x H) has a significant effect on the heat pick-up. (See Fig. (4) in "The computation of air temperature increases in advancing stopes"[18]).

<u>Case (iii)</u> The wetness factor was varied keeping the VRT at 120°F and the air velocity at 220 ft/min. Wetness factors of 0.0 (completely dry), 0.5 and 1.0 (completely wet) were used.

The results (Fig. (2.6)) show that when completely dry conditions prevail, a variation in H introduces a fairly large error. For $f = 0.5$ and $f = 1.0$ only the curves for 2 x H smooth pipe are shown, since the three cases are almost colinear.

When $f = 0$ only convective heat transfer takes place. In practice evaporative heat transfer dominates, even when only a small amount of water is present.

2.4 <u>The computer experiment for E</u>

In order to determine the sensitivity of heat pick-up to the mass transfer coefficient E, H was kept constant at twice the smooth pipe value with E taking the value

$$E = CH ;$$

where C was given values ranging from Co/100 to 2Co (Co being the value given by the Lewis relation) for three different VRT's; viz. 100°F, 120°F, 140°F. The wetness factor was taken as $f = 1.0$ and the air velocity as 220 ft/min. The remaining conditions were the same as those in the previous calculations.

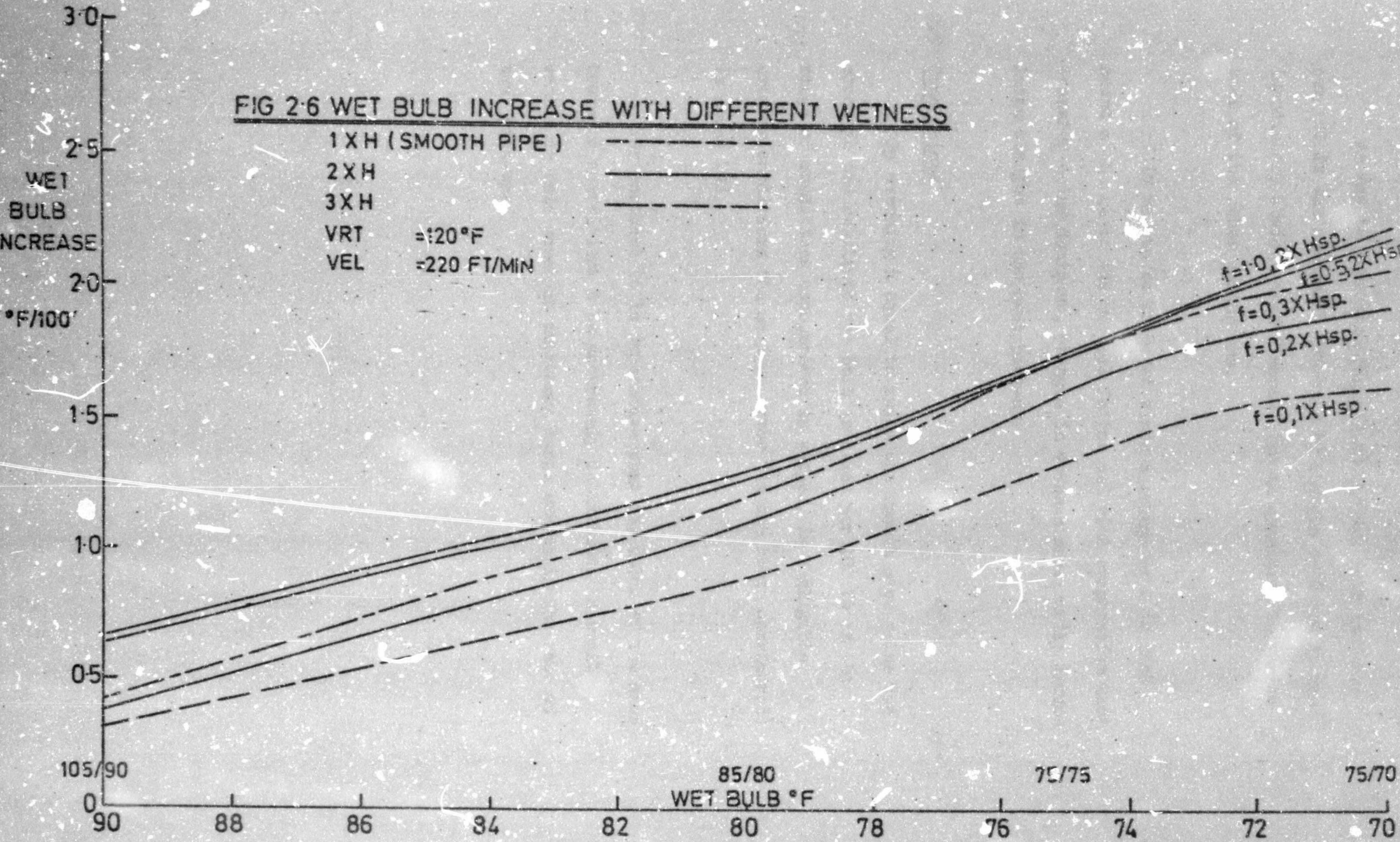


FIG 2·6 WET BULB INCREASE WITH DIFFERENT WETNESS
1 X H (SMOOTH PIPE)
2 X H
3 X H
VRT =120°F
VEL =220 FT/MIN
WET BULB INCREASE °F/100'
3·0
2·5
2·0
1·5
1·0
0·5
0
f=1·0, 2X Hsp.
f=0·5 2X Hsp.
f=0,3X Hsp.
f=0,2X Hsp.
f=0,1X Hsp
105/90
85/80
75/75
75/70
WET BULB °F
90
88
86
84
82
80
78
76
74
72
70

As may be seen from Fig. (2.7) the wet bulb increase per 100 ft was radically affected by changes in C and it was immediately obvious that E would also be sensitive to variation of the other parameters.

This was to be expected since a change in C in fact meant a change in the wetness factor and with evaporative heat transfer being dominant, changes in wetness necessarily induce large changes in the heat pick-up.

2.5 Conclusions

By assuming H equal to twice the smooth pipe value the error in the resultant wet bulb increase per 100 ft in the range of conditions encountered in stopes, is negligible. In extreme conditions the maximum error (in the range considered) is about 12%.

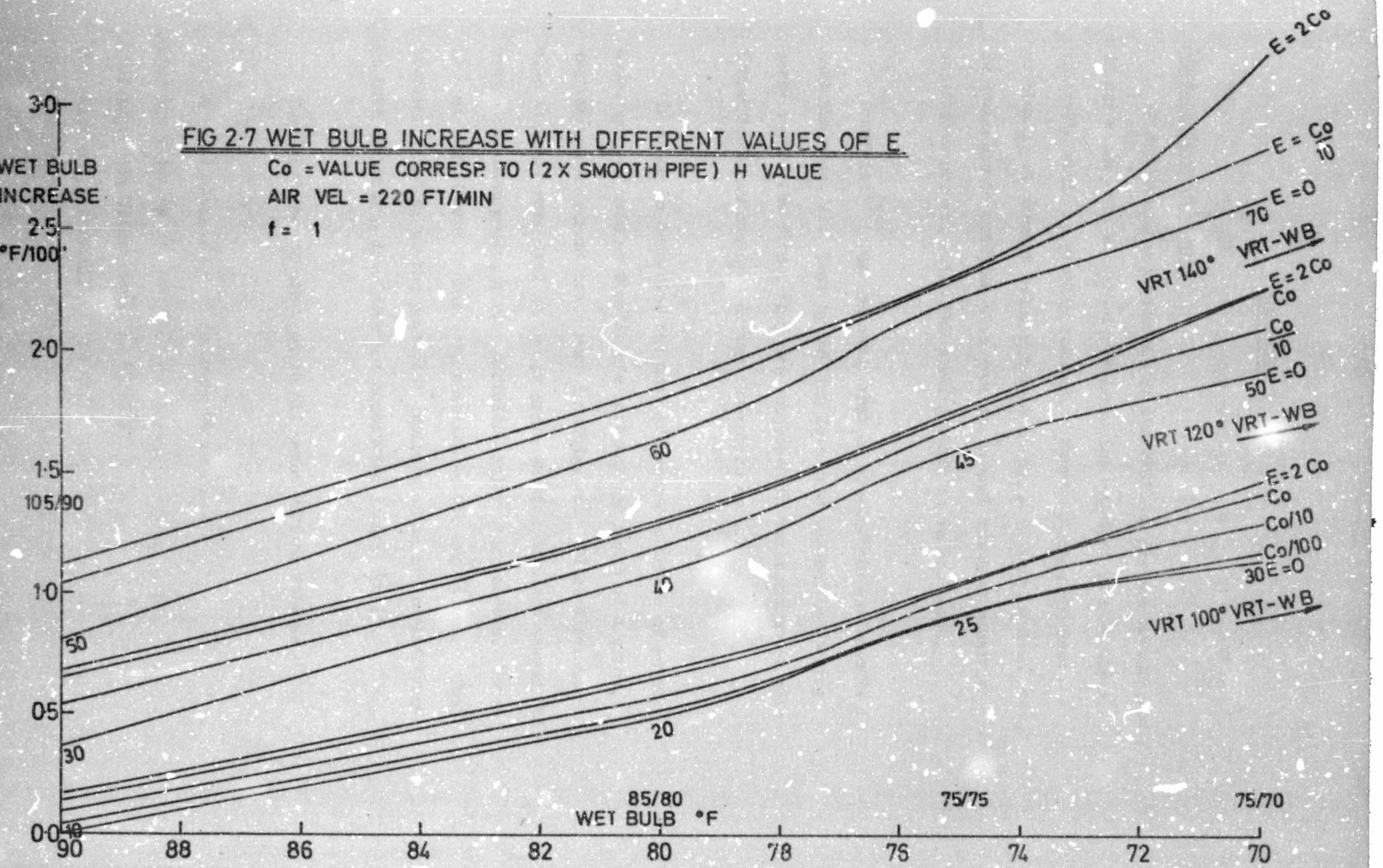
By contrast it is imperative that the value of the mass transfer coefficient E be accurately determined, as small errors in this constant introduce large errors in the rate of heat pick-up.

FIG 2·7 WET BULB INCREASE WITH DIFFERENT VALUES OF E

Co = VALUE CORRESP. TO (2 X SMOOTH PIPE) H VALUE

AIR VEL = 220 FT/MIN

f = 1



CHAPTER 3

Wetting down in stopes

If dry mining was possible at the VRT's at present encountered in our mines, the amount of refrigeration required to keep the air tolerable would be greatly reduced. However, since the dust problem is at present being resolved by means of wetting down, it is desirable to optimise this process so that the best possible conditions prevail while the working shift is in the stope.

Starfield[18] has indicated that at present the converse is in fact the case, viz. that by wetting down just before the working party enters the stope, they are subjected to the maximum wet bulb temperatures encountered during the entire cycle.

In order to determine the most advantageous method of wetting down, use was made of Starfield's mathematical model of a stope, and various different cases were investigated. Since discrete time elements were used in the program, wetting down was assumed to occur instantaneously, giving unrealistically sharp curves. Nevertheless significant trends were revealed by the experiment. The problems relating to the practical implementation of the different methods of wetting down were not considered in any detail.

The input parameters used in all cases were as follows :-

(i) VRT : 115°F

(ii) Rate of advance : 2 ft every 24 hours

(iii) Air velocity : 100 ft/min

(iv) Inlet air temperature : 85/82°F

(v) Face to scatterwall : 12 ft

(vi) Heat source to simulate the presence of broken rock : decreasing from 200 to 50 BTU/ft hr over the first 12 hours after blast

(vii) Thermal conductivity of rock : 3.0 BTU/ft^2 hr (^{o}F/ft)

(viii) Thermal diffusivity of rock : 0.10 ft^2/hr.

(ix) Surface heat transfer coefficient : H = 1.0 BTU/ft^2 hr ^{o}F

(x) Mass transfer coefficient : E = 0.11 lb/ft^2 hr in. Hg.

Wet and dry bulb temperatures were calculated at a point 300 ft along the stope face.

The physical significance of the wetness factor f is not known. In the calculations which follow it was assumed that the wet stope could be simulated by f = 1, while f = 0.2 reflected a stope which was not quite dry. It is unlikely that a "dry" stope has a wetness factor exceeding 0.2(18) and the results given therefore represent a lower bound on the benefits which may be obtained by controlled wetting down. The "wet" value of f = 1.0 is not critical and therefore would not be a large source of error. (See Starfield(18)).

3.1 <u>The general analysis of different wetting down cycles</u>

Firstly four general methods of wetting down were programmed :

(a) The stope was kept fairly dry (wetness factor f = 0.2) for the complete cycle.

(b) A wetness factor of f = 1 (completely wet) was imposed for the first 10 hours, with f = 0.2 for the remainder. This simulated wetting down from immediately after blast until 10 hours after blast.

(c) The present method of wetting down was next programmed, i.e. with f = 0.2 for the first 10 hours and f = 1 for the remainder of the cycle.

(d) Finally, the completely wet case was run, taking f = 1 over the complete cycle.

The results are shown in Fig. (?.1). The most noticeable feature of the curves is the sudden rise of the wet bulb on wetting down. Since results were obtained in discrete time steps, the sharpness of the curves is greatly exaggerated and this necessitated some interpolation where sudden wet bulb changes were involved.

Assuming the main working shift to enter the stope 12 hours after blast, it may be seen that the present method of wetting down (curve (c))subjects the workers to the maximum wet bulb encountered during the entire shift.

Keeping the stope wet for the complete cycle produces a slight improvement over the present method.

The advantage that would result if the stope were kept completely dry (f = 0) over the whole cycle ("dry mining") may be gauged from curve (a), which with f = 0.2 represents at least a damp stope. The advantage of allowing the stope to dry, even partially, after wetting is illustrated in curve (b) where a wetness of 0.2 was assumed over the latter part of the cycle.

The best method of wetting down within the range considered here is obviously case (b). This is to be expected since

/early

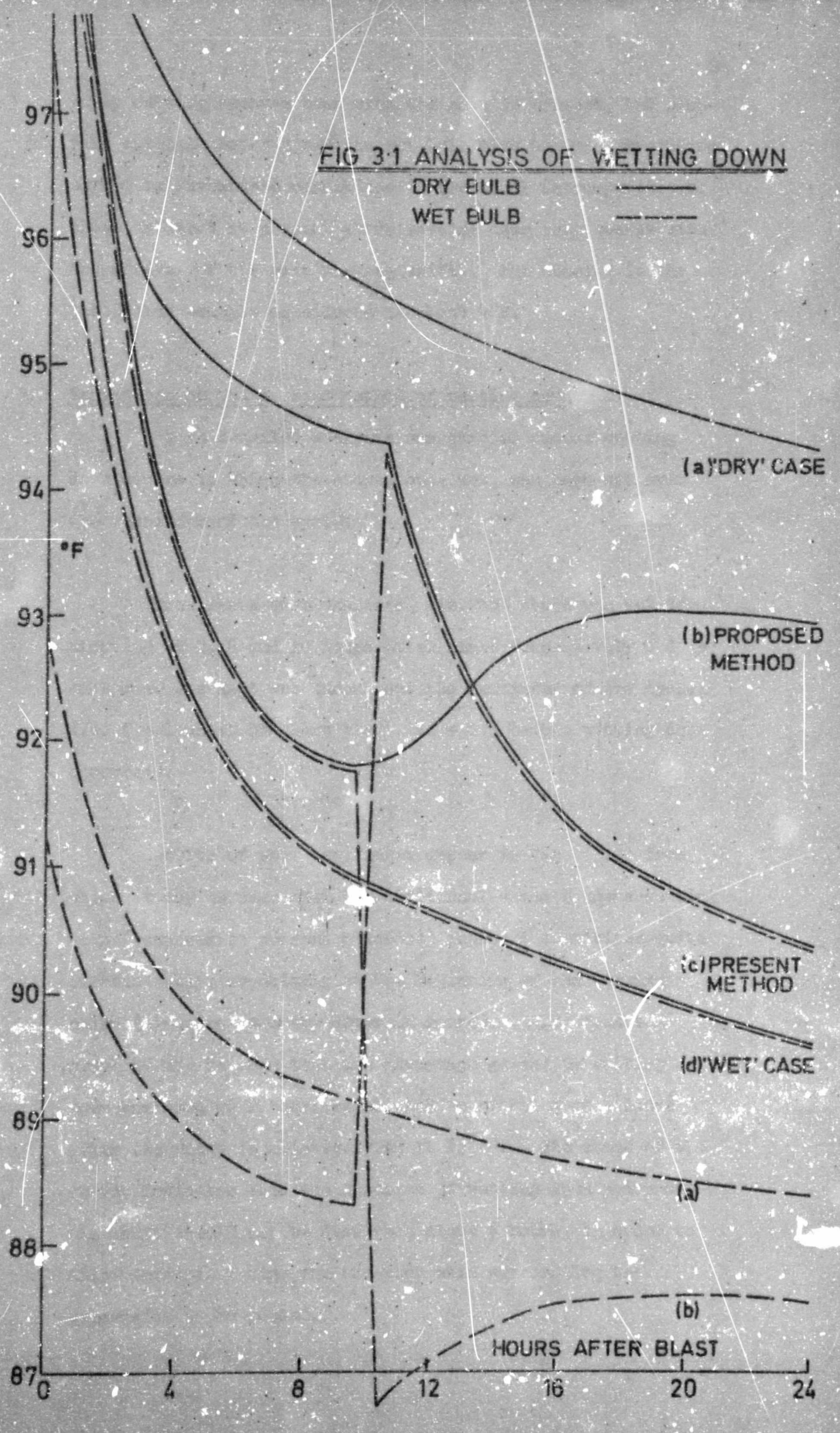


FIG 3·1 ANALYSIS OF WETTING DOWN
DRY BULB
WET BULB
97
96
95
94
93
92
91
90
89
88
87
°F
(a)'DRY' CASE
(b) PROPOSED METHOD
(c) PRESENT METHOD
(d)'WET' CASE
(a)
(b)
HOURS AFTER BLAST
0
4
8
12
16
20
24

early wetting removes heat when the rock is hottest, and stopping after 10 hours gives the wet bulb time to drop, producing extremely favourable conditions in the stope in comparison to those obtained at present where wetting down only starts with the arrival of the main working shift. The benefit in the particular example considered is about 4°F.

3.2 Variations on the present method of wetting down

A more detailed analysis was carried out on wetting down cycles in which the stope, once wet, was kept wet over the remainder of the cycle.

Three cases were examined, viz. the stope was wet down starting at 2, 6 and 10 hours after blast respectively and in each case was kept wet throughout the remainder of the cycle, i.e. $f = 1$ until the next blast. ($f = 0.2$ before wetting down occurred).

Results of this experiment appear in Fig. (3.2) from which it may be seen that the additional 4 and 8 hours wetting down (compared to present practice) improved conditions quite substantially, especially at the beginning of the working shift (assuming re-entry after 12 hours). Also from the graph it may be seen that the advantage gained by wetting down starting at 2 hours as opposed to starting at 6 hours after the blast is relatively small (½°F). The shape of the curves indicates that the duration of wetting down prior to the shift should not be less than about 6 hours, in order to allow sufficient time for the rock skin surrounding the excavation to be cooled.

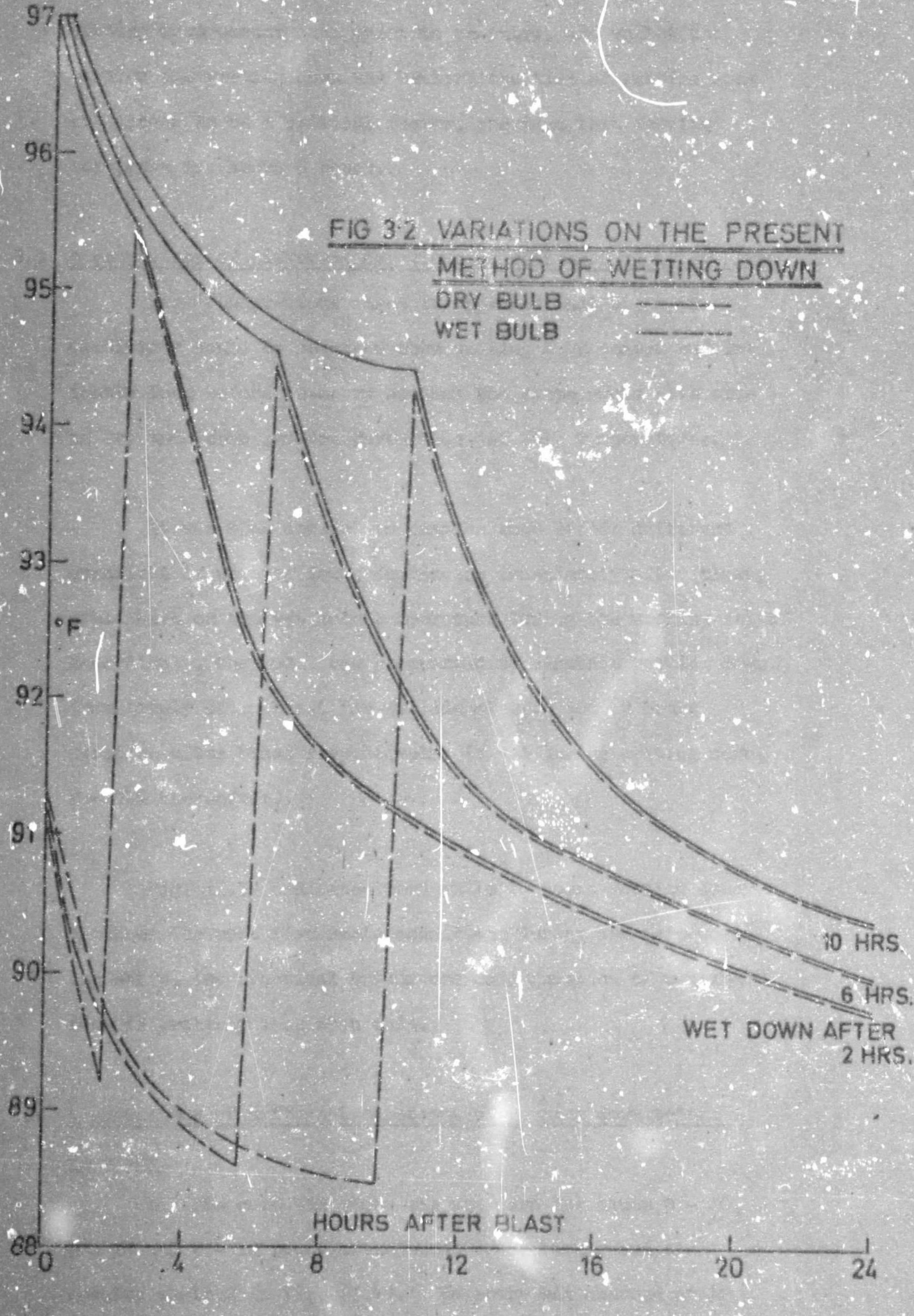


FIG 3·2 VARIATIONS ON THE PRESENT METHOD OF WETTING DOWN
DRY BULB
WET BULB
97
96
95
94
93
92
91
90
89
88
°F
10 HRS.
6 HRS.
WET DOWN AFTER 2 HRS.
HOURS AFTER BLAST
0
4
8
12
16
20
24

The method to be avoided therefore, is that in which wetting down occurs just prior to re-entry, and whilst the earlier the wetting down the better, the time of wetting does not appear to be a critical factor, provided that wetting continues for about 6 hours.

3.3 <u>A comparison of different durations of wetting down after blast</u>

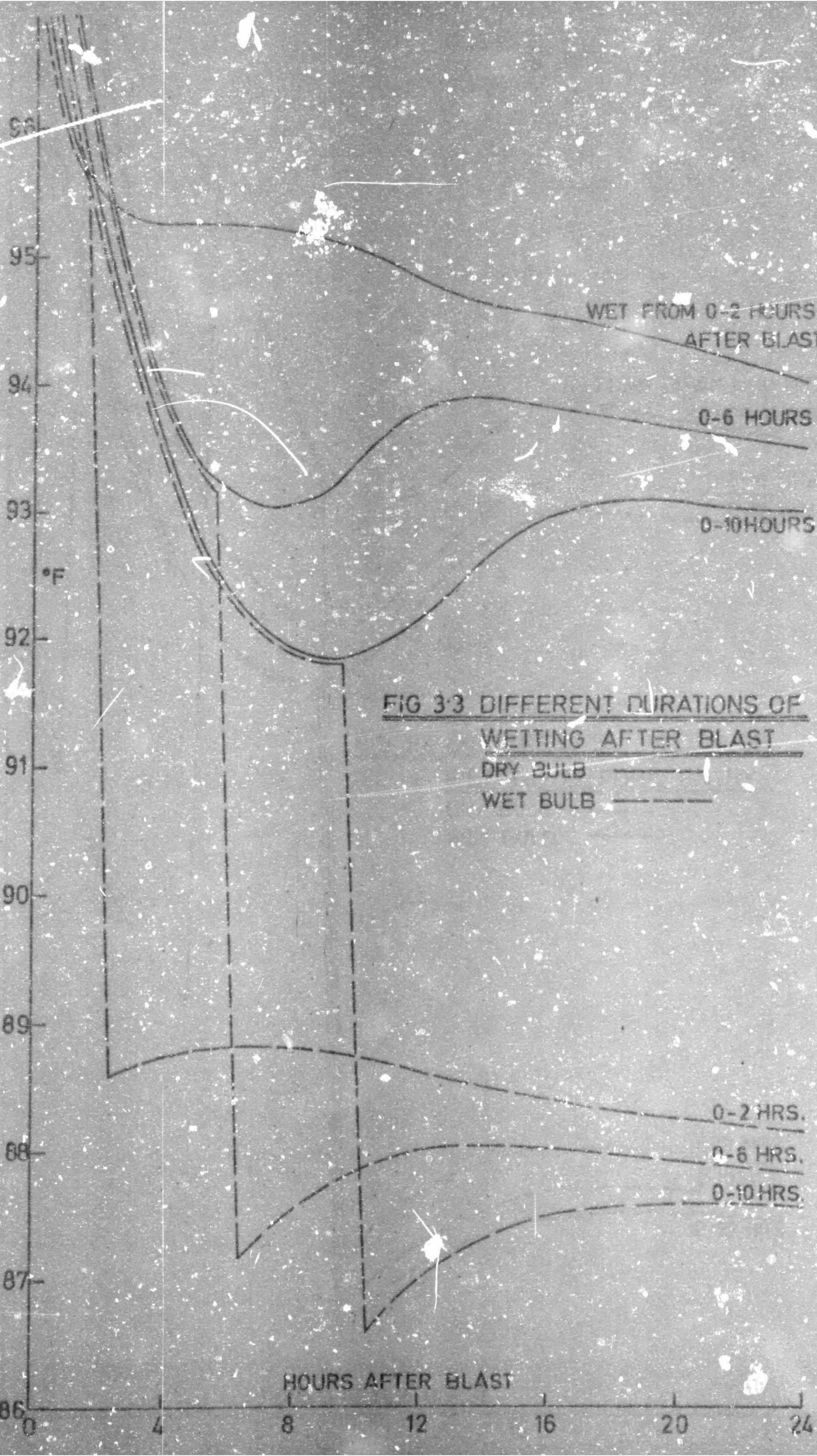
From the previous cases it appeared that the optimum conditions would be obtained when wetting down ceased sufficiently long before re-entry so that the stope would have time to dry and hence produce favourable wet bulb temperatures.

It was thus decided to examine what effect different durations of wetting down, commencing immediately after blast, would have on the wet bulb temperature during the working shift. Accordingly, the model was programed to simulate wetting down immediately after blast for periods of 2, 6 and 10 hours duration after blast respectively; ($f = 1$ during wetting down, $f = 0.2$ thereafter).

Fig. (3.3) indicates that while 10 hours wetting down produces the most favourable conditions during the main working shift, the practical and/or economic duration of wetting down is probably less than this.

3.4 <u>A comparison of different durations of wetting down before re-entry</u>

In this case the stope was wet down for times 0 - 10, 2 - 10 and 6 - 10 hours after blast respectively and the results plotted in Fig. (3.4). Re-entry was assumed at 12 hours after blast.


WET FROM 0-2 HOURS AFTER BLAST
0-6 HOURS
0-10 HOURS
°F
FIG 3·3 DIFFERENT DURATIONS OF WETTING AFTER BLAST
DRY BULB
WET BULB
0-2 HRS.
0-6 HRS.
0-10 HRS.
HOURS AFTER BLAST
86
87
88
89
90
91
92
93
94
95
96
0
4
8
12
16
20
24

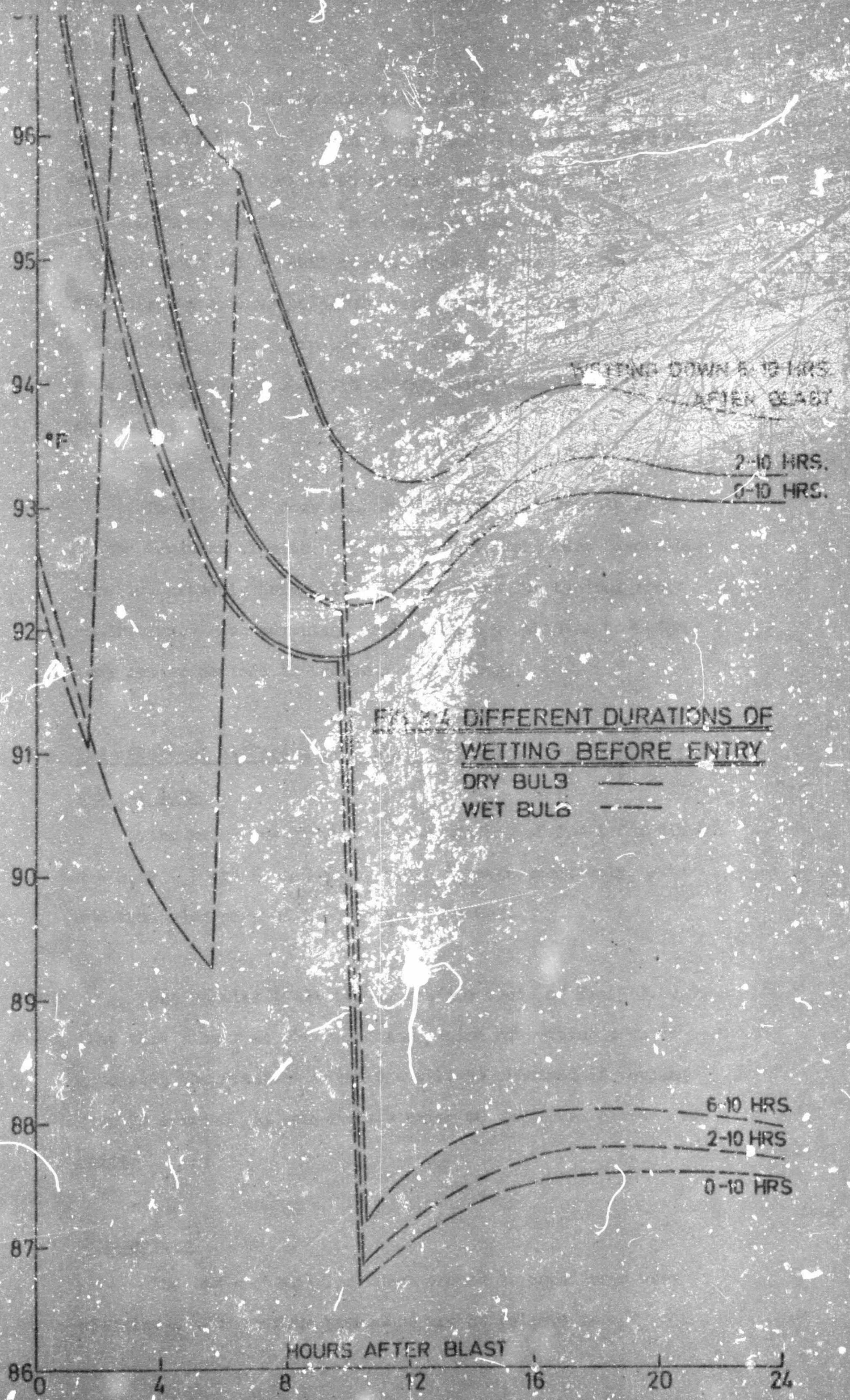


FIG. 4 DIFFERENT DURATIONS OF WETTING BEFORE ENTRY