Dental Erosion in Industry

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Five hundred and fifty-five acid workers were examined between March 1962 and October 1964. One hundred and seventy-six (31.7%) were affected by industrial dental erosion at the first examinations. In 33 cases (6.0%) the dentine was affected. During the period of the survey, 66 (20.4%) of 324 workers examined more than once showed evidence that erosion was progressing. The prevalence and incidence of erosion were highest among battery formation workers, lower among picklers, and least among other processes covered by the survey. The age of workers did not appear to influence their susceptibility to erosion. The habit of working with the lips slightly parted had little effect. Erosion superimposed upon attrition predisposed to more severe loss of tooth structure than either operating alone. Little inconvenience or functional disability was suffered by acid workers due to erosion. Twenty-seven (23.7%) of 114 erosions were considered to be disfiguring. Regular dental treatment was sought less by acid workers than by controls, and the oral hygiene of the latter was superior. There was no evidence to show any difference between caries experience among acid workers and controls. Calculus and periodontal disease were more prevalent among acid workers than among controls, but it was not possible to attribute this to the working environment. Black staining in iron picklers was considered to be due to the working environment. The use of closed acid containers or lip extraction on open acid vats prevented significant atmospheric contamination and diminished the prevalence of erosion. The use of wall fans and detergent foaming agents was helpful.

In 1960 the Industrial Diseases Sub-committee of the Industrial Injuries Advisory Council considered the question whether dental erosion, due to acids used in industry, should be prescribed under the National Insurance (Industrial Injuries) Act 1946. Owing to the inadequacy of evidence concerning the prevalence of dental erosion, the Committee was unable to reach a conclusion.

In March 1959 the British Dental Association presented a Memorandum to the Council which concluded: 'that industrial dental erosion was a hazard which existed, and that in the majority of cases severe dental damage, resulting in disfigurement, occurred.' The need for further research into the pattern and causes of dental erosion in industry was pointed out. Oral evidence was heard from the Association of Industrial Medical Officers.

In the last 20 years, published reports of industrial dental erosion have been limited to observations on the effects of nitric and sulphuric acids at a Royal Ordnance Factory (Lynch and Bell, 1947), tartaric acid (Elsbury, Browne, and Boyes, 1951) and

sulphuric acid as used in the manufacture of lead-acid electric storage batteries (Malcolm and Paul, 1961; Paul, 1962).

The work of Malcolm and Paul is of most interest as it covers a group of 84 workers who had natural teeth. The group was employed under modern conditions. Oral evidence of these observations was given to the Industrial Diseases Sub-committee.

In 1960, information on industrial dental erosion was confined to isolated studies, often carried out on workers employed under abnormal conditions by modern standards. In view of the lack of data on the prevalence of the condition in modern industrial environments, it was recommended that a field survey be undertaken to provide the Committee with this evidence.

The objectives of the survey were to determine: (1) the prevalence of industrial dental erosion, with particular reference to certain industrial processes; (2) the severity of the condition in those affected; (3) the rapidity of onset and advance; and (4) the extent of dental treatment sought and the degree of inconvenience, disfigurement or functional disability suffered by those affected.

Duration of Survey

The work of Malcolm and Paul (1961) and Paul (1962) agreed with older reports in so far as erosion might become retarded or even static, on clinical examination, once a certain level relative to the position of the lips had been reached. Most reports have indicated that industrial erosion affected incisors and occasionally canine teeth; premolar and molar teeth were never affected. Only the labial surfaces which did not normally make contact with the lips were involved, and surfaces protected by the lips and cheeks were not attacked.

Thus it appeared that severe erosion which had developed under poor working environments, perhaps many years ago, could have become retarded or even static as the lip line was reached or as industrial conditions improved. It was clear that a single examination of workers, relating severity of erosion to duration of employment with acids, would give a picture of the prevalence of erosion which was not representative of modern working conditions. If it may be assumed that industrial environments in this country have improved, it might be that erosion now takes longer to develop or indeed may not occur at all.

It was therefore essential to observe a group of workers who were representative of modern industrial conditions over a span of time. This period had to be sufficiently long to determine which cases were static and which were progressing whatever the degree of erosion at the outset. While a long-term survey would give the most precise information, it also depended on workers and conditions remaining unchanged. This seemed unlikely, and early answers to the questions posed were required. It was therefore decided to examine workers four times at intervals of eight months, thus allowing a period of two years' observation.

Method

It was decided to conduct the survey in three distinct major industrial areas. These were Manchester, Glasgow, and Wolverhampton. H.M. Factory Inspectorate in these areas prepared lists of firms that it considered suitable for the survey. An attempt was made to include a range of industrial processes and a variety of firms, some using modern equipment and some older works. By this means it was hoped to achieve as true a cross section of industry as possible. In some cases the Inspectorate tended to put forward those firms which were known to be likely to co-operate; the effect of this bias on the results of the survey cannot be assessed.

The Inspectorate informed all firms that had been selected, and, following this preliminary notice of the

survey, the managements were approached by the author, through the firm's medical officers where possible, by means of an explanatory letter requesting co-operation.

Twenty-four firms were approached in the Manchester area, including three in Liverpool; 10 firms were approached in Glasgow and 39 in the Wolverhampton area, including one in Birmingham. Seventy per cent of Manchester firms, all Glasgow firms, and 80% of Wolverhampton firms replied to the explanatory letter. A small number of firms which replied no longer operated acid processes. These and firms which had not replied were discarded. Of the remainder, 96% agreed to take part in the survey. The three firms in Liverpool and the single firm in Birmingham were included because the Inspectorate felt that the processes operated might be of particular interest.

The number of factories visited in each area and the total number of workers exposed to acids, including edentulous workers, are shown in Table I.

TABLE I
DISTRIBUTION OF FIRMS AND EXPOSED WORKERS
AMONG THE AREAS

Area	No. of Firms	No. of Workers
Manchester	17	212
Glasgow	8	108
Wolverhampton	23	463
Total	48	783

Control Workers All control workers came from acid-free departments of the firms participating in the survey. No worker was accepted as a control if he had at any time worked with acid in any previous employment. Considerable difficulty was experienced in obtaining sufficient workers to act as controls.

Managements were inclined to make available as controls workers from the younger, unskilled apprentice section of the labour force. Skilled workers, making up the older age groups, could not easily be spared without loss of production, as many of the processes required integrated team work. Rarely were whole departments of men available to act as controls. Controls were taken from the same socio-economic groups as exposed workers. Office staff, though often available, were avoided. The age difference between the exposed group and the control group was noted (Fig. 1). Although the latter was a satisfactory control when factors where age plays no part were considered, its validity when age was known to be a factor influencing the experience of disease, for example periodontal disease, was doubtful.

All control workers were found to be free from industrial dental erosion. Controls were examined only once, and it must be admitted that over the two-year period in which exposed employees were observed, some deterioration in the dental condition of the controls

FIG. 1. Number of acid workers and controls in five age divisions.

could not be ruled out. However, since at the time of examination 67% of the controls had been in their employment more than two years, and some had lengths of service of up to 35 years, it was thought most unlikely that any erosion could develop in the group during the survey period. The distribution of control firms and workers is shown in Table II. No edentulous controls were examined.

TABLE II
DISTRIBUTION OF CONTROL FIRMS AND WORKERS
AMONG THE AREAS

Area	No. of Firms	No. of Workers
Manchester	1	67
Glasgow	1	38
Wolverhampton	5	188
Total	7	293

Edentulous Workers Thirty-eight per cent of workers exposed to acid examined at the first visit to all firms were edentulous. Although some of these workers were able to describe the conditions of their teeth prior to extraction, and it was clear from some of these descriptions that the teeth had been eroded, it was not possible to conclude that erosion had been the reason for the extractions. No control edentulous group was found to be possible. The evidence of the edentulous workers was not reliable, and edentulous workers were excluded from the results of the survey.

Wastage of Workers It was found that a number of workers examined once or more were not available at follow-up visits to their firms. This wastage was due to normal labour turnover, redundancy, take-overs of firms resulting in closures, and transfer of workers to non-acid processes. New workers were included in the survey at the second, third, and fourth visits to factories and, although these employees did not have the duration of exposure to acid of the workers lost by wastage whom they replaced, they did help to provide information about the early stages of erosion.

The distribution of all workers having natural anterior teeth seen throughout the survey is shown in Table III.

TABLE III
DISTRIBUTION OF ALL WORKERS HAVING NATURAL
ANTERIOR TEETH AMONG THE AREAS

Area	No. of Workers
Manchester	158
Glasgow	60
Wolverhampton	337
Total	555

Examination of Workers At the first examination of each worker a history was taken with personal particulars and details of employment. Observations were made on the degree of erosion, and an assessment was made of the caries experience and periodontal condition of the anterior teeth. At the first and subsequent visits a colour transparency was made, using Kodachrome II daylight film, with standardized lighting provided by

annular flash equipment. At all follow-up visits the degree of erosion was assessed from clinical examination, and changes in conditions of employment were noted. Transparencies were used to show advancing erosions within particular grades of erosion. The grade of erosion was based on clinical observation alone.

Examination of workers began in March 1962 and was completed in October 1964. Table IV shows the proportion of workers examined once, twice, three times, and four times over the survey period.

TABLE IV
PROPORTION OF ACID WORKERS EXAMINED AT
1, 2, 3, and 4 VISITS TO FIRMS

No. of Visits	Time of Observation (months)	No. of Workers Examined	% of Total Workers
1	—	231	41.6
2	8	95	17.1
3	16	55	11.8
4	24	164	29.5

Acid Processes Covered by Survey The acid processes on which exposed workers were engaged are shown in Table V. It should be noted that a number of men fell into more than one process category; for example, a man might work as a pickler and as a plater. Some firms were engaged on more than one process involving acids.

The Clinical Picture in Industrial Dental Erosion

Industrial erosion first affected the surfaces of the teeth most exposed to the atmosphere. These were the incisal one-third to one-half of the labial surfaces of the incisor teeth. The canine teeth

were rarely affected and then generally only on the labial surfaces nearest the midline. No erosion of the posterior teeth was seen during this survey.

The first sign of industrial erosion has been described as an etching of the inciso-labial surfaces; the appearance has been likened to ground glass. This was seen as an early sign in a number of workers, though not in every case that became affected.

As the condition progressed, loss of labial incisal enamel was observed. The enamel surface acquired a smoother, polished, rounded appearance though a few cases still retained the etched surface. As the enamel was eroded, an anterior open bite sometimes developed.

When the process had advanced to involvement of dentine, the dentine became stained but was not more rapidly eroded than enamel. The most severe cases showed erosion to the level of secondary dentine, but pulpal exposure was not observed.

The labial surface was always worst affected so that in severe cases all labial enamel was missing and the dentine was extensively involved. The labial surfaces sloped away obliquely towards the lingual. The protective influence of the lips and cheeks has been stressed by Malcolm and Paul (1961). In mildly affected teeth the etched or eroded surfaces corresponded to the opening between the lips when slightly parted. The shape of the space between the upper and lower teeth, when erosion had caused anterior open bite, similarly reflected the position of the lips. The pattern of erosion was sometimes modified when attrition of the teeth was evident.

Pain was very rarely reported and, when present, was described as a hypersensitivity to cold, especially when brushing. Of all 555 workers examined, five reported pain for which erosion was

TABLE V
ACID PROCESSES ON WHICH EXPOSED WORKERS WERE EMPLOYED: NUMBER OF FIRMS AND ACIDS USED

Process	Acids	No. of Firms	No. of Workers
Plating	Chromic, nitric, sulphuric, hydrofluoric, phosphoric	9	114
Galvanizing	Hydrochloric, sulphuric	17	114
Other acid pickling	Hydrochloric, nitric, sulphuric, hydrofluoric	13	231
Battery manufacture	Sulphuric	3	90
Sanitary cleanser manufacture	Acid sodium sulphate	1	25
Munitions manufacture	Nitric, sulphuric	1	12
Sulphuric acid and Sulfan manufacture	Sulphuric	1	11
Soft drinks manufacture	Citric	1	5
Process engraving	Nitric	1	4
Crystal glassworks	Hydrofluoric	1	2
Dyestuffs container cleaning	Hydrochloric	1	7
Enamel manufacture	Sulphuric, hydrochloric	1	1

considered to be the cause. In each case there were either rapidly advancing or extensive erosions. However, most progressing and severe erosions were painless.

Erosion lesions had rounded margins. This was a consistent sign and may be regarded as diagnostic of industrial erosion from airborne acids, when severe loss of structure is confined to the anterior teeth. With loss of tooth structure from mechanical wear, as seen in attrition and abrasion, sharply defined margins are evident. Teeth which have been fractured also show sharp margins. Erosions caused by dietary constituents, for example citrus fruits, affect all the teeth rather than the labio-incisal surfaces affected by airborne acid. The loss of structure seen in dental caries occurs in the stagnation areas between the teeth, near the gingival margin and in fissures, and is characterized by softening and cavitation. In contrast, industrial erosion lesions occur on exposed surfaces and are hard and convex without cavitation.

The Classification of Industrial Dental Erosion

Malcolm and Paul (1961) observed that any estimation of the degree of erosion must be subjective, since the original dimensions of the teeth are not known. Nevertheless they divided the degrees of erosion into etching of the enamel surface and three groups of erosion, based on an estimate of tooth loss deduced from an assumed size of tooth crown. In their group 1, this loss did not exceed one fifth (2 mm.) of the incisal enamel; in group 2 there was loss of one-fifth to one-half of the tooth crown; and in group 3 there was loss of more than half of the tooth crown.

It was considered that this classification was unsatisfactory because it is difficult to estimate loss by subtracting the remaining tooth substance from assumed dimensions for the original crown. Secondly, the transition from group 1 to group 2 could not easily be defined. Therefore a broad classification based on the tissues involved was adopted as follows:

Definition of grades of erosion (Fig. 2)

Etching (Et)

This consisted of a dull, ground-glass appearance of the enamel surface without loss of contour (Plates 1 and 2)

Grade 1 erosion (G.1)

Loss of enamel only (Plates 3 and 4)

Grade 2 erosion (G.2)

Loss of enamel with involvement of dentine (Plates 5 and 6)

FIG. 2. The classification of erosion.

Grade 3 erosion (G.3)

Loss of enamel and dentine with exposure of secondary dentine (Plates 7, 8, and 9)

Grade 4 erosion (G.4)

Loss of enamel and dentine resulting in pulpal exposure

Results

Prevalence of Erosion The degree of erosion was noted at the first examination of each worker and, where several grades were apparent in different teeth in the same mouth, the case was graded by the erosion seen in the most severely affected tooth. The prevalence of erosion, found at the first examination of all workers, is shown for the groups of exposed and control workers in Table VI.

No case of grade 4 erosion was observed, although Lynch and Bell (1947) and Malcolm and Paul (1961) each reported such a case. It was likely that pain would lead to early treatment of grade 4 erosion, in most cases by extraction. The chances of such a case being encountered, at one of four examinations or less in two years, were slight.

Battery Formation Process The battery formation process has been described in detail by Malcolm and Paul (1961). Battery formation and charging workers were the subject of their investigation. Two large and one small firm, engaged in the manufacture of lead-acid electric storage batteries by a similar process, were included in the present survey.

Lead plates were placed vertically in tanks and connected up to make an electrical circuit by means of lead bars, which were tacked on to the plates

COLOUR PLATE 1. Etching of inciso-labial surfaces of central incisors: battery formation worker after 7 years' service.

COLOUR PLATE 2. Etching of inciso-labial surfaces of central incisors: galvanizing worker after 11 months' service.

COLOUR PLATE 3. Polished, rounded appearance of grade 1 erosion: acid dipper with 9 years' service in a Royal Ordnance factory.

COLOUR PLATE 4. Same case as in 3: lateral view.

COLOUR PLATE 5. Grade 2 erosion with staining of dentine: battery formation worker after 8 years' service.

COLOUR PLATE 6. Same case as in plate 5: lateral view.

COLOUR PLATE 7. Grade 3 erosion and anterior open bite: galvanizing pickler with 10 years' service.

COLOUR PLATE 8. Same case as in 7: occlusal view showing involvement of secondary dentine.

COLOUR PLATE 9. Grade 3 erosion, black staining, and anterior open bite: galvanizing pickler after 10 years' service.

COLOUR PLATE 10. Grade 3 erosion: battery formation worker with 19 years' service. There was a marked overbite and attrition on the palatal surfaces of the upper central incisors.

COLOUR PLATE 11. Same case as in 10: closed position showing overbite.

COLOUR PLATE 12. Black stain pattern: worker engaged on 'wheeling out' pickled work. This case had 3 months' service, had an open lip habit, and did not clean the teeth.

TABLE VI
PREVALENCE OF INDUSTRIAL EROSION AMONG GROUPS AT FIRST EXAMINATION

Grade	Manchester	Glasgow	Wolverhampton	Total	Control
Negative	106 67.1%	31 51.7%	242 71.8%	379 68.3%	293 100%
Et	21 13.3%	10 16.7%	50 14.8%	81 14.6%	—
G.1	20 12.7%	10 16.7%	32 9.5%	62 11.2%	—
G.2	9 5.7%	4 6.7%	10 3.0%	23 4.1%	—
G.3	2 1.3%	5 8.3%	3 0.9%	10 1.8%	—

The number of workers affected by each grade is shown, and also expressed as a percentage of the workers in that group.

with a blow torch. The tanks were filled with dilute sulphuric acid, the specific gravity varying between 1.02 and 1.15. A current was then passed which charged or 'formed' the plates. This caused small bubbles of hydrogen to be given off. The bubbles rise rapidly to the acid surface and burst, causing a fine acid mist. This mist is capable of causing severe dental erosion.

It was noticeable that men working in the charging departments and some inspection workers showed less erosion than formation workers. There is less acid in the atmosphere of charging departments as the completed batteries have lids, whereas the tanks in the formation process are open. Malcolm and Paul estimated that the atmospheric sulphuric acid load in their charging department was of the order of one-quarter to one-fifth that in the formation department. There are also departments concerned with 'dry charging' of plates; this procedure involves the removal of acid from the plates by washing, dipping in paraffin, and drying.

The prevalence of erosion at the first examination of all workers in formation departments is shown in Table VII. Charging and inspection workers are also shown. Some of these workers had been employed for only short periods and showed progressive erosion at subsequent examinations.

Almost 20% of formation workers showed grade 2 or grade 3 erosion in the combined figures of the

two larger firms. The smaller firm did not operate a night shift and the work was so arranged that the forming took place at night in the absence of the workers. No erosion was observed in this firm, but it should be added that no worker had been employed for longer than 14 months.

Galvanizing Hot dip galvanizing consists of coating clean iron surfaces with zinc in order to protect the surface from rusting. The acid used to clean the iron was usually hydrochloric though sulphuric was occasionally employed.

Depending upon the type of work being treated, the metal was pickled in hydrochloric acid which varied in strength from commercial concentrated acid (28 Twaddell¹) diluted 1:1 with water to dilutions of 1:3 acid to water. Hydrochloric acid was generally used at room temperature, so that fume was worse in summer. Sulphuric acid was generally used at 60°C. at concentrations of up to 10%. Hydrochloric acid is volatile and may be lost to the atmosphere by fuming, even when the surface of the acid is still. Sulphuric acid is not volatile to this extent and is only lost to the atmosphere when the acid surface is disturbed as, for example, with the bubbling that takes place in battery formation. The above higher temperature of sulphuric acid does not greatly predispose to fuming; however, raising the temperature of hydrochloric and nitric acid increases fuming considerably.

After the work had been cleaned by pickling in the acid bath, it was washed and dried and then passed over to the molten zinc bath to be dipped. Considerable fume arose from the zinc bath, as ammonium salts were added to act as a flux, but it is unlikely that this had any eroding effect on the teeth.

The prevalence of erosion at the first examinations of all men working in galvanizing shops is shown in

TABLE VII
PREVALENCE OF EROSION AT FIRST EXAMINATION
AMONG 70 BATTERY FORMATION WORKERS AND
16 CHARGING AND INSPECTION WORKERS

Grade	No. of Workers	
	Formation	Charging/Inspection
Negative	28	11
Et	18	2
G.1	11	3
G.2	10	—
G.3	3	—

¹Twaddell is a hydrometer scale used in the United Kingdom (Specific Gravity = $1 + \frac{1 \text{ degree on scale}}{200}$).

Standard temperature of scale is 60°F.

Table VIII. Workers employed on stages of the process other than pickling, for example, zinc dipping or wheeling work out, will be referred to as 'non-picklers'.

TABLE VIII
PREVALENCE OF EROSION AMONG 72 PICKLERS AND
35 NON-PICKLERS AT FIRST EXAMINATIONS, IN
GALVANIZING SHOPS

Grade	Picklers		Non-picklers	
	No. of Workers	% of Total	No. of Workers	% of Total
Negative	31	43.1	28	80.0
Et	18	25.0	3	8.6
G.1	16	22.2	3	8.6
G.2	3	4.2	1	2.9
G.3	4	5.6	—	—

It was observed that 20% of non-picklers were affected by erosion, compared with 57% of the picklers. The latter were more affected in all grades, including etching, and it is considered that the higher prevalence is due to more direct contact with acid. Of all galvanizing workers, 7.5% were affected by grade 2 or grade 3 erosion, compared with 20% among battery formation workers.

Other Pickling Treatments This was a group of processes which involved the etching or cleaning of metal surfaces prior to a variety of treatments. Sulphuric and hydrochloric acids were generally used, though nitric and hydrofluoric acids were employed for stripping or descaling purposes. This was a widely scattered group, and the degree of exposure to acids of workers varied considerably among processes. The only common factor among the workers was that they were picklers, not in the galvanizing process. The group was designated 'non-galvanizing picklers', and the prevalence of erosion among the workers is shown in Table IX.

TABLE IX
PREVALENCE OF EROSION AMONG 132 NON-GALVANIZING
PICKLERS

Grade	No. of Workers	% of Total
Negative	94	71.2
Et	20	15.2
G.1	16	12.1
G.2	1	0.8
G.3	1	0.8

On comparison with Table VIII it appears that galvanizing picklers suffered more erosion than the non-galvanizing picklers. However, the lengths of service of a number of the latter group were short. For example, whereas only four out of 30 galvanizing picklers had less than one year's service in Wolverhampton, the figure for non-galvanizing picklers in that district was 52 out of 102. It is clear that Tables VIII and IX are not strictly comparable. The influence of length of service on the prevalence of erosion will be discussed under the section on rate of erosion.

Plating This category covered workers in chrome and nickel plating, cadmium plating, and specialized zinc plating. Metal surfaces were generally acid etched prior to plating. The plating solutions themselves were acidified; for example, in chrome plating, chromic acid with one part of concentrated sulphuric acid added per hundred parts of chromic acid was used.

Both hydrochloric and sulphuric acids were used for etching. The range of concentrations for the former acid was 3.2%-50% commercial concentrated acid, and for sulphuric acid 5.2%-65%. For normal chrome plating of steels the chromic acid concentration varied between 250 and 500 g. per litre with several firms using 450 g. per litre. Specialized solutions were used to etch and plate alloys.

TABLE X
PREVALENCE OF EROSION AMONG 76 PLATING WORKERS:
PREVALENCE AMONG 34 CHROME PLATERS SHOWN
SEPARATELY

Grade	All Platers		Chrome Platers	
	No. of Workers	% of Total	No. of Workers	% of Total
Negative	65	85.5	30	88.2
Et	7	9.2	2	5.9
G.1	4	5.3	2	5.9
G.2	—	—	—	—
G.3	—	—	—	—

The prevalence of erosion among all plating workers is shown in Table X. Chrome platers included in this total are also shown separately, as they make up almost half the total.

It was noted that the prevalence among platers was low compared with all classes of picklers. The standard of fume extraction in shops using chromic acid was high, because of the risks peculiar to

chromic acid. Some firms operated fully automatic processes, so that employees were exposed to acid only when replenishment of a tank was required or in the event of the occasional breakdown.

It will be understood that the terms plater and pickler have been handed down in industry and they are used to cover men engaged on various processes, which involve greatly differing degrees of exposure to acid. It is useless to try to define a standard pickler, and broad groups are inevitable.

Other Processes Each remaining process was observed at one factory only. The prevalence of erosion among workers is shown in Table XI.

TABLE XI
PREVALENCE OF EROSION AMONG REMAINING WORKERS

Process	No. of Workers					
	Total	-ve	Et	G.1	G.2	G.3
Munitions manufacture	12	7	1	1	1	2
Sulphuric acid and Sulfan manufacture	11	11	—	—	—	—
Sanitary cleanser manufacture	25	19	3	1	2	—
Soft drinks manufacture	5	4	1	—	—	—
Process engraving	4	4	—	—	—	—
Crystal glassworks	2	2	—	—	—	—
Enamel manufacture	1	1	—	—	—	—
Dyestuffs container cleaning	7	—	1	3	3	—

The Rapidity of Onset and Advance of Erosion

Association between Length of Service and Degree of Erosion Attention has already been drawn to the errors of correlating the length of service in acid environments with the degree of erosion seen at a single examination. It was necessary to examine workers on at least two occasions, in order to establish whether erosion was static or advancing, or whether the condition occurred at all under modern industrial environments.

Nevertheless, there did appear to be a relationship between erosion experience and length of service, as found at a single examination. This is shown in Figure 3. Workers were divided into 10 lengths of service divisions¹, and the percentage of

FIG. 3. The relationship between degree of erosion, at first examination of 555 acid workers, and length of service.

workers in each division who were free of erosion or showed etching, or grade 1, 2, or 3 erosion was determined. The proportion of negative cases reduced as the length of service increased. Etching increased to a peak in the 2-5 years service division and then fell off, while grade 1 cases appeared from four to six months and the proportion of workers affected by this grade increased steadily. Grade 2 cases first appeared in the 2-5 years service division and the proportion increased steadily, while the earliest grade 3 cases occurred in the 6-10 years division. It should be noted that the number of grade 3 cases seen was small, and it was also found that the relationship did not hold good in workers with more than 20 years' service. It seems likely that this was due to the increasing proportion of static erosions.

Proportion of Cases Observed to be Advancing Erosions During the two-year period of the survey, of the 379 workers unaffected at their first examinations (Table VI), 32 advanced to show etching and five of these progressed further to grade 1. A further seven workers advanced to grade 1, etching being unobserved. Thus 12 workers in all progressed from negative to grade 1.

Of the 81 cases exhibiting etching at the first examinations, seven advanced to grade 1. No workers were observed to advance into the more severe grades 2 and 3, but progressing erosion was detected in a number of cases within the limits of the grades in which these cases were classified at their first examinations. Thus progressing erosion, but without grade advancement, occurred in eight cases of etching, seven cases of grade 1, four cases of grade 2, and in a single case of grade 3.

¹Length of service divisions were: 0-3 months, 4-6 months, 7-12 months, 13-24 months, 2-5 years, 6-10 years, 11-20 years, 21-30 years, 31-40 years, more than 40 years.

TABLE XII
DISTRIBUTION AND PROPORTION OF WORKERS SHOWING PROGRESSING EROSION

<i>Extent of Progress of Erosion Observed</i>	<i>Manchester</i>	<i>Glasgow</i>	<i>Wolverhampton</i>	<i>Total</i>
Negative to etching	6	2	19	27
Negative to grade 1	4	1	7	12
Etching to grade 1	—	—	7	7
Progress within etching grade	2	—	6	8
Progressing erosion within G.1	1	—	6	7
Progressing erosion within G.2	1	—	3	4
Progressing erosion within G.3	—	—	1	1
No. of workers showing progressing erosion ..	14	3	49	66
No. of workers examined more than once ..	83	32	209	324
Proportion showing progressing erosion ..	16.8%	9.8%	23.4%	20.4%

The distribution and proportion of workers showing progressing erosion are shown in Table XII.

Occupations of Workers showing Progressing Erosion The occupations of the 66 workers showing progressing erosions are shown in Table XIII. The proportion of workers showing active erosion who were examined more than once is indicated.

It was noted that 50% of battery formation workers, examined more than once, showed active erosion. The figure for galvanizing picklers was 24.5% and for non-galvanizing picklers 22.3%. All other occupations taken together showed 7.3% of employees affected by active erosion.

These results supported the prevalence figures, in that the battery formation process is the most likely to produce dental erosion. Furthermore,

these results are based on cases actually observed to advance under modern industrial environmental conditions. Thus the incidence of erosion is highest among battery formation workers, lower among galvanizing and other picklers, and lowest among workers on other processes. Analysis of the other processes was of no value, as there were but 10 cases showing active erosion in total, and these were widely scattered.

Earliest Cases of Erosion Five cases of etching developed within three months' exposure, and a further 10 cases within six months. The earliest case was in a battery formation worker after five weeks' service.

Eight cases of grade 1 erosion occurred within 18 months' exposure. Of these the earliest was within six months and two further cases within nine months.

TABLE XIII
OCCUPATIONS IN FOUR CATEGORIES OF 66 WORKERS SHOWING ACTIVE EROSION, AND THE PROPORTION OF WORKERS, SHOWING ACTIVE EROSION, IN THE OCCUPATIONS

<i>Extent of Progress of Erosion</i>	<i>Occupations (no. of workers)</i>			
	<i>Battery Formation Workers</i>	<i>Galvanizing Picklers</i>	<i>Non-galvanizing Picklers</i>	<i>Other Processes</i>
Negative to etching	5	5	12	5
Negative to G.1	5	1	4	2
Etching to G.1	3	1	2	1
Progress within etching grade	3	1	2	2
Progressing erosion within G.1	4	2	1	—
Progressing erosion within G.2	4	—	—	—
Progressing erosion within G.3	—	1	—	—
No. of workers showing progressing erosion ..	24	11	21	10
No. of workers examined more than once ..	48	45	94	137
Proportion showing progressing erosion ..	50%	24.5%	22.3%	7.3%

The earliest cases of grade 2 erosion were observed in two workers who had two-and-a-half years' service and in two further workers who each had five years' service.

Grade 3 erosion was encountered in only 10 cases, and the earliest observed was in a worker who had six years' service.

The Value of a Prospective Survey

It is interesting to compare Table VI with Table XII. Table VI shows the prevalence of erosion, based on a single examination, or cross-sectional survey. The prevalence of erosion was similar in Manchester and Wolverhampton workers, though the small number of grade 2 and grade 3 cases must be stressed. However, the Table indicates a higher prevalence in Glasgow, although the sample of workers was smaller.

It was noted from Fig. 4 that the Glasgow group had greater lengths of service in acid environments than the Manchester and Wolverhampton groups. It was possible that some of the severe erosions seen in Glasgow were long-established cases, perhaps caused by less satisfactory working environments than are found today; indeed these cases may have been clinically static.

Table XII is based on several examinations of workers, *i.e.*, a prospective survey reflecting present industrial working conditions. It can be seen that the Glasgow group shows the lowest proportion of advancing cases, even though the cross-sectional

assessment by Table VI shows the highest prevalence.

During the survey the author spoke to many workers who considered that working environments had been greatly improved while they had been employed by their firms. Erosion may be much reduced or even eliminated by the installation of efficient exhaust systems, redesign of equipment so that acid is remote from workers, or the improvement of raw materials, for example the quality of steel from modern rolling mills, so that weaker acid can be used for treatments.

Although a relationship has been shown between length of service and degree of erosion in a cross-sectional survey, a prospective assessment gives a more reliable picture of erosion under modern conditions.

The Influence of Age on Erosion

It has been shown that the permeability of enamel decreases with age, particularly in the third decade (Atkinson, 1947). This may have some influence on erosion. To test this, the first three age groups (Fig. 1) were compared. Clearly, workers in the older age groups would tend to show more erosion than younger workers because the latter cannot have such long lengths of service. Therefore it was necessary to study the degree of erosion in each length of service division of every age group. There was no evidence to suggest that erosion affects one age group more or less than another (ten Bruggen Cate, 1966).

FIG. 4. The number of workers in each length of service category. This is also expressed as a proportion of the group total.

The Role of Attrition

Attrition is a mechanical wearing down of the occlusal, incisal, and proximal surfaces of the teeth during masticatory movements, resulting in polished facets having sharp margins. Severe attrition may occur from the habit, known as Bruxism, of grinding the teeth during sleep.

Attrition was noted in 71 cases (12.8%) of acid workers and in 22 cases (7.5%) of control workers. Table XIV shows the degree of erosion in the 71 attrited acid workers and indicates the proportion they represented of all workers in their erosion grades. The Table is based on the first examination of each worker.

TABLE XIV
NUMBER AND PROPORTION OF WORKERS SHOWING
ATTRITION IN EACH GRADE OF EROSION

	Degree of Erosion				
	Negative	Et	G.1	G.2	G.3
Total no. of workers	379	81	62	23	10
No. of workers showing attrition	32	4	14	14	7
Proportion as % showing attrition	8.5	4.9	22.7	60.9	70.0

It was noted that the prevalence of attrition increased strikingly among workers suffering the more severe grades of erosion. Furthermore, it was found that nine cases (13.6%) of the 66 workers who showed advancing erosion during the survey exhibited attrition.

There is reason to believe that workers having attrition, or a marked overbite (both may occur through the loss of posterior teeth), develop erosion, particularly of the lower incisors, to a more severe degree than workers without these occlusal characteristics (Plates 10 and 11).

In some workers with grade 3 erosion, an anterior open bite had developed, so that there was a space corresponding to the opening between the lips, between the upper and lower anterior teeth. In these cases the eroded teeth could not be brought into contact, and attrition could not play a part in the loss of tooth substance (Plates 7 and 9).

The enamel of acid-eroded teeth is abnormally fragile at the surface, judging by extracted teeth that have been kept moist, sectioned, and polished for histological examination. The author has the impression that acid-eroded enamel is more easily attrited than normal enamel; attrition and erosion

operating together may cause more rapid loss of tooth structure than either operating alone.

The cases showing severe loss of tooth structure in the presence of a marked overbite resembled the 'chisel' type erosions described by Malcolm and Paul (1961).

The Influence of Lip Posture

Many workers with normal lip postures and with teeth that were considered to be in a normal relationship to the lips (*i.e.*, not prominent) were found to work with their lips apart. It was likely that acid workers breathed through their mouths, when the acid level in the atmosphere became so high that nose breathing became unpleasant. Workers were questioned about this matter, and an examination of the lips in the rest position was also made. An attempt was made to divide the workers into those having open lip habits and those with closed lip postures. The degree of erosion was compared between the two groups, and it was found that the habit of working with the lips slightly parted did not greatly influence the likelihood of erosion developing. It is pointed out that very few men had prominent teeth with short upper lips; the latter may predispose to erosion.

The number and proportion of open lip habits among exposed, eroded, and control workers are shown in Table XV.

TABLE XV
NUMBER AND PROPORTION OF OPEN LIP POSTURES
AMONG EXPOSED, ERODED, AND CONTROL WORKERS

Lip Posture	All Acid Workers		Acid Workers Showing Erosion		Control Workers	
	No.	%	No.	%	No.	%
Open	107	19.5	51	24.0	99	33.8
Closed	441	81.5	162	76.0	194	66.2

Seven Indian Wolverhampton workers could not be assessed because of language difficulties.

Comparison of Environments Producing Active Erosion with Those having No Effect

Although all workers were not equally affected by any one environment, it was reasonable to postulate that erosion became more prevalent as the atmospheric acid load increased. An attempt was made to test this by comparing the working environments of two groups of men.

The first group having active erosion was made up of the 66 workers showing active erosion during the survey period and any other workers showing erosion with not more than two years' service, even if examined only once. It was assumed for the purpose of this comparison that the latter had active erosion. Confirmed static erosions were ignored. By this means an 'active erosion' group of 106 workers was collected.

The group of men used for comparison with the active group consisted of those workers who had been examined at least twice and showed no progression and of whom none had less than two years' service. Thus it could not reasonably be argued that as a group they had less exposure than the active group and might have developed erosion after longer exposure. This unaffected group numbered 116 workers.

These groups were considered to be representative of industrial conditions as found between 1960 and 1964.

Exhaust and ventilation methods were divided into the categories of lip extraction, consisting of an exhaust system drawing fume into an opening

around the lip of the acid vat and preventing escape into the atmosphere; roof or wall fans, which operated to remove air containing acid fume from the atmosphere of the work place; and natural ventilation. The latter depended upon the sides of the building containing the acid being open; natural ventilation relied upon weather conditions.

Some of the common combinations of acid concentrations and related exhaust methods seen during the survey are shown in Table XVI. It can be seen that in general the complexity and efficiency of exhaust and ventilation systems are related to the concentration and temperature of the acid. Thus, if there was heavy emission of fume, lip extraction was usually employed; if little fume was given off, roof fans or natural ventilation were regarded as adequate by most managements.

The influence of single factors on the number of active erosions and unaffected cases is shown in the upper half of Table XVII. The influence of more than one factor is shown in the lower half.

The number of part-time workers and those employed near acid, though not directly involved, is indicated by each total.

TABLE XVI
RELATION BETWEEN CONCENTRATION OF ACID AND PREVENTIVE MEASURES, TO LOWER THE ATMOSPHERIC ACID LEVEL

Dilutions	Temperature (°C.)	Preventive Measures
<i>Sulphuric Acid Commercial conc. (95%)</i>		
Pure	R.T.	Completely enclosed
65%	R.T.	No fan, but remote from men
18%	R.T.	Wall fans and Zeromist ¹
15%	60	Lip extraction
12%	80	Lip extraction
8-12%	65	Lip extraction
7%	65	Lip extraction
10%	65	Wall fans
2-5%	60	Wall fans
10%	R.T.	Roof fans
3.5%	R.T.	No fans, but Zeromist
<i>Hydrochloric Acid Commercial 28 Tw. (28 Twaddell is approx. 28%)</i>		
28 Tw. undiluted	R.T.	Lip extraction and Zeromist
Acid: water = 1:1	R.T.	Lip extraction and lids
1:1.5	R.T.	Lip extraction
1:2	R.T.	Lip extraction or wall fans
1:3	R.T.	Wall fans
1:3	R.T.	Open air, no fans
1:4	R.T.	No fans, often roof ventilation
1:5	R.T.	No fans or ventilation
<i>Nitric Acid Commercial conc. (70%)</i>		
22%	R.T.	Enclosing exhaust hood
10%	60	Lip extraction

R.T. — room temperature.

¹Zeromist is a product used to reduce loss from liquid surfaces due to evaporation, fuming, and spraying (see text).

TABLE XVII
EFFECT OF ISOLATED FACTORS ON THE PREVALENCE OF EROSION IN TWO GROUPS OF WORKERS

Environmental Common Factor	Active Erosion			Teeth Unaffected		
	Total	Near Acid	Part Time	Total	Near Acid	Part Time
Hydrochloric acid	44	7	—	53	19	—
Sulphuric acid	52	2	1	57	9	2
Nitric acid	3	—	—	29	—	—
Chromic acid	4	—	—	21	3	—
Hot acid (over 60°C.)	15	1	3	27	3	3
Cold acid	91	8	—	89	25	1
Lip extraction	23	5	1	69	16	1
Roof or wall fans	60	4	1	52	12	2
No fans	37	3	2	25	3	2
Natural ventilation	77	7	—	69	23	3
No natural ventilation	29	2	3	47	5	1
Masks	10	—	—	10	—	—
<i>More than one common factor</i>						
Pickling cold hydrochloric acid	28	—	—	20	—	—
Pickling hot sulphuric acid	11	—	—	18	—	—
Cold hydrochloric acid with lip extraction	9	—	—	32	—	—
Hot sulphuric acid with lip extraction	10	—	—	14	—	—
Lip extraction, fans, natural ventilation	7	—	—	18	—	—
No fans and no ventilation	2	—	—	6	—	—

It was observed that hydrochloric acid and sulphuric acid accounted for far more erosion cases than nitric or chromic acids. Moreover, the proportion of workers showing active erosion is higher among those working with the former two acids than among those employed on work using the latter acids. This was to be expected from results on prevalence and rate of erosion; battery formation workers (sulphuric) and picklers (hydrochloric and sulphuric) showed more erosion than platers. Chromic acid was seen to have been used in only four instances of active erosion, and records showed that these workers were also exposed to sulphuric and nitric acids. It has already been pointed out that chrome plating production lines were often fully automatic and fume was particularly efficiently extracted.

The Table indicates that hot acid produced less erosions than cold acids, group for group. This was because battery formation and pickling with hydrochloric acid are carried out cold, and exhaust facilities needed to be more effective with hot acids as there was likely to be more fume.

It was also observed that when lip extraction was operating the ratio of the number of workers showing active erosion to the number unaffected was

lower than when wall fans were used. In turn, the ratio was lower in the presence of wall fans than in their absence. Also, the presence of natural ventilation appeared to show a lower ratio than the 'no fans' category. The odd finding that no natural ventilation showed less erosion than natural ventilation is explained by the fact that lip extraction or wall fans, or both, were operating in the absence of natural ventilation.

When more than one factor was compared, as in the lower half of Table XVII, the sample of workers in each category decreased markedly. This produced some bizarre results; for example, in pickling, hot sulphuric or cold hydrochloric acid is generally used, and it appeared that hydrochloric acid produced more erosion. However, when lip extraction was used with these acids (not only for pickling) the position was reversed and sulphuric acid appeared to produce more erosion. This cannot be explained by the appearance of the battery formation figures in the total for sulphuric acid (other than pickling) as lip extraction was not used in formation tanks.

Assuming that lip extraction systems result in a lower atmospheric acid load than the use of wall fans and that the use of the latter keeps the load to

reasonable proportions more effectively than natural ventilation, the ratio of active erosion to unaffected cases for the three systems supports the postulate: *i.e.*, erosion becomes more prevalent as the acid level in the atmosphere increases.

Otherwise the value of Table XVII is limited; it may merely be concluded that few workers are employed under conditions likely to produce rapid, severe erosion, and that extraction exhaust arrangements are usually geared to the magnitude of the acid hazard. The desirability of lip extraction systems is clear.

Mention should be made of surface tension reducing agents in their application for the purpose of reducing acid mist. The product Zeromist is especially designed for the purpose of reducing loss of liquids by evaporation, fuming, and spraying. Teepol is a detergent product having a similar effect but it is not specifically designed for this industrial application. Both products operate by forming a foam on the surface of the liquid, in this case acid, the foam trapping bubbles rising to the surface causing spray and also preventing fuming and evaporation.

The advantage of this system over exhaust systems is that there is less loss of acid, which would otherwise require constant replenishment, exhaust equipment is not so quickly corroded, and there is less pollution of the outside atmosphere.

The medical officers of the two large battery manufacturing firms considered that the working environment of the formation departments had greatly improved with the introduction of these products.

The Extent of Dental Treatment Sought by Workers

Throughout the survey there was no evidence of treatment to restore function or appearance to acid-eroded natural teeth. Thirty-three (6%) of 555 workers showed erosion involving dentine (Table VI). Three workers having grade 3 erosion were provided with full dentures in the survey period.

The restoration of grade 2 or grade 3 eroded teeth requires the preparation of the teeth and the construction of faced inlays or jacket crowns. Conservative treatment of extreme cases involves devitalizing the teeth, root canal therapy, and the preparation of post retained crowns. These procedures are time-consuming and require precision if the end result is to be of lasting service to the patient.

It is certain that a number of workers were not interested in this level of dental treatment; equally,

some were unaware that it was possible. To gain information on the dental awareness of workers, all were asked whether they attended a dental surgeon regularly, or if they consulted a dental surgeon solely for the relief of pain, when necessary. For this purpose an annual check-up was considered as regular attendance.

It was found that 5.1% of acid workers attended regularly for treatment compared with 23.9% of the control workers. The control group consisted of younger workers and these, particularly the apprentices, had a more enlightened attitude to dental health. Nevertheless, there was still a marked difference between acid workers and controls in the older age groups. Tooth brushing was also more regular among controls than among acid workers, though the disparity was less than that seen in the figures for regular dental treatment.

The Degree of Inconvenience, Disfigurement or Functional Disability suffered by Acid Workers

Inconvenience and disfigurement are subjective and cannot be measured by standards that apply to all workers. It is difficult to obtain information without posing leading questions.

It was noticeable that some workers with obvious erosion were quite unconcerned about the appearance of the teeth, while others, with no erosion but having large, untreated carious lesions, expressed concern and in some cases held their work responsible for their dental condition.

Inconvenience It has been mentioned that in five cases acid workers reported hypersensitivity of the teeth to cold, and erosion was considered by the author to be the cause. It was pointed out that no evidence was observed of conservative procedures to restore function or appearance to eroded teeth and that the proportion of acid workers under regular dental care was 5.1%. Therefore it may be concluded that acid workers suffered little inconvenience from toothache or from restorative treatment, over and above normal requirements, that could be attributed to their working environment.

Disfigurement Because of the wide variation in the attitude of workers to dental health and appearance, an attempt was made to measure disfigurement by the author's personal assessment. This is necessarily subjective and it is possible that some cases classed as disfigurement would not be regarded as such by the workers concerned and *vice versa*.

All workers showing grades 1, 2 or 3 were considered. The most recent photograph of the teeth in each case was examined and any teeth showing obvious loss of contour from erosion were counted disfigured. For this purpose staining, attrition, poor oral hygiene or missing teeth were ignored.

The number of workers showing disfigurement according to this assessment is shown in Table XVIII. It was observed that of the 33 workers

TABLE XVIII
NUMBER AND PROPORTION OF WORKERS SHOWING
DISFIGUREMENT IN EACH GRADE OF EROSION

	Grade of Erosion		
	G.1	G.2	G.3
No. of workers showing disfigurement	2	15	10
No. considered	81	23	10
Proportion showing disfigurement (%)	2.5	65.2	100

having erosion to dentine, 25 were disfigured. The remaining eight cases were early grade 2, or cases with only the lower incisors affected and having a pronounced overbite. The two workers disfigured by grade 1 erosion were seen to have the entire labial surface of the enamel of upper and lower incisors affected. This was very rarely seen. Thus 23.7% of the erosions were classed as disfiguring.

Functional Disability Industrial erosion may produce functional disability because it sometimes causes the condition of anterior open bite. In this situation the individual has a space in the vertical dimension, between the upper and lower incisor teeth when the posterior teeth are meeting. This space is oval, corresponding to the lip opening (Plates 7 and 9). The anterior teeth cannot be brought together and it is difficult to incise certain foods, for example beef sandwiches.

Anterior open bite was produced by erosion in three grade 2 and four grade 3 cases. It was difficult to determine the degree of functional disability suffered by these seven workers, but the author has the impression that they overcame their difficulties by using the canine teeth, and that little disability was caused.

Dental Caries, Periodontal Disease, and Staining of the Teeth in Acid Workers

Dental Caries Acids are thought to play a major part in the destruction of tooth substance seen

in dental caries. It is widely believed that at pH values below a critical level, depending partly upon the concentration of calcium and phosphate ions in the saliva, solution of the mineral salts of the enamel takes place. The critical level of pH varies between 5.5 and 6.5, depending upon the saliva (Jenkins, 1966).

It was possible that the pH around the teeth of acid workers was lowered by airborne acids and that these teeth might be particularly prone to attack by dental caries.

The number of decayed, missing, and filled incisor and canine teeth was recorded in each worker. The premolar and molar teeth were ignored as it was impossible to diagnose interproximal caries in these teeth, under the conditions in which workers were examined, at most firms.

One hundred and thirty-seven acid workers showing etching or erosion were compared with 195 controls. All workers in both groups had at least two years' service. The groups were compared by age divisions, and it was found that there was no constant difference between acid workers and controls (ten Bruggen Cate, 1966). It is concluded that acid environments have no influence on caries experience.

Periodontal Disease Dental calculus is believed to be an important factor in the development of periodontal disease, and the composition of calculus, though variable, always consists of about 80% inorganic material containing calcium, magnesium, phosphate, and carbonate. As this fraction would be soluble in acid, it was possible that periodontal disease might be less prevalent among acid workers than among controls. It must at once be stated that oral hygiene and regular scaling treatment will have a great influence, and it has been shown that the control group was more conscientious in these respects than the acid workers.

The same groups that were compared for caries experience were assessed for the presence or absence of calculus. The results did not indicate that less calculus is deposited around the teeth of workers having etching or erosion: indeed they supported the reverse.

The results were complicated by the high proportion of coloured workers in Wolverhampton engaged on acid work. These men had much more calculus deposition than European workers. Furthermore, there was but a small proportion of coloured workers among the controls.

In order to make a more accurate comparison, only European workers out of the 137 acid workers showing etching or erosion and the 195 controls

were considered. It was found that acid workers still showed more calculus deposition. Bearing in mind the unsatisfactory nature of the control group, because of the better oral hygiene, there seems to be no evidence that calculus deposition increases with erosion, but it certainly does not decrease.

A direct assessment of periodontal disease was made at the first examinations of all workers. No account was taken of change during the survey, because several workers improved their oral hygiene and periodontal condition following treatment, suggested by the author and carried out by local dental surgeons.

The periodontal condition was graded according to the degree of inflammation, stagnation, and pocketing around the teeth. Workers were classed as good, fair, poor, and bad.

The results indicated that acid workers suffered more periodontal disease than the controls (ten Bruggen Cate, 1966). It was not possible to attribute this difference to the working environment, as differences in age and oral hygiene may have the same effect.

Staining It was noticeable that many acid workers, particularly picklers, complained of staining of the teeth. The staining was seen on the surfaces of the teeth that were not in contact with the lips, *i.e.*, the same exposed surfaces prone to erosion (Plate 12). When regular brushing was carried out this stain was reduced or even confined to the stagnation areas, in the crevices between the teeth, beyond easy reach of the tooth brush. Carious lesions were often deeply stained.

This deep black stain was confined to iron picklers and workers near the pickle baths. It was rarely observed in other acid workers. Brown or green staining was sometimes present and this was particularly noticeable when oral hygiene was poor. The latter staining may be improved and even eliminated by normal brushing, but the author is of the opinion that the most rigorous brushing regime must be carried out in order to keep the black stain, seen in picklers, to even reasonable proportions. This black staining can be temporarily removed by brushing and prophylaxis carried out by a dental surgeon or hygienist, but it quickly returns in the interproximal stagnation areas.

Postscript

On completion of the survey, the findings were communicated to the Industrial Diseases Sub-committee of the Industrial Injuries Advisory Council.

In the light of the data provided by the survey the

Sub-committee considered the question whether erosion of the teeth, due to airborne acids in industry, should be prescribed under the National Insurance (Industrial Injuries) Act 1965.

The Chairman of the Industrial Injuries Advisory Council forwarded the Report of the Sub-committee to the Minister of Pensions and National Insurance on July 30, 1966. The Report is contained in a publication of the Ministry of Social Security entitled "Erosion of the Teeth," and is available from H.M.S.O. (Ref. Cmnd. 3114).

The summary of the Report states:

'We recognize that a case for the prescription of tooth erosion can be made out. We feel, however, that the nature of the condition and the difficulties inherent in prescription provide arguments which carry the greater weight. The condition is trivial. It only affects the front teeth. It causes no loss of faculty in most cases, and the cosmetic effect is very small. We have grave doubts whether the number of speculative claims could be kept to a tolerable minimum. The form of occupational cover presents considerable difficulty, and we can see no completely satisfactory way of dealing with the problem of diagnosis after the teeth have been extracted. Taking all these factors into account, we recommend that tooth erosion due to industrial acid should not be prescribed.'

There was a note of dissent by one member of the Council.

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