AIR pollution
WATER conservation

in the **copper** and **aluminium** industries

Edited Proceedings
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Organised by The British Non-Ferrous Metals Research Association

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Preface

These edited Proceedings of the Second International Conference organized by the British Non-Ferrous Metals Research Association form a valuable work of reference specific to the non-ferrous metals industry on two important aspects of Environmental Control, namely Air Pollution and Water Conservation.

The Conference, which was attended by delegates from 15 countries is an indication of the increasingly international outlook of the BNF, which is reflected in the ever widening membership of firms concerned with the extraction, fabrication or uses of non-ferrous metals.

The BNF has been engaged actively in research on the Air Pollution problems of various sections of the aluminium and copper industries since 1959, and has among its staff considerable knowledge and expertise in the sampling, classification and analysis of fume, and much experience in the performance and economics of plant for cleaning fume. On this occasion, however, a number of experts were brought together to supplement this experience with details of plant construction and performance data. The resulting collection of papers on air pollution is unique.

Water Conservation by industry is a subject which has assumed importance more recently. As populations increase and industry grows, water conservation is likely to become ever more pressing. Already many countries are promulgating strict regulations against increased water abstraction. The four papers on the subject in these Proceedings form a useful introduction to the more economic use of water.

The British Non-Ferrous Metals Research Association wishes to thank all those who contributed to the success of the Conference, particularly the authors of the papers, the Chairman of the technical Sessions, and the Directors of Metallwerke A.G., Dornach, who kindly allowed delegates to visit their works.

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The British approach to air pollution problems of the non-ferrous metals industry

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It is a great honour to me to have been asked to present the opening paper at this Conference and I wish you every success during the next three days.

INTRODUCTION

For the purposes of air pollution control, legislation in the United Kingdom has been separately passed by England and Wales, Scotland and Northern Ireland. It is similar in all three areas, but I am going to talk about England and Wales where I am responsible for administering the Alkali, etc., Works Regulation Act 1906. Emissions to air from industry are controlled normally by the nuisance provisions of the Public Health Act 1936, by the Clean Air Acts 1956 and 1968 and by the Alkali, etc., Works Regulation Act 1906.

The Public Health Act and the Clean Air Acts are administered by local authorities. The first permits action to be taken when nuisance has been caused to the public and the second gives powers to control emissions of smoke, grit and dust from the combustion of fuel, to control chimney heights and to set up smoke control areas. With certain exceptions these Acts do not apply to works scheduled under the Alkali Act. The Alkali Act is administered by a central government inspectorate and the remainder of this paper is about its operation in England and Wales.

History of the Alkali Act

The first Alkali Act was passed in 1863 to control emissions of hydrochloric acid gas liberated from Alkali Works operating the first stage of the now defunct Leblanc process for the manufacture of alkali, or sodium carbonate. The first Alkali Act recognised that it was not possible completely to eliminate the emission and a limit was put on the slip of acid gases to air, thus allowing the proper development of the process and of the heavy chemical industry in Britain. This Act of 1863 was followed by a series of Acts adding more processes and noxious or offensive gases until the Alkali, etc., Works Regulation Act 1906 consolidated all the earlier Acts. It is our operative legislation today and is a measure to control emissions from certain, specified industries. In 1926 the Minister was given power to add to the lists of scheduled works and noxious or offensive gases by means of Orders, after consultations with interested parties and the holding of Public Inquiries, without the formality of introducing legislation through Parliament. Eight such Orders have been laid and the last in 1966 consolidated all the earlier Orders. Thus, all the operative legislation is contained in the 1906 Act and the 1966 Order. Fifty-six different types of works are scheduled, in addition to three mentioned specifically in the Act, and these include the bulk of the chemical industry, petroleum, petro-chemicals, iron and steel, electricity generation, gasification of coal and oil, cement, lime, ceramics and non-ferrous metals. The number of works registered under the Act at the end of 1968 was 1793 involving the operation of 2970 separate processes.

The main provisions of the Alkali Act are briefly as follows:

(i) No scheduled works may operate without first having obtained a certificate of registration, which is renewed annually on payment of the Stamp Duty of £6 (SFr. 62.50).

(ii) A condition of first registration of a scheduled works is that at the time of registration it is fitted with the proper appliances, to the satisfaction of the chief inspector, for meeting the provisions of the Act.

(iii) All scheduled works must use the best practicable means to prevent the emission of noxious or offensive gases and where such gases are necessarily discharged to render them harmless and inoffensive.

(iv) The expression "best practicable means" has reference not only to the correct use and effective maintenance of equipment installed for the purpose of preventing emissions to air, but also to the proper control by the owner of the process giving rise to the emission.

Policy of the Inspectorate

From the outset in 1863, the first chief inspector, Dr. Angus Smith, F.R.S., set out to gain the co-operation of owners and to use coercion as little as possible, for he firmly believed that the best results would be obtained by this method of approach. In the early days when there were only a few qualified scientists in industry, the inspectors were able to assist owners with their technical problems of control, which helped to improve the efficiency of the processes and prevent air pollution. Inspectors carried out research and investigations in their own laboratories, which were of great value to industry and this help laid the foundation for a partnership which has continued to thrive to this day. As industry grew and employed its own qualified scientists, the inspectorate was unable to offer the same help as formerly. By that time industry had become indoctrinated, the inspectors were accepted as friends and industries were prepared to spend money on specialised research and investigation into their own air pollution problems.

Today the inspectorate consists of a chief inspector and two deputies at headquarters in London, twelve district alkali inspectors each in charge of his own district and eleven alkali inspectors. All are highly qualified scientists with a basic chemical background of a university degree or equivalent and many also have qualifications in chemical engineering and/or fuel technology. The minimum age of entry to the lowest grade is 30 and nearly all have had a considerable industrial experience before becoming inspectors.

The general plan of campaign is for the chief inspector, assisted by his two deputies, to formulate broad national policies, usually in consultation with representatives of industry, and for these policies to be applied at site level and in detail by the inspectors and individual works managements. Provided they keep within the broad framework laid down by the chief inspector, district inspectors have freedom to work out the more detailed strategy for their districts and negotiate best practicable means with the works under their control. Inspectors are made as autonomous as possible and each man goes into a works as the personal representative of the chief inspector with full authority to negotiate and reach agreement. Inspectors are able to give decisions across a desk or on site or with but a little delay and it is this ability to take responsibility and give quick decisions which pleases industry in its negotiations with the inspectorate. Industry is prepared to pay for time saved and will accept tougher decisions than it might otherwise gain from protracted argument. This form of training and delegation of authority is a major reason why we are able to cover England and Wales with such a small inspectorate.

When difficult technical problems are encountered, industry is offered a partnership with the inspectorate in finding solutions. Working parties and discussion groups are set up consisting of representatives of the industries concerned, their research associations if any and members of the inspectorate. The emissions are investigated by the three parties, research and investigation are carried out by the industrial sides with their own specialists and at their own expense and the results are reported to both the industry and the inspectorate. Solutions have to be found and eventually standards of emission may have to be set. It is the chief inspector who must take final responsibility for decisions on best practicable means, but this only follows mutual discussions with the industrial representatives, if possible gaining their approval.

This participation by the trade associations is a good guarantee of their support in enforcing requirements amongst their members. It is to the trade's advantage to have uniformity of application of control measures and it would be patently unfair to give one works an advantage over another. Works do sometimes violate the requirements of the chief inspector, as may be seen from the annual reports. On all such occasions they are sent official letters by inspectors, notifying the owner of the illegality and seeking comment. If suitable apologies are given and steps are taken to obviate a recurrence, legal action is not sought. The infraction conditions are always investigated by the inspector and management and it may be necessary to issue new instructions to operators, arrange for planned maintenance, install a stand-by unit, use better materials of construction, etc. The main point is that permanent solutions are sought to problems which only come from operating experience and could not readily have been foreseen. Because of their wide experience in many works, inspectors can play a leading part in setting managements on the best road to success. Inspectors make routine visits, without prior warning, to major works not less than eight times a year but usually much more, and to the minor works not less than twice a year. Interesting information is reported to headquarters and advice given which will help the chief inspector to keep best practicable means up-to-date. The expression, best practicable means, allows the chief inspector to alter his requirements at will to keep pace with an advancing technology, taking economics into account. There are many examples of standard of emission having been made more stringent by the chief inspector as technical knowledge has enabled the prevention process to be carried out more efficiently. Naturally the industry is consulted before changes are made and equipment which was installed to meet the standard of the day is allowed to run its economic life before improvements are required.

The non-ferrous metals industry

Some non-ferrous metal processes have been registered under the Alkali Act for many years, mainly because their emissions were offensive or a health hazard. These are Smelting Works, Arsenic Works, Zinc Works and Lead Works. The year 1958 was important for the inspectorate, because an Order was made which scheduled under the Alkali Act many new works which could not meet the smoke, grit and dust requirements of the Clean Air Act. Technical difficulties were involved in the control of emissions and the inspectorate was charged with the finding of solutions. Amongst the many types of works added to the schedule were Copper Works and Aluminium Works and to these were later added Uranium, Beryllium, Selenium, Chromium, Magnesium, Cadmium, Manganese and Metal Recovery Works. The most important of these newly-scheduled works were copper and aluminium and it is of these that I mainly want to address you and demonstrate our relationship with the trade associations and their research association. Scheduled non-ferrous metal works are defined in Appendix I.

The first task in 1958 was to have all the works meeting the new definitions registered and surveyed by the inspectors in the field. The emission problems were diagnosed, possible remedies were discussed with managements and items needing investigation were proposed. Information was relayed to headquarters in London, where the chief inspector and his two deputies studied details and planned policy. Periodically, all the inspectors were called to meetings at headquarters to exchange experiences and give their opinions to the chief inspector. Meantime the chief inspector had made contact with the British Non-Ferrous Metals Federation, the Aluminium Federation, the Association of Light Alloy Refiners and Smelters and the British Non-Ferrous Metals Research Association and armed with the information provided by the inspectors, he and his two deputies began discussions and negotiations. There was thus a two-pronged attack on the problems by inspectors at individual works and by the chief inspector on a national scale.

The obvious emissions, which caused public complaint, were dark smoke and dense white fumes, although there were other pollutants which were not so obvious to the eye. There was a dearth of information about the composition of emissions, volumes, mass emissions, temperatures, frequency, etc. etc. and all parties concerned placed great reliance on the expertise of the British Non-Ferrous Metals Research Association to carry out research and investigations. We were extremely fortunate to be dealing with men who had an enlightened attitude to the necessity for industry to solve its own air pollution problems and be a good neighbour. The Research Association did an excellent job of investigation and issued to its members and the inspectorate a series of valuable Research Reports, which enabled sensible decisions to be formulated.

In the early days of scheduling, the industries needed guide-lines to which they could work and make progress, even though complete information about emissions and remedies was not available. After consultation with the associations, the chief inspector laid down temporary requirements which he called "interim best practicable means", pending more complete solutions being found. In the main these consisted of a reduction of smoke and dispersal of the fumes at suitable heights. Dispersion can never be an alternative to prevention and we have continually pursued a policy of preventing emissions of noxious or offensive gases. This is an ideal we have not yet achieved, but there has been continued steady progress in this direction. As an example, the major emission problem of the secondary aluminium smelting industry is that of salt fumes arising from the use of bulk salt as a flux. Several works installed fume arrestment plants which were unsatisfactory because of the plant manufacturers lack of appreciation of the corrosion problems, resulting in the use of the wrong materials of construction. Indeed, one works had an arrestment unit composed of stainless steel and it lasted about two weeks. The Aluminium Federation thereupon organised a meeting to which were invited 19 plant manufacturers, the research association and the inspectorate. The problem was discussed, proposals were offered for trial and the research association acted as project co-ordinators. Pilot scale units were operated with the help of engineers loaned by the plant suppliers and eventually the technical difficulties were overcome. The expenses of these trials were contributed by the Federation, plant manufacturers and individual works. The inspectorate held a watching brief. The technical work took several years to complete and was a triumph for collective effort, but it was not the end of the story. The economic evaluation had still to be considered and this was elucidated only after a survey of all works concerned. In December 1968, after discussing the survey with industry representatives, the chief inspector was able to put to the industry his final requirements for "best practicable means". New plant will have to comply from the outset, existing works where trouble is being experienced with emissions causing a local nuisance, must install requisite plant as soon as possible on a schedule to be agreed with the local inspector and the remainder must meet the requirements by the end of 1973. This seems to be a sensible and equitable arrangement.

It is the practice of the inspectorate to meet regularly with the trade associations and research association merely to keep in touch with developments and progress. These meetings preferably take place annually, although working parties and committees set up to study specific problems will meet more frequently. The British Non-Ferrous Metals Research Association has not confined its investigations to copper and aluminium. It has done valuable work in connection with the use of cadmium and zinc in alloy manufacture and galvanising.

Cost of air pollution control

It would be useful to know the cost-benefit details of air pollution, but so far no reliable estimates have been made. Indeed, it would surprise me if they were ever made. Many of the assessments are intangible, e.g. amenity, aesthetics, health, damage to buildings, vegetation, fabrics, etc. Even to make an attempt at such an exercise would probably take a large team several years, by which time the situation would have changed from that pertaining at the start, such is the rate of modern industrial revolutions. Last year an exercise was carried out in England and Wales to try and ascertain the amount of money spent by works scheduled under the Alkali Act during the 10-year period 1958 to 1968 on air pollution control. From the answers received from individual works, trade associations and research associations, it appears that about SFr. 1,560 million was spent on capital items and about SFr. 3,360 million on operating costs, including depreciation and interest. The share of the non-ferrous metals industry was about SFr. 60 million on capital and SFr. 172 million operating costs. Research, mainly involving the British Non-Ferrous Research Association, amounted to about SFr. 6,830,000. It is not easy to identify money spent on air pollution control because of the interrelation with other facets of plant spending and the costs should be regarded as good estimates.

Conclusion

No attempt has been made to enumerate the many technical subjects discussed with representatives of the non-ferrous metals industry and the valuable reports issued. Some of these can be seen by studying the annual reports of the chief alkali inspectors, others are confidential to members. Our relationships with industry are excellent, but nowhere are they brighter than with the non-ferrous metals trade associations and research association. We are extremely grateful to them for their co-operation and enlightened attitude to the industries' air pollution control problems. In Britain there is no longer a need to argue a case for clean air with industry. Both sides realise that there is a job to be done and we have got on with the protection of health and amenities of future generations.

APPENDIX I

List of registrable non-ferrous metal works—Alkali, etc., Works Regulation Act, 1906 and Alkali, etc., Works Order, 1966.

Smelting works

Works in which sulphide ores, including regulus, are calcined or smelted.

Arsenic works

Works for the preparation of arsenious acid, or where nitric acid or a nitrate is used in the manufacture of arsenic acid or an arsenate and works in which any volatile compound of arsenic is evolved in any manufacturing process and works in which arsenic is made.

Zinc works

Works in which by the application of heat, zinc is extracted from the ore, or from any residue containing that metal, and works in which compounds of zinc are made by dry processes giving rise to fume.

Lead works

Works (not being works for the recovery of lead from scrap by direct liquation) in which, by the application of heat, lead is extracted from any material containing lead or its compounds, and works in which compounds of lead are manufactured from metallic lead or its compounds by dry processes which give rise to dust or fume.

Copper works

Works in which:

(*a*) by the application of heat
- (i) copper is extracted from any ore or concentrate or from any material containing copper or its compounds; or
- (ii) molten copper is refined; or

(iii) copper or copper alloy swarf is degreased; or
(iv) copper alloys are recovered from scrap fabricated metal, swarf or residues by processes designed to reduce the zinc content; or

(*b*) copper or copper alloy is melted and cast in moulds the internal surfaces of which have been coated with grease-bound or oil-bound dressings. (But this paragraph does not apply to works in which the aggregate casting capacity does not exceed 10 tons per day.)

Aluminium works

Works in which:

(*a*) aluminium swarf is degreased by the application of heat; or
(*b*) aluminium or aluminium alloys are recovered from aluminium or aluminium alloy scrap fabricated metal, swarf, skimmings, drosses or other residues by melting; or
(*c*) aluminium is recovered from slag; or
(*d*) molten aluminium or aluminium alloys are treated by any process involving the evolution of chlorine or its compounds.

Uranium works

Works (not being works licensed under the Nuclear Installations (Licensing and Insurance) Act, 1959, and not being nuclear reactors or works involving the processing of irradiated fuel therefrom for the purpose of removing fission products) in which:

(*a*) any ore or concentrate or any material containing uranium or its compounds is treated for the production of uranium or its alloys or its compounds; or
(*b*) any volatile compounds of uranium are manufactured or used; or
(*c*) Uranium or its compounds are manufactured, fashioned or fabricated by any dry process giving rise to dust or fume.

Beryllium works

Works in which:

(*a*) any ore or concentrate or any material containing beryllium or its compounds is treated for the production of beryllium or its alloys or its compounds; or
(*b*) any material containing beryllium or its alloys or its compounds is treated, processed or fabricated in any manner giving rise to dust or fume.

Selenium works

Works in which:

(*a*) any ore or concentrate or any material containing selenium or its compounds is treated for the production of selenium or its alloys or its compounds; or
(*b*) any material containing selenium or its alloys or its compounds other than as colouring matter is treated, processed or fabricated in any manner giving rise to dust or fume.

Chromium works

Works in which any chrome ore or concentrate is treated for the production therefrom of chromium compounds or chromium metal is made by dry processes giving rise to fume.

Magnesium works

Works in which magnesium or any compound of magnesium is made by dry processes giving rise to fume.

Cadmium works

Works in which metallic cadmium is recovered or cadmium alloys are made or any compound of cadmium is made by dry processes giving rise to fume.

Manganese works

Works in which manganese or its alloys or any compound of manganese is made by dry processes giving rise to fume.

Metal recovery works

Works in which metal is recovered from scrap cable by burning the insulation.

B.N.F.M.R.A. work on the measurement and control of fume

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The operation of the Alkali Act insofar as it affects the non-ferrous metals industry has been dealt with in Appendix I of the paper by the Chief Alkali Inspector. Large portions of the industry became newly scheduled under the Act in 1958 because of the difficulty such works would have had in meeting the requirements of the 1956 Clean Air Act. This Act is in effect administered by the local authorities, it being the duty of the local authority to see that the occupiers of buildings in their area comply with the Act and do not permit the emission of dark smoke and that all practicable means are taken to minimise the emission of grit and fume. Under the Alkali Act, certain processes of the non-ferrous metals industry became removed from the operation of the Clean Air Act and instead became subject to the control of the Chief Alkali Inspector. One great advantage of this, so far as the industry is concerned, is that the standards applied are uniform throughout the country and do not vary from one district to another.

The BNF became involved early in 1959, when the Alkali Inspector through the then Department of Scientific and Industrial Research requested the Association to "consider research to provide such additional knowledge as may be necessary to reduce atmospheric pollution arising from the operations of the copper industry". Some time later, the work was extended to cover the problems of the secondary aluminium industry, also scheduled under the Act. The BNF has also briefly investigated the problem of fume control in the galvanising industry, though this particular section of the non-ferrous metals industry is not subject to the control of the Alkali Inspector.

The BNF's work concerned with air pollution has been almost entirely field work, carried on outside the laboratories in members' works, and it would not have been possible without the very ready co-operation, not only of members but also of several manufacturers of air cleaning plant who at various times have made available pilot plant for evaluation. Nor could the BNF have borne the high cost of the research, except by raising special funds, were it not for the equipment and services freely loaned by many plant manufacturers and the facilities so readily provided by member firms. Throughout, the exercise has been a model of co-operation, not least on the part of the Alkali Inspector.

PART I: THE COPPER INDUSTRY

Initially a survey was made of the sources of smoke and fume emitted in:

(*a*) primary and secondary copper refining and melting; and

(*b*) melting and casting copper alloys.

Later, where appropriate, quantitative information on the amount of fume emitted was collected, usually by isokinetic sampling of the stack emission. This work considerably narrowed the range of operations where fume emission was a problem of serious consequence.

1.1. Copper refining and melting

Tests on a large oil-fired reverberatory furnace showed, as might be expected, considerable variations in the dust burden at different stages of the twenty-four hour refining cycle, and also marked differences from one cycle to another depending on the charge and mode of operation of the furnace. The highest emission took place during the oxidising stage, when the average copper emission was 0·23 g/m^3 at NTP. These large reverberatory furnaces are usually equipped with waste heat boilers which fortuitously act as collectors for the coarser dust particles. The average figures obtained suggested a loss of copper in the stack gases of approximately 0·4 kg/tonne metal melted (0·04%). However, because of the large particle size the emission is not very noticeable and dispersal through the tall chimneys with which these furnaces are usually equipped seemed to provide an adequate answer. Typical figures for fume emission are given in Table I.

TABLE I—*Tests on 183 tonne (180 ton) furnace while firing with oil*

	CHARGING AND "MELTING TO FLAT"			MELTING OFF BOTTOM			OXIDISING			POLING		
	LOWEST	HIGHEST	AVERAGE (15)	LOWEST	HIGHEST	AVERAGE (5)	LOWEST	HIGHEST	AVERAGE (7)	LOWEST	HIGHEST	AVERAGE (6)
Average gas temperature during test, °C			187			182			182	176		
Volume in stack at temperature, m^3/min.			580			603			695			545
Volume at NTP, m^3/min.			340			354			410			325
Dust burden at NTP, g/m^3	0·15	0·80	0·41	0·30	1·00	0·47	0·37	1·14	0·73	0·28	0·66	0·47
Kg of dust emitted/hour	3·08	16·33	8·16	6·36	20·9	9·90	9·00	28·00	18·3	4·65	12·70	9·05
% copper in the dust	8·7	49·0	32·2	19·6	37·7	29·9	18·3	42·5	37·1	24·2	50·0	39·7
Copper emission g/m^3 at N.T.P.	0·04	0·37	0·14	0·06	0·34	0·15	0·15	0·40	0·23	0·14	0·23	0·17
Kg copper emitted per hour	0·79	7·50	2·80	1·27	7·05	3·08	3·82	9·55	5·88	2·70	4·70	3·37

Obviously there can be considerable variation according to the method of working and type of charge, and if emission from these furnaces is considered to be excessive, as a first step a detailed investigation of the refining process should be made to determine the reasons for a high dust burden. Segregation or pretreatment of those materials which are found to produce a lot of fume during charging and melting down might sometimes be advisable, and in this connection the melting of scrap cable presents a special problem. This is dealt with later.

There has been no opportunity to examine the emissions from the large rotary furnaces sometimes employed for refining scrap copper, but tests were made on a five tonne Sklenar furnace processing baled wire and rod scrap. This type of reverberatory furnace is short and is designed so that the flames impinge on the metal, giving rapid heat transfer and partial oxidation during melting. The final oxidation stage takes only ten to fifteen minutes, and in this works the metal is then tapped and poled in a small cylindrical holding furnace, releasing the Sklenar for further melting. Typical results obtained from sampling at various stages of the furnace cycle are given in Table II.

TABLE II—*Emission of fume from oil-fired 5 tonne Sklenar furnace*

	SAMPLE NUMBER				
	1	2	3	4	5
STAGE OF OPERATION	IMMEDIATELY AFTER SECOND CHARGE	STARTED AFTER CHARGE OF BALED SCRAP	COMPLETELY MOLTEN	OXIDISING	FIRST CHARGE
Total dust emission, NTP g/m^3	0·298	0·241	0·494	0·424	0·369
Copper emission, NTP g/m^3	0·039	0·037	0·064	0·060	0·112
% copper in the dust	13·3	15·6	13·0	26·9	16·3
Sampling time, min.	25	33	10	13	20
Total dust emission, kg/h	3·85	3·10	6·35	5·44	4·75
Total copper emission, kg/h	0·50	0·47	0·82	1·45	0·72

In this installation there was a large quantity of induced air from the shop and the gas flow, 215 m^3/min at NTP, was high in relation to the furnace capacity, hence the proportion of copper in the stack emission was low. In general it has been found that when melting light scrap in these furnaces the copper loss is about 0·4 kg/tonne.

Arc furnaces are used only as melting furnaces and differ from the previous furnaces in that high temperatures are produced in the immediate vicinity of the electrodes, giving rise to metallic fume of a very small particle size, visible as a red-brown cloud. Reliable estimates give the copper loss as about 2·5 kg per tonne of copper melted, and some system of filtration is necessary. Bag filters have been used, but the furnace examined was equipped with an electrostatic precipitator. Two tests were made, the first when only a small amount of copper was charged and the second while considerable amounts of scrap were added. Table III gives the results, and it is worth noting that in neither case was there visible emission from the stack.

TABLE III—*Copper emission from 5 tonne/h arc furnace. Gas volume 96·3 m³/min at NTP*

	1	2
Total fume emission from furnace, g/m³ at NTP	2·66	3·23
% copper in the dust	87·8	74·9
Total fume emission from furnace, kg/h	15·3	18·6
Copper emission from the furnace, kg/h	13·4	13·9
Total emission from the precipitator, g/m³ at NTP	0·11	0·16
% copper in dust	78·4	75·4
Total fume emission to atmosphere, kg/h	0·66	0·92
Copper emission to atmosphere, kg/h	0·51	0·70
Precipitator efficiency, %	95·7	95·0

1.2. Cable scrap

Many copper refiners have to treat quantities of scrap cable which is plastic or rubber insulated. This produces an objectionable smoke and smell on heating and in the case of some plastics the fumes may have undesirable effects. By burning the cable in a suitably designed furnace with a secondary heating zone to consume the smoke produced, the emission can be kept reasonably light in colour, but the smell and any noxious gases remain. Mechanical strippers now seem to have replaced almost entirely the older process of burning, and constitute a satisfactory, if expensive, solution to the fume problem. The machines chop the scrap into small lengths, remove the insulation and separate it from the copper in a process analogous to winnowing.

1.3. Melting copper alloys

Since the low frequency electric furnace is used so extensively for melting copper base alloys, attention was concentrated on this and emissions were measured for three representative alloys: 85/15 gilding metal, 70/30 brass and 60/40 free-cutting brass. The former two alloys are mostly produced as strip which gives rise to fairly "clean" scrap in the form of trimmings. Tube and wire are also made, and again any scrap arising is "clean". Data from the melting of these two alloys in 0·75 tonne furnaces are given in Table IV, the charge in each case consisting of clean scrap, copper and spelter.

TABLE IV—*Emission from furnaces melting 70/30 and 85/15 alloys*

	70/30 BRASS	85/15 GILDING METAL
Emission during charging	Rabbling spelter into the bath—average 0·64 g/m³ at NTP for 2 min 15 sec	No peak emission. Average over 40 min while charging and stirring the bath 0·05 g/m³
Emission during skimming	0·23 g/m³ for 80 sec	0·28 g/m³ for 97 sec
Emission during pouring	2·45 g/m³ at NTP for 69 sec	2·2 g/m³ for 49 sec
Volume of gas	89 m³/min at NTP	82 m³/min at NTP

Very little fume was produced during charging: stirring in the zinc made a moderate emission for a short time, and the highest emission occured in pouring, though again only for a short time. It is obvious that melting and casting these two alloys presents little of a fume problem except from the combined operations of several furnaces.