REPORT ON FIRE BEHAVIOUR STUDIES IN JARRAH FUEL TYPES DWEELINGUP, WESTERN AUSTRALIA.

by A.G. McArthur.

April 1959

REPORT ON

FIRE BEHAVIOUR STUDIES

IN

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S U M M A R Y.

Preliminary fire behaviour studies were carried out in a 25 year old Jarrah fuel type during the period 7th - 10th April, 1959. This fuel type carries the heaviest quantity of fine fuel per acre so far encountered in Australia and the 15 experimental fires burnt provided valuable data on the effect of this fuel quantity variable on fire behaviour characteristics.

The techniques used in the experimental burning and in the analysis of the data were identical to those developed in similar work in the A.C.T.

The close similarity of the correlations between rate of spread and meteorological factors in this Jarrah fuel type compared to relationships established from a large number of burnings in eucalypt fuel types in the A.C.T. enabled an extrapolation of the Jarrah data to cover virtually the entire range of conditions which might be expected in the Dwellingup area.

The forward progress, perimeter and area of fires burning in various hazard classes for various time intervals is given. This data, together with an estimate of rate of line construction, enabled an estimate to be given of the initial attack force needed to control fires in the various hazard classes within certain time limits. Information such as this would form the basis of state of preparedness guides.

The flame height and height of leaf scorch which may be expected under various hazard conditions is given, and this information would enable control burning specifications to be drawn up.

As this 25 year old fuel type is fortunately not typical of the present day Jarrah bush, experimental studies in say 5, 10 and 15 year old fuels would be necessary before complete data could be furnished on fire behaviour characteristics of the Jarrah forest.

A prediction graph is provided which will enable a reasonably accurate forecast of hazard stick moisture contents to be made from meteorological forecasts.

Hazard sticks provide a good estimate of fuel moisture content in this climate and their continued use in any system of fire danger or rate of spread rating is strongly recommended. It is stressed, however, that the use of wind velocity in conjunction with a fire hazard rating is essential in order to give the field forester a true indication of fire behaviour under all conditions.

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REPORT ON FIRE BEHAVIOUR STUDIES UNDERTAKEN IN JARRAH FUEL TYPES, DWELLINGUP, WESTERN AUSTRALIA.

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1. INTRODUCTION.

During a visit to Western Australia in April, 1959, facilities were made available by the Forestry Department, to carry out some preliminary fire behaviour studies in 25 year old Jarrah fuel types.

This fuel type carries the largest quantity of fine fuel per acre so far encountered in Australia, and so experimental fires in this type provided some very valuable data as to the effect of fuel quantity on rate of spread and general fire behaviour characteristics. In addition, the generally flat topography and very even fuel distribution on the area make this fuel type ideally suited for such experimental studies.

As it was not originally intended to carry out experimental burning on this inspection of fire control activities in Western Australia, certain equipment normally used in such studies was not available. Consequently, many measurements normally made on such work were not taken. Despite these limitations, the small number of fires burnt provided excellent data on rate of spread in this particular fuel quantity class. Taken in conjunction with previous work in dry sclerophyll eucalypt fuel types in the A.C.T., it was possible to extrapolate the data so as to cover the range of burning conditions which may be expected in Western Australia.

This is particularly important as it would be physically impossibl to burn and control experimental fires in such heavy fuel under dangerous conditions.

The willing cooperation and help afforded me by field officers of the Dwellingup Division and the facilities made available by the West Australian Forestry Department contributed largely towards the results achieved in this preliminary study.

2. LOCATION OF EXPERIMENTAL AREA.

All experimental burnings were carried out in Compt.10, Kennedy Section. The general location of the area and the position of individual fires is shown in ~~Appendix~~ FIGURE No. 12. Numbered pegs were placed at the point of origin of each fire.

3. PERIOD OF BURNING.

Fifteen individual fires were burnt over the four day period, 7th - 10th April, 1959. The burning time on each fire ranged from 22 to 48 minutes with an average burning period of 34 minutes. The four day sequence of burning followed light rain which fell overnight on Monday, 6th April, and provided conditions which gave some indication of the effect of rainfall in this fuel type, and the effect of changing synoptic situations following the more or less normal weekly cycle of pressure systems.

4. COMPOSITION OF THE STAND AND FUEL TYPES.

An unevenaged stand of Jarrah comprising old dead topped over-mature trees around 100 - 120' in height and a well stocked stand of Jarrah pole sizes around 25-30 years old and 40-50' in height. A fairly dense understory of Banksia spp. occurred in patches, with a ground cover of Blackboys (Xanthorrhoea spp) and various Proteaceous shrubs. Typical fuel types on the experimental area are shown in photographs 1-4. The heaviest fuel concentrations occur under the dense patches of Banksia, where Banksia leaves form a high proportion of the total fuel volume. The blackboys burn very fiercely and have a major influence on fire behaviour in this type of bush. The bark characteristics of Jarrah and the high proportion of dead tops in the over-mature trees create a very high potential for spotting, which makes experimental burning in this fuel fairly hazardous, even under relatively mild meteorological conditions.

5. METEOROLOGICAL CONDITIONS.

A frontal passage accompanied by light rain passed over the area on the evening of Monday, 6th April. Burning commenced the following morning, and continued for the next four days. Temperatures rose gradually and fuel moisture contents dropped during the week. Monday, 6th April, was a day of fairly high fire danger, and numerous forest fires were burning in the Kalamunda-Mundaring area. Consequently, both light and heavy fuels were in a dry condition, and the light rain on the evening of the 6th, did not have any appreciable effect on moistening the full fuel layer. Another cold front accompanied by heavy thunderstorms yielding over 100 points, passed over the burning area on the evening of April 10th and 12th. Further burning was impossible on the following Monday and Tuesday, whilst fires would just run on Wednesday, 15th. Variations in air temperature, relative humidity and wind velocity over the burning period is given in Table 1.

Table 1. Meteorological Conditions 7-10th April,1959., at Kennedy 10, Dwellingup.

Date.	Time. hrs.	Air Temp. °F.	Relative Humidity. %.	Wind Velocity & direction. Wells Tower. (Beaufort Scale)		Fuel Moisture Content. %.	Hazard Stick.MC. (open exposed).
7.4.59.	1200	69	54	SW	4-5	8.6	17.2
	1500	67	43	SW	4-5	6.5	13.2
8.4.59.	1200	64	47	ESE	2-3	7.2	12.2
	1500	69.5	37	SW	2-3	8.3	10.3
9.4.59.	1200	77	42	S	3	9.5	11.9
	1500	83	36	SSE	3	8.8	8.4
10.4.59.	1200	82	43	NW	4	8.0	10.4
	1500	84	40	WSW	3	9.2	8.8

Diurnal variations in air temperature, relative humidity and fuel moisture contents are shown in Figures **5-7**. The interesting effect of a total eclipse of the sun can be seen in Figure 5.

6. EXPERIMENTAL TECHNIQUE.

The technique of measurement and recording on these fires was identical to that developed in experimental burning in the A.C.T. Briefly, the rate of forward progress and perimeter spread at 2 minute intervals throughout the course of each fire is fixed by wooden markers. These markers are subsequently surveyed and the perimeter of the fire drawn for each 2 minute period. The rate of forward progress perimeter and area spread can then be calculated. Concurrently with the progress of the fire, wind measurements are taken by a sensitive 3 cup anemometer. Notes on flame height, varying fuel quantities, spotting, colour and direction of the smoke column, together with any factor considered significant during the course of the fire are noted. Prior to the commencement of each fire, fuel moisture samples are collected, and readings of air temperature and relative humidity taken. Fuel moisture contents were subsequently determined by oven drying at Dwellingup. Hazard rod and other meteorological readings taken at Dwellingup were also used in the general study. The detection time as given by Wells and Teesdale fire towers was also noted.

7. ANALYSIS OF THE DATA.

Individual fire data were analysed in the same manner as developed for similar experimental fires in the A.C.T. Briefly, the maximum rate of spread on each fire is plotted against wind velocity in the forest and the average fuel moisture content during the burning period. The number of fires burnt in the 25 year old Jarrah fuel type were insufficient for this type of analysis, especially as only a limited range of conditions were sampled. However, due to the very good rate of spread, fuel moisture and wind velocity correlations established in the 7-15%. fuel moisture content range and the almost exact parrelism between the Jarrah data and relationships established from over 150 experimental fires burnt in eucalypt fuel types in the A.C.T. an extrapolation of the data to cover the [redacted] range of conditions which may be expected in the Jarrah bush was considered reasonable until such time as further data can be obtained. The rate of spread figures should thus be accepted as very tentative, but are produced so as to give field personnel an indication of fire behaviour in this specific fuel type. The extrapolated data has been checked against recorded rates of spread of various wildfires in the Dwellingup area, and appears to give a reasonably good comparison.

Fire behaviour information appearing in this report must only be applied to the heavy Jarrah fuel types unburnt for 20 years or more. In lighter fuels, the rate of spread, flame heights and height of leaf scorch would be considerably lower for a given set of meteorological conditions.

8. RESULTS.

(a) Rate of Forward Spread.

The rate of forward progress is shown in Figures 1 & 2. Two points are open to doubt. Firstly, it has been assumed that a wind speed of 5 miles per hour near the floor of the forest is the maximum which may be expected in this forest type. This corresponds to a wind speed of approximately 25 miles per hour in the open. Average wind velocity of 30-35 occur on an average of twice per season in the eastern states, and it is thought such velocities may occur in Western Australia.

Secondly, it is assumed that a fuel moisture content of 2%. will be reached under worst possible conditions. This is based on data derived from more open stands in the A.C.T., and it is more probable that the lowest possible value of fuel moisture content reached in Jarrah bush would be around 3%.

The maximum calculated rate of forward progress at 2%. F.M.C. and a wind speed of 25 mph. in the open is 190 chains per hour. At a F.M.C. of 3%. and a wind speed of 30 mph. in the open, the calculated maximum rate of forward progress is around 130 chains per hour. The latter appears to be a more reasonable figure.

The relationship between air temperature, relative humidity and fuel moisture content is shown in Figure 8, and the relationship between wind velocity in the forest and in the open is shown in Figure 9.

(b) Rate of Perimeter Spread.

Perimeter spread for various combinations of wind velocity and fuel moisture content is given in Figure 3. At the likely worst possible conditions of 3%. F.M.C. and 30 mph. wind velocity, the rate of perimeter increase is approximately 270 chains per hour. It should be noted that under the same hazard conditions, but under near calm conditions, the rate of perimeter increase is between 50-60 chains per hour.

(c) Area Spread.

A separate analysis of area spread has not been made, but the area of small fires up to one or two hours from commencement can be readily calculated from perimeter spread on the basis that perimeter is that of a circle corresponding with the area,

It is important to recognise the fact that whilst both rate of forward progress and perimeter spread increase in direct proportion to the time from commencement of a fire, the area increases as the square of time. In other words, the area of a fire at 2 hours from commencement is 4 times the area at 1 hour, whilst at 4 hours from commencement it is 4 times the area at 2 hours, and 16 times the area at 1 hour. Thus, if burnt area is to be kept to a minimum, fast initial attack and prompt control is fundamental.

(d) Flame Height and Height of Leaf Scorch.

Flame height is almost directly related to fuel moisture content for a given fuel quantity class. The relationship for 25 year old Jarrah fuel is shown in Figure 4. Data on height of leaf scorch was insufficient to give a clear cut indication, and the scorch height figures given also in Figure 4 may be somewhat high at the higher fuel moisture contents. It is interesting to note that the two lines meet at a height of 120 feet, which is the approximate height of the dominants in this stand.

Such relationships should form the basis of control burning specifications, and a simple specification could be drawn up which defines the meteorological conditions under which control burning could be carried out so as to give a maximum height of leaf scorch of say 15 feet.

It is fairly clear that in this heavy fuel type, control burning could not be carried out until after fairly heavy rain, when the lower fuel layer is too moist to burn. The effect of a moist lower litter layer means that the fuel quantity is reduced from say 15 tons per acre to around 5-7 tons.

Fuel quantity plays a very significant part in influencing all factors of fire behaviour, and fuel reduction is, of course, the basis of most control burning policy. In this heavy fuel, it is estimated that crown fire development would occur at a fuel moisture content of around 5 per cent. In lighter fuels running at around 6-8 tons per acre in the A.C.T. crown fire development does not occur until a moisture content of around 3.6%. is reached, whilst at 2-4 tons per acre, crown fire development is virtually impossible.

9. APPLICATION OF THE DATA TO WESTERN AUSTRALIAN HAZARD.CLASSIFICATION.

Rate of spread figures given in this report relate to the moisture content of fine fuels on the floor of the forest. These moisture contents can be calculated from a forecast of maximum air temperature and relative humidity by reference to Figure 8. However, as the use of P. radiata hazard sticks was pioneered in Western Australia over 25 years ago, and their use continued to this day as a measure of fire hazard, it appeared desirable to relate fuel moisture content of the fine fuels to the corresponding hazard stick moisture content and hazard class.

The approximate relationship between hazard stick moisture content and the moisture content of eucalypt leaf litter is given in Table 2.

TABLE 2. Relationship between Hazard Stick Moisture Content and the fuel moisture content of eucalypt litter.

Hazard Classification.	Range of Hazard Stick M.C. %.	Corresponding Range of Fuel M.C. %.	Mean F.M.C.
Dangerous	3.2 - 4.2	2.6 - 3.2	3.0
Severe	4.2 - 5.3	3.2 - 3.6	3.5
High Summer	5.3 - 6.5	4.1 - 6.5	4.5
Average Summer	6.5 - 7.8	5.1 - 8.0	6.0
Moderate	7.8 - 11.0	6.1 - 9.5	8.0
Low	11.0 - 16.9	10.0 - 18.0	14.0

Using the fuel moisture content corresponding to the mean of each hazard class, the forward spread perimeter and area of fires at 1, 2 and 4 hours from commencement is shown in Table 3.

TABLE 3 RATE OF FIRE SPREAD AT VARIOUS TIME INTERVALS RELATED TO FIRE HAZARD CLASSIFICATION IN 25 YEAR OLD JARRAH FUEL

A. FORWARD PROGRESS (CHAINS)

FIRE HAZARD CLASS	A^1. AT 1 HOUR WIND VELOCITY (M.P.H.)					A^2. AT 2 HOURS WIND VELOCITY (M.P.H.)					A^3. AT 4 HOURS WIND VELOCITY (M.P.H.)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
DANGEROUS	21	30	43	64	90	42	60	86	128	180	84	120	172	256	360
SEVERE	15	22	32	49	69	30	44	64	98	138	60	88	128	196	276
HIGH	10	14	20	30	43	20	28	40	60	86	40	56	80	120	172
AVERAGE	5	8	11	18	25	10	16	22	36	50	20	32	44	72	100
MODERATE	3	5	7	10	15	6	10	14	20	30	12	20	28	40	60
LOW	1	2	3	4	6	2	4	6	8	10	4	8	12	16	20

B. PERIMETER SPREAD (CHAINS)

FIRE HAZARD CLASS	B^1. AT 1 HOUR WIND VELOCITY (M.P.H.)					B^2. AT 2 HOURS WIND VELOCITY (M.P.H.)					B^3. AT 4 HOURS WIND VELOCITY (M.P.H.)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
DANGEROUS	60	75	100	140	190	120	150	200	280	380	240	300	400	560	760
SEVERE	43	57	77	113	152	86	114	154	226	304	172	228	308	452	608
HIGH	31	40	52	75	100	62	80	104	150	200	124	160	208	300	400
AVERAGE	17	24	32	49	65	34	48	64	98	130	68	96	128	196	260
MODERATE	12	17	23	31	45	24	34	46	62	90	48	68	92	124	180
LOW	6	8	10	17	24	12	16	20	34	48	24	32	40	68	96

C. AREA SPREAD (ACRES)

FIRE HAZARD CLASS	C^1. AT 1 HOUR WIND VELOCITY (M.P.H.)					C^2. AT 2 HOURS WIND VELOCITY (M.P.H.)					C^3. AT 4 HOURS WIND VELOCITY (M.P.H.)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
DANGEROUS	26	40	74	140	290	100	155	300	550	1100	400	650	1100	2200	4000
SEVERE	14	25	45	90	160	55	100	180	360	540	220	400	720	1440	2160
HIGH	6	12	18	40	70	25	50	70	160	280	100	200	280	640	1120
AVERAGE	2	4	7	18	30	8	16	30	65	115	30	70	120	260	450
MODERATE	1	2	4	7	14	4	8	15	28	55	15	32	60	120	220
LOW	1/2	1/2	3/4	1 1/2	4	1	2	3	9	11	4	8	12	35	45

The figures given in Table 3 disregard the establishment period of the fire which will vary from 6-20 minutes. Consequently, actual fire spread will be slightly less than that shown by these tables.

Using the rate of spread figures given in Table 3, the manpower requirements needed to control fires within certain allowable periods can be obtained from the formula:-

$$N = \frac{R}{2C} + \frac{Rt}{CT}$$ where:-

N = the number of men (or fire units) needed to control the fire.

R = rate of spread in chains perimeter per hour.
C = resistance to control in chains per hour.
t = elapsed time, in hours, from origin to arrival.
T = elapsed time, in hours, from arrival to control.

Before this dispatcher formula can be accurately applied it is necessary to have concrete values of "C". For the purpose of this report I have estimated certain values based partly on the limited experimental burnings in this fuel type and partly on actual line construction figures obtained in the A.C.T. These estimates of "C" for the 25 year old Jarrah fuel are given in Table 4, and should be accepted with extreme reservation.

TABLE 4. Estimate of Rate of line construction by manual methods in 25 year old Jarrah fuel type. (Fireline constructed and held in chains per manhour).

Hazard Class.	Wind Velocity (mph).				
	1	2	3	4	5
Dangerous	2	2	1	1	1
Severe	4	4	3	2	1
High	6	6	5	4	3
Average	8	8	6	5	4
Moderate	10	10	8	6	5
Low	10	10	10	10	8

Using the formula given above, the assumed values of "C" and rates of spread given in Table 3, the initial attack force needed to control a fire in one hour, assuming arrival of the gang(s) one hour after commencement of the fire, is given in Table 5.

TABLE 5. Initial attack force needed to control a fire, arriving one hour after commencement (number of men using manual tools).

Hazard Class.	Wind Velocity (mph).				
	1	2	3	4	5
Dangerous	30	38	100	140	190
Severe	11	14	29	56	152
High	5	7	10	19	34
Average	3	3	6	10	18
Moderate	2	2	3	5	9
Low	1	1	1	2	3

It should be realised that, if mechanical methods of fire trail construction are used, the "C" figure would be much higher and so the number of men required would be less.

Similarly, if initial attack can be made in 30 minutes from commencement of the fire, the number of men required will also be less.

Despite any inherent errors in the assumptions made in the use of this manpower formula, the relative suppression effort required for a particular combination of hazard and wind velocity will remain similar. Tables similar to the example given should form the basis of operational orders aimed at ensuring prompt and efficient suppression of fires. It is obvious that at low and moderate fire hazards, an initial attack force of one gang can easily suppress fires within 30 - 60 minutes of arrival. At dangerous or severe hazards, it is apparent that an initial attack force of one and even two gangs cannot control such fires within one hour of arrival, and the fire boss must realise that prompt and efficient mobilisatiob of outside forces will be necessary for control by say sunset or 10 a.m. the next morning.

In Table 6, an estimate is given of situations where control should be possible by the initial attack gang(s); where initial attack may fail and control should be achieved by sunset, and situations where quick mobilisation of emergency gangs and mechanical equipment will be necessary for control by 10 a.m. the next morning.

TABLE 6. Probability of control of fires in 25 year old Jarrah fuel.

Hazard Class.	Wind Velocity (mph).				
	1	2	3	4	5
Dangerous	Y	Y	Z	Z	Z
Severe	Y	Y	(Y)	Z	Z
High	X	(X)	Y	Y	(Y)
Average	X	X	X	Y	Y
Moderate	X	X	X	X	(X)
Low	X	X	X	X	X

Symbols. X = control within 30-60 minutes after arrival, by initial attack force of 1 gang.
Y = initial attack by 1 gang will fail. Two gangs or more plus dozen equipment needed for control by sunset.
Z = Quick mobilisation of emergency gangs plus at least four bulldozers needed for control by 10 a.m. the next morning.
(X) borderline case.

From rate of spread figures and the probability of control within the limits given in Table 6 above, an estimate is made of the final size of the fires in each hazard and wind velocity class. These estimates are given on Table 7. Once again, even if specific assumptions are incorrect, the relative final size of each fire should remain in much the same proportion.

TABLE 7. Estimates of final fire size (in acres) assuming the fire starting at 1 p.m.

Hazard Class.	Wind Velocity (mph)				
	1	2	3	4	5
Dangerous	400	800	2000	4000	8000
Severe	200	400	1500	3000	4000
High	20	50	250	600	1000
Average	6	15	30	200	400
Moderate	3	6	10	20	40
Low	1	2	3	8	10

A prediction graph has been prepared which will enable field foresters to estimate hazard stick moisture content and so fire hazard from meteorological forecasts and 7 a.m. hazard stick readings. This graph and the method of use is shown in Figure 10. It has been produced from a limited amount of data and undoubtedly could be improved. However, it should give 75%. of forecasts to within ± 0.5%. m.c. and 95%. of forecasts to within ± 1.0%. m.c.

Hazard stick readings relate very closely to the fuel moisture content of eucalypt litter on the floor of the forest, and consequently, I would very strongly recommend the continued use of hazard sticks in any system of fire danger or rate of spread index which may be derived for West Australian conditions.

The incorporation of wind velocity in any such system is, however, of fundamental importance in order to give field foresters a reasonably accurate forecast of fire behaviour in a given fuel type. As wind movement in any high forest is very low, the necessity for extreme accuracy on the part of the forecaster in estimating free air movement becomes less, and little practical error is involved between a forecast of say 20 and 25 knots or 25 and 30 knots. The necessity for an accurate forecast of wind direction and wind changes is, however, essential for the planning of successful fire suppression tactics. All estimates of rate of spread must, of necessity, assume a constant wind direction, and will be grossly underestimated if a sudden wind change takes the whole face of a fire away in a new direction.

Conclusion.

Rates of spread and various fire behaviour characteristics have been given for the heaviest type of Jarrah fuel, together with estimates of manpower requirements, and final fire sizes which may reasonably be expected.

The fuel is, however, not typical of the Jarrah bush, and further work is necessary both in this fuel type and in lower fuel quantity classes before an overall picture of fire behaviour in Jarrah can be assessed.

Fire behaviour studies in say four fuel quantity classes representing 5,10, 15 and 20-25 year old fuel should give data sufficient to cover the full range of fuel and meteorological conditions which would be experienced by the field forester and enable practical operational orders and control burning specifications to be drawn up for all combinations of fuel types.

I am convinced that work of this nature would be of great help to the field forester, and should enable him to improve an already extremely efficient fire suppression and control burning organisation. With the help of relationships already established from a large number of experimental fires in similar eucalypt fuels in the A.C.T., it should not be necessary to carry out more than 30 - 40 experimental burnings in each fuel quantity class in order to access the fire behaviour characteristics of the complete range of fuel types in the Jarrah bush.

In conclusion, I would like to express my appreciation to Messrs. Beggs, Rutherford, Van Noort, Hatch and Smart of the West Australian Forestry Department for their enthusiastic help in carrying out the experimental burns and for advice given during the analysis of the data presented in this report.

(A.G. McArthur)
<u>Senior Forestry Officer.</u>

FIGURE 1

RATE OF SPREAD IN 25 YEAR OLD JARRAH FUEL

A. FORWARD PROGRESS

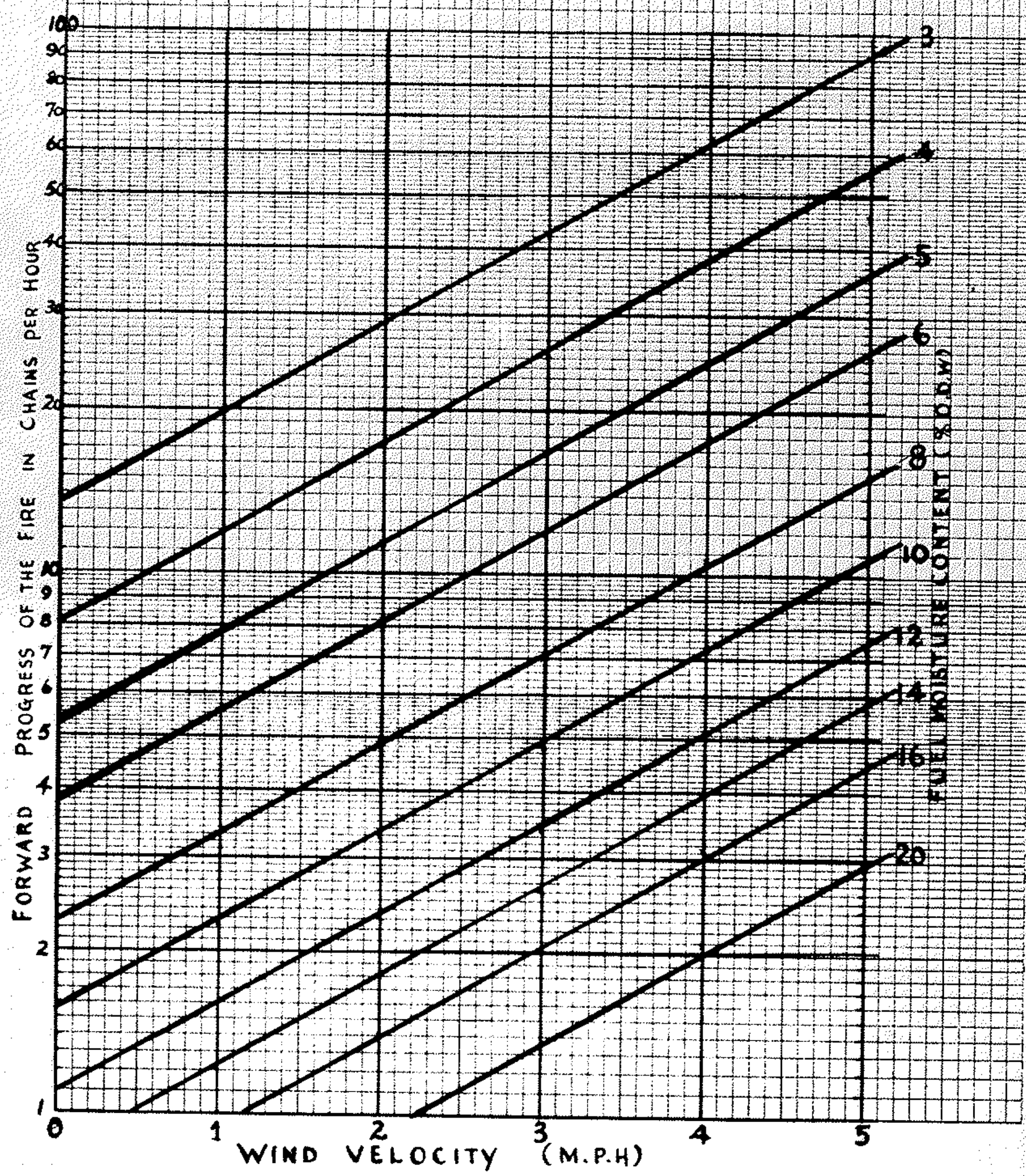
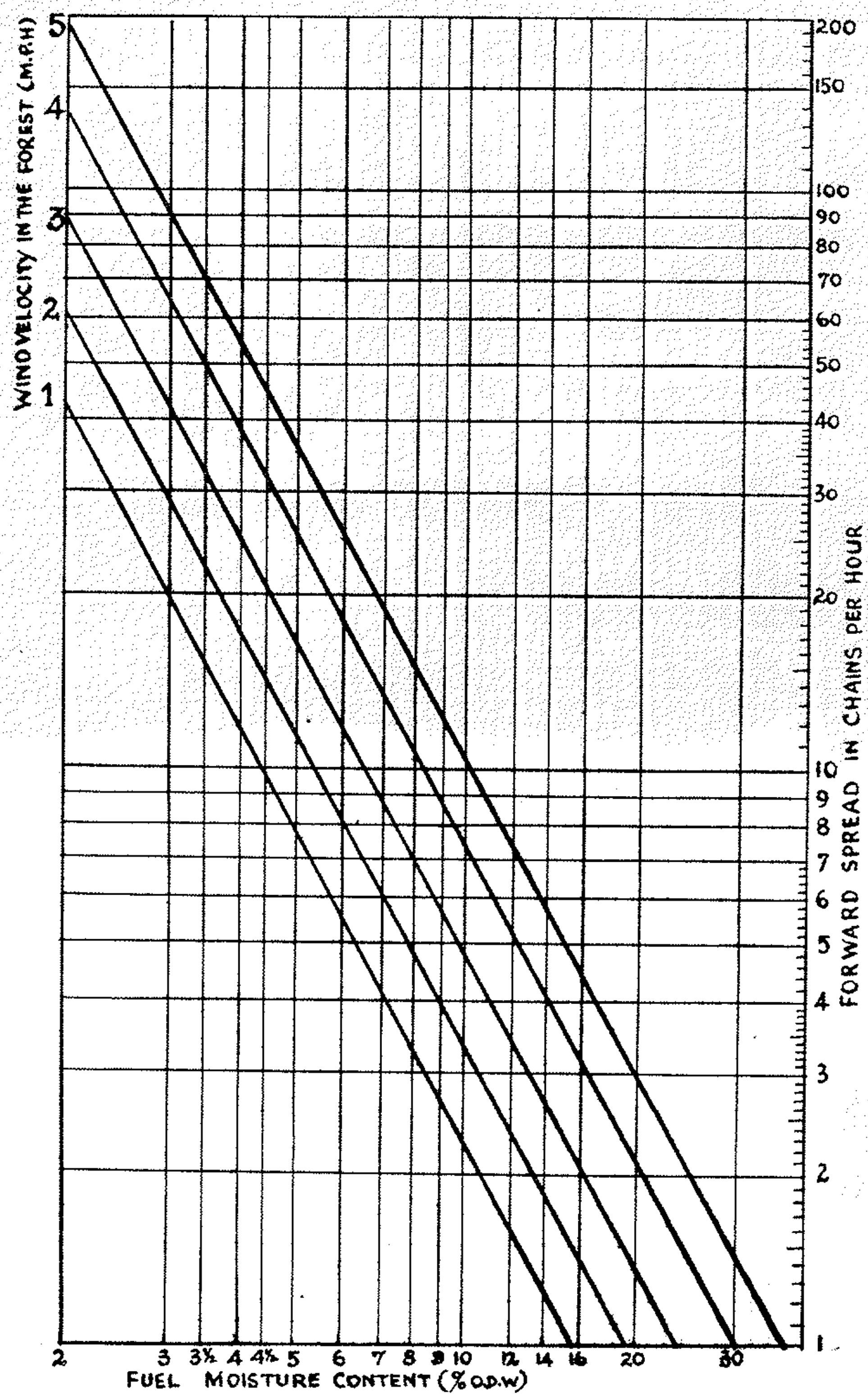


FIGURE.2.

RATE OF SPREAD IN 25 y.o JARRAH FUEL

A1. FORWARD PROGRESS



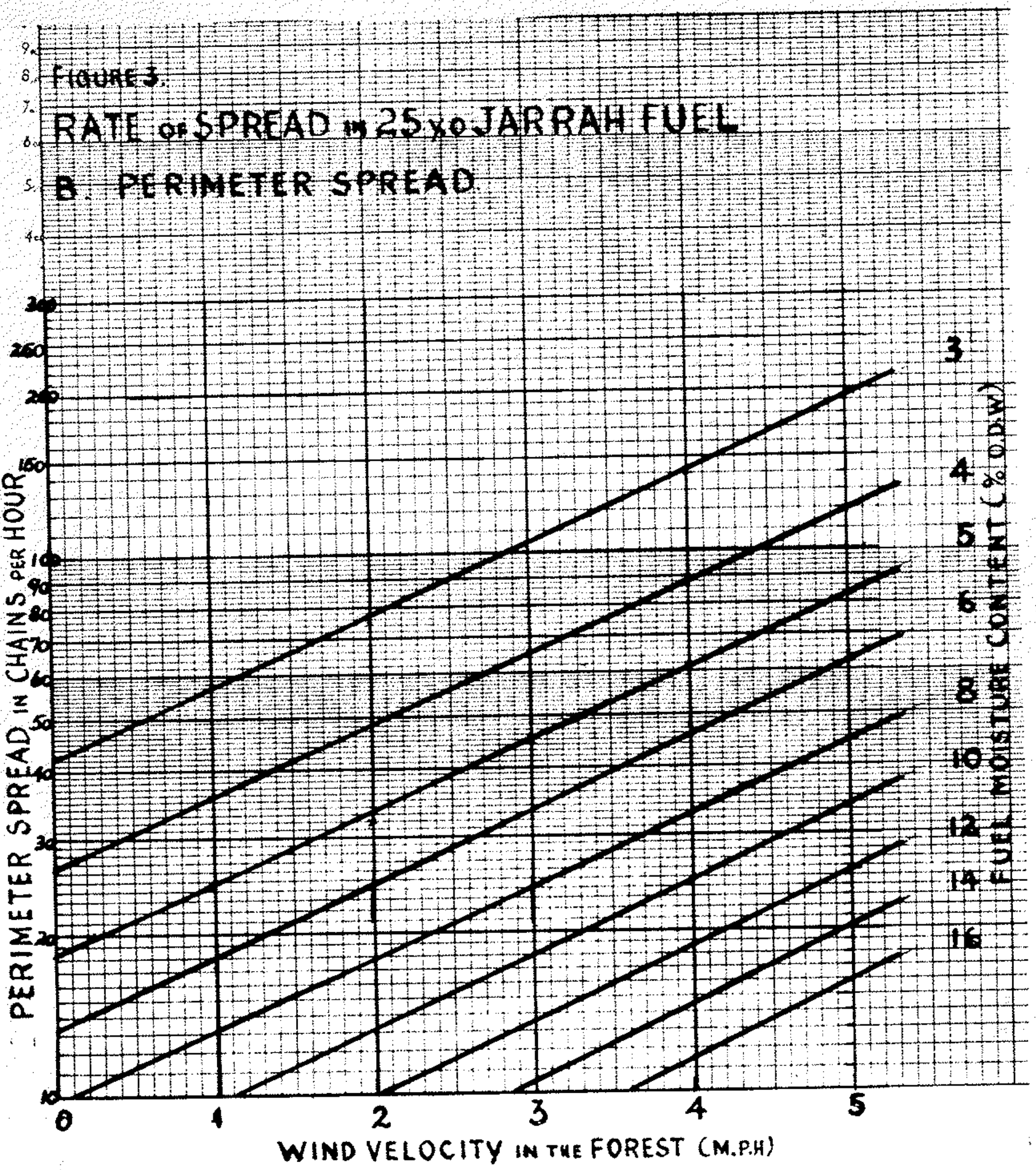


FIGURE 3.
RATE OF SPREAD IN 25 x 0 JARRAH FUEL
B. PERIMETER SPREAD
PERIMETER SPREAD IN CHAINS PER HOUR
FUEL MOISTURE CONTENT (% O.D.W.)
3
4
5
6
8
10
12
14
16
0
1
2
3
4
5
WIND VELOCITY IN THE FOREST (M.P.H)

FIGURE 4.

FIRE BEHAVIOUR IN JARRAH

A. RELATIONSHIP OF FLAME HEIGHT TO FUEL MOISTURE CONTENT.

B. RELATIONSHIP BETWEEN HEIGHT OF LEAF SCORCH AND FUEL MOISTURE CONTENT

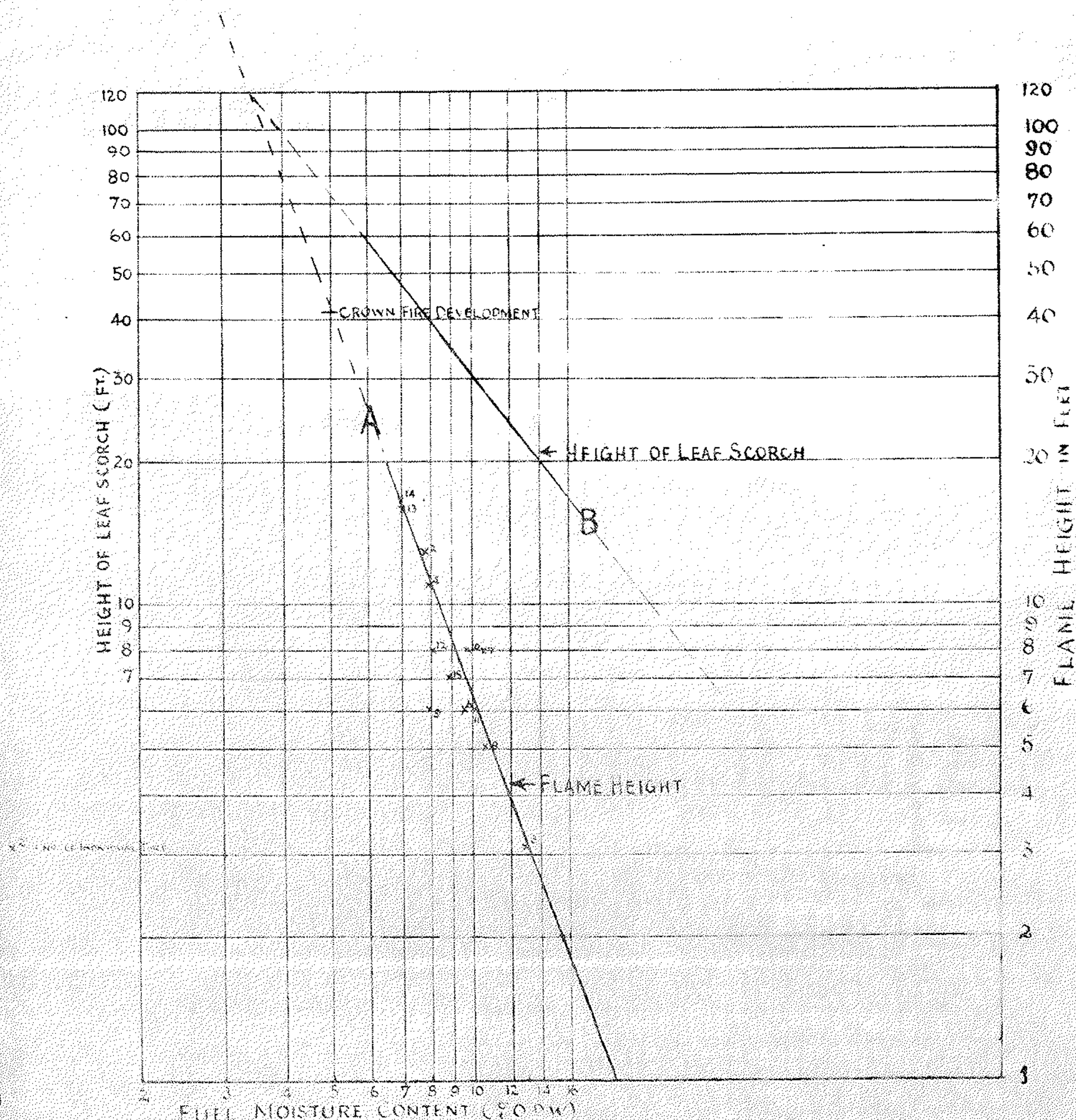


FIG.5 PROGRESSIVE CHANGE IN RATE OF SPREAD DURING THE DAY 8.4.59.

25-30 YEAR OLD JARRAH LITTER FIRE 3,4,5,6.

KENNEDY 10 DWELLINGUP

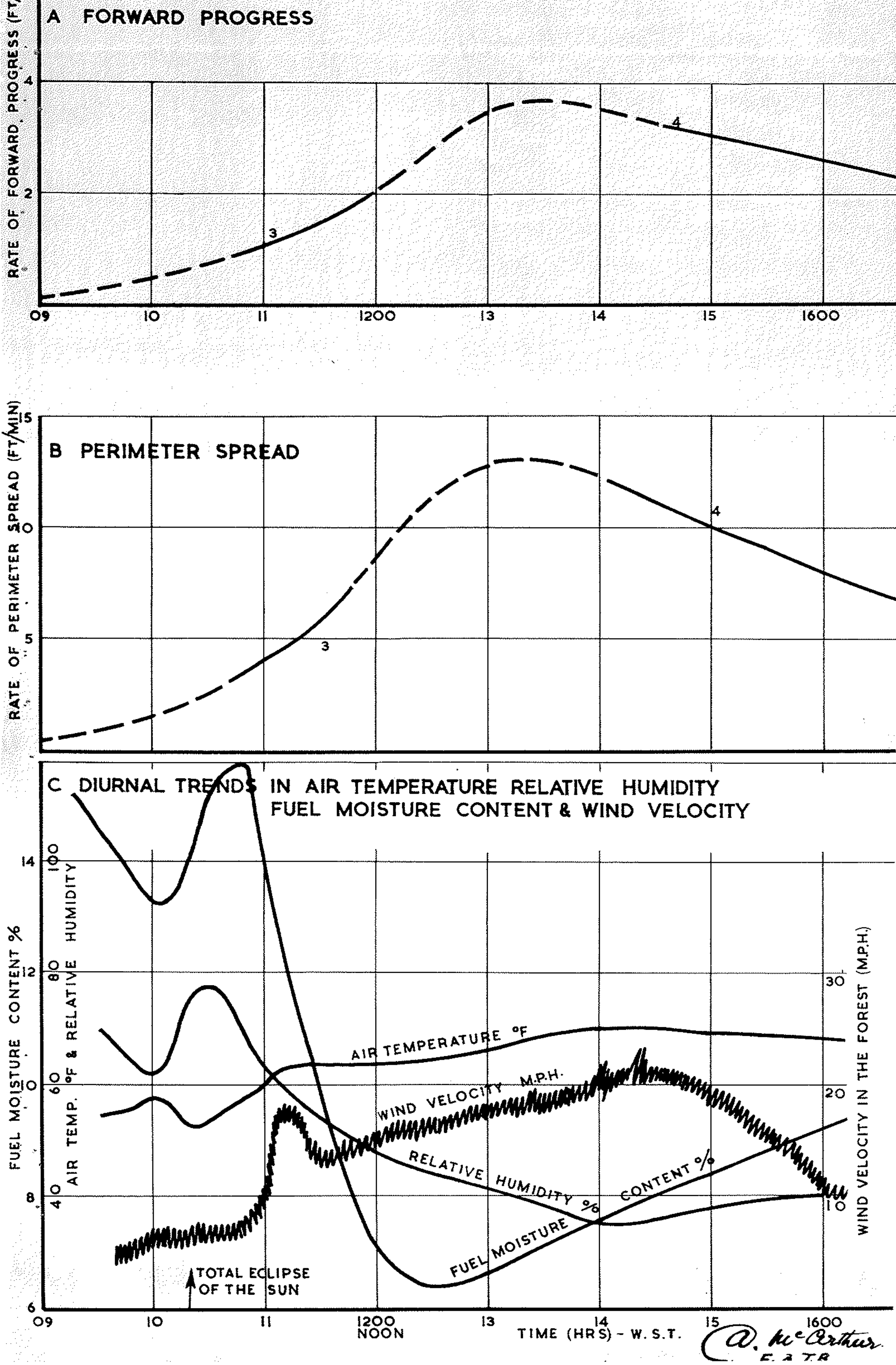


FIG. 6 PROGRESSIVE CHANGE IN RATE OF SPREAD 9·4·59

DURING THE DAY.

FIRES 7, 8, 9, 10

25-30 YEAR OLD JARRAH LITTER

KENNEDY 10 DWELLINGUP

A. FORWARD PROGRESS

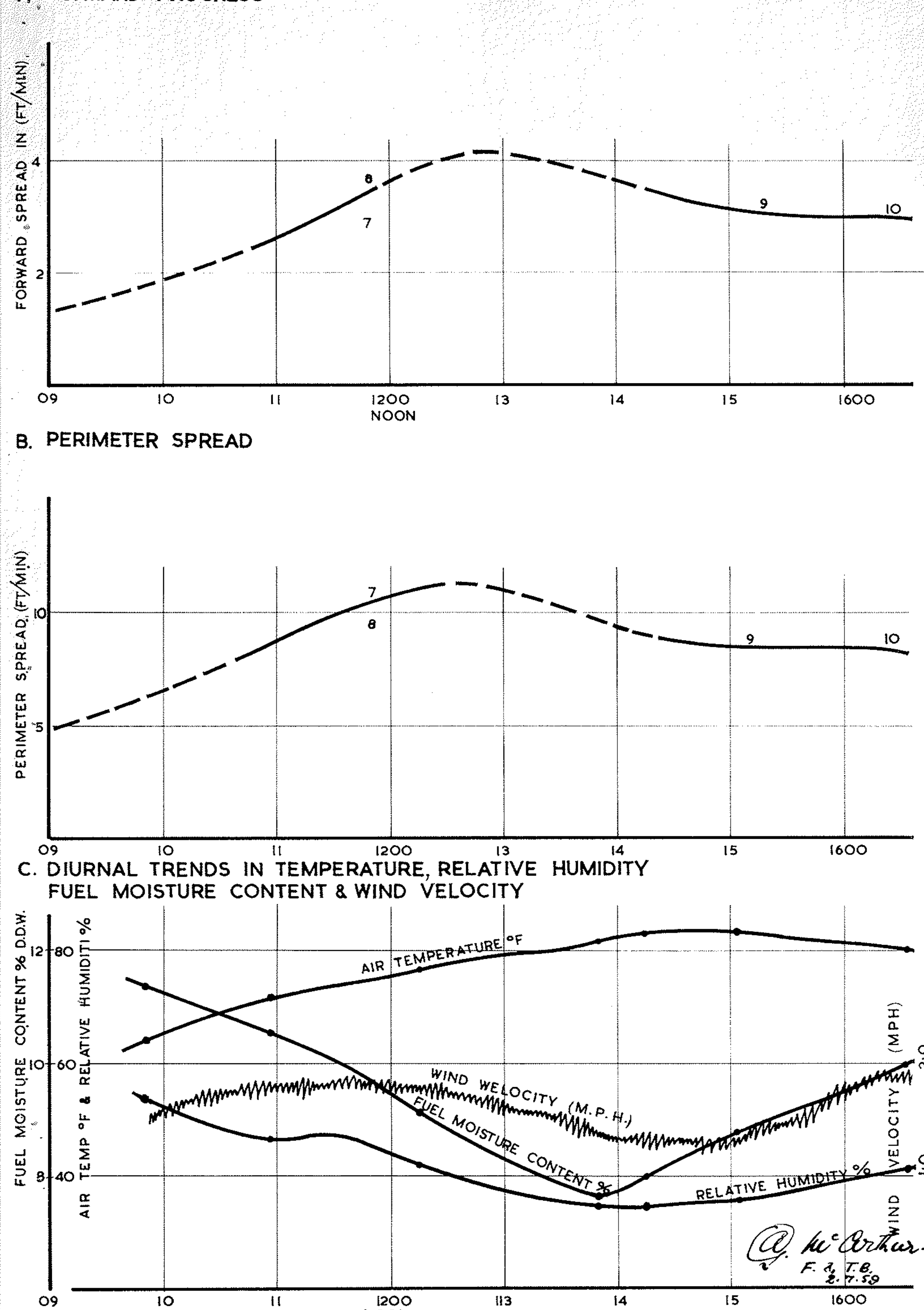


FIG. 7 PROGRESSIVE CHANGE IN RATE OF SPREAD

DURING THE DAY

25-30 YEAR OLD JARRAH LITTER

KENNEDY 10 DWELLINGUP

10.4.59.

FIRES.11,12,13,14,15.

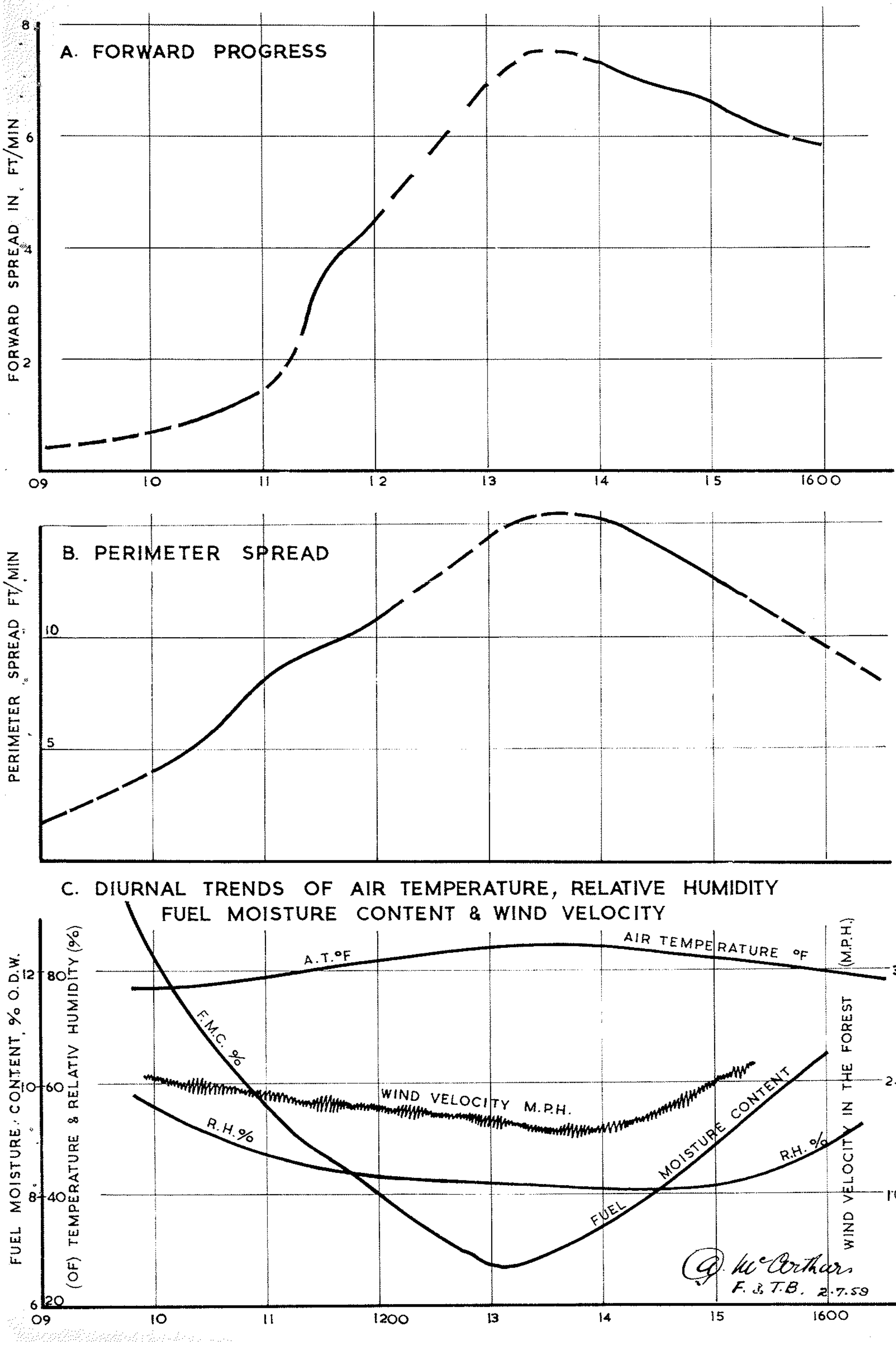
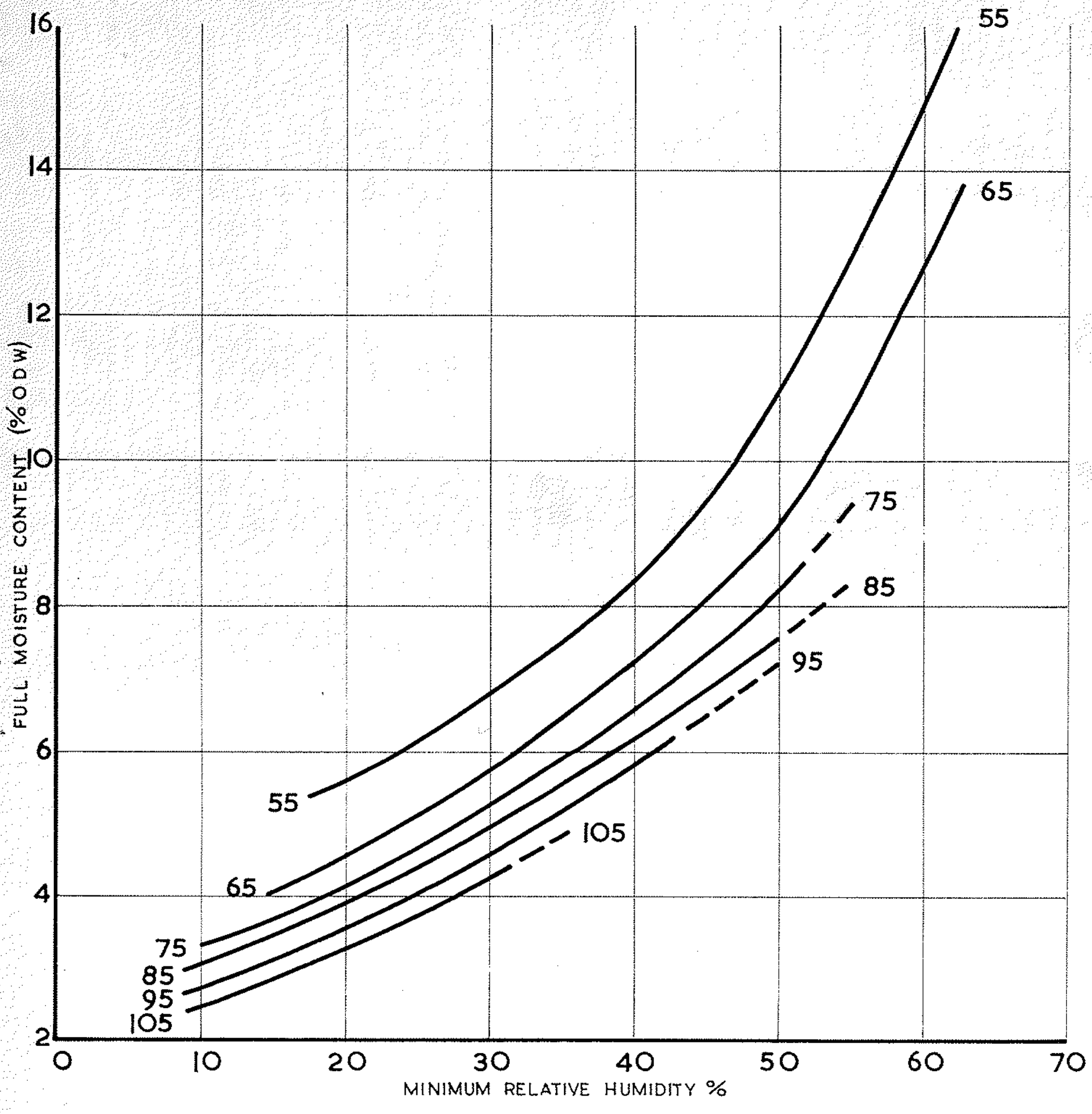


FIG. 8

RELATIONSHIP BETWEEN THE MOISTURE CONTENT OF EUCALYPT LITTER ON THE FLOOR OF THE FOREST, MAXIMUM AIR TEMPERATURE & RELATIVE HUMIDITY



NOTE.(1) THIS GRAPH IS DERIVED FROM CANBERRA DATA AND IS FROM A LOW QUALITY FOREST ALLOWING A HIGH PROPORTION OF SUNLIGHT THROUGH THE CANOPY. IN HIGH FOREST, SUCH AS JARRAH, MOISTURE CONTENT VALUES FOR A GIVEN TEMPERATURE & RELATIVE HUMIDITY SHOULD BE SOMEWHAT HIGHER BECAUSE OF THE MORE SHADED FOREST FLOOR.

(2) THE GRAPHS APPLY ONLY TO THE MINIMUM M.C. WHICH WILL BE REACHED BETWEEN 1200-1400 HRS AND ARE NOT APPLICABLE TO ADSORPTION OR DESORPTION CONDITIONS

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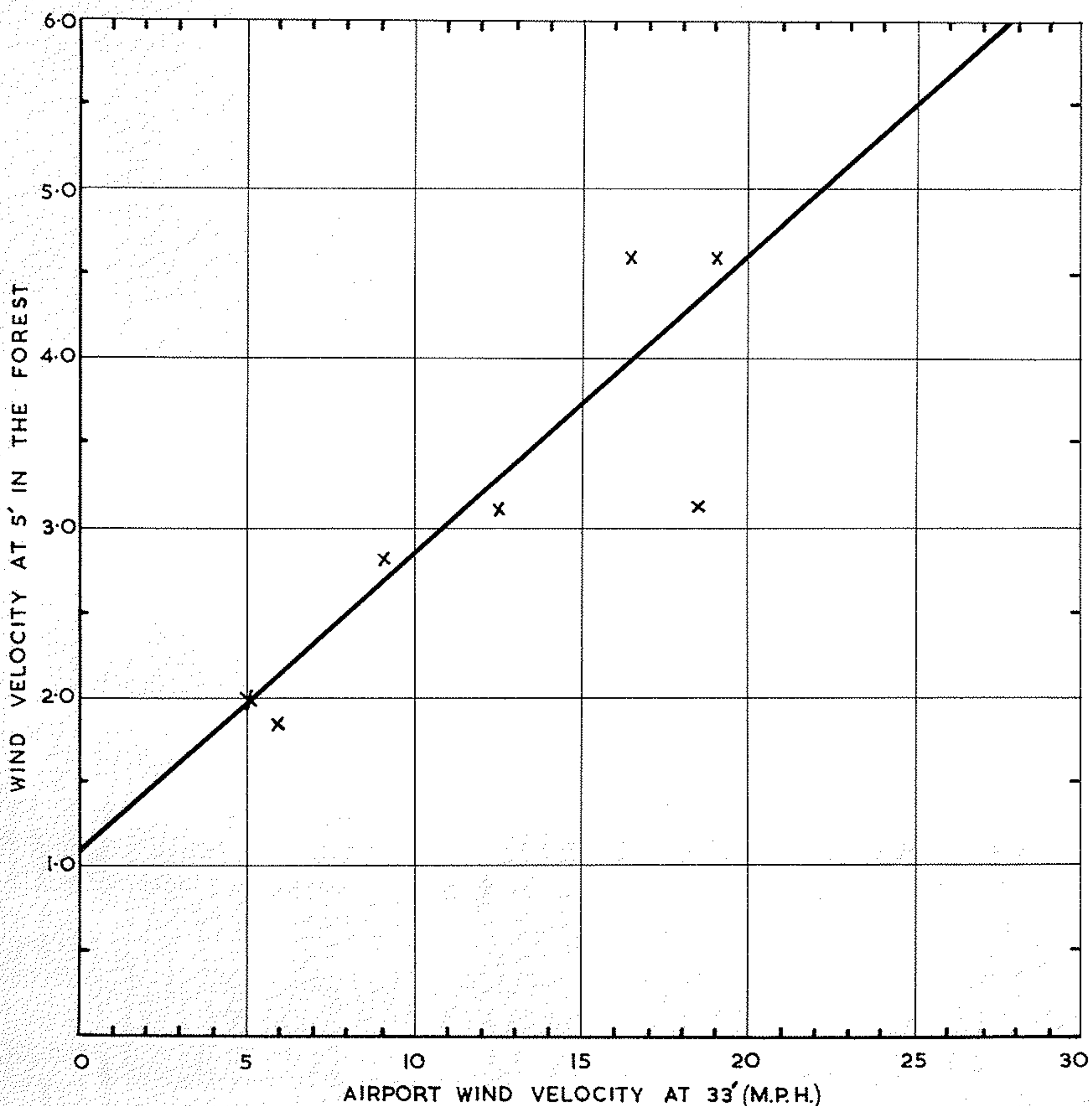
F. & T.B. 2.7.59

FIG.9. RELATIONSHIP BETWEEN AIRPORT VELOCITY AND WIND VELOCITY IN THE JARRAH FOREST



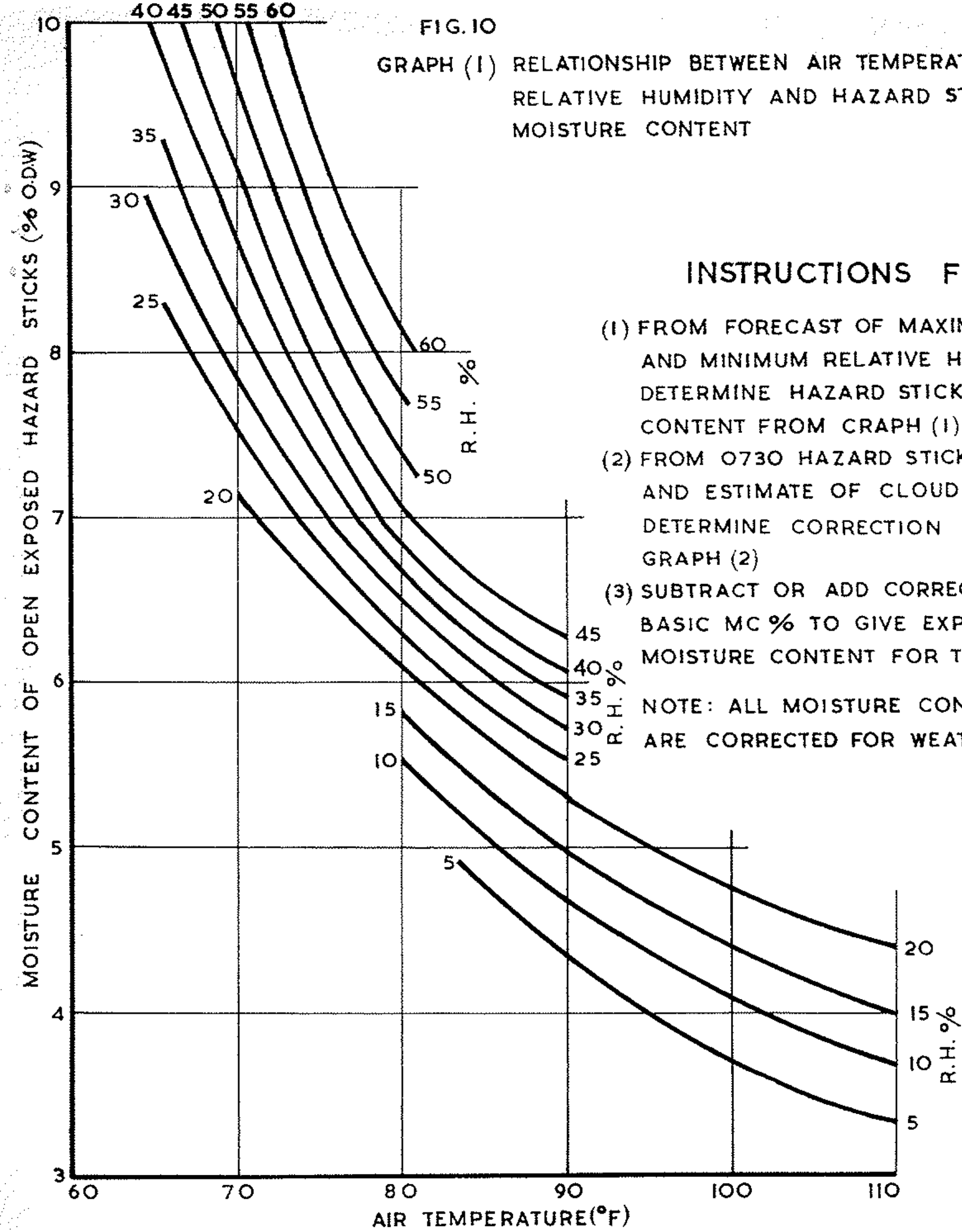
THE RELATIONSHIP HAS BEEN ESTABLISHED LARGELY FROM CANBERRA OBSERVATIONS. DATA FROM JARRAH BURNINGS RELATED TO PERTH AIRPORT VELOCITIES ARE SHOWN BY X ON THE GRAPH.

FOR ALL PRACTICAL PURPOSES, WIND VELOCITY ON THE FLOOR OF THE JARRAH FOREST CAN BE TAKEN AS EQUIVALENT TO THE BEAUFORT NUMBER.

AIRPORT VELOCITY M.P.H.	BEAUFORT Nº	VELOCITY IN THE FOREST M.P.H.
1-3	1	1·4
4-7	2	2·1
8-12	3	2·9
13-18	4	3·8
19-24	5	4·9
25-31	6	6·0

FIG. 10

GRAPH (1) RELATIONSHIP BETWEEN AIR TEMPERATURE RELATIVE HUMIDITY AND HAZARD STICK MOISTURE CONTENT



INSTRUCTIONS FOR USE

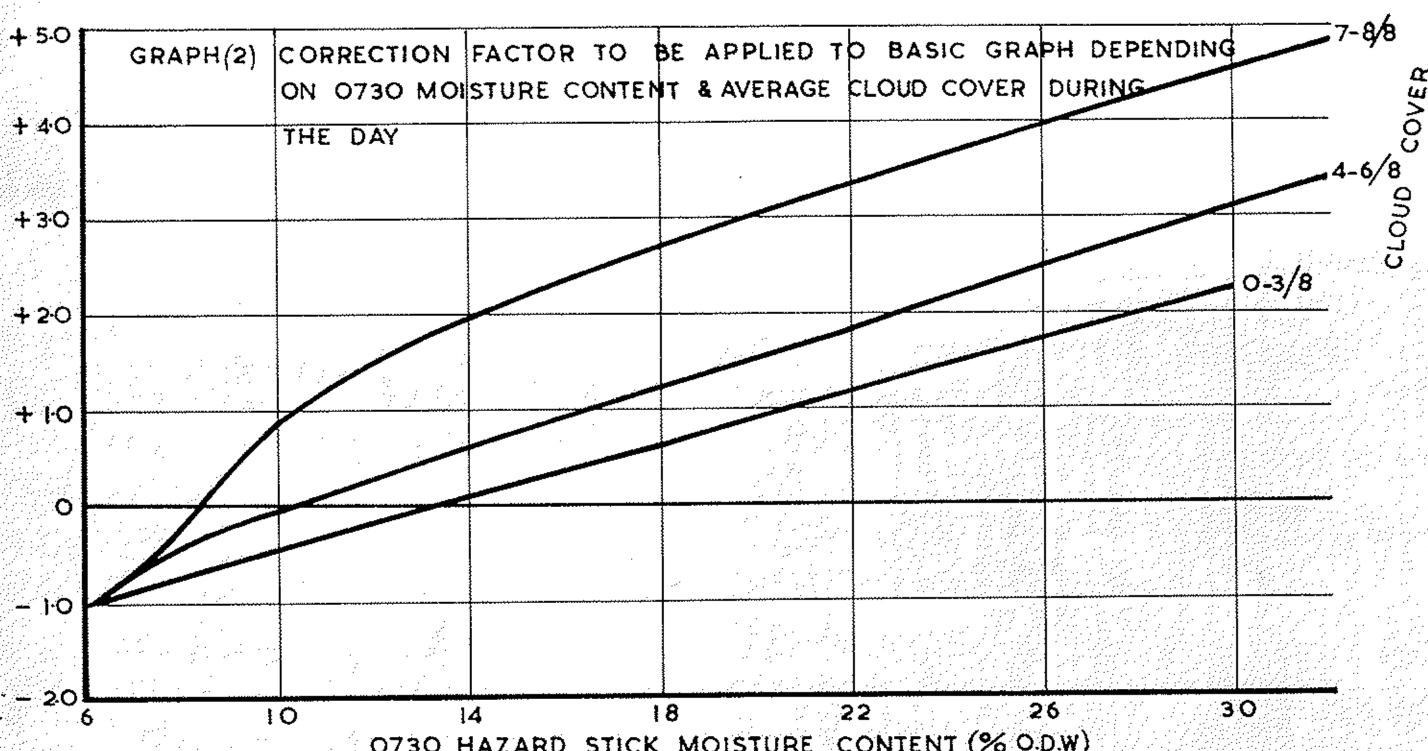
(1) FROM FORECAST OF MAXIMUM TEMPERATURE AND MINIMUM RELATIVE HUMIDITY, DETERMINE HAZARD STICK MOISTURE CONTENT FROM CRAPH (1)

(2) FROM 0730 HAZARD STICK MC% AND ESTIMATE OF CLOUD COVER, DETERMINE CORRECTION FACTOR FROM GRAPH (2)

(3) SUBTRACT OR ADD CORRECTION FACTOR TO BASIC MC% TO GIVE EXPECTED MINIMUM MOISTURE CONTENT FOR THE DAY.

NOTE: ALL MOISTURE CONTENTS ARE CORRECTED FOR WEATHERING

GRAPH (2) CORRECTION FACTOR TO BE APPLIED TO BASIC GRAPH DEPENDING ON 0730 MOISTURE CONTENT & AVERAGE CLOUD COVER DURING THE DAY



RELIABILITY:

75% OF READINGS WITHIN ±0·5% M.C.

20% " " ±0·6–1·0% M.C.

10% " " OUTSIDE ±1·0%

THE PREDICTION CANNOT BE MADE ON A DAY WHEN RAIN FALLS.

A. McArthur.
F. & T.B.
2.7.59

FIG. II

DIURNAL MOISTURE CONTENT TRENDS

OF A. 1/2" P RADIATA HAZARD STICKS OPEN EXPOSED 10" ABOVE GROUND

B. EUCALYPT LITTER ON THE FLOOR OF THE FOREST

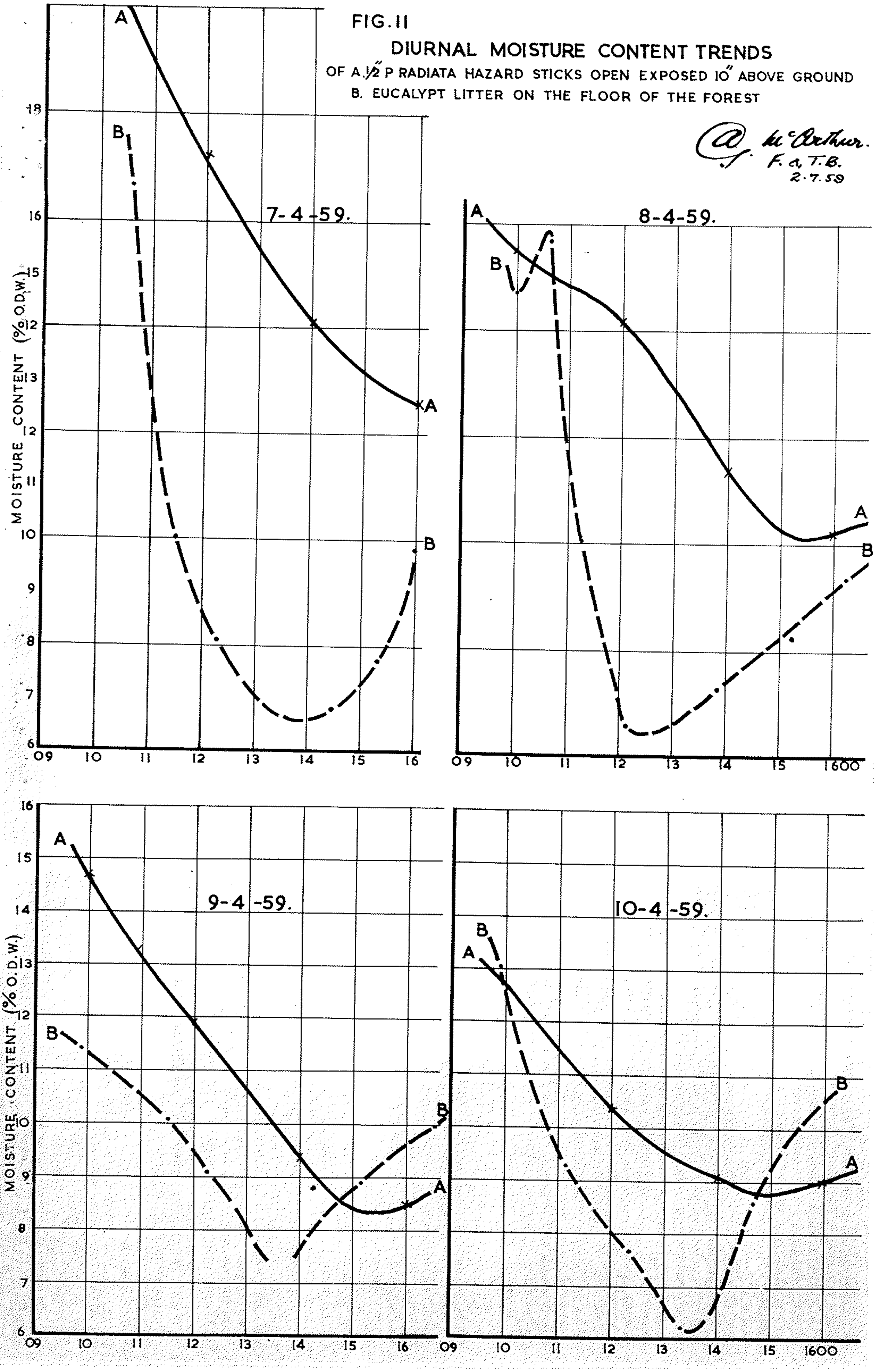
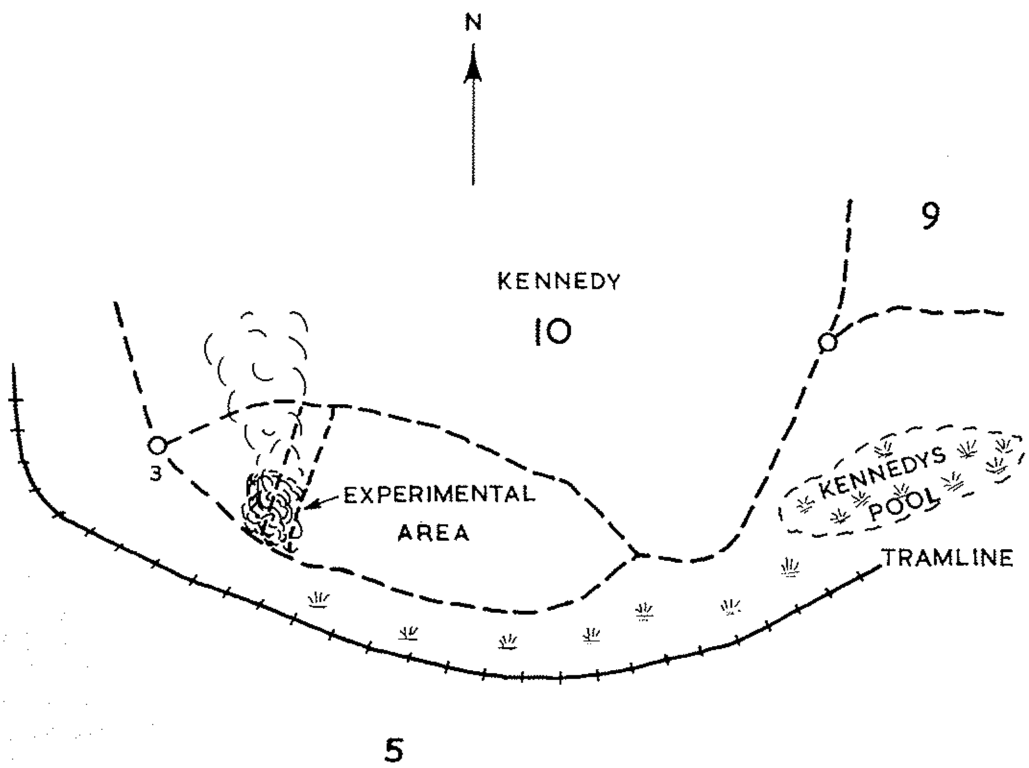


FIG. 12

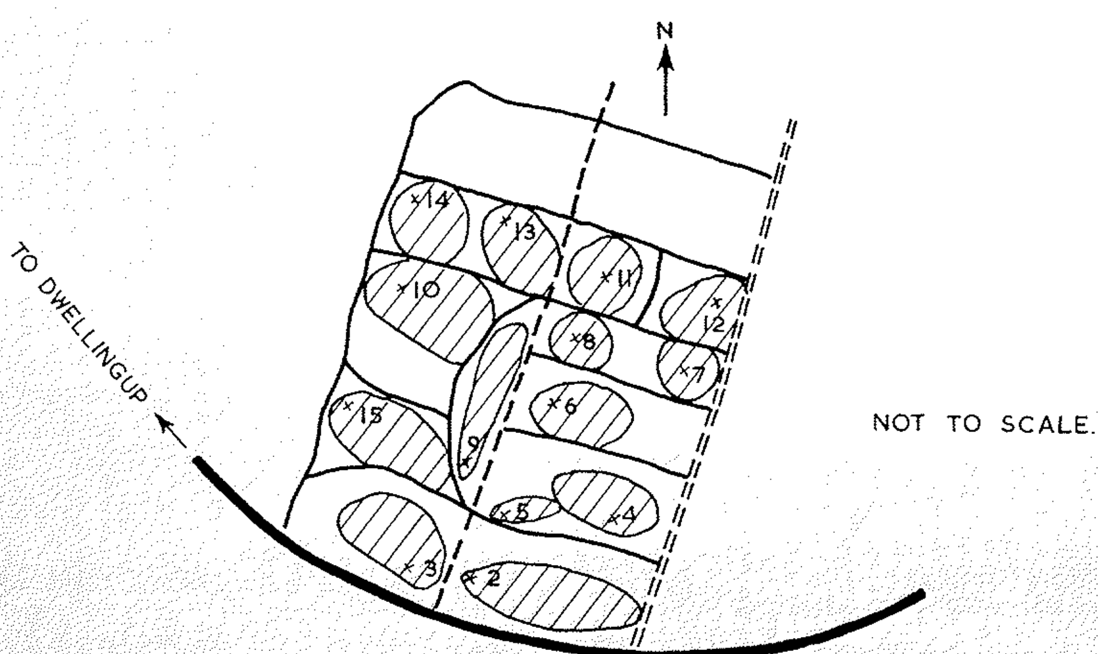
FIRE BEHAVIOUR STUDIES IN JARRAH

LOCATION OF EXPERIMENTAL BURNS

(A) GENERAL LOCATION PLAN

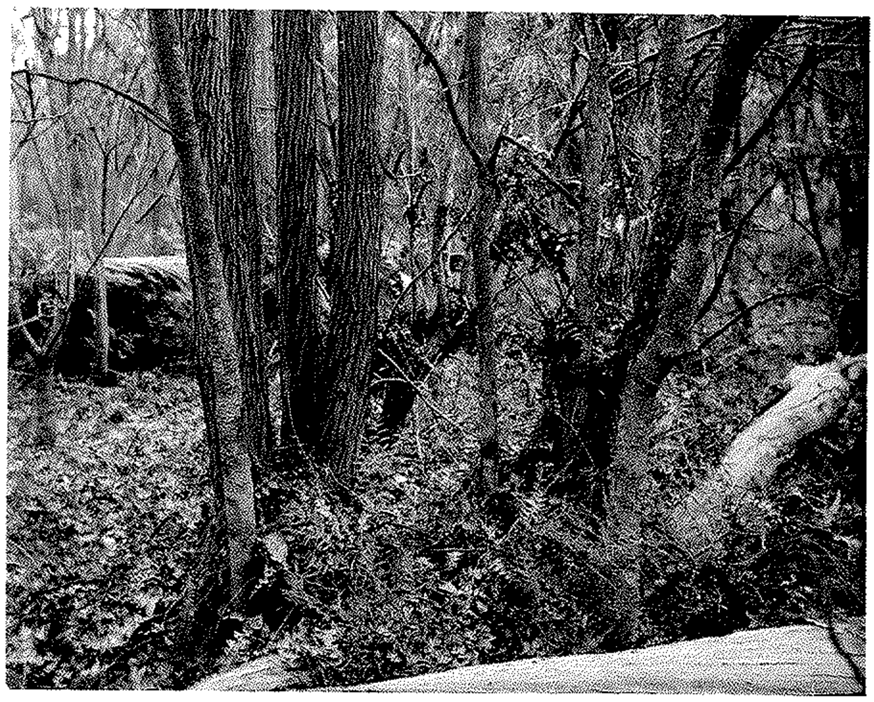


(B) POSITION OF INDIVIDUAL FIRES



NUMBERED PEGS HAVE BEEN PLACED AT POINTS OF ORIGIN AS SHOWN IN SKETCH

(1). Overmature Jarrah bush with a high proportion of dead tops.



(2). 25 year old Jarrah fuel type. Banksia leaves contribute greatly towards the heavy build up of fuel.

(3). 25 year old Jarrah fuel type.

(4).Blackboys flare badly and have a significant effect on fire behaviour in this 25 year old fuel.

(5).Fire No.1 at 26 minutes from start and burning in the heavier Banksia- Blackboy fuel. Flame height 2-3' but flaring 8-10' in blackboys.

(6). Total eclipse of the sun at 1017 hrs. 8-4-59

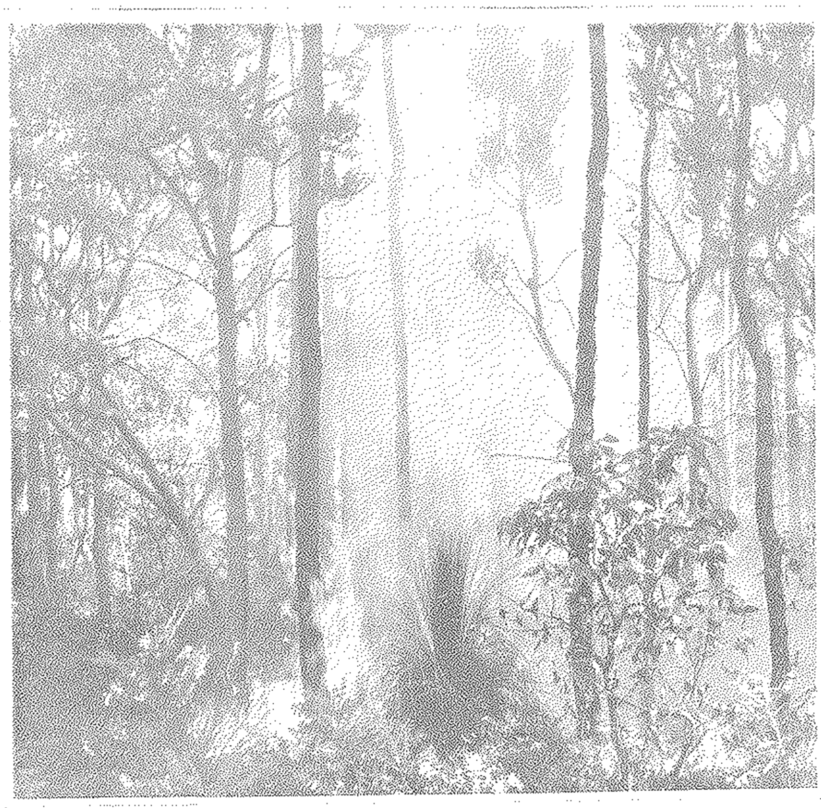
(7). Total eclipse at 1018 hrs.

(8).Fire No. 10 at 1516 hrs. (46 minutes from the start) Flame height 8-10' in lighter type of fuel. 9-4-59.

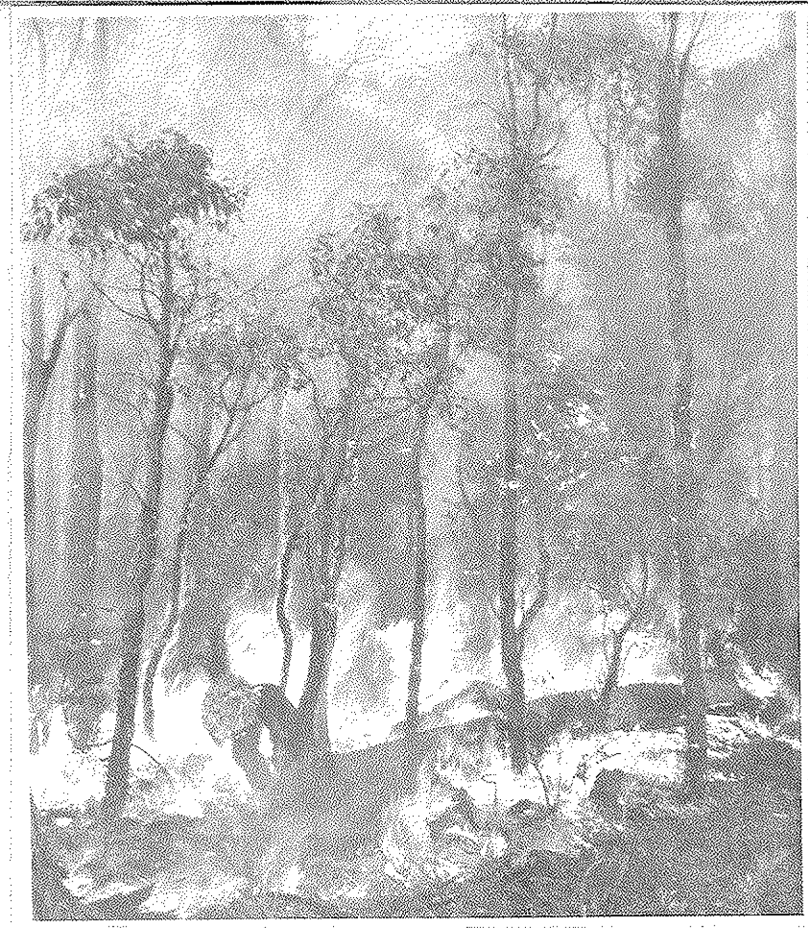
(9). Fire No. 10 reaching edge of break at 50 minutes from start.

(10). Burnout of Fire No. 10 at 1605 hrs. Jarrah alight to 80-90'. Spotting heavily. T 81° RH 38%

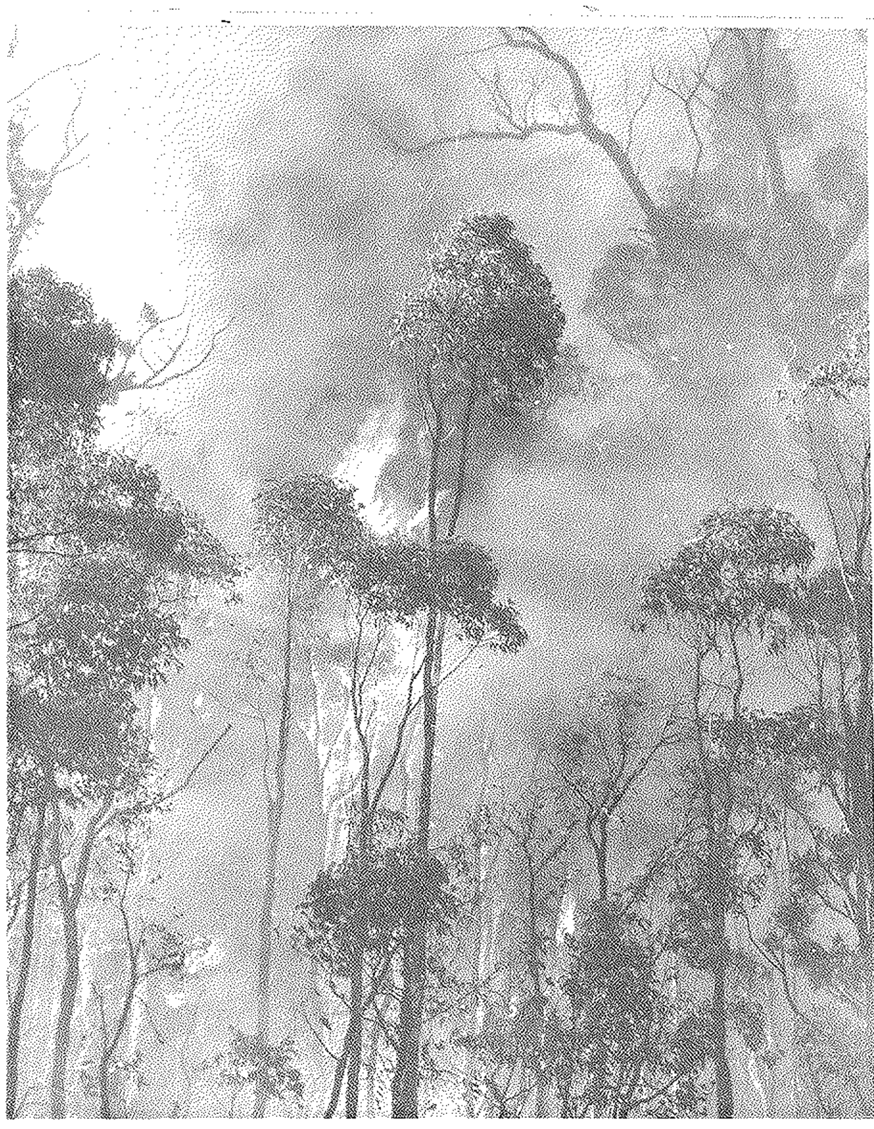
(11). Fire No.13 at 4 mins. from start(1347hrs.) Burning hotly into Blackboys. T 83°RH 42%



(12). Fire No. 13 at 16 mins. Starting to burn up Jarrah regeneration.



(13). Fire No. 13 at 25 mins. Very intense fire and spotting heavily.



(14). Fire No. 15 at 30 mins. Crowning into 30 - 40' Jarrah and spotting heavily.
10-4-59