THE INFLUENCE OF CLOTHING ON THE PATTERN AND SEVERITY OF BURNS STUDIED IN SOME RECENT COLLIERY FIRE-DAMP IGNITIONS

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Recent reports have demonstrated the important role of flammable clothing material in domestic burning accidents (Colebrook, Colebrook, Bull, and Jackson, 1956; Tempest, 1956). Such burns are extensive both in area and depth and they thus carry a high mortality. Indeed, some 90% of deaths from domestic burns are associated with the ignition of clothing. This matter is discussed in the report of the British Standards Institution (1957), which indicates the measures which could be taken to avoid such accidents. Happily these matters are attracting much attention in relation to domestic burns, but in industry little emphasis has so far been laid on the problem. Published references to the role of clothing in industrial burning accidents are few, but the Air Ministry Pamphlet No. 168 (1956) "First Aid and Early Treatment of Burns in the R.A.F." contains an excellent section on the protective value of clothes.

The fact that miners' clothing may catch fire in ignitions of fire-damp has many times been noted. For instance, in the report of H.M. Divisional Inspector for South-Western Division upon the explosion at Bedwas colliery in 1952 (Jones, 1953), we read that a small group of volunteers went inbye to explore the scene of the explosions and . . . extinguished several small fires where discarded articles of clothing were burning or smouldering. . . . In the top level they found the dead body of deputy A. G., badly burned with his clothing still on fire."

Again, in his report on the ignition at Glyncorrwg colliery in 1954, we read ". . . men came running down the [coal] face, some with their clothing on fire. . . ." and that later when the assistant manager and an overman explored ". . . they found articles of clothing on fire. . . ." (Jones, 1955).

Experience in Four Recent Colliery Ignitions

A recent series of underground gas ignitions has given us the opportunity to study in some detail the influences of clothing on burning injuries. During the period December, 1956, to June, 1957, four major accidents occurred in British coal-mines, resulting in burns to 13, 11, 19, and 23 men respectively.

The material for study in these 66 cases* consisted of detailed records of the extent, distribution, and severity of the burned areas in each case, together with necropsy findings in most of the 28 cases which proved fatal. Arrangements were made for recording in detail the clothing worn by each man at the time of the incident, and so far as possible the extent of burning suffered by these garments. In one incident, each item of clothing was examined by a panel of three doctors, including two of us, and an agreed record of the state of each set of clothing was made. Similar records were obtained for the clothing in the other three incidents, but in one of these (colliery S) our information on the extent of burning suffered by the clothing is incomplete. However, experience of the other incidents has enabled us to fill in, by inference, but with some assurance, these missing details.

Further information was obtained by questioning the patients, and other witnesses such as rescue and first-aid workers. Finally, the opinion of H.M. Inspectors of Mines has been sought as to the extent of the exposure to burning gas and material in these incidents in terms of duration and probable temperatures.

*Space forbids the detailed description or illustration of the burned skin and clothing in these cases. The complete case notes upon which this study has been based may be inspected on application to M. N. Tempest, F.R.C.S. (Ed.), St. Lawrence Hospital, Chepstow, Monmouthshire.

In general, there was exceedingly close agreement between the areas of skin and of overlying clothing which showed evidence of burning in all cases in this series. Very exceptionally cases occurred where this correspondence was incomplete; areas of skin were burned beneath clothing which was apparently intact, or the skin had escaped beneath clothing which showed evidence of burning. The former cases involved areas where hot gases could penetrate under a free edge of clothing, such as the arm and shoulder regions and shins. The latter demonstrated that even partly-burned clothing might yet give some protection to the skin beneath.

In all the incidents, exposure to burning gas had been of short duration—at most a matter of a few seconds.

Exposures at Collieries S, C, and B are likely to have been momentary—less than one second; at Colliery A it may have been for as long as 10 seconds. In none, as far as could be judged by expert examination of material evidence and the questioning of witnesses, had there been significant exposure to secondary conflagration, such as that of timber, belting, or coal. Estimates of the temperatures reached by burning gases in these incidents have been difficult to make, but 600° F. is required for the ignition of fire-damp and would be a minimum for burning gas, while exposure to spent gases following combustion will have been for longer periods but at lower temperatures.

Naturally, the severity of burns sustained by exposed areas of skin varies with both the duration of contact and temperature of the hot gases, as well as with the site and texture of the skin surface. Thus, for example, mucous membranes and the thin skin over the back of the hand and front of the neck suffer more severely than the tougher keratinized covering of the palms or soles.

Burns of Unclothed Areas.—In all these incidents, burns occurred commonly on the face, neck, hands, and forearms, these being areas usually unprotected by clothing: in this respect there is close similarity between burns in collieries and those occurring elsewhere. At Collieries C and S, however, working conditions were such that coal-face workers habitually wore only trousers, boots, and helmet while at work. In these men, therefore, “primary” burns of unclothed areas involved up to 70% of the total skin surface. (By “primary” burns we mean those which are caused by exposure to hot or incandescent gases or solid objects surrounding the subject, other than clothing. Burns caused by the ignition of garments are here considered as “secondary”.)

Working conditions were different at Collieries A

FIG. 1 (a) and (b).—This man was exposed to “flash” during a colliery ignition. The outline of his singlet can be clearly seen silhouetted on the trunk and shoulder. Note the lack of protection given to the axilla and upper arm by this type of garment. Extensive scarring in each axilla caused marked limitation of shoulder movement, especially on the left side.

and B; here more clothing was worn, though varying much according to the personal preferences of the men. Areas of primary burning in these men were accordingly less extensive. In primary burn cases where a shirt or singlet is worn, the outline of the clothing is left silhouetted on the skin (Fig. 1, a and b).

Mention will be made below of the significance of primary burns in certain areas, including the respiratory tract. Here it will simply be remarked that such burns in colliery ignitions are rarely deep, usually involving only superficial layers of the dermis. Exceptions to this rule are found in the skin of forehead, nose, and ears; over the sternum and bony prominences in thin subjects; in the axillae and on the hands (Fig. 2). Colliery S provided nine examples of extensive primary burns, covering up to 45% of the skin surface. None of these was complicated by areas of full-thickness burning. The clothing of none was ignited. Among all the 66 cases in the whole series there occurred only two others (from Colliery B) where the primary burns were

TABLE 1
EXTENT OF SKIN BURNING IN MINERS OF FOUR COLLIERIES TO INDICATE PROTECTIVE QUALITIES
OR OTHERWISE OF CLOTHING WORN

Colliery	Case No.	Age	Fatal (F) or Not Fatal (N/F)	Necropsy Findings and Other Injuries	Total Percentage of Skin Burned	Area (%) of Total Skin Surface Not Covered by Clothing		Area (%) of Total Skin Surface Covered by Clothing		Severely Burned beneath Burned Clothing
						Potentially Unprotected	Burned	Potentially Protected	Burned	
A	1	37	F	No necropsy	95	? 40	40	? 60	55	55
	2	69	F	No necropsy	98	? 40	40	? 60	58	58
	3	57	F	No necropsy	90	? 40	40	? 60	48	48
	4	27	F	No necropsy	90	? 40	40	? 60	48	48
	5	41	F	Pulmonary embolus	30	15	15	85	15	—
	6	39	N/F		30	15	12	85	18	—
	7	50	N/F		10	15	6	85	4	—
	8	43	N/F		30	15	15	85	15	—
	9	46	N/F		10	15	8	85	2	—
	10	36	F	Inspiratory burns; duodenal ulcer	60	15	15	85	45	40
	11	40	F	Inspiratory burns	60	40	15	60	45	35
	12	35	F	No necropsy	45	15	15	85	30	27
	13	18	F	Inspiratory burns	50	15	12	85	38	20
B	1	33	N/F		25	15	15	85	10	5
	2	46	N/F		6	15	4	85	2	2
	3	54	N/F		2	15	2	85	0	0
	4	37	N/F	Laceration of scalp	18	15	11	85	7	5
	5	43	N/F		25	20	19	80	6	2
	6	53	N/F		12	15	12	85	0	0
	7	37	N/F		30	15	15	85	15	3
	8	36	F	Inspiratory burns Bronchopneumonia and duodenal ulcer Toxic kidneys and liver	40	20	19	80	21	18
	9	55	F	No necropsy	63	20	20	80	43	35
	10	41	F	Inspiratory burns Toxaemia; lungs congested and oedematous	50	20	17	80	33	25
	11	32	F	No necropsy	50	40	40	60	10	0
	12	48	F	Inspiratory burns	45	20	15	80	30	15
	13	20	N/F	No necropsy	35	15	14	85	21	10
	14	26	N/F		31	15	13	85	18	8
	15	35	N/F		15	15	13	85	2	2
	16	28	F	Depressed fracture R. temporo-parietal Coronal suture open	18	15	10	85	8	6
	17	43	N/F		22	15	15	85	7	5
	18	42	N/F		18	15	10	85	8	6
	19	20	N/F	Concussion	5	15	5	85	0	0
S	1	52	N/F		35	10	6	90	29	? 20
	2	30	F	No necropsy report	65	50	40	50	25	? 20
	3	56	F	Inspiratory burns	45	50	45	50	0	0
	4	33	F	Inspiratory burns	60	50	42	50	18	? 10
	5	16	F	Inspiratory burns	50	15	14	85	36	? 30
	6	45	F	No necropsy report	45	50	42	50	3	? 0
	7	31	N/F		9	50	9	50	0	0
	8	46	N/F		25	50	25	50	0	0
	9	31	N/F		67	50	50	17	17	? 0
	10	23	N/F		28	50	20	50	8	0
	11	37	N/F		38	10	8	90	30	0
	12	46	N/F		50	50	30	50	20	0
	13	40	N/F		20	50	20	50	0	0
	14	31	N/F		45	50	40	50	5	0
	15	28	N/F		10	50	10	50	0	0
	16	29	N/F		32	50	42	50	8	0
	17	23	N/F		40	50	42	50	8	0
	18	51	N/F		10	50	10	50	0	0
	19	34	N/F		40	50	40	50	0	0
	20	29	N/F		45	50	45	50	0	0
	21	33	N/F		30	? 50	? 30	? 50	? 0	0
	22	18	N/F		50	50	50	50	0	0
	23	16	N/F		57	25	17	75	40	10
C	1	31	F	COHb 75% Inspiratory burns	31	10	5	90	26	12
	2	45	F	COHb. 70% Inspiratory burns	32	10	9	90	23	13
	3	40	F	COHb. 80% Inspiratory burns	32	10	9	90	23	12
	4	23	F	Duodenal ulcer COHb. 77% Inspiratory burns	33	10	10	90	23	14
	5	47	F	Inspiratory burns Toxaemia. Bronchopneumonia	65	50	50	50	15	8
	6	36	F	Bronchopneumonia Toxaemia	55	10	10	90	45	12
	7	21	F	Bronchopneumonia Toxaemia	60	75	47	25	13	5
	8	29	F	Inspiratory burns Bronchopneumonia Toxaemia	35	30	30	70	5	5
	9	27	N/F		55	75	39	25	11	3
	10	19	N/F		31	30	15	70	16	10
	11	48	N/F		35	10	10	90	25	8

FIG. 2.—The late results of a flash burn showing very clearly the protection afforded by clothing. The victim was wearing a thick shirt and a muffer round his neck. The shirt sleeves caught fire at each elbow and the secondary burns at this site healed with considerable scar contracture. Note the protection given to the forearm which contrasts strikingly with the extensive keloidal scarring over the dorsum of the unprotected hand and fingers. Note also the protection given to the axilla and upper arm by garments with sleeves.

probably not complicated by burns from the subject's own ignited clothing.

Burns from Failure of Clothing Protection.—

Table I shows the extent to which protection was afforded by the clothing worn by each subject in this series; care was taken to ascertain not only what clothing was worn, but how it was worn, for example, shirt sleeves rolled up, neck of shirt fastened, and so on. It will be seen that, except in Colliery S where the majority of men wore only trousers, socks, boots, and helmet, the extent of the burns in areas covered by clothing was greater in most cases than their extent in areas not so potentially protected. Thus evidently the clothing worn by the miners in this series fell far short of what is desirable for protection; and also, as we hope to show, of what is possible in practice. An example of superficial burns because clothing was not sufficiently protective is seen in Fig. 3.

Burns Due to Ignition of Clothing.—Clothing may not only fail to protect the skin from burns but by itself becoming ignited it may contribute very severe burns not only of underlying areas of skin but of other areas also.

It seemed reasonable to infer that burns beneath severely burned clothing in contact with the skin, if of greater severity than would have been expected had the area concerned been unclothed, could fairly be attributed to such contact with burning fabric. An attempt has therefore been made in Table 1 to assess the area in each case which could be said to have been burned in this way. It will be seen that the direct contribution to the injuries in these cases made by contact with burning clothing is by no means negligible—and in some cases is very considerable. Indeed, this component of the injuries may be said to have been responsible for the deaths of at least nine and possibly as many as 13 of the 28 fatal cases in this series; Case A10 (Fig. 4) illustrates this effect of contact with burning clothing.

Corroborative evidence of the importance of ignition of clothing in determining the extent and severity of burns came from study of the comparison between burns of the ventral and dorsal aspects of the bodies of the men in this series. The results of such an analysis are set out in Table 2, where it will be seen that except at Colliery B, there was a striking excess of burns on the dorsal aspects of the victims' bodies compared with their ventral aspects, and this despite a somewhat greater susceptibility of ventral skin to burns.

TABLE 2
DISTRIBUTION OF BURNS IN MEN FROM FOUR COLLIERIES

Colliery	Greatest on Ventral Aspects	Equal on Dorsal and Ventral Aspects	Greatest on Dorsal Aspects
A	0	6*	7
B	3	11	5
C	1	0	10
S	0	8	15
All collieries	4	25	37

*Including four cases with burns of 90 to 100% of body surface.

It seems impossible to account for such a preponderance of burns on the dorsal aspects of these men on the basis of their position at the time of the ignition. In one incident (Colliery A), for example, it is known that the men were grouped in a narrow circle around the point of ignition and probably all facing it yet none suffered more extensive burns on the ventral aspect. A more probable explanation is that some of the men had sufficient warning of danger to enable them to turn their backs to it.

FIG. 3.—Drawings illustrating failure of clothing to protect the body in Case C.6.

Note protection afforded by undergarments, despite the failure of overalls due to their ignition and partial destruction. The burns of legs, arms, and upper trunk were of similar severity to those of unprotected areas, the hands, face and neck. Small areas, amounting to 12% of body surface, were deeply burned beneath the overalls. (Charring of clothing and full thickness burns are indicated by heavy shading. Lighter shading indicates superficial burning only of clothing or skin.)

FIG. 4.—Drawings showing burns due to ignition of clothing in Case A.10.

Note the severity of the burns of upper arms and trunk in contrast to the superficial burning of forearms and hands. This man was working with his shirt sleeves rolled up above his elbows.

The shaded area of the back of the shirt was missing, having been burned away from the rest of the garment. It is likely that its tail would have been intact. (Charred areas indicated by heavy shading; superficial burning by lighter shading.)

This man had very severe inspiratory burns.

But the most probable explanation of this predominance of dorsal burns lies in the greater opportunity for observing and extinguishing clothing which is burning on the front of the body. Clothing on the back of trunk and limbs which has caught fire is unlikely to be noticed by the victim until he feels his flesh burning, and then is not easily extinguished without help.

The contribution of burning clothing to these injuries is not confined, however, to burns of the immediately underlying skin in contact with it. We have found it difficult to deduce with accuracy the extent to which flash burns have been aggravated by burning clothing in this series as a whole, but the cases of Colliery S provide some measure of this. In this episode there were 15 men with evidence of ignition of clothing (usually of trousers); facial burns occurred in all but two of these 13 men. In the eight men whose clothing showed no evidence of burning, there were only four with facial burns. It would seem natural to expect such aggravation to occur mainly in the upper parts of the body, including the face, neck, shoulders, and upper chest, as these would be most likely to be licked by flame from clothing alight on the upright subject. Other parts likely to be so affected are forearms and hands (see below) and the respiratory tract.

Inhalation Burns.—Inhalation burns are a well-known complication of explosions and fires in confined spaces; the classical case of the Coconut Grove disaster provided many examples (Aub, Pittman, and Brues, 1943; Beecher, 1943). Such burns are of special significance for oedema of the epithelium of the respiratory tract interferes with gaseous exchange; oxygenation of the tissues is already impaired after severe burns by circulatory collapse, excessive destruction of red cells by burning, and in some cases also poisoning by carbon monoxide. Many of those with inhalation burns develop respiratory infections which, despite antibiotics, oxygen therapy, and tracheotomy, often prove fatal.

Unfortunately owing to incomplete necropsy data it is not possible to offer more than an indication of the incidence of these burns in the present series. There was, however, evidence of inhalation burns in at least 21 of the 28 cases which proved fatal, and they were presumed to have been present on clinical grounds, or observed by laryngoscopy, in many of those who recovered.

It seems to us probable that in this type of burn, too, a considerable part may be played by the ignition of clothing, though proof of this is difficult. At Colliery A, the clothing of eight of the men who were grouped roughly in a circle around the point

of ignition was extensively destroyed. Six of these are known to have suffered inhalation burns, and it is likely that the remaining two who died within minutes of the ignition would have exhibited such burns had examination been made at necropsy. There were no signs of inhalation burns in the five men whose clothing was much less extensively burned. Again, close correlation between inhalation burns and the extent of clothing destruction was seen in the cases from Colliery B but it was less close in cases from Collieries S and C.

So far as we are aware, no study has been reported elsewhere of the respiratory response of individuals to sudden exposure to flame. Reflex inhibition of respiratory movement is, however, provoked by any sudden danger signal, sometimes preceded by a partial inspiratory gasp. To account for the large number of inspiratory burns associated with mine gas ignitions, such strangled gasps would have usually to occur at the precise moment at which incandescent gas is passing the victim. It is a striking fact that although severe burns of the eyelids commonly occur in mine gas ignitions, burns of the conjunctivae are rare; indeed not one such burn occurred among the 66 men here considered. This fact is an indication of the efficacy of the blinking reflex as a protective mechanism, and suggests moreover that the eyes are usually kept closed or shielded throughout the danger period—perhaps to the detriment of other parts which may be burned by unextinguished clothing. It seems likely that a similar pattern of mechanisms protects also the respiratory tract, overcome only by severe anoxia: by then in most cases danger will probably have passed, except that from burning garments. However, it seems to us that the respiratory responses to danger should be studied.

From these considerations it seems probable that the majority of severe inhalation burns may be due to the inhalation of flame and hot gases arising from the ignited clothes worn by the subject. Those of lesser severity (probably more numerous than is commonly realized) could also be due to inhalation of spent gases after passage of the flame.

Carbon Monoxide Poisoning.—A frequent complication of injuries in those injured in underground fires and explosions is respiratory embarrassment due to carbon monoxide poisoning. Thus, for example, the four bodies recovered from the scene of the incident at Colliery C had blood saturations of carboxyhaemoglobin respectively of 75%, 70%, 80%, and 77%. All had extensive inspiratory burns, as well as extensive burns of the skin surfaces.

The clothing of all four men was also extensively burned, and it cannot be doubted that some at least

(a)

(b)

FIG. 5.—Extensive burns due to ignition of clothing.

Note the very extensive deep burn of the whole of the left upper extremity with the striking exception of the hand which was protected by a glove at the time of the accident (Case A.12).

FIG. 5 (a).—Profile and (b) dorsal views of hand burnt in a colliery ignition. The thin skin over the back of the hand and wrist is seriously damaged, whereas the tougher thicker skin over the palm is virtually undamaged.

of the carbon monoxide they breathed originated in their smouldering clothes. Unfortunately, it is rarely possible to obtain reliable carboxyhaemoglobin estimations in those rescued alive but burned; however, carboxyhaemoglobin in concentrations, over 30% was found in all but two of the nine least severely burned in Colliery A, and these included all the six men in this group who had inspiratory burns; the clothing of these seven men known to have been affected by carbon monoxide was severely burned.

Burns of Hands.—Flash burns of the hands are almost the rule in colliery ignitions. In a considerable number of cases in this series, however, hand burns were unusually severe; nearly all those whose hands were severely burned and who survived long enough to be questioned on the point, described their attempts to extinguish clothing on fire, either on themselves or their workmates. It cannot be doubted that such attempts are an important cause of burns on the hands and forearms.

The prevalence of burns of the hands is indicated by the fact that they occurred in all the 11 cases at Colliery C, in all but three of those at Colliery B, and in all but one of the men at Colliery A. This last

man was the only one wearing gloves, but he sustained a burn of part of one hand due to a split in the glove covering it. At Colliery S, by contrast, nearly all the men escaped injury to their hands, thanks to the almost universal habit among men at this colliery of wearing gloves.

Needless to say, burns in this situation are of the greatest significance for the recovery of full working efficiency. They are the cause of prolonged incapacity in many burning accidents and may require protracted reconstructive operations (Fig. 5).

Burns of Scalp.—According to our information, all but one of the 66 men in this series was wearing a standard miner's safety helmet at the time of ignition of gas. Yet at Colliery B the hair of all 19 men injured was singed, nine having also extensive scalp burns, and a further three receiving a serious head injury, which was fatal in one case.

Extensive burns occurred in all cases also at Colliery A (Fig. 6), except in one man wearing a beret who alone escaped. A severe scalp burn involving the bony vault was the main injury in one of the fatal cases. Nine of the 11 men at Colliery C had scalp burns, the hair of the remaining two being severely singed. Only at Colliery S, apparently,

FIG. 6.—Full-thickness burn of the greater part of the scalp and the back of the neck, caused by a colliery ignition. Several similar examples were seen in the course of this survey and illustrate our contention that the standard miner's helmet gives inadequate protection against burns (Case A.8).

was protection to the scalp afforded by the safety helmet; here only one man suffered a burned scalp. There is evidently need to investigate further this widespread failure of "safety" helmets, including, if possible, the reasons for their success in the incident at Colliery S; here they may have remained on the heads of the men during the crucial period. The escape of these men's scalps may, however, have been for other, as yet unknown, reasons; for it was a feature of this incident that facial burns were fewer than usual.

Burns of Axilla.—Burns of this site are of special importance because of the frequency with which they are followed by troublesome scarring, leading to limitation or total prevention of movements at the shoulder joint.

Such burns occurred in a significant proportion of our cases, especially in those wearing singlets or vests without sleeves, and in those working stripped to the waist. It could be inferred from study of many of the burn diagrams that burns of this site were often due to attempts to protect the face with

the forearms and hands, resulting in exposure to injury of this otherwise relatively inaccessible region.

Flammability of Miners' Clothing

The evidence presented above may be held to demonstrate the inadequacy of the clothing worn by these miners to provide protection from injury in these four incidents, which are probably representative of colliery gas ignitions. It seems likely that the clothing would have proved even less adequate to protect these men had they been involved in a general conflagration such as sometimes occurs underground.

Investigations have been made at certain burns centres in Britain, in collaboration with the Fire Research Station at Boreham Wood, Herts., to determine the correlation which exists between the flammability of the fabrics first ignited in domestic burning accidents and the extent and severity of the burns suffered by the wearer. Preliminary results of this work are indicated in the report of the British Standards Institution (1957) to which attention has already been drawn.

The flammability ratings of fabrics are based on the test devised by Lawson, Webster, and Gregsten (1955) and now incorporated in British Standard No. 476, part 2, 1955, "Flammability test for thin textile materials". Briefly the rating is expressed by the time taken in seconds for flame to be propagated 100 inches along a vertically-hung test strip of the material. Domestic burns due to clothes catching fire are usually associated with flammability ratings of 15 to 80.

Flammability tests were kindly made for us by the Fire Research Station on all the items of clothing salvaged from the ignition at Colliery A. The cotton shirts and singlets examined all had ratings of 30 to 80, with the exception of one shirt of heavy cotton with a rating of 102, and a cotton singlet which was given a rating in excess of 200; yet both these garments were almost completely destroyed by fire. Various serge and drill trousers and two woollen pullovers gave ratings in excess of 200, as one might have expected from the nature and weight of such fabrics; yet even part of these garments was destroyed by fire. It is thus evident that the temperatures to which the men were exposed in this colliery ignition must have been considerable. As already mentioned, exposure to flame may have lasted up to about 10 seconds.

The extent to which permeation of miners' garments by fine coal dust and sweat may influence flammability of the fabrics concerned is a question which is being investigated on our behalf at present by the Fire Research Station, but we suspect that

these two factors will, in practice, usually cancel one another out.

Conclusions

The evidence we have obtained from study of these incidents has satisfied us that a major factor in determining the outcome of these and probably all similar colliery ignitions is the ignition of clothing. There was ample evidence of the protective value of clothing, provided this did not itself ignite. When that happened, as is usually the case with present-day garments worn underground, there was immediately risk of aggravation of the original primary burns, especially of the upper parts of the body; of burns of the hands and forearms sustained in attempts at extinguishing fired clothing; of inhalation burns; and possibly of added risk of carbon monoxide poisoning. If burning clothing remains in close proximity to skin, there is danger of very deep burns.

This leads us to conclude that some of the more serious consequences in loss of life and disablement of such colliery incidents could be avoided if more suitable clothing could be devised and worn by miners. From the point of view of protection from burns, working clothes should satisfy two requirements. These are, first, that so far as possible all vulnerable areas should be protected by clothing. Thus gloves should be worn, and the upper trunk should be protected by a shirt or vest, which should have at least short sleeves to give protection to the axillae; elbow-length sleeves would be preferable. The scalp should be protected by a properly designed helmet which will not easily become dislodged. Secondly, all outer garments should possess a high degree of resistance to ignition. This can be achieved in three ways: by use of naturally resistant fabrics such as wool or wool and nylon mixture (which avoids danger from static electrical charges); by using textiles rendered "flame-proof" by an acceptable chemical process; or finally, by the use of a flame-resistant rinse after laundering. Of these, the first and second appear to offer the most satisfactory solutions.

Tests are about to begin in the South Wales coalfield, at the instance of the Area Council of the National Union of Mineworkers, of working clothes thought to satisfy the above requirements. The garments will be tried out both for practicability and resistance to fire. It is to be hoped that following these tests it may be possible to induce increasing numbers of miners to adopt such clothing. In this there are of course numerous difficulties, including sometimes that of habituation to a style of clothing which is no longer demanded by present-day working conditions. More important, however, is the fact

that miners provide their own working clothes, and usually wear their cast-off or partly outworn ordinary clothes at work. This practice raises difficulties because flame-proof garments are at present somewhat more expensive than ordinary ones.

Finally, there is the question of the helmets, which in three of these incidents so signally failed to afford protection to the men at the crucial moment. It seems highly desirable that the design of such helmets should be reviewed in the light of this finding, and that account should be taken of experience in other fields, such as aviation and motor cycling, so that the best possible protection can be afforded by the miner's helmet.

Summary

Experience of burning accidents affecting 66 men in four recent underground gas ignitions is reviewed.

Evidence is presented to show that while clothing has a valuable protective function, this is usually lessened in practice by the liability of the clothing now commonly worn by miners to ignite.

It is shown that many of the more extensive and severe burns are the result of clothes catching fire. This serious hazard of existing types of clothing is seen also in a probable increase in risk of burns of the respiratory tract, additional risk of burns of the hands, and perhaps also of carbon monoxide poisoning, in those whose clothing catches fire.

A striking feature of these incidents was the frequency with which deep burns of the scalp and head injuries occurred. It is suggested that the present type of miner's safety helmet needs consideration in the light of these findings and of experience with protective helmets used by other persons risking head injury.

Recommendations are made on the requirements for safer clothing than that now usually worn by miners to reduce the risk of serious injury by burning in colliery accidents.

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THE APRIL (1958) ISSUE

The April (1958) issue contains the following papers:—

Respiratory Function during the Day in Cotton Workers: A Study in Byssinosis. By C. B. McKerrow, M. McDermott, J. C. Gilson, and R. S. F. Schilling.

A Histological Study of the Lungs in 52 Cases of Chronic Beryllium Disease. By W. Jones Williams.

The Effect of Diamond Dust Alone and Mixed with Quartz on the Lungs of Rats. By E. J. King, M. Yoganathan, and G. Nagelschmidt.

The Prevalence of Pulmonary Tuberculosis in a Northern Transvaal Copper Mine Related to the Importance of Pre-employment Radiographs. By G. E. Dalton.

Some Preliminary Thoughts on the Human Demands of Automation. By A. T. Welford.

A Clinical Study of Beat Knee. By J. T. Watkins, T. A. Hunt, R. H. P. Fernandez, and O. P. Edmonds.

The Paradox in the Treatment of Beat Knee. By R. H. P. Fernandez.

The Sedimentation Rate and Fragility of Human Erythrocytes *in vitro* after Exposure to Lead Chloride. By T. W. Clarkson and J. E. Kench.

The Effects of Bursts of Loud Noise on a Continuous Visual Task. By M. M. Woodhead.

A Method for the Determination of Trinitrotoluene in Air. By J. Mackay, K. W. Holmes, and R. E. Wilson.

Miscellanea:

Some Enquiries into the Toxicology of Zinc Stearate. By H. E. Harding.

A Human View of a Great Port. By M. W. Goldblatt.

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