	39,653	42,022	41,994	41,438	39,359
88 - 90.9°F	13,502	17,749	19,588	19,639	18,366	17,627	16,523	15,362
91 - 92.9°F	2,378	3,147	3,635	4,079	4,811	4,046	3,263	2,831
More than 93°F	271	408	320	365	547	455	551	498

## NUMBERS OF MEN WORKING ABOVE VARIOUS W.B. TEMPERATURES

Less than 80°F	82,130	69,787	74,476	70,864	69,688	74,808	70,534	70,992
More 80°F	76,939	86,371	97,467	100,823	105,393	108,630	106,709	103,253
" 84°F	44,035	59,254	60,597	63,136	65,746	63,522	61,775	58,650
" 88°F	16,151	21,304	23,593	23,483	23,729	21,528	24,337	18,691
" 91°F	2,649	3,555	3,955	4,444	5,358	4,501	3,814	3,329
" 93°F	271	408	320	365	547	455	551	498



TABLE 3NUMBERS OF MEN AT VARIOUS WET-BULB TEMPERATURES

Class intervals of W.B.	<u>Y e a r s</u>		
	1957	1961	1964
Less than 80°F	82,130	69,688	70,992
80 - 83.9°F	32,306	39,647	45,207
84 - 87.9°F	28,482	42,022	39,359
88 - 90.9°F	13,502	18,366	15,368
91 - 92.9°F	2,378	4,811	2,831
Above 93°F	371	547	498

TABLE 4INCIDENCE OF HEAT STROKE DURING THE PERIOD 1956 - 1961

Temperature	Total Number	Fatalities	Fatalities per 1000	Cases	Cases per 1000
Less than 80°F	371318	0	.0000	3	.0081
80°F - 83.9°F	177960	0	.0000	6	.0337
84°F - 87.9°F	178536	15	.0840	44	.2464
88°F - 90.9°F	89113	16	.1795	62	.6957
91°F - 92.9°F	17507	10	.5712	28	1.5994
More than 93°F	1800	6	3.3333	8	4.4444

Figure 1.

**NUMBER OF STOPEs AND AVERAGE AIR VELOCITIES ON STOPE FACE  
AT VARIOUS CLASS INTERVALS OF WET BULB TEMP.**

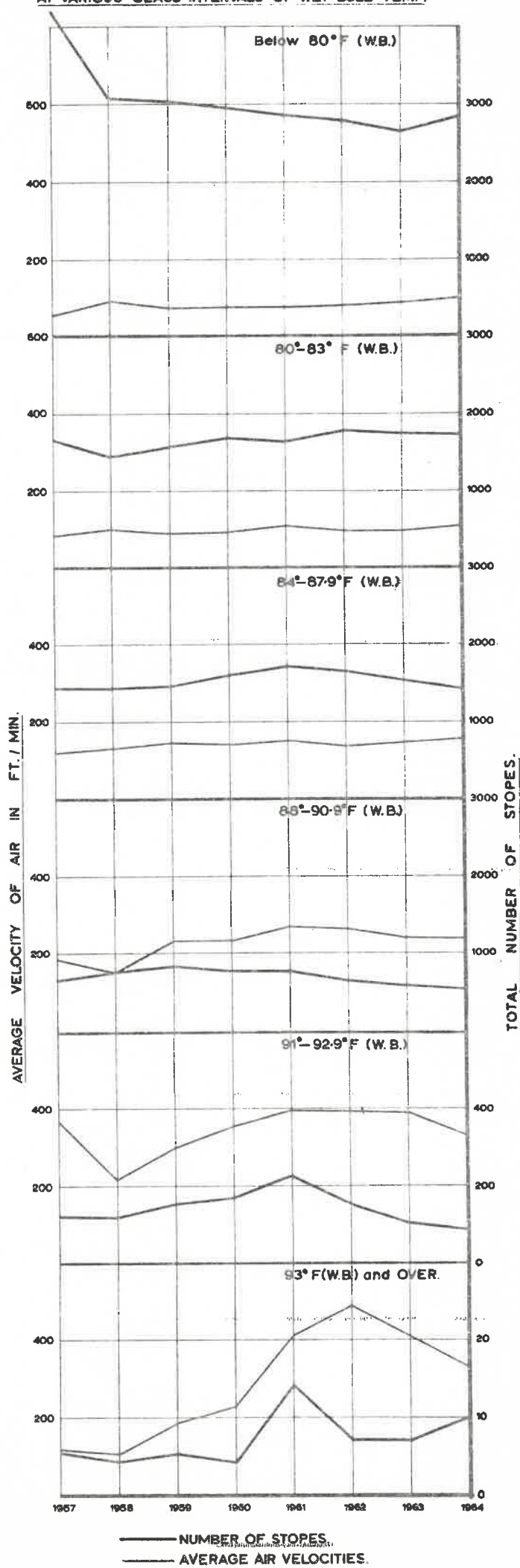


Figure 2.

NUMBER OF DEVELOPMENT ENDS AND VOLUMES OF AIR AT VARIOUS CLASS INTERVALS OF WET BULB TEMPERATURES.

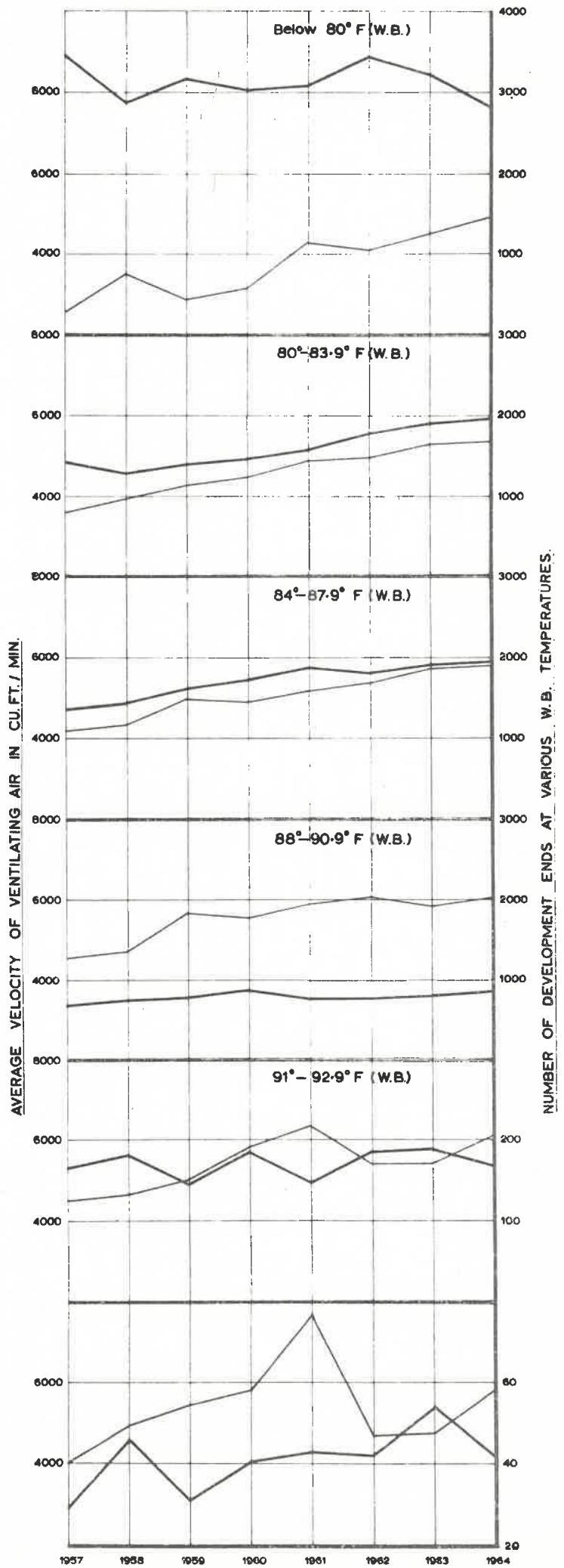


Figure 3.

NUMBER OF STOPEs ABOVE VARIOUS WET BULB TEMPERATU

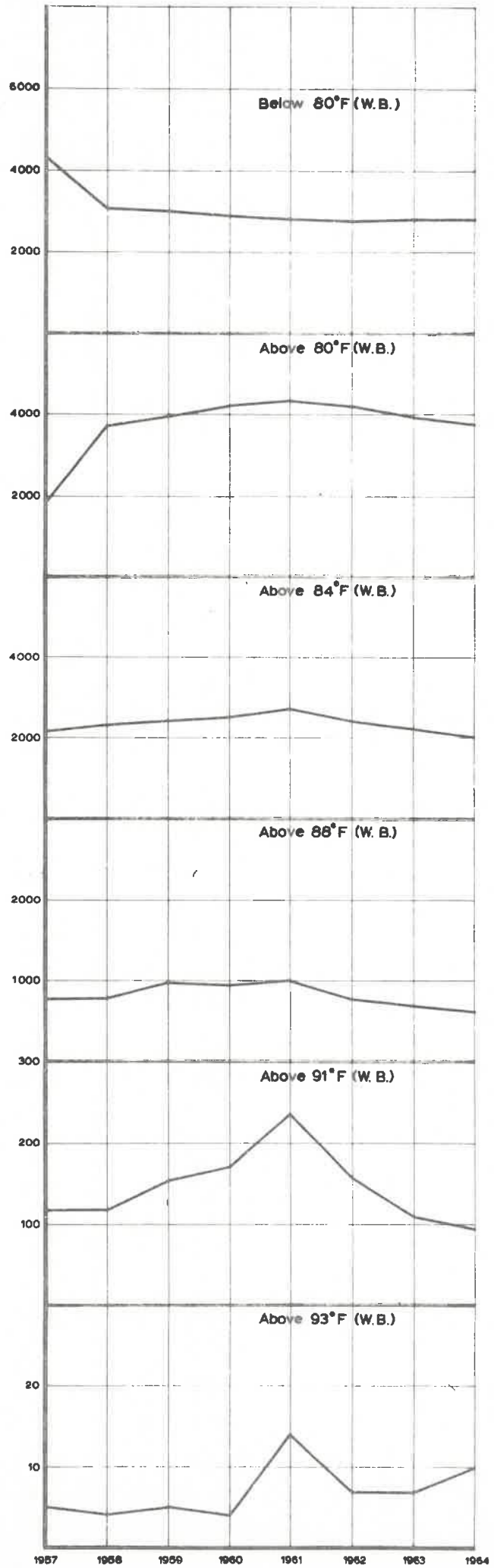


Figure 4.

NUMBER OF DEVELOPMENT ENDS ABOVE VARIOUS WET BULB TEMPS.

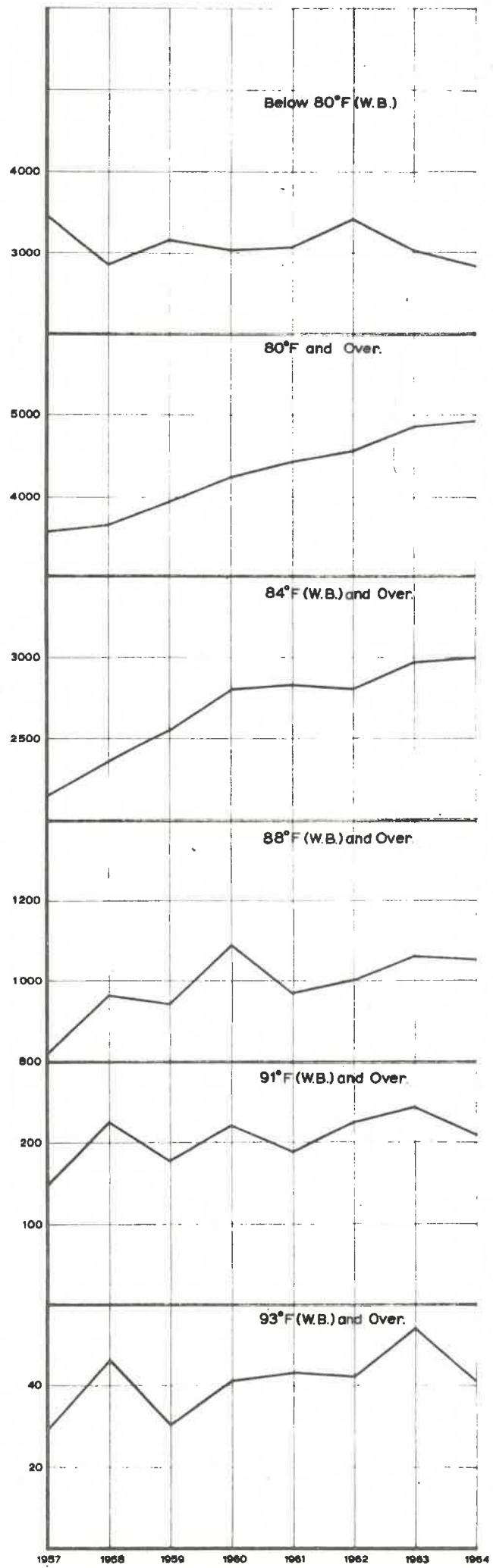




Figure 5.

NUMBER OF MEN IN DIFFERENT INTERVALS OF WET BULB TEMPERATURES.

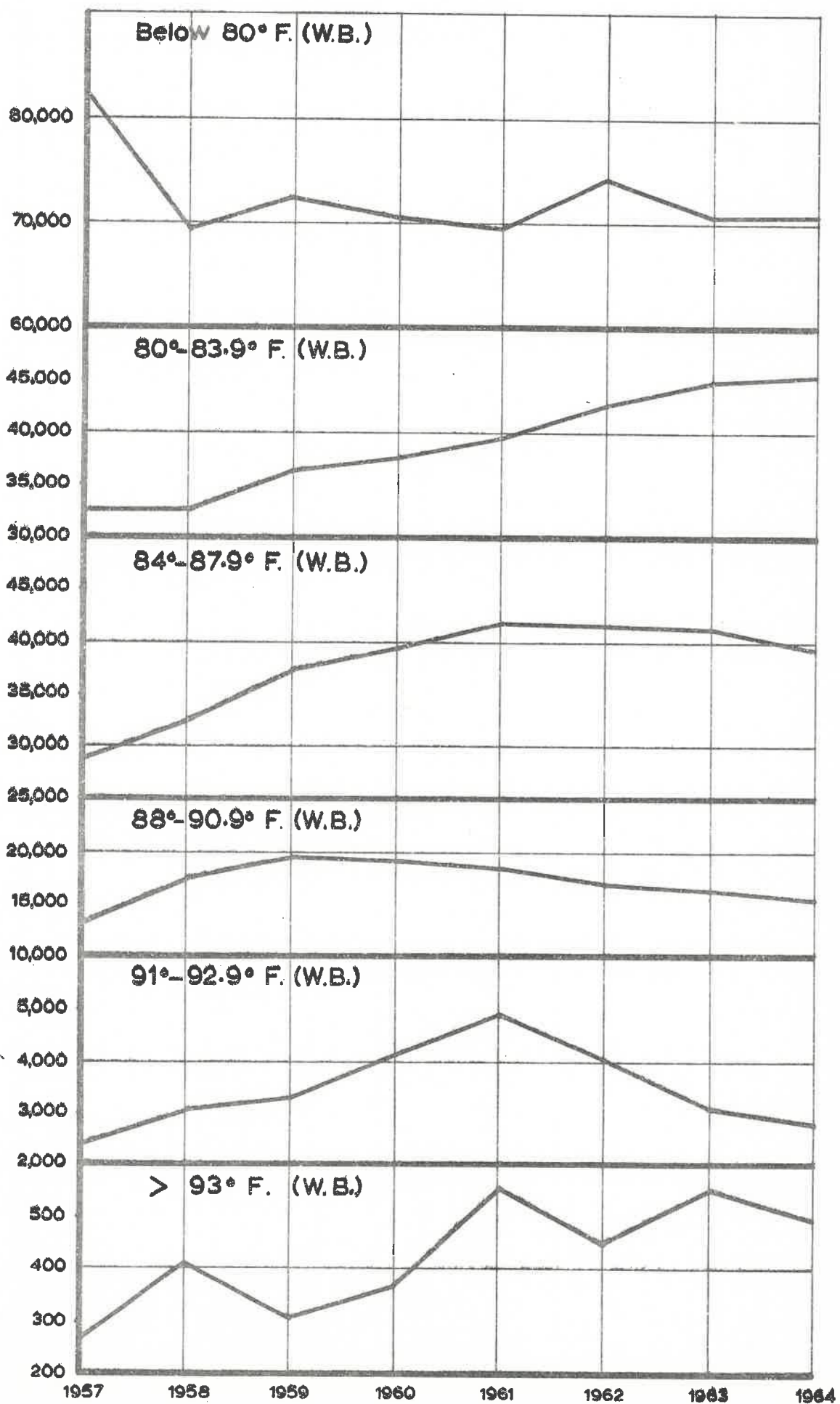


Figure 6.

NUMBER OF MEN ABOVE CERTAIN WET BULB TEMPERATURES AND HEAT STROKE DEATHS IN PERIOD 1957 — 1964.

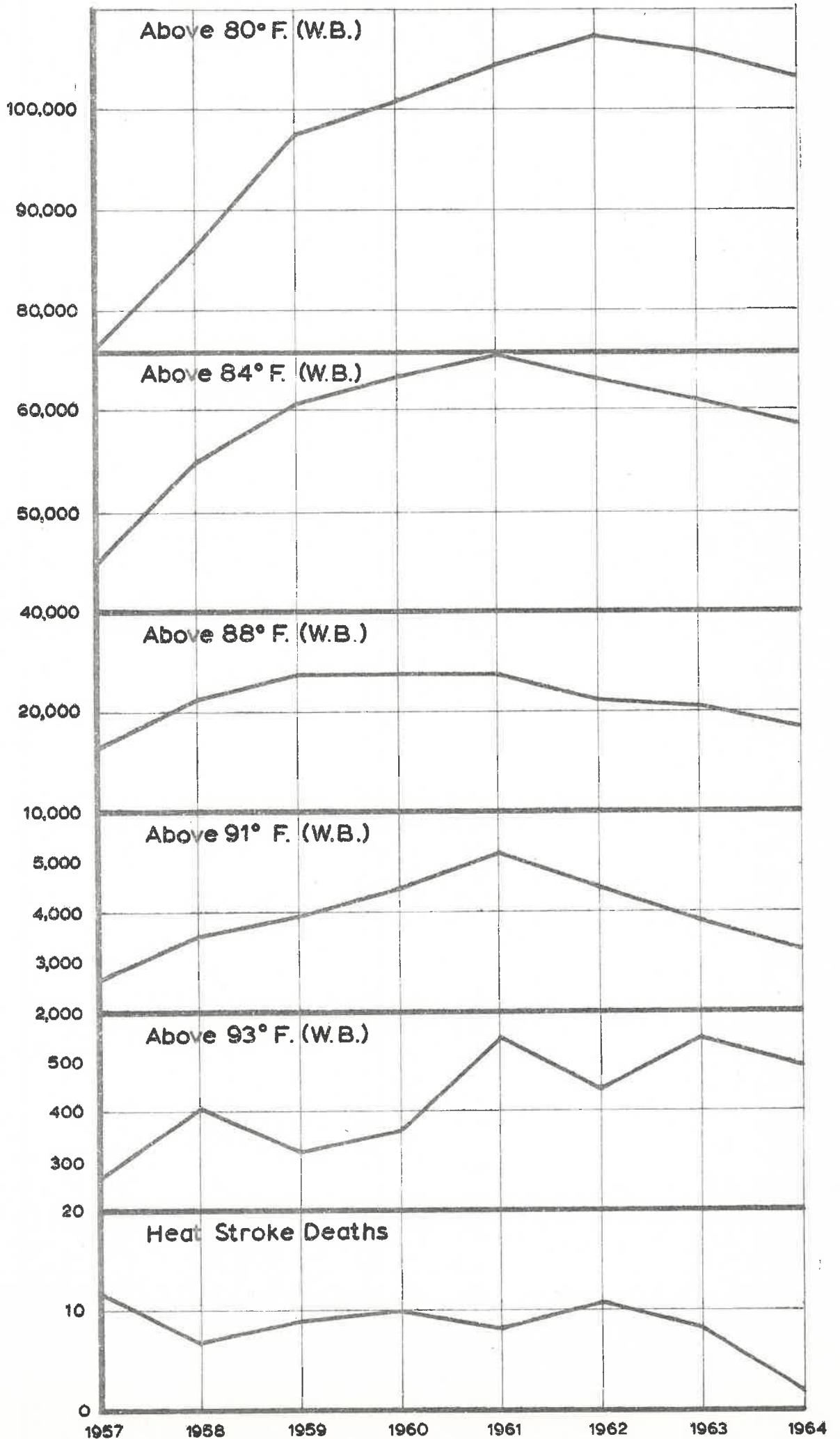


Figure 7.

