Some aspects of energy and the environment in the steel industry

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SYNOPSIS

The relationship between population growth and steel consumption since the beginning of the twentieth century is indicated, reference being made to the increasing capacity of production units and the resultant increased pollution in the same area. The need for the control of fugitive emissions with its associated high cost is pointed out. There is a direct relationship between energy and pollution, and examples are given of several improvements that have been made to achieve better energy usage and reduced pollution. Several practical examples of air-pollution control systems are described as applicable to the main metallurgical steel processes of today.

In conclusion, reference is made to the fact that, with the improvements attained in reducing pollution, the public will not tolerate a decline in the standards already attained. Environmental control and better energy utilization will continue to be important aspects of steel-plant design and operation.

SAMEVATTING

Die verwantskap tussen die bevolkingstoename van die wêreld- en staalproduksie word aangedui en dit toon aan dat die gebruik van staal per kapita sedert die begin van hierdie eeu steeds toeneem. Daar word verwys na die oprigting van steeds groter en groter produksie-eenhede wat groter hoeveelhede besoedeling op dieselfde werksoppervlakte tot gevolg het. Daar bestaan nou 'n behoefte om ook aandag te skenk aan die beheer van sekondêre emissies en die hoë koste hieraan verbonde word genoem. Daar bestaan ook 'n direkte verhouding tussen energie verbruik en besoedeling en voorbeelde van werksverbeteringe in die staalnywerheid word genoem wat aanleiding gee tot beter energieverbruik en afname in besoedeling. Daar word verwys na die energiebehoeftes van die verskillende staalmaakprosesse asook die bydrae tot besoedeling. Voorbeelde van besoedelingbekamping van die belangriker metallurgiese prosesse word behandel, asook die sukses behaal. As gevolg van gedurige verbeteringe behaal met besoedelingbekamping sal die publiek in die toekoms geen agteruitgang of swakker omgewingsstandaarde aanvaar nie. Omgewingsbeheer en energiebenutting sal steeds belangrike gesigspunte wees in die ontwerp en bedryf van die staalnywerheid.

Introduction

There has been phenomenal industrial growth over the past century, closely coupled with an unprecedented growth in world population. Table I illustrates this growth in the iron and steel sector. In spite of an alarming population growth, the consumption of steel *per capita* is still growing.

TABLE I

GROWTH IN POPULATION AND IN STEEL PRODUCTION[1]

Year	World population $\times 10^6$	Steel production $t \times 10^6$	Consumption *per capita* kg
1900	1 600	37	23
1925	1 900	92	48
1950	2 486	192	77
1970	3 632	596	165
1972	3 782	630	168
1974	3 850	710	184

All the stages in the processing of steel produce some kind of pollution for which controls are needed. Apart from the accelerated yearly production rates, the size of the production units is continually being stepped up. For example, in the last ten to fifteen years, single production units have increased their output up to ten times. Blast-furnace units of 1000 t/d have now been superseded by units of 10 000 t/d, which means that in the same area the pollution effects are being increased proportionately.

In discussions on environmental pollution by steel works, the general tendency is to consider only air pollution, but, although air pollution is the main contributor in contaminating the environment, water pollution is almost as serious, followed to a lesser extent by that of noise, radiation, and waste material accumulation.

Closely associated with the larger production units referred to is an increase in secondary or fugitive emissions. The control of such emissions calls for highly sophisticated and expensive equipment, requiring greater technical and financial resources than those required by the main process-control systems. This is mainly due to the large number of smaller emissions involved, often occurring in inaccessible areas and being almost impossible to collect. As a result of the increased rate of steel production virtually in the same confined areas, pollution-control regulations are being stepped up, resulting in higher production costs. Cases are known, especially in the U.S.A., where companies have preferred to restrict their operations or to close down, rather than to incur high investment costs to meet new regulations or to pay the exorbitant fines that would be imposed for non-compliance with the new regulations. Such conditions, especially in present times of serious financial shortages, have led to unemployment and serious dissatisfaction. Although it is correct to combat pollution wherever required, an acceptable approach and understanding between industry and controlling authorities is necessary.

Energy and Pollution

Nearly all the definitions of pollution include the concept of energy. Steelmaking involves vast amounts of energy, especially to produce heat and to move

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TABLE II

CONSUMPTION OF COKE, 1920–1975

Year	Total coal per ingot ton kg	Total coke per ton of iron kg
1920	3 000	2 000
1955	1 500	1 000
1975	1 000	600

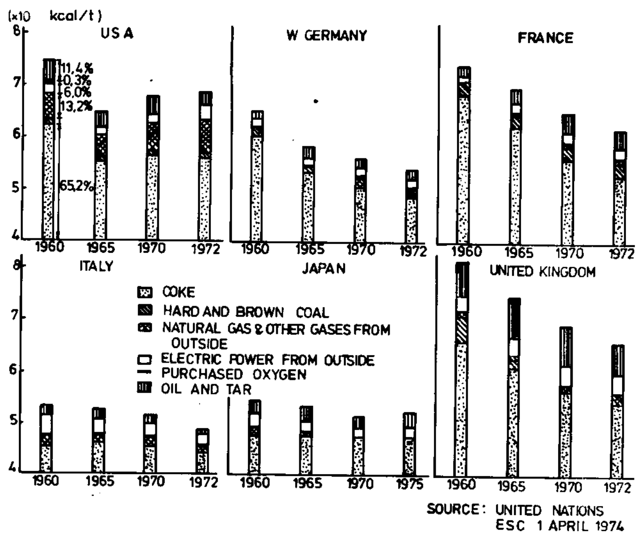

Fig. 1—Consumption of energy (per ton of steel) in various countries

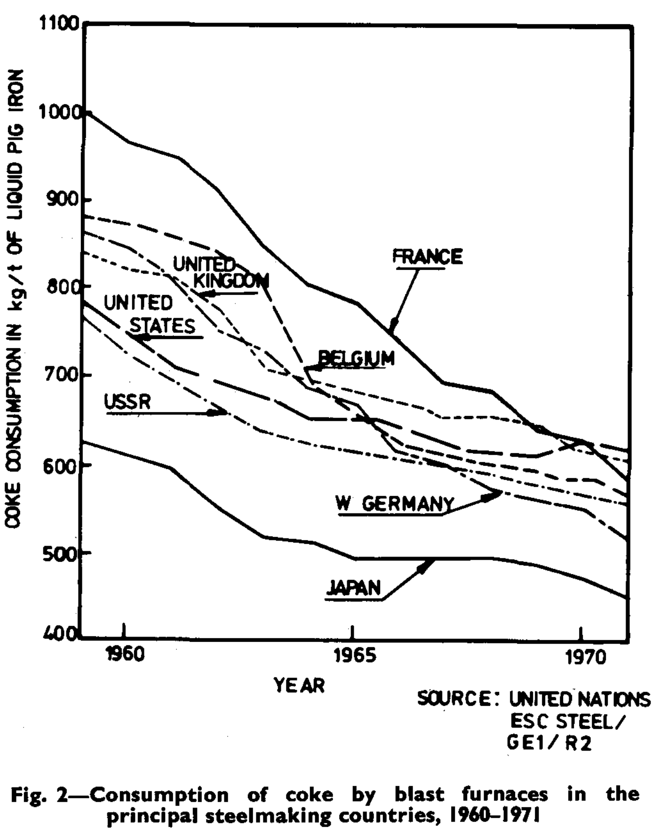

Fig. 2—Consumption of coke by blast furnaces in the principal steelmaking countries, 1960–1971

heavy materials. It is therefore appropriate to define pollution as 'the results of the interaction between energy and the environment.' Since fuel and power (i.e., energy) represent about one-fifth of the total operating cost of a steel works, it is no wonder that special attention is continuously being given to the improvement of energy efficiencies. Since the future and progress of mankind are vitally dependent on energy resources, which are already limited, it remains to be seen how effectively and efficiently man is going to utilize these resources. During 1970, the world steel industry utilized the equivalent of 750×10^6t of coal[2], representing 11 per cent of the world's total energy consumption of 6800 million t of coal equivalent. Fig. 1 shows the trend of energy consumption in the steel industry for several countries. In the United Kingdom and France, there was a 16 per cent reduction between the years 1960 to 1972. The main source of energy is coking coal, representing 60 to 65 per cent of the total energy required to produce one ton of steel. Continued concerted efforts by the steel industry successfully reduced the consumption of coke by 30 to 35 per cent over the period 1960–1971, as shown in Fig. 2. Table II shows the consumption of coke in blast furnaces over the period 1920–1975.

Coke rates in Japan are the lowest in the world (400 to 500 kg/t). Iscor uses 650 to 700 kg/t, which is mainly due to the poor coking coal that is available in South Africa.

As stated previously, about one-fifth of the total expenditure on an integrated works is for energy — this, for the Iscor Works at Vanderbijlpark, which produces approximately $3{,}33 \times 10^6$ t of ingot steel per annum, amounted to $R83 \times 10^6$ during 1975–1976. The energy make-up of some 329×10^6 MJ/d or 8×10^6 kcal/t of ingot steel is shown in Table III. The percentage energy

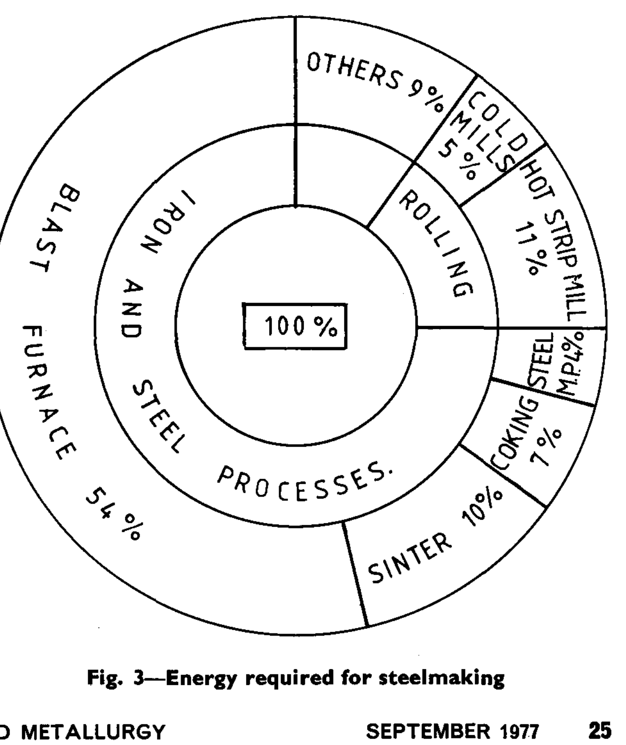

Fig. 3—Energy required for steelmaking

TABLE III

ENERGY CONSUMED AT THE ISCOR WORKS, VANDERBIJLPARK

Source of energy	Consumption per month	MJ/month $\times 10^6$	%
Coking coal	204 293 t at 290,125 MJ/kg	5 927,1	60,0
Blast furnace tar	3 896 t at 37,136 MJ/kg	144,7	
Producer coal	9 330 t at 25,067 MJ/kg	233,9	
Furnace oil	2 800 t at 42,7 MJ/kg	119,6	
Electricity bought		123,7	9,1
L.P. gas	138 t at 47,8 MJ/kg	6,6	
Burner oil	1722,8 t at 42,7 MJ/kg	73,6	
Ind. gas (Sasol)		195,7	
C.O. gas	$2,6 \times 10^6 \times 30$ m^3 at 17,136 MJ/m^3	1 336,6	13,5
B.F. gas	$17 \times 10^6 \times 30$ m^3 at 3,354 MJ/m^3	1 710,8	17,3
Total		9 872,3	99,9

$$9\,872 \times 10^6 \text{ MJ} = 2\,400 \times 10^9 \text{ kcal/d}$$
$$= 8 \times 10^6 \text{ kcal/(t of steel)}$$

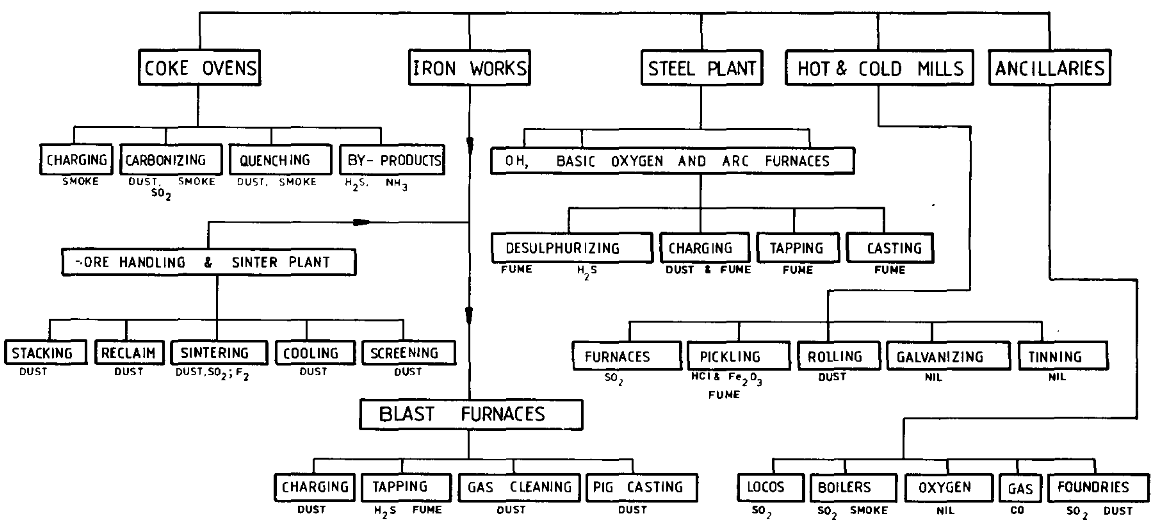

Fig. 4—Possible sources of air pollution in an integrated steelworks

derived from coking coal including its gas value is approximately 90 per cent of the total requirement.

A breakdown of the energy consumed by various production processes in a steel works is shown in Fig. 3. The ironmaking and steelmaking processes — generally known as the metallurgical processes — account for approximately 75 per cent of the energy requirements, leaving only a quarter of the total energy for the subsequent rolling processes and ancillary services.

Fuel economy lowers environmental pollution, and energy saved is money saved. By practising fuel economy, the steel industry has effected considerable reductions in environmental pollution. The following approaches to steelmaking practices are noteworthy in requiring less energy and reducing pollution.

(a) The use of electric power produced by outside authorities like Escom rather than of self-generated power.
(b) Thorough cleaning of blast-furnace and coke-oven gas for use in subsequent furnace operations.
(c) Employment of specialist combustion or fuel engineers and environmental engineers.
(d) Improved and automatic combustion controls.
(e) Conversion from solid fuels to gaseous and liquid fuels. Examples include gas in reheating furnaces and boiler houses, oxygen in steelmelting furnaces replacing producer gas, tar, oils, and coal.
(f) Replacement of coal-fired locomotives with diesel or electric units.
(g) Replacement of soaking-pit furnaces with continuous casting machines for ingot casting.

Main Sources of Pollution

Fig. 4 gives a picture of the sources and nature of the air pollutants that arise in an integrated steelworks. These sources can be grouped into three sections as follows.

(i) The metallurgical section, which comprises coke-ovens, sinter plants, blast furnaces, basic oxygen steelmelting plant (B.O.F.), and electric arc furnaces.
(ii) The rolling mills — hot and cold types, including acid pickling, galvanizing, and electrolytic tinplating.
(iii) Ancillary services like steam, oxygen, gas, and transport.

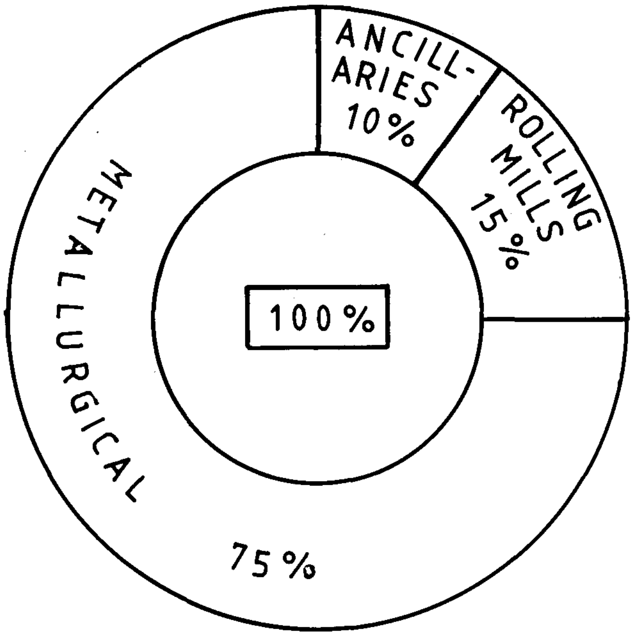

Fig. 5—Contributions to air pollution by the sections of an integrated steelworks

The contribution of these sections towards air pollution is about 70 per cent, 15 per cent, and 10 per cent respectively (see Fig. 5).

The types of polluting material encountered on a steel plant are as follows:

(1) Particulate matter of the following sizes:
Grit — larger than 76 μm in size
Dust — between 76 μm and 10 μm in size
Fume — smaller than 10 μm.

(2) Gaseous matter, which usually consists of smoke, mists, and harmful gases, and is usually smaller than 1 μm in size. Gases of H_2S, SO_2, and HF are often dangerous when exceeding certain limits.

Two categories of pollutants are encountered — point or primary emissions and secondary or fugitive emissions. Point emissions are relatively easier to collect and treat, and usually do not present insurmountable problems because the technology is well developed and available. The second type is more difficult to handle. These comprise gases, fumes, and particulate matter escaping as leakages during short periods of routine operation; e.g. during the loading and pushing of coke ovens, the loading and tapping of furnaces, and the opening of doors and chutes. Fugitive emissions have been tolerated in the past, but, now that the larger production units are creating more and more emissions, pressures from regulatory agencies are mounting and the steel industry has to face additional disposal problems and costs. The control of operations like these requires the specific technology and ingenuity of environmental control engineers. The costs involved are comparable with those for the control of point or primary emissions; large volumes are often to be exhausted, requiring the same power requirements as those for the removal of primary emissions. It has been shown that the generation of this additional power could result in sulphur dioxide and particulate emissions comparable with the emission being removed.

Some Obstacles and Their Solutions

Coke Ovens

One of the most difficult air-pollution problems on a coke-oven is the elimination of emissions during the loading and pushing of the oven. Many steel companies have invested millions of rands in research and have at last developed several systems to control such pollution. An idea of the improvements that can be attained with modern control measures is given by Table IV.

Oven Charging

The most popular system now followed during the loading of coal into an oven is the steam aspiration system accompanied by sequential charging through the four charge holes of an oven. Provision is also made for proper sealing between the coal charging chute and the charge hole. During charging, an aspirating steam injector forces steam in the goose-neck or duct of each cokeoven's take-off, causing a negative pressure in the

TABLE IV

DISCHARGE OF DUST PER TON OF COKE[3]

Operations	Without controls kg	% Loss	With controls kg	Improvement %
Charging of ovens	0,15	6	max. 0,015	90
Discharging of ovens	0,40	17	0,070*	82
Coke quenching	0,35	15	max. 0,070	80
Handling of coke	1,50	62	max. 0,030	98
	2,40	100	0,185	92 average

*Authors assumption

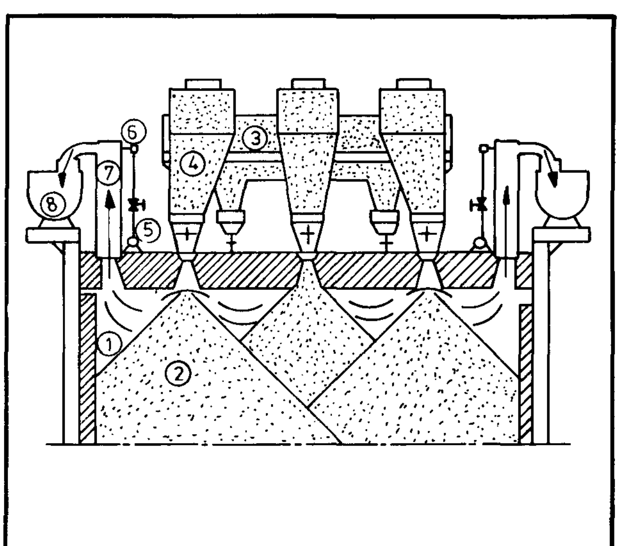

Fig. 6—A gravity charging car with double take-off mains
1. Coke oven
2. Coal
3. Larry car
4. Charging hopper
5. Steam pipe
6. Steam injector
7. Ascension pipe
8. Collecting main

oven that sucks off smoke, gases, and grit during its loading. This system works satisfactorily when a coke-oven battery is equipped with double take-off mains, where two steam ejectors can be employed simultaneously. Fig. 6 illustrates a gravity charging car with double take-off mains. Fig. 7 shows a larry charging car operating on an oven with a single take-off main without steam ejection facilities but equipped with fans and wet scrubbers bolted on the larry car. The exhausted gas and smoke mixture is ignited and wet scrubbed, and the clean gas is discharged to atmosphere. This system is not very satisfactory.

Fig. 8 shows a preheated-coal charging system, where dry preheated coal at 250 °C is loaded into an oven by means of a pipe-line using steam to move the coal into the oven. Since preheated coal runs freely like sugar,

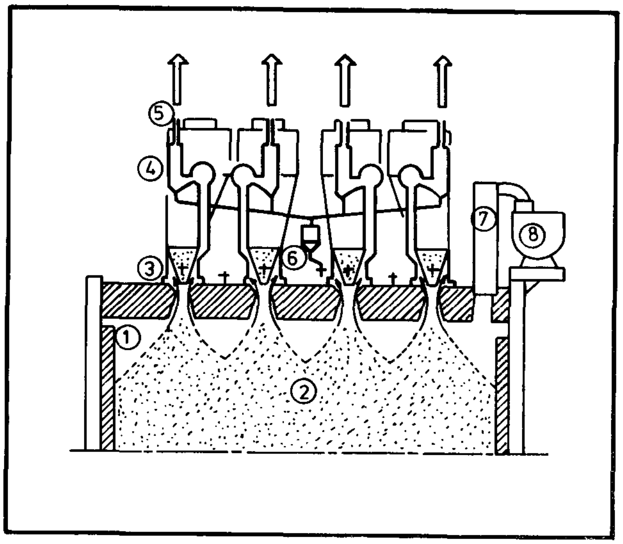

Fig. 7—A larry charging car with a single take-off main
1. Coke oven
2. Coal
3. Sealed drop sleeves
4. Washer ventilator
5. Clean release
6. Sludge discharge
7. Ascension pipe
8. Collecting main

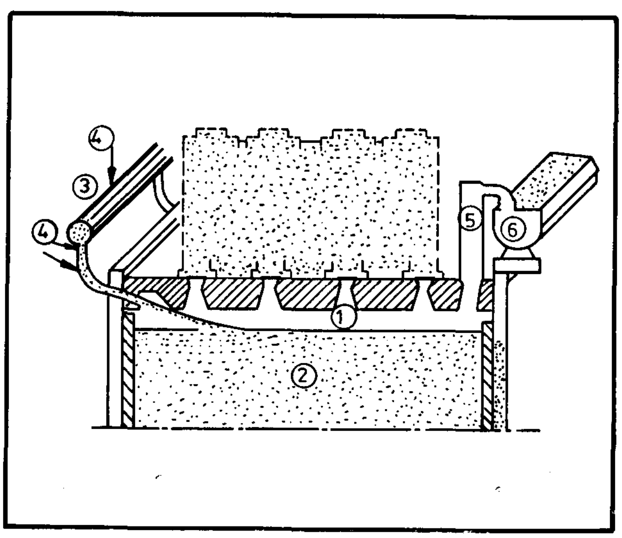

Fig. 8—A preheated-coal charging system
1. Coke oven
2. Preheated coal
3. Charging pipe line
4. Steam injection
5. Ascension pipe
6. Collecting main

no overhead charging holes and e quipment are needed Intense disturbances, however, occur in the oven during such loading, resulting in the entry of large quantities of dust and grit into the take-off main and thereby contaminating the tar recovered.

Oven Discharging

During the push to empty a coke oven into a coke car, considerable dust and smoke are set free. A large proportion of this can be prevented by producing a well-baked charge. In most systems so far developed, some form of a collecting hood is used to cover and seal the coke guide and coke car. A negative pressure is created under the hood by means of a suction device, and the dust-laden gases so collected are purified. Some systems provide a self-contained unit — a collecting hood with a suction and scrubbing device on wheels. During pushing of the coke into the hooded car, the fans exhaust the dust and smoke through the scrubber attached. After scrubbing, the mobile unit discharges its glowing contents into a fixed quenching station, the latter being equipped with water sprays and an exhaust stack (Fig. 9).

In other systems, the hood is separate from the quench car and is mobile on wheels. Above the battery doors is a common horizontal take-off main, terminating at a scrubber–exhaust station. Before an oven is pushed, the hood is connected to the common take-off main while the coke car is positioned under the hood. While the oven is being pushed, the exhaust fan and scrubber situated at the end of the common take-off main come into action, collecting and cleaning the smoke and dust generated.

A hooded car developed at the Gneisenau coke plant, West Germany, consists of a coke guide car with collecting hood coupled to an extraction plant, all as a mobile unit on wheels. On top of the hood are several powerful Rotovent venturi extractors operating with steam, the steam-raising equipment being attached to the mobile unit. Fig. 10 shows the extraction and quenching system. Although the system operates effectively, it is extremely heavy, and, as a result of the prolific white plumes of exhaust steam issuing from its eight Rotovent venturi scrubbers, it is referred to as Der Weisse Riese — The White Giant.

Coke Quenching

The current method of quenching, in which a strong spray of water is directed onto the red-hot coke charge in a vertical open-top tower, causes only limited pollution. The installation of wooden louvres in the upper portion of the tower with additional water sprays and with the tower stack somewhat offsets results in a carry-over of water vapour, and the particulate matter is further reduced. This system of control is generally accepted.

Dry Quenching

Dry quenching of coke, in which an inert gas like nitrogen is circulated through the hot coke in an enclosed chamber, is not a new concept, having been introduced in Europe in the 1920s and more recently in the U.S.S.R., where fifty such plants are in use. This system of quenching takes a major portion of the sensible heat in the coke to a waste-heat boiler. Several notable

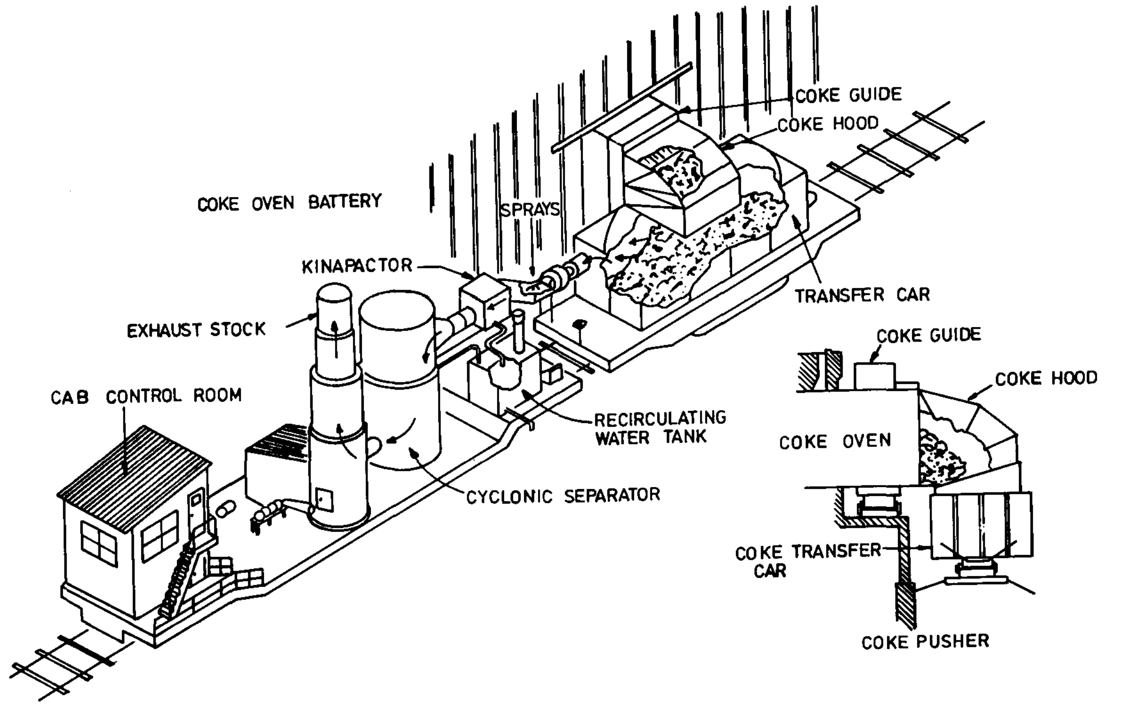

Fig. 9—A completely enclosed pushing system at the Brown's Island coke battery. A hood covers the oven door and the opening of the transfer car during the push, and air-cleaning equipment on the double unit disposes of the trapped emissions

advantages result: air- and water-pollution problems are eliminated and there is an effective saving in energy. A study indicates that this process can save 450 to 500 kg of high-pressure steam per ton of coke quenched, which is equivalent to between 1,3 and 1,5 × 10^6 MJ per ton of coke. Dry quenching of coke with heat recovery is popular in the U.S.S.R. because of the advantages indicated, especially the energy savings and the improvement of coke quality and blast-furnace performance. Many European steelmakers believe that the heat recovered in dry quenching is competing with a low-cost product (steam), which could be produced without difficulty from low-grade coal. They are therefore of the opinion that dry quenching is a costly undertaking in spite of the so-called advantages. Fig. 11 shows a cross-section of a dry-quenching tower.

The Sinter Plant

Sintering is an important operation in which reuseable fine materials like iron ore fines, coke fines, oxide scale, and iron-bearing sludges from blast-furnace and steel-plant operations are mixed and sintered for use in blast furnaces.

Uncontrolled sinter operations can be a serious source of low- and high-level emissions of dust, sulphur dioxide, and even fluorides, and greatly contribute to the total emissions from a steel works. Without controls, a medium-size plant producing 2500 t of sintered material per day could discharge 50 to 60 t of particulate matter per day around a steel works. A plant of this capacity at Iscor's Vanderbijlpark Works is reasonably well controlled with the aid of cyclones and electrostatic precipitators. Cyclones are used to control the emissions from the sinter combustion zone and from the ore-preparation rooms, whilst dust arisings from the cooling zone and from where sinter cascades down a chute to the cooling platforms are handled by an electrostatic precipitator.

In Iscor's Newcastle Works, which has a modern sinter plant to handle 7000 t of sinter per day, the controls for handling dust at the mixing rooms, sinter heat zone, and sinter cooling platforms are among the most modern in the world. It is estimated that 175 t of dust will be collected daily at an overall collecting efficiency of 95 per cent. No provision is made to control

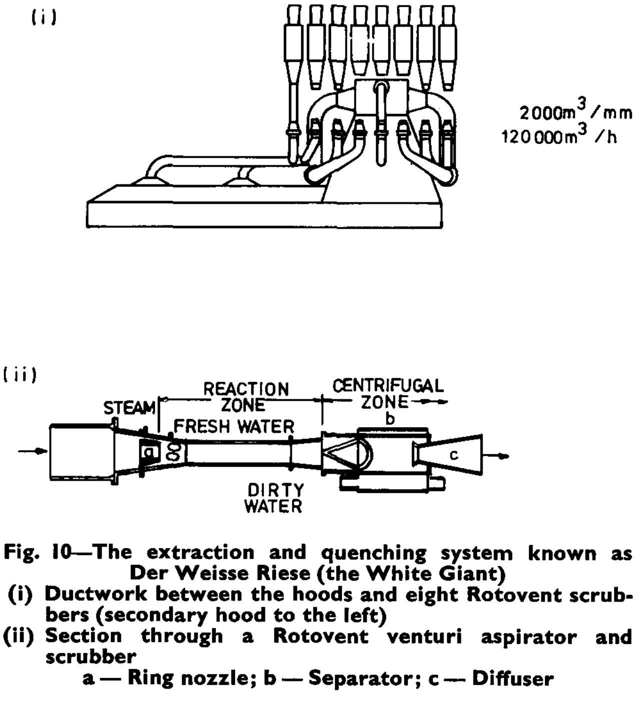

Fig. 10—The extraction and quenching system known as Der Weisse Riese (the White Giant)
(i) Ductwork between the hoods and eight Rotovent scrubbers (secondary hood to the left)
(ii) Section through a Rotovent venturi aspirator and scrubber
a — Ring nozzle; b — Separator; c — Diffuser

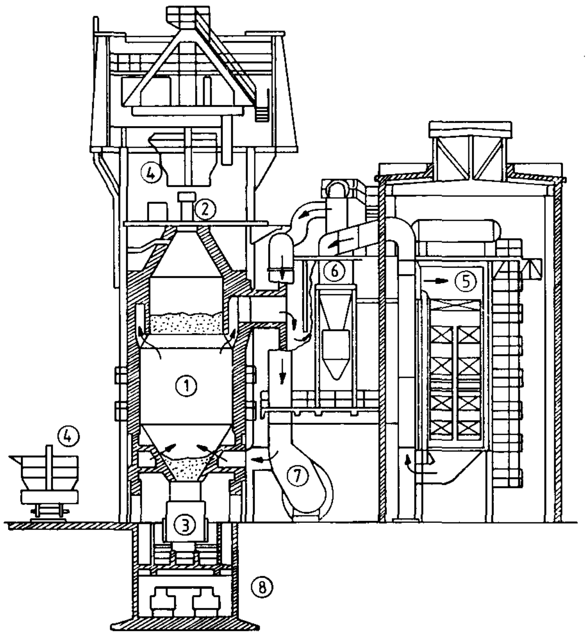

Fig. 11—Soviet type of dry quenching unit
1. Coke-quenching cell
2. Coke-entry airlock
3. Coke-exit airlock
4. Coke car
5. Heat-recovery boiler
6. Dust-removal cyclones
7. Gas-recirculating ventilator
8. Quenched-coke conveyors

1 ton of coke = $7,15 \times 10^6$ kcal (42% of heat recovered by dry quenching)
= 300 000 kcal/(t of coke)
= 430 kg of steam per ton of coke
= 100 kW/(t of coke)

emissions of sulphur dioxide and fluoride. The production of fluorides depends on the basicity* of the sinter mix. Calculations and tests indicate that, with a basicity of 2,3 to 1,8 in the sinter mix, between 6 and 24 kg of fluoride per hour could escape to atmosphere at concentrations of 0,004 to 0,018 g/m^3.s. For South African conditions, these quantities are not of any significance.

Table V shows the expected conditions at the Newcastle Works, where there will be 7150 t of sinter per day and a total extraction volume of 3 300 000 m^3/h. The capital cost of dust control units on the Newcastle sinter plant is high at R2,4 $\times$ 10^6, which is equivalent to 16 per cent of the total capital costs of the sinter plant.

Steelmaking

For almost a century, the Bessemer and open-hearth furnaces were regarded as the most acceptable steelmaking units. The open-hearth furnaces using producer gas, coke-oven gas, and blast furnace gas were never regarded as a threat to air pollution, except when oxygen blowing was practised. On the other hand, the Bessemer with its copious discharge of dense red-oxide fumes has always been a serious source of environmental pollution; up to 3 per cent of the furnace contents can reach the atmosphere and travel long distances.

With the development of the basic oxygen steel furnace, known as the B.O.F., there was a revolution in steelmaking. B.O.F. units of up to 300 t capacity are capable of producing steel in a round cycle of 40 minutes, compared with 6 to 7 hours in the open-hearth furnace. It is therefore not strange that most steel producers are switching over to the B.O.F. method of steelmaking, as shown in Table VI. In order to produce steel by this method, it is absolutely necessary to incorporate a positive working system to control atmospheric pollution.

Foremost in designing and supplying oxygen top-blown converters are the Japanese, who have also given serious attention to the control of oxide fume emissions. Their process of controlling such fumes is known as the O.G. process (Oxygen Converter Gas Recovery System), which is a wet gas-cleaning system with suppressed combustion during melting. Fig. 12 shows the converter and gas-cleaning system. The O.G. system differs from others in that it applies a moveable skirt round the

*Basicity is defined as the ratio $\dfrac{\%\,CaO + \%\,MgO}{\%\,SiO_2 + \%\,Al_2O_3}$

TABLE V

EXPECTED CONDITIONS AT THE NEWCASTLE SINTER PLANT

	In		Out		Removal %
	t/d	g/m^3.s	t/d	g/m^3.s	
Electrostatic: Room dedusting	96,0	10	0,67	0,07	99
Electrostatic: Sinter combust	62,4	2	2,18	0,07	96,5
Multi-cellular cyclones: Sinter cooling	19,2	0,5	6,98	0,12	76
	177,6	2,24	9,83	0,124	
Loading	24,8 kg/t		1,37 kg/t		
Overall efficiency of the units					94,5

TABLE VI

WORLD STEEL OUTPUT BY THE B.O.F. PROCESS

Year	B.O.F. %	Total t × 10^6
1960	4%	348
1970	43%	596
1980	67%	1 000

mouth of the converter, which is lowered during oxygen blowing, thus minimizing the entry of air to the furnace and largely suppressing combustion. This greatly reduces both the volume and the temperature of the evolved gases and fumes, allowing a substantial decrease in the gas-cleaning system and attendant power requirements. Many other oxygen furnaces allow sufficient ingress of air to ensure complete combustion for safety purposes, thus necessitating a large cooling and scrubbing plant. By operating a closed suppressed combustion system, this procedure would reduce the gas volume by up to 85 per cent. Energy derived from the carbon monoxide gas during the blowing of oxygen is equivalent to some 0,5 × 10^6 kJ per ton of steel and, for Iscor's Vanderbijlpark Works, 3,79 × 10^6 MJ/d. If such gas is used to generate power via a steam station of 70 per cent efficiency, some 34 000 kW.h/d could become available. However, there are several disadvantages associated with the collection of such gas, which is produced intermittently and not continuously.

In the O.G. system as installed at the Vanderbijlpark and Newcastle Works (150 t units), two-stage venturi scrubbers, mist eliminators, and subsequent combustion of carbon monoxide gas at the top portion of the stacks operate with great success. Measurements indicate that less than 120 mg/m^3 of dust discharges from the stacks, and the discharge is often as low as 80 mg/m^3. This achievement, together with the collection of secondary dust and fume at the ore bunkers and furnace mouths during furnace loading, is excellent and to the satisfaction of the authorities. The next step for the collection of fugitive dust and fume during casting, deslagging, etc. is now being pursued at several overseas plants. With these modern controls, oxygen steelmelting has now become one of the cleanest operations on a steel works.

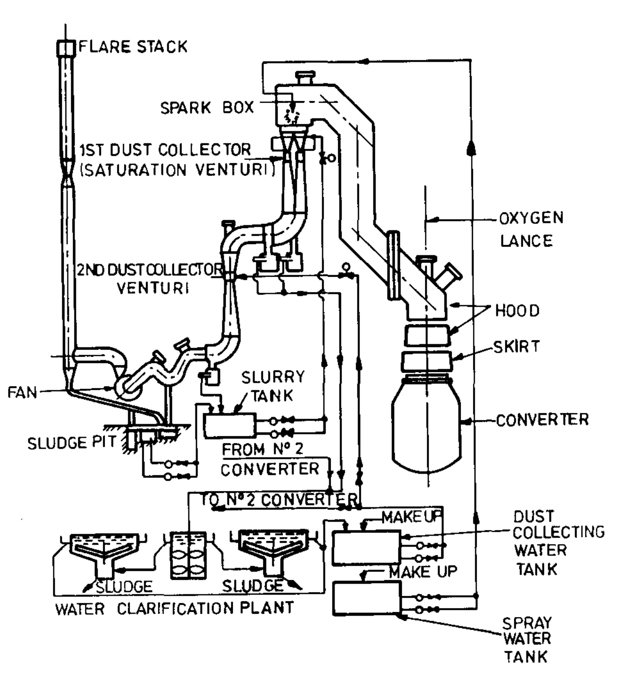

Fig. 12—Simplified diagrammatic arrangement of a spray and dust-collecting water system

The Electric Arc Furnace

The tendency in electric arc melting is for larger furnaces, and faster melting and refining with the aid of oxygen. Furnaces of up to 350 t capacity are not unusual these days. All these factors lead to increased rates of fume production, requiring higher investment and operating costs to take care of the approximate 1 per cent of iron oxide fume that is liberated. With the advent of direct reduction of iron ore, large tonnages of sponge iron will be passed directly to electric arc furnaces, thus bypassing the basic oxygen furnace. For many years, it was acceptable to collect only the emissions during melting, which could be withdrawn by direct evacuation. This is practised widely by evacuation through the fourth hole in the furnace roof. The fumes and gas are combusted by introduction of air at the water-cooled elbow to prevent explosions. The gases are then cooled by radiation–convection tubes before being cleaned in bag filters. Despite the negative pressure created by the extraction fan, fume escapes through the electrode openings and the charge door and during the tapping of the hot metal.

Owing to the severity of the requirements for the control of air pollution, it is now mandatory to collect and treat these secondary emissions, especially during charging and tapping. After many attempts to collect these emissions at their source, there appears no better way than to collect these under canopy hoods located in the roof of the building above the charging and teeming cranes. In order to be effective, large hoods with high extraction rates are required, and these have high capital and running costs.

At its Vanderbijlpark Works, Iscor has recently added a third 150 t arc furnace — the largest of its kind in South Africa. The first two units were equipped with direct evacuation through the fourth hole, but, to improve conditions, overall shop ventilation is now being provided for all three furnaces. This is being achieved by the introduction of six canopy hoods, each 19 m by 12 m over the three units. The hoods are interconnected and supplied with bladed louvre dampers, the operation of which is interlocked with the furnace control system. The cooler gases passing through the canopies cool the very hot gases exhausted from the furnaces and so protect the filter bags.

The extraction volume from the two existing furnaces of 7700 m^3/min will now be increased by a further 20 000 m^3/min. The ringed Dacron bags are capable of handling fume of 140°C with a gross air-to-cloth ratio of 0,85:1 and a net ratio of 0,94:1. The concentration of the emissions after filtration will be less than 100 mg/m^3, which is well below the legal requirements of 120 mg/m^3.

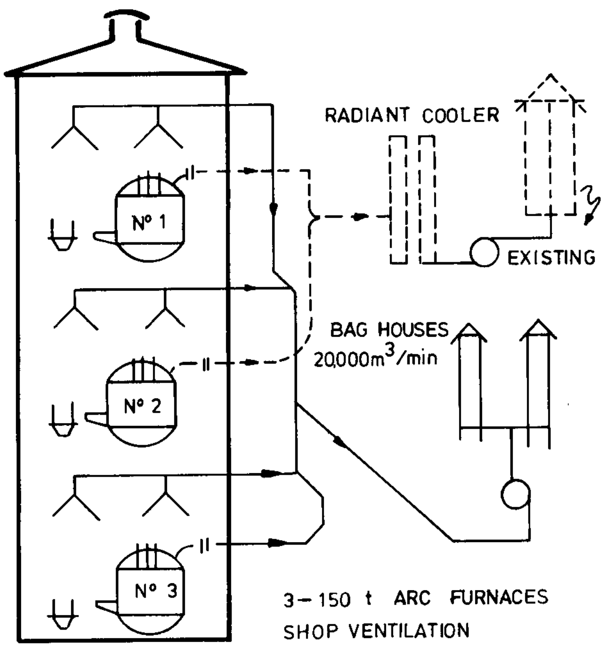

Fig. 13—The fume control system at Iscor's Vanderbijlpark Works

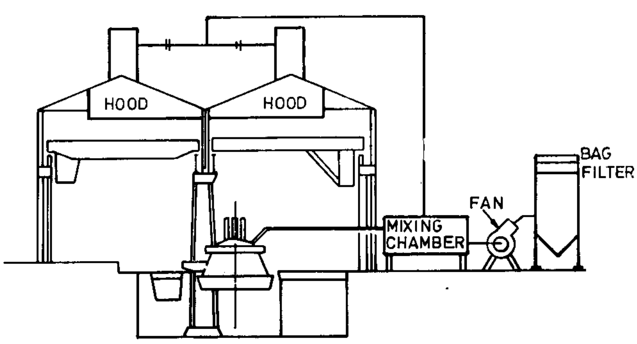

Fig. 14—Combined furnace extraction with full roof extraction

Figs. 13 and 14 show the arrangement as recently installed. The capital cost for the additional improved fume control system is approximately R1 $\times 10^6$, representing 11 per cent of the cost of the third arc furnace. For the first two units, the original cost for fume control was R0,85 $\times 10^6$, representing 8 per cent of the furnace cost.

Emissions of Sulphur

Emissions from steel works usually consist of sulphur dioxide and hydrogen sulphide, originating mainly from the primary fuel combusted (coal) and, to a lesser extent, from fuel such as oil and tar. The release of these gases to the atmosphere at a steelworks is probably not so serious since the bulk of such material is carried over in the coke to the blast furnaces and is found locked-up in the slag whilst some is discharged via high stacks at the coke ovens. With the dwindling supply of low-sulphur fuel — mainly coal — and with more stringent pollution-control measures, we in South Africa now have to control such gaseous emissions as well.

Table VII, which is a sulphur dioxide balance for Iscor's Pretoria Works, indicates that 45 per cent of the sulphur present in the Works is locked up in the slag. Although this sulphur is fixed, some is set free during slag granulation, although the amount has not yet been determined.

Table VIII indicates the approximate amounts of sulphur as sulphur dioxide in order of severity that discharges to the atmosphere from the Pretoria Works.

The technology for the removal of sulphur in the form of hydrogen sulphide is well proven, and many such installations are in operation in steel works and other plants. Such plants are capable of recovering valuable sulphur for sale, or can oxidize the sulphur on site to produce sulphuric acid. Iscor at its Newcastle and Vanderbijlpark Works has recently obtained such recovery plants for the removal of hydrogen sulphide from coke-oven gas and devil-gas vapours — the latter from its ammonium sulphate absorbers. The process involves the absorption of hydrogen sulphide with ammonia, followed by the Sulphammom process in which the hydrogen sulphide and other acidic gases are converted in an incinerator to sulphur dioxide and sulphur trioxide and ultimately to sulphuric acid. The process will ensure that 85 per cent of the hydrogen sulphide in the gas will be removed, i.e. from approximately 12 g/m^3 to between about 1,5 and 2 g/m^3.

If it is considered necessary to remove higher percentages of hydrogen sulphide from the gas (as is now necessary at Sasol, where large quantities of waste gas containing hydrogen sulphide are causing an unpleasant odour in Sasolburg and its surroundings), the Stretford process is most suitable. Such a plant is now in operation.

TABLE VII

HOURLY SULPHUR DIOXIDE BALANCE FOR ISCOR'S PRETORIA WORKS

	kg	%
Slag	1 332	45,1
Gas: Coke oven and blast furnace	392	13,3
Sinter: Fine coke	104	3,5
Gas producers: Coal	184	6,2
Steam boilers: Coal	386	13,1
Tar	70	2,4
Coke-oven effluent	40	1,4
Devil gas and by-products at coke ovens	200	6,8
Diverse: Difference	242	8,2
	2 950	100

TABLE VIII

HOURLY DISCHARGES OF SULPHUR DIOXIDE FROM THE PRETORIA WORKS

Operations	kg	%
Coke ovens in battery stacks and by-products operation	626	44,3
Steam boilers	429	30,3
Steel-melting furnaces — using large volumes of coke oven and producer gas	227	16,0
Sinter plants	132	9,4
Total	1 414	100,0

This process is capable[4] of removing over 99 per cent of the hydrogen sulphide, amounting to 57 t/d, which is of great value for the manufacture of sulphuric acid.

There is really no need to desulphurize blast-furnace gas because its sulphur content is extremely low (0,02 g/m^3 in contrast to coke-oven gas, which has a sulphur content of 4,8 g/m^3). After the sulphur has been removed from coke-oven gas, there is still, according to Table VIII, 50 to 60 per cent of the sulphur emission to be accounted for. This sulphur is present in the boiler, steelmelting, and sinter-plant stacks as sulphur dioxide. In time, as the Pretoria Works is modernized, the boilers could operate on gas and the steel plants on oxygen, leaving the sinter plant as the only source of sulphur dioxide. The latter's contribution is rather low. The removal of sulphur dioxide from sinter or boiler plants is a costly undertaking involving large plant. Although practised in Japan on a large scale, that being a highly industrialized country, such removal is not yet generally demanded in Europe, America, and South Africa. However, with the tendency to build larger and larger sinter plants, the removal of sulphur dioxide will no doubt become mandatory. With these recovery plants, the sulphur removed is generally in the form of calcium sulphate (gypsum), which has almost no resale value.

Conclusion

The several examples given do not present the total air-pollution picture of a steel works, but industry appears to be able to control the main sources of emissions. Controlling authorities are now also demanding the removal of secondary emissions like sulphur dioxide, hydrogen sulphide, fluorides, and phenol. The costs involved for this could exceed that for the control of primary emissions.

There is already sufficient evidence to show that, during the past decade or so, the amount of polluting matter emitted to the environment has decreased significantly. The public has now accepted this continuous improvement, and it stands to reason that people will not tolerate a decline in the standard of their local environment.

According to the British Royal Commission's Fifth Report[5] 'People's standards seem to rise as pollution lessens, so that from the enforcing authorities' viewpoint, expectations are always running ahead of what can be done'. If the industrial output continues to rise, one can expect the amount of polluting matter emitted per unit of product to fall — especially to keep our rivers and atmosphere in an acceptable condition. However, it is a well known fact that the removal of the more dilute portions of polluting matter becomes increasingly more difficult and costly.

Hence, pollution control will continue to be an increasingly important and costly aspect of process and plant design and of supply. It is also not difficult to see that pollution control will have an increasingly important bearing on the economic success of an industrial undertaking. Will the consumers always be prepared to pay for the additional costs involved, and what will the state of the environment be should there be a world war?

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