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Deter gjort en analyse av svovel tilførsel og etterspørsel og hvilke regioner som er viktige i denne sammenheng. Det er vurdert elementær svovel, Pyritt og andre svovelkilder. Faktorer som vil påvirke framtidig pyritt-forbruk er evaluert.
Markedene for Stordøkis som vaskegods og som flotasjonskis vurderes spesielt og det konkluderes med at bare i spesielt gunstige tilfeller vil verdien av avbrann og syre dekke kostnadene til transport.

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FERTILIZER CONSULTANCY & MINERALS INDUSTRY STUDIES

Associated with the British Sulphur Corporation Limited

CONFIDENTIAL

April 1969

REPORT ON

WORLD SULPHUR SUPPLY & DEMAND
AND THE MARKET PROSPECTS
FOR STORDO PYRITES

PREPARED FOR

AKTIESELSKABET STORDO KISGRUBER

BY

FERTILIZER CONSULTANCY & MINERALS INDUSTRY STUDIES

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SECTION - 1

DEMAND

World consumption of sulphur in all forms has increased in the period 1950 - 67 at an annual cumulative rate of 6% p.a. to reach 34.1 million tonnes S. Consumption in the Western World in this period rose from 11.2 million tonnes S to 26.6 million tonnes S corresponding to a cumulative growth rate of 5.2%.

In the period under review 1963-67 three distinct market developments occurred in the Western World. Early in 1963, after 5 years of relatively slow growth, world sulphur demand started to accelerate; during the subsequent $2\frac{1}{2}$ years it was boosted by the coincidence of strong demand growth in several major sulphur/ sulphuric acid use sectors, especially phosphate fertilizers. From 1966 onwards demand growth slowed down markedly, principally because of the build-up of large fertilizer stocks in N. America, due to over optimistic expectations of growth of domestic fertilizer demand and AID requirements.

Significantly the recession in sulphur demand affected primarily N. America and also Oceania, where adverse climatic conditions and a fall in the world prices of the major agricultural products of Australia and New Zealand caused a stagnation in fertilizer use and output and thus of sulphur use.

Elsewhere sulphur demand maintained its rate of growth, and especially in W. Europe sulphur demand in 1967 advanced significantly, stimulated by the sulphur requirements of the fibres industries. In the Communist Countries of E. Europe sulphur demand expanded at a slower rate than in previous years and especially in the U.S.S.R. it has come within the range of growth rates experienced in the industrialized countries of the Western World. Because the increase in world sulphur demand was primarily due to increased sulphuric acid requirements, the proportion of sulphur consumed for acid manufacture advanced to 84% (compared with 80% in 1963). The requirements of the non-acid sulphur industries stagnated.

The limitation on brimstone supply was most severely felt in Asia, notably in India and Taiwan, and in a small number of other markets such as Tunisia, Venezuela, S. Africa, which had previously looked to Mexico as their predominant supply source. In the U.S.A., apart from isolated company shortages, the overall supply met demand. In W. Europe the limited world brimstone supply did not cause serious repercussions, partly because of a more modest rate of increment in sulphur demand, but principally because of the greater employment of existing pyrites acid capacity and the expansion of facilities based on sulphur in other forms, notably SO2 in smelter gases, as well as of anhydrite. The amount of unused pyrites based sulphuric acid capacity in W. Europe totalled about $1\frac{1}{2}$ - 2 million tonnes (100% H_2SO_4), although because of obsolescence of plant and inability to attain rated output level, the effective margin probably did not exceed on average $\frac{3}{4}$ million tonnes H_2SO_4, or $\frac{1}{4}$ million tonnes S. This margin was, however, adequate to satisfy the expanding sulphur requirements in W. Europe and is reflected in the increased level of pyrites use in this period. It is, however, significant that while the sulphur "crisis" and attendant increase in brimstone prices resulted in an immediate acceleration of new mine developments and other expansions of fertilizer production capacity, expansion of pyrites roasting capacity was confined to producing countries and, as indicated above, only one plant, in Belgium, was built in an importing country. With the possible exception of Japan, which because of inadequate pyrite mine production capacity had to import pyrites, mainly from the U.S.S.R., not only was the world supply and production capacity of pyrites adequate to meet demand, but individual producing countries and producing companies especially in W. Europe had an ample margin between their production capacity and output, which was kept in line with demand.

The main weight of the sulphur demand boom 1964 - 1966 fell on brimstone. This is not surprising since the bulk of increased demand occurred in N. America where over 70% of sulphur use is in the form of brimstone and because new sulphuric acid plants built in this period in countries dependent on imported sulphur were, with exceptions, also brimstone based. The exceptions were the pyrite based sulphuric acid plant of Produits Chimiques de Limbourg in Belgium and the anhydrite acid plant of Solway Chemicals Ltd. in the U.K. Apart from this, new pyrites based acid plant construction occurred only in pyrites producing countries, notably Spain, Scandinavia, Italy, Japan, Philippines, Morocco and W. Germany. The sharp increase in world sulphur prices also re-stimulated interest in pyrites in a number of countries which, although possessing pyrite resources, had previously tended to look to imported brimstone to satisfy increasing sulphur/sulphuric acid needs. Thus in S. Africa, Australia, Taiwan new projects were initiated but these did not affect the current consumption pattern, as their completion was not due until 1968 - 1969. Similarly renewed interest in new pyrites based acid plants was evident not only in sulphur importing countries of W. Europe but also in the U.S.A. The recession in sulphur demand in the U.S.A. and the new brimstone supplies in sight, however, caused the U.S.A. projects to be abandoned, before construction had even started.

In W. Europe, because of adequate plant capacity, the need for new plant construction was not too pressing so that individual projects were being repeatedly re-evaluated in the light of the changing brimstone supply/demand and price situation.

In 1963 there was much unused pyrites based acid capacity which was progressively being taken up so that as brimstone became more expensive, European pyrites acid capacity became fully employed, while brimstone acid plants were being underemployed. Also a significant part of new acid demand was being met by new plants based on SO_2 in smelter gas, the number of which in this period was fortuitously above average.

The resultant evolution of world sulphur demand was as follows:

	Million tonnes S				
	1963	1964	1965	1966	1967
TOTAL	26.5	28.7	30.7	33.2	34.4
Western World	20.8	22.3	23.9	25.8	26.6
Communist Countries	5.7	6.7	6.8	7.4	7.8

The pattern of consumption of sulphur in the various forms was as follows:-

Western World					
Brimstone	11.3	12.5	13.9	15.3	15.5
Pyrites	5.7	5.9	6.0	6.3	6.7
S in other forms	3.7	3.9	4.0	4.2	4.4
Communist World					
Brimstone	1.6	1.9	2.1	2.3	2.5
Pyrites	3.0	3.2	3.3	3.5	3.6
S in other forms	1.1	1.3	1.4	1.6	1.7

This corresponds to the following annual growth rates:

Consumption	Percentage increase over preceding year			
	1964	1965	1966	1967
Western World: TOTAL	7.7%	7.2%	7.9%	3.1%
Brimstone	10.6%	11.2%	10.1%	1.3%
Pyrites	3.5%	1.6%	5.0%	6.3%
S in other forms	5.4%	2.6%	5.0%	4.8%
Communist World: TOTAL	12.3%	6.3%	8.8%	5.4%
Brimstone	18.8%	10.5%	9.5%	8.7%
Pyrites	6.7%	3.1%	6.0%	2.9%
S in other forms	18.2%	7.7%	14.2%	6.3%

REGIONAL DEMAND

N. America

The abundant brimstone supplies in N. America, in particular the availability of low-cost Frasch sulphur in Texas and Louisiana, and of recovered sulphur in Alberta and the proximity and export surplus of Mexican Frasch sulphur, inevitably orient consumption and new plant construction towards these sources of sulphur supply.

About 75% of sulphur consumption in the U.S.A. and about 60% in Canada is in the form of brimstone, of which in the U.S.A. about 90% and in Canada 60% is delivered in liquid form to conumsers plants.

U.S. Frasch sulphur is consumed predominantly by phosphate fertilizer industry of Florida, along the Atlantic seaboard and the U.S. Gulf, and up-river along the Mississippi and major tributaries. Mexican Frasch sulphur is imported almost exclusively by consumers in Florida and those along the Eastern seaboard, whereas Canadian recovered sulphur supplies the West coast of the U.S.A., the North Western States and increasingly the North Central States where it meets and competes with Frasch sulphur coming up-river. The additional substantial U.S. recovered sulphur supplies are mostly used locally although because of local surpluses, notably in Texas, the output from some plants is often railed over long distances to consuming plants.

Pyrites consumption is almost wholly integrated, although the largest single consumer Allied Chemical Corp. depends on imported Canadian pyrite concentrates bought on long term contracts and shipped to plants situated at freight favourable locations in the North Central States. The decline in pyrites production and use in the U.S.A. is wholly attributable to the closure of the mines in Shasta Co., California which, had the Stauffer project been realised would have re-opened.

In Canada also pyrites consumption is wholly integrated. The potential supplies of pyrite concentrates arising as tailings at non-ferrous sulphide ore treatment plants are vast and consumption is dependent on rail freight cost and valorisation of the residue which is almost pure iron oxide, with low Cu/Zn values within limits of acceptability by the steel works.

Of the large consumption of sulphur in other forms in N. America the use of acid sludge accounts for nearly one-half. It is a special feature of the oil refining industry and usually sludge is delivered over the fence from the refinery to a sulphuric acid plant where the sludge is burnt to SO_2 and the virgin acid supplied back to the oil refinery. Most of the balance of sulphur in other forms is used as SO_2 in metal smelter gas converted into sulphuric acid and some into liquid SO_2.

Latin America

Sulphur consumption throughout Latin America is predominantly in the form of brimstone, mainly as the result of the traditional export pressure of U.S. Frasch sulphur coupled with the indigenous supplies of refined native sulphur in most South American countries. The use of pyrites is confined to a single operation in Chile where a small tonnage of flotation pyrites is captively roasted to sulphuric acid. Cosnumption of sulphur in other forms is mainly a reflection of metal smelter activity and the attendant production of sulphuric acid from SO_2 in smelter gases. The utilisation of this sulphur source is however only a fraction of the potential, and much SO_2 continues to be wasted, as the volume of acid production is circumscribed by the level of local acid demand. Of all Latin American countries only Mexico is wholly self-suggicient and all other markets import brimstone, which with few exceptions, supplements domestic productions of native refined sulphur production or of recovered sulphur from oil refinery operations. U.S. Frasch sulphur accounts for the greater part of imports but increasing quantities are supplied by France, Mexico and of course, intra-regional trade of native refined sulphur mostly from Bolivia and some from Chile. New projects are based on the use of brimstone and only in Brazil has the use of indigenous pyrites received consideration.

W. Europe

Traditionally a significant proportion of European sulphur requirements have been met in the form of pyrites and sulphur in other forms and brimstone consumption still does not exceed 40% of total use. Since the late 1950's the growth in pyirtes use has been confined to pyrites producing countries, although in italy much of the growth is attributable more to increased imports of Rumanian pyrites rather than to increased domestic pyrites supplies. In importing countries pyrites consumption has declined and even during the period of tight world brimstone supplies of the mid-1960's consumption failed to show a significant increase mainly due to limitations of roasting plant capacity and in this period only one new pyrites roasting plant was installed, i.e. in Belgium based on Iberian pyrites.

The mounting brimstone requirements of W. Europe are met in the first place by supplies of recovered sulphur from sour gas in S.W. France (SNPA at Lacq) and from oil refining and by the traditional exporters of U.S. and Mexican Frasch sulphur. Hitherto Canadian recovered sulphur supplies have played only a negligible part in the W. European supply pattern, whereas since 1967 Poland has assumed increasing importance.

Africa

Sulphur consumption in Africa is in the main based on indigenous resources of pyrite where those exist and imported brimstone, since apart from a small production of recovered sulphur in S. Africa and in Egypt, Africa lacks a supply source of brimstone. At the large scale metallurgical activities in the Congo, in Zambia and in S. Africa a part of the SO_2 is utilized, but especially in Zambia, the potential is much greater.

The only importers of pyrites are Egypt and Tunisia and occasionally S.W. Africa; Tunisia receives its pyrites from neighbouring Algeria, the intermittent requirements in S.W. Africa are met by Spain and Egypt, formerly a buyer of Cyprus pyrites, is currently a buyer of Spanish and Yugoslav pyrites, almost exclusively procured on a barter basis. Of much greater importance are the pyrite based sulphuric acid operations in S. Africa and Morocco and to a lesser extent in Rhodesia, where indigenous pyrites supply, in S. Africa in the form of by-product flotation concentrates, accounts for a large part of total sulphur consumption.

Asia

Except in Japan and on a much more modest scale in the Philippines, the sulphur consumption pattern in Asian countries is determined by imported brimstone. Even in Taiwan where there is a modest consumption of indigenous pyrites and of indigenous native and recovered sulphur, the bulk of sulphur demand is met in the form of imported sulphur. In Japan the entire sulphur requirements of the sulphuric acid sector are met by pyrites and sulphur in other forms, notably SO_2 in smelter gas and sulphur ore for direct use in roasters. Despite the magnitude of Japan pyrites mining industry, the second largest in the world, it is found necessary to import pyrites from time to time and the substantial imports in 1966 and 1967 originated from the U. S. S. R.

Oceania

In Australia about one-half of the sulphur requirements are met by imported brimstone, and pyrites and sulphur in other forms (SO_2 in smelter gases) account for about one-quarter each. Pyrites use is subsidised on a sliding scale in relation to the landed price of imported brimstone, but nevertheless pyrites consumption has stagnated in the past ten years and has recently declined when West Australia plants ceased using pyrites. At the same time there are abundant supplies of by-product flotation concentrates for which there is no local markets and due to high shipping costs no export markets. The whole of New Zealand's and Polynesia's sulphur needs are met in the form of imported brimstone.

Communist Countries

Sulphur consumption in the Communist countries of E. Europe and the Far East, which during the past two decades has expanded at very high rates of growth mainly due to the low level of consumption in the immediate postwar period, remains based substantially on indigenous supplies of sulphur in various forms.

The abundant availability of pyrites, especially in the U.S.S.R., China, and several E. European countries, has resulted in a use pattern in which pyrites predominates. There is also strong emphasis on the use of sulphur in other forms mainly SO_2 in smelter gas and in E. Germany also anhydrite/gypsum. Brimstone use is prevalent only in Hungary and has a relatively important position in Czechoslovakia and Poland. The brimstone requirements of U.S.S.R. and several Comecon countries necessitated imports from the Western World, mainly from Canada and the U.S.A. and to a lesser extent Mexico and France, and these substantially exceeded the marginal exports to Western European markets, notably Scandinavia and Central Europe, of exports of brimstone from U.S.S.R./Poland/E. Germany. Brimstone demand within the Communist Bloc is met by U.S.S.R. and increasingly by Poland. China's exports, both to E. Europe and some Free World markets (Japan, Australia, Italy) were temporarily in evidence in the mid-1960's.

The volume of pyrites trade between Comecon countries is not significant in relation to total usage and is mainly represented by Jugoslav and Roumanian pyrites shipped to Czechoslovakia and U.S.S.R. pyrites shipped to E. Germany. Of more significance are the pyrite exports to W. Europe which until 1968 by far exceeded those of brimstone.

WORLD SULPHUR SUPPLIES

In 1967 world production of sulphur in all forms totalled 34.5 million tonnes, of which 51.9% was produced as brimstone, 30.3% as pyrites and 17.8% as sulphuric acid (including liquid SO_2). In the Western ("Free") World the relative importance of brimstone in the supply pattern is greater, amounting to 58.7%, at the expense of pyrites which represent 27.5%, whereas the proportion of sulphur in the form of sulphuric acid (including SO_2) is also 17.8%.

In Table I and II, the supply pattern is analysed according to the sulphur sources.

Table I

World Sulphur Supply - 1967

	Million Tonnes S	%	Produced and Consumed in the form of:	
			Brimstone %	Other Forms %
Native Sulphur Ores of which:	11.6	33.6		
by Frasch process	9.1	26.4	26.4	-
by Conventional mining	2.5	7.2	6.6	0.6
Pyrites	10.6	30.7	0.4	30.3
Sulphide Minerals	3.6	10.4	+	10.4
Oil and Gas	6.4	18.6	17.4	1.2
Sulphates	0.9	2.6	-	2.6
Coal	0.6	1.7	1.1	0.6
Other Waste Products	0.8	2.4	-	2.4
	34.5	100%	51.9	48.4%

\+ less than 0.1%

Table II

Western "Free" World

	Million Tonnes S	%	Produced and Consumed in the form of: Brimstone %	Other Forms %
Native Sulphur Ores of which:	9.6	37.0		
by Frasch process	8.9	34.2	34.2	-
by Conventional mining	0.7	2.8	2.0	0.8
Pyrites	6.5	24.9	0.4	24.5
Sulphide Minerals	2.3	8.9	+	8.8
Oil and Gas	5.9	22.7	22.1	0.7
Sulphates	0.7	2.6	-	2.6
Coal	0.2	0.8	0.1	0.7
Other Waste Products	0.8	3.1	-	3.1
	26.0	100%	58.7	41.3

+ less than 0.1%

Evolution of Free World Production

During the period 1950-1967, Free World supplies of sulphur in all forms have increased from 11.2 to 26.0 million tonnes S, at an annual compound rate of growth of 5.1%. The strong growth of world sulphur demand in the mid 1960's stimulated Free World sulphur production which has advanced as follows:

	Production (Million tonnes S)	Increase over preceding year: Million tonnes	Increase over preceding year: %
1964	21.7	1.59	6.9
1965	23.3	1.62	2.3
1966	24.8	1.52	6.5
1967	26.0	1.28	5.2

Sulphur production in the Communist countries, Eastern Europe (including U.S.S.R.) and the Far East, has increased from 1.8 million tonnes S in 1950 to 8.5 million tonnes S in 1967. The rapid economic growth in Communist countries is also reflected in the evolution of sulphur production and consumption.

	Free World	Communist Countries	World
	(Growth rate % p.a.)		
1950/1960	5.1	7.8	5.3
1950/1967	5.1	10.3	5.8
1960/1967	5.1	12.1	5.8

Pattern of Free World Sulphur Supply

The pattern of world sulphur supply has undergone three significant changes in the past 15 years. The proportion of total world sulphur supply represented by sulphur in pyrites has declined substantially after a short-lived increase after the sulphur crisis in the early 1950's; that represented by sulphur in "other" forms after a rapid increase during the 1950's has been declining since 1960, whereas the proportion of total world supply represented by brimstone, after decreasing up to the late 1950's, has since expanded sharply. These changes of the world sulphur pattern reflect primarily the availability and the price level of brimstone, which to the sulphur user, notably the sulphuric acid manufacturers, is the preferred sulphurous raw material, mainly because of the simplicity and relatively low capital and operating cost of plant in which it is consumed.

The world pattern of sulphur supply has changed as follows:

	1950	1955	1960	1965	1967
Production (Million tonnes S)	11.2	15.6	18.5	23.3	26.0
Represented by: (%)					
Brimstone	53.2	49.5	50.9	56.2	58.8
Sulphur in Pyrites	32.4	34.4	30.5	26.5	24.3
Sulphur in other forms	14.4	16.1	18.6	17.3	16.9

In the evolution of the supply pattern of brimstone, the outstanding features are rapid growth of the share of recovered sulphur, notably from sour natural gas and oil refinery gases, and the decline of the importance of elemental sulphur refined from mined natural ores, the high production cost of which compared with world market prices has restricted the output. The pattern has changed as follows:

Free World Brimstone Production in Various Forms

('000 tonnes)

	Frasch Sulphur %	Recovered %	Native %	TOTAL
1950	88	6	6	5,970
1955	83	11	6	7,704
1960	67	27	6	9,418
1965	59	37	3	13,101
1967	58	38	3	15,271

Brimstone Suppliers

In the Free World there are currently 5 major sources of brimstone supply, which account for about 93% of the total supply of about 14.2 million tonnes.

Frasch sulphur in the U.S.A.	46%
Frasch sulphur in Mexico	12%
Recovered sulphur in Canada	15%
Recovered sulphur in France	11%
Recovered sulphur in the U.S.A.	9%

FRASCH SULPHUR

U. S. A.

Sulphur Bearing Dome Structures

Salt dome structures in the U. S. A. in which sulphur bearing ores have been identified occur in:

(a) The northeast of Texas and Louisiana, and the States of Mississippi and Alabama. These occurences do not offer exploitable resources.

(b) West Texas

(c) The coastal areas of Texas and Louisiana

(d) Off the shores of Texas and Louisiana including the outer Continental shelf.

West Texas

In West Texas, important new developments are at present in progress. One production plant came on stream in February 1968, one in June 1968 and one further structure is being developed. The latter, in Culberson County, represents reserves, as reported by Duval Corporation, of over 50 million tonnes sulphur and exploitation is due to start in 1970 at an annual rate of $1\frac{1}{2}$ million tonnes.

The significance of the West Texas developments lies in the fact that although sulphur ore does not occur in dome formation, they are amenable to exploitation by hot water injection similar to the classic Frasch process.

Dome Structure in the coastal regions of Texas and Louisiana

To date exploitation has, with the exception of one dome, taken place exclusively in the coastal region, where some 69 domes have been evaluated as potential sources of Frasch sulphur. Of these, 9 are at present being exploited and five previously exploited domes have been reactivated. There are some 1 or 2 similar domes which may be capable of being reactivated. 33 domes have been eliminated either by exploitation or for reasons of unfavourable geology, and 10 have been exhausted following exploitation on various scales. Of the remainder, some 7 are considered to be unfavourable, but the possibility of their successful exploitation cannot be excluded. A number of small domes said to number 4-6 have been identified and their exploitation is likely to be undertaken.

Reserves

There are no official data of either total or recoverable sulphur reserves in individual domes. Producing companies in the U.S.A. are understood to refrain from making exact evaluations of total reserves in view of prevailing tax regulations. The data shown are estimates based on available information.

U.S. Sulphur Domes

	No.	Estimate of Reserves Min.	Max.
		(million tons)	
Domes currently being exploited	14	92	135
Domes capable of being reactivated	1-2	1	10
Domes considered unfavourable	7	0	20
Domes as yet unexploited	4-6	2	10

Off shore domes

To date three sulphur bearing dome structures have been brought into operation, i.) Grand Isle (Block 18) exploited by Freeport Sulphur Company; ii.) Caminada (Block 16) exploited by Freeport Sulphur Co.; iii.) Lake Hermitage (5 miles off Galveston) by Jefferson Lake Sulphur Co. It is evident that with the present off shore sulphur mining technology, the number of economically viable operations will be substantially fewer than those on dry or marsh land, as the capital cost of off shore operations postulates large scale production and reserves, whereas on dry or marsh land, small to medium sized domes have been exploited profitably. To date some 10-12 off shore domes have been prospected for sulphur (including San Luis Pass, 25 miles west of Galveston, West Delta Block 30).

Explorations on the outer Continental Shelf have to date failed to identify an economically exploitable sulphur dome structure. Off shore dome sulphur reserves are estimated at 50-70 million tonnes.

Production and Producers

U.S. Frasch sulphur is the largest source of world supply, a position which it attained in the early years of this century when its output passed that of the flourishing Italian/Sicilian sulphur mining industry and that of the pyrites industry on the Iberian Peninsular. Its dominant position in the world sulphur industry was impregnable until the mid-1950's, and in 1956 it attained a production peak of 6.42 million tonnes unsurpassed until 1966. The advent of other major low cost sources of sulphur supply, i.e. Mexican Frasch sulphur and large scale sulphur recovery from sour gas in France and Canada, put an end to the U.S. Frasch sulphur industry's virtual monopoly in world export markets and also faced it with serious competition in the home market. Statistically this is reflected in the recession of output in the period 1957 - 1964.

U.S. Frasch Sulphur

	Production	Domestic Deliveries	Exports
1961	5,460	3,555	1,611
1962	5,076	3,440	1,557
1963	4,959	3,482	1,592
1964	5,311	4,313	1,819
1965	6,214	4,790	2,576
1966	7,112	5,490	2,310
1967	7,098	5,820	2,020

U.S. Frasch sulphur remains the largest supplier to world export markets, although its importance has declined from supplying over 90% in the early 1950's to about 35%, due to the increasing share of world trade being claimed by its main competitors, Mexico, Canada and France. The principal market for U.S. Frasch sulphur remains Western Europe, the U.S. export pattern being as follows:

U.S. Sulphur Exports

	1964 %	1965 %	1966 %	1967 %
Western Europe	39	54	52	47
Asia	20	15	9	17
Oceania	17	9	14	13
Africa	1	3	5	3
North America	8	6	7	6
South and Central America	12	11	12	14
Communist Countries	3	1	1	+

Producers

Until last year the industry was represented by four companies:

Freeport Sulphur Company

The world's largest single sulphur producer, output from the company's domes in 1966 and 1967 exceeded 4 million tons. The operating domes, all of which are located in Louisiana, are as follows:

	Production 1967 (million tons)	Started	Production to date (million tons)
Grand Ecaille	1.4	1933	32.6
Garden Island Bay	0.8	1953	7.9
Lake Pelto	0.6	1960	3.2
Grand Isle	1.4	1960	4.6
	4.2 +		

+ does not add due to rounding

In February 1968 the company brought on stream Caminada Dome, about 7 miles off shore, which is expected to have an annual capacity of at least one half million tons brimstone.

Texas Gulf Sulphur Company

Although the company recently diversified its mining interests into phosphate, potash and non-ferrous metals, it retains its traditional dominant interest in sulphur, which is reflected by world-wide exploration and holdings of potential sources of sulphur in various forms (see Canada, Mexico). In 1966 the company produced about 2.5 million tons sulphur from the following operating domes in the U.S.A.

	Production 1966 (million tons)	Started	Production to date (million tons)
Boling (New Gulf)	1.5	1929	61.8
Fannett	0.2	1958	1.9
Gulf	0.1	1919*	12.5
Moss Bluff	0.2	1948	5.1
Spindletop	0.6	1952	6.6
	2.5 +		

(* Restarted in 1965)

+ total does not add due to rounding

In June 1968 the company brought on stream Bullicamp dome, La., which is expected to have an annual capacity of about 300,000 tons brimstone.

Jefferson Lake Sulphur Company

A subsidiary of Occidental Petroleum Company, the company has a long tradition of Frasch sulphur mining and through its subsidiary it is also substantially engaged in the production of recovered sulphur in Canada. It operates one dome, Long Point, in Texas, which in 1967 produced about 0.3 million tonnes. Since the start of operations in 1946, the dome has produced 4.8 million tonnes brimstone.

The company has brought on stream in February 1968 a Frasch plant at Lake Hermitage dome, La., which is expected to produce 200,000 t.p.a.

Duval Corporation

The company's operating dome, Orchard, is nearing exhaustion. In 1967 it produced about 0.1 million tons, having since its start-up yielded 5.3 million tons brimstone.

New Frasch sulphur production facilities have been developed by the company in the Fort Stockton area, West Texas, where new capacity of 400,000 t.p.a. came on stream early in 1968. Based on this experience, the company plans to develop a similar formation in Culberson County, West Texas with an initial production capacity of $1\frac{1}{2}$ million t.p.a.

Sulphur Export Corporation

Re-established in 1958, Sulexco acts as an overseas sales corporation for the four traditional U.S. Frasch sulphur producers and exporters operating within the terms of the Webb-Pomerene Act. It is constituted by Texas Gulf Sulphur Company (42%), Freeport Sulphur Company (42%), and Jefferson Lake Sulphur Company (16%), Duval Corporation having resigned in 1967. Each of the member companies allocate its export availability to Sulexco which acts as the contracting party with overseas buyers.

In addition to the above named producers, there are four companies which entered the Frasch sulphnr industry with the object of re-activating and exploiting sulphur domes which had been abandoned in the past. Their ability to do this etems in part from the availability of new equipment (mobile boiler plants), improved techniques and principally the higher level of sulphur prices now prevailing. They are:

Union Texas Oil Co., a subsidiary of Allied Chemical Corporation, which started production in September 1966 at Sulphur Dome, La., originally operated by Union Sulphur Company and abandoned in 1924.

Phelan Sulphur Company, which in October 1966 resteamed Nash Dome, Texas, operated until 1956 by Freeport Sulphur Company. None of these operations has yet come up to expectations, but may do so if Texas Gulf Sulphur Company's experience at Old Gulf is any guide.

Hooker Chemical Co. resteamed Bryan Mound in 1967. Operations abandoned in August 1968.

John Mecom & Co. resteamed Nash Dome in 1967.

Quality

The bulk of U.S. Frasch sulphur is "off-colour" or "dark", i.e. it contains varying quantities of bitumen. The only major dome producing "bright sulphur", i.e. sulphur with less than 0.08% C, is Texas Gulf Sulphur Company's Boling Dome. Producers requiring bright sulphur to meet customers' needs subject dark sulphur to a treatment process.

Liquid Sulphur

Some 90% of deliveries to U.S. domestic market, representing about 5 million tons, and about one quarter of U.S. exports, 0.6 million tons, are moved in liquid form by ocean going liquid carriers, barges, rail and road tankers. This mode of transport assumed increasing importance from the late 1950's onwards. Currently there are about 50 terminal installations in the U.S.A. owned, operated or used by U.S. Frasch producers and two - Rotterdam and Dublin - owned and operated by Sulexco abroad.

MEXICO

Salt dome formations

On the Isthmus of Tehuantepec are mineralogically similar occurrences to those on the U.S. Gulf coast, but their geological structure appears to be more irregular and indeterminate, which has a direct bearing on any evaluation of actual or potential sulphur reserves. Although very large potentially sulphur bearing structures are known to exist, to date there has been relatively little detailed drilling exploration with the result that the margin of error in evaluating sulphur resources of Mexico could be very large. Of the areas explored to date, about 5% have been proved to be productive.

An estimate of reserves of recoverable sulphur is therefore subject to a wide margin of error:

Mexican Sulphur Domes

	No. of domes	Estimate of Reserves (million tonnes)	
		Min	Max
Domes currently being exploited	2	30	50
Other identified dome formations	4	10	20
Other formations	-	10	200

Production

The sulphur formation on the Isthmus of Tehuantepec was identified and explored by the Brady Brothers in the 1940's. Sulphur production started in 1954 and to date five companies have developed and exploited individual dome formations. Of these, three companies are active today, one failed due to lack of adequate reserves, and the fifth did not progress beyond intermittent preliminary operation of the dome which may, however, be resumed by another company with better plant in the near future. In addition there are 12 companies, all at least 66% Mexican owned, engaged in exploration, having obtained concession areas from the Government.

As indicated below, domestic deliveries to date account for less than 9% of total shipments and Mexican Frasch sulphur is destined primarily to the U.S.A. which accounts for about one half of total deliveries, and to world markets, notably the major markets in W. Europe and Oceania.

	Production	Domestic Deliveries	Exports
		('000 tonnes)	
1961	1,173	35	1,148
1962	1,374	55	1,324
1963	1,480	92	1,468
1964	1,648	122	1,884
1965	1,592	102	1,556
1966	1,650	139	1,630
1967	1,824	155	1,649

Producers

1. Cia. Azufrera Panamericana

Operates the Jaltipan dome, which is within a concession area of 7,500 acres. Production in 1967 totalled 1.5 million tonnes, dome production started in 1954 and output to date is 11.7 million tonnes. To meet the requirements of the Mexican Government, the company in the past two years has been engaged on an intensive exploration programme, and has proved some 25 million tonnes sulphur reserves.

In 1967 the Mexican Government and Mexican private investors purchased from Pan American Sulphur Company (PASCO), 66% of the share capital, at the same time appointing PASCO, which retains 34% of the capital, as managing and operating consultants.

2. Gulf Sulphur Corporation (Division of Gulf Resources and Chemical Corp.)

This U.S. company, through its subsidiary Cia. Azufrera de Veracruz, operates the Mezquital dome. Production in 1967 totalled about 0.3 million tonnes, and since its start-up in 1956, the dome has produced about 3.3 million tonnes brimstone. The company has developed reserves on the adjacent Salinas dome, and exploration is on the point of starting, using the existing plant at Mezquital which has been expanded. Mexicanisation of the company is imminent.

3. Cia. Exploradora del Istmo

As a wholly-owned subsidiary of Texas Gulf Sulphur Co., this company operated from 1957 to 1960 the Nopalapa dome, producing about 0.3 million tonnes which is stockpiled in a vat at the mine site. In 1967 Texas Gulf Sulphur Company formed a new company, of which 66% is owned by the Mexican Government and Mexican investors, and resumed Frasch sulphur production at Nopalapa. Plans to install a 500,000 t.p.a. Frasch plant on the company's Texistipec concession are expected to be deferred until the mid 1970's.

4. Azufrera Anahuac

The company formed by International Helium Company (34%), in association with Mexican interests holding 66% of the share capital, plans to install a Frasch plant with 400,000 t.p.a. capacity at the Texistipec dome which has been previously developed and operated for a short period.

5. Mexican Gulf Sulphur Co.

This company exploited San Cristobal dome from 1954 to 1957, producing 160,000 tonnes. Operations ceased due to inadequate reserves and lack of capital to explore further within the concession area.

Quality

All Mexican Frasch sulphur mined to date is "dark" sulphur containing up to 0.3% C, normally 0.15 - 1.25% C. Part of the production of PASCO is subjected to an acid treatment and filtering process resulting in a product containing less than 0.08% C. and in future all solid sulphur for export will be of this quality.

Liquid Sulphur

All three producers supply liquid sulphur in ocean going carriers to terminals in Tampa, Fla. and the Atlantic Seaboard and PASCO also ships to a terminal at Immingham, U.K.

Legislation

Under Mexican Mining Laws of 1960, companies engaged in mineral mining must be more than 50% Mexican owned. In the case of sulphur mining companies established after 1960, the proportion of share capital held by Mexican nationals must be at least 66%. This law did not apply retrospectively but is being applied in respect of newly formed companies or newly issued concessions.

POLAND

The development of hot-water injection process similar to the Frasch process, has permitted the exploitation of some of the Polish sulphur structures by this method, notwithstanding that these are not sulphur domes.

Since 1966 when pilot plant operations started, two deposits are now being fully exploited - Grzybow and Jeziorko - and two further deposits are being developed. Production level in the second half 1968 was about 1,200 tonnes per day and 900/1,000 tonnes per day. (Statistical details are included under the section on conventional sulphur ore mining/refining.)

U.S.S.R.

Recent reports indicate that the Russians are also employing a hot-water injection process at their deposits in the Ukraine, which are an extension of the Polish deposits. No details on production levels are known, but recently Russian "Frasch Sulphur" has been offered in W. European markets.

RECOVERED SULPHUR

The recovery of sulphur contained in natural gas, oil refinery gases, and other industrial gases is determined by two distinct considerations. In the case of natural gas the extraction of sulphur which is present as hydrogen sulphide and organic sulphur compounds is mandatory to comply with specifications laid down for pipelines and by gas users. The volumes of extracted H_2S postulate recovery in the form of elemental sulphur, which together with extracted LPGs contributes to the valorisation of the crude gas. Thus there is a direct correlation between production of sour natural gas and recovered sulphur. This does not apply elsewhere except in the case of pyritic smelting (see below). Refiners of sour crudes, i.e. crude oil containing varying quantities of sulphur, results in the presence of H_2S and organic sulphur compounds in the various refined products. The quality requirements of the lighter fractions, i.e. down to Gas and Diesel oils, as a rule necessitate extraction of sulphur. Part is removed in unrecoverable form but the bulk is converted to H_2S which is subsequently recovered as elemental sulphur or as sulphuric acid (see below - Sulphur in Other Forms).

By far the greater part of the sulphur originally present in the crude oil, however, remains in the heavy fraction fuel oils, residue, coke and bitumen and to date is not recovered except in two known instances.

In a few instances of carbonisation of sulphur containing coals, the generated H_2S is extracted and recovered as elemental sulphur, but other means of extracting (ferrous oxide) or recovery (sulphuric acid) are more common. In the case of pyritic smelting, the labile S-atom of pyrite (one third of the sulphur present in pyrites) is recovered in elemental form.

To date only major sources of recovered sulphur from sour gas are France, W. Canada and the U.S.A.

At the vast oil and gas fields in the Near East, exploitation is on the point of being started. To date, all sources of recovered sulphur other than sour natural gas operations are individually small and scattered and therefore serve no more than a local market, whereas the former represent major sources of supply. The potential scope of sulphur recovery from crude oil will be discussed under "Future Supply".

France

Societe Nationale des Petroles d'Aquitaine

The company which is 53% owned by the French Government, operates the world's largest single sulphur recovery plant, based on sour gas, at Lacq, S.W. France. Production in 1967 totalled 1.64 million tonnes. Since the start of production in 1957 the company has produced about 11½ million tonnes brimstone.

The company is constantly engaged in exploration in France and abroad in respect of oil and gas, and in Mexico (see above) its subsidiary has been granted an exploration concession on a sulphur dome formation which the company plans to develop for operation by the Frasch process, if adequate reserves exist.

The company's sulphur output at Lacq is transported in liquid and as dry bulk sulphur by rail to consumers in France, and also some 60 miles to the Port of Bayonne where the company has storage and loading facilities for liquid and dry bulk sulphur. It also owns sulphur terminals at Rouen, Rotterdam and Immingham.

	Production	Domestic Deliveries	Exports
		('000 tonnes)	
1961	1,108	367	564
1962	1,356	356	529
1963	1,418	471	1,010
1964	1,518	538	967
1965	1,533	603	968
1966	1,530	698	881
1967	1,636	681	1,010

Production of sulphur is at or slightly in excess of rated gas treatment and sulphur recovery plant capacity so that the mounting requirements of the French industry are diminishing the export capability of SNPA.

For logistic reasons, the company's main market is in W. Europe and the Mediterranean countries, the export pattern being as follows:

	1964	1965	1966	1967
Western Europe	86%	84%	89%	80%
Africa	9%	13%	8%	10%
Asia	1%	1%	2%	5%
Communist countries	3%	2%	1%	3%
Central & South America	1%	-	-	2%

Canada

The development and exploitation of the sour natural gas resources of W. Canada, in particular of Alberta, which started on a small scale in 1954 and acquired momentum from 1959 onwards, has resulted in recovered sulphur production reaching 2.2 million tonnes in 1967. This is produced from 20 plants in Alberta, 1 in Saskatchewan and 1 in British Columbia, with capacities ranging from 7 to 15,000 tons per day. In 1965 employment of plant capacity of some 2.4 million t.p.a. was about 65%.

The principal producers are as follows:

Shell Canada Limited
Texas Gulf Sulphur Company
Jefferson Lake Petrochemicals Limited
Gulf Oil Canada Limited (formerly British American Oil Co.)

In addition American Oil, Canadian Superior and Hudson Bay are becoming major producers, their new plants contributing substantially to the overall recovery capacity expansion, and are adding to the number of major suppliers to the North American and overseas export markets.

Deliveries are made as dry bulk sulphur and increasingly in liquid form by rail direct to consumers in Canada and the U.S.A. For overseas export through Vancouver where two forwarding companies operate terminals, deliveries are in unit trains of solid sulphur.

	Production	Domestic Deliveries	Exports
		('000 tonnes)	
1961	492	197	
1962	10,051	259	198
1963	1,302	395	363
1964	1,496	432	745
1965	1,615	504	1,174
1966	1,720	462	1,364
1967	2,199	533	1,336
			1,677

In parallel with the growing home market in which W. Canadian suppliers have extended their markets eastwards, into Ontario and even Quebec, sales to U.S.A. continue to expand and to account for over one half of total exports. Amongst overseas markets, the freight favoured Pacific area is the most important outlet for W. Canadian sulphur which shows the following export pattern.

	1964	1965	1966	1967
Western Europe	9%	7%	6%	3%
North America	49%	47%	53%	45%
Central and South America	3%	3%	-	1%
Asia	11%	12%	11%	24%
Oceania	15%	16%	18%	17%
Africa	4%	7%	7%	4%
Communist countries	9%	8%	5%	6%

U.S.A.

There are some 90 sulphur recovery plants in the U.S.A. with an aggregate capacity of just under 2 million t.p.a., 46% based on sour gas, and 54% on oil refinery and other industrial gases. The output of these plants is marketed independently by each producer and sold almost exclusively in the U.S.A. In 1967 about 12% of the total output was exported through merchants largely because of high world market prices.

	Production ('000 tonnes)
1961	894
1962	937
1963	986
1964	1,064
1965	1,237
1966	1,275
1967	1,335

Other

Sulphur recovery plants attached to oil refineries and other industrial plants throughout the world, those associated with sour natural and well-head gas, notably in Mexico and Saudi Arabia, and the pyritic smelting plant of Outokumpu Oy in Finland, produce about one half million t.p.a. brimstone, of which all but about 3% is consumed within the country of origin.

	Production ('000 tonnes)
1961	528
1962	501
1963	480
1964	519
1965	553
1966	619
1967	657

The failure of recovered sulphur production to maintain earlier growth rates is attributable to the greater use of sweet crudes, notably in European oil refineries and to the cessation of pyritic smelting by the Orkla process first in Norway (1962) and then in Portugal (1963), while operations in Spain ceased in 1965 but resumed in 1967.

REFINED NATIVE SULPHUR

World production of refined native sulphur in 1967 totalled 0.52 million tonnes, originating mainly from Japan (0.26 million tonnes), South America (0.15 million tonnes), and Italy/Sicily (0.1 million tonnes). Although Italy/Sicily and Chile have in the past supplied to export markets, currently the entire output of native sulphur, with the exception of that in Bolivia which is exported to neighbouring countries, is consumed in the country of origin.

Adverse economics of mining and refining and high transport costs in respect of the usually inaccessibly located native sulphur ore deposits exploited by conventional mining techniques have prevented this source of sulphur being exploited to a greater extent under prevailing conditions of world supply and prices. At a number of deposits, economically viable exploitation may be warranted in future. The exploitation of similar deposits in Poland and the U.S.S.R., where annual production is currently about one half million tonnes and $1\frac{1}{2}$ million tonnes respectively, points to the merits of large scale operations.

	Free World Production ('000 tonnes)
1961	587
1962	555
1963	486
1964	464
1965	445
1966	480
1967	522

POLAND

	'000 tonnes	
	Production	Exports
1963	235	124
1964	304	151
1965	436	241
1966	477	272
1967	700	404

The entire output originates from the Piaseczno opencast mine near Tarnobrzeg. Opencast mined ore is subjected to flotation and the concentrate is purified in filter presses to yield a 99.2 - 99.6% product. Annual capacity is 500,000 tonnes brimstone. A second opencast mine, Machow, is at an advanced stage of development and will come into production in Spring 1969 with a capacity rising to 800,000 t.p.a. brimstone.

U.S.S.R.

	'000 tonnes	
	Production*	Exports+
1963	950	104
1964	1125	81
1965	1300	152
1966	1500	220
1967	1550	206

The principal source of supply is the Rozdol mine in the Ukraine. Small quantities up to 70,000 t.p.a. are still believed to be produced in Kazakhstan from where until 1957 all mined/refined sulphur originated.

PYRITES

Just over one quarter of the Free World sulphur supply or nearly one third of total world sulphur supply - underlining the major part played by pyrites in the sulphur supply pattern of the Communist countries of E. Europe and the Far East - is represented by sulphur in pyrites and pyrrhotite. In 1967 Free World production of sulphur in pyrites was 6.32 million tonnes S. This originated from:

Western Europe	57%
North America	12%
Rest of World	31%

Pyrites production in Communist countries was 3.89 million tonnes S in 1966 and 4.11 million tonnes in 1967.

An analysis of the world supply of pyrites discloses two distinct aspects:

1. Origin:

   (a) Pyrites mined as the primary product irrespective of its grade in relation to commercial or technical qualitative requirements.

   (b) Pyrite concentrate arising as co-product or by-product in beneficiation processes of other - usually non-ferrous metal sulphide-ores.

2. End use:

   (a) Whether or not the mine production is integrated with consumption.

This can be identified most commonly in respect of individual companies and accordingly for industry sectors. On a national scale where the use of pyrites is promoted within the framework of economic policy the only clear cut example is to be found in Spain.

It is, however, evident that in countries where there is a significant national production of pyrites and a dependence on imported brimstone, the benefit of security of sulphur supply tends to outweigh any adverse cost comparison with brimstone. In some instances, e.g. South Africa, pyrites are in any case the cost-favoured material. In others, e.g. Australia, the cost factor - accentuated by the geographical distribution pattern of the sulphur using industries, has so far severely restricted the use of indigenous pyrites.

Origin

Of the current Free World production of pyrites of about 6.32 million tonnes S, approximately two thirds is represented by pyrites mined as primary product and supplied as crude pyrite failing to conform with commercially or technically acceptable standards, as washed pyrite or concentrate.

The principal sources of this type of supply are:

Country of origin	Estimated supply 1967 ('000 tonnes) S content	Primary pyrite as proportion of total output
W. Europe:		
Spain	1100	95%
Portugal	242	100%
Greece	100	100%
Italy	575	95%
Norway	200	70%
Cyprus	150	35% (1 company)
France	37	100%
Turkey	54	100%
Rest of world:		
Morocco	108	100%
Rhodesia	30	100%
Japan	1030	75%
Australia	59	45%
Taiwan	13	100%
S. Africa	54	25%

The balance, corresponding to about $4\frac{1}{2}$ million tonnes product, is represented by co-product and by-product material arising as follows:

Country of Origin	Estimated supply 1967 ('000 tonnes) S content	Remarks (arising in connection with the following mine products)
W. Europe:		
Cyprus	300	Copper concentrate
W. Germany	280	Zinc concentrate, iron ore.
Norway	90	Copper & zinc concentrates, iron ore
Finland	97	Copper concentrates
Sweden	230	Copper/lead/zinc conc.
Rest of World:		
Algeria	25	Iron ore
S. Africa	163	Gold ore/uranium
Chile	7	Copper concentrates
Philippines	73	Copper & gold concentrates.
Japan	350	Copper/zinc concentrate
Australia	71	Copper concentrates
U.S.A.	361	Copper/zinc/lead/ molybdenum concentrates.
Canada	434	Copper/lead/zinc concs. and nickel ore.

With few exceptions, the cost of pyrites mined as primary product reflects the value of its sulphur content as well as that of the iron and non-ferrous metal content of the residues which have to be valorised to enable the producers to get an adequate return on capital. Whether the producer retains a title to the residue, selling only the sulphur value to the sulphuric acid manufacturer, or whether the user pays the all-values price for pyrites and recoups the residue value is not relevant.

In the case of co-product pyrites concentrates, representing the tailing of non-ferrous metal sulphide ore which has been beneficiated for its non-ferrous metal content, much if not all the cost of mining and treatment has been covered by the producer enabling him to cost the by- or co-product at its incremental value so that the main criterion becomes its market-ability in terms of transport and conversion costs.

With few exceptions, however, the value of the product is its sulphur content as the residue has virtually no recoverable non-ferrous metal values whereas the value of the iron content is depressed or nullified by the impurities in the form of non-recoverable, non-ferrous metals.

Integration

The adverse economics of pyrites use, mainly as a function of the higher capital costs of pyrites based sulphuric acid plants compared with that of plants using brimstone, have as shown above resulted in significant decline in the share of pyrites in the overall world sulphur consumption pattern. The main area in which pyrites use has declined or failed to expand in line with total sulphur consumption has been in respect of imported pyrites. In twelve years to 1967, exports by Free World producers of pyrites have declined from about 5 million tonnes product to 3.8 million tonnes product and the proportion of trade to production from 44% to about 21%. Significantly however, in this period Free World consumers, notably in W. Europe, increased their imports from Communist countries (E. Europe including U.S.S.R.) from about 150,000 to over 1 million tonnes product p.a.

The substantial increase in consumption of indigenous pyrites is associated mainly with the closer integration of production and end-use. Typical examples are:

Country	Company links
Sweden	Boliden Gruv A/B - Reymersholm/Forenade
Norway	A/S Borregaard - own plant
W. Germany	Sachtleben A.G. - "
Morocco	O.C.P. - "
Greece	Hellenic Co. of Chemical Products - own plant
Philippines	Various producers - local sulphuric acid plants
S. Africa	Gold/uranium mining companies - own plants
Canada	COMINCO - own plant
Canada	International Nickel Co. - Canadian Industries Ltd.

In Japan and especially in Spain, the integration between pyrites production and end use has been promoted by Government policy, with the result that in both countries pyrites has continued as dominant sulphurous raw material. In Japan this has been aided by the traditionally large proportion (about 70%) of the pyrites output owned or controlled by the large chemicals/sulphuric acid manufacturers, whereas in Spain this aspect has been strengthened by the inegration at company level of pyrites output by Cia. Rio Tinto Ltda. with its own pyrites based sulphuric acid plant(s).

World Production and Exports

Free World producers of pyrites total 22 of whom 12 are also exporters, but only 6 effect annual exports in excess of 50,000 tonnes S-equivalent, i.e. Spain, Cyprus, Norway, Canada and Portugal and Turkey. In the Communist countries (including Cuba) there are 10 producers of whom 4 are exporters, but only the U.S.S.R. and Yugoslavia are significant.

World production of pyrites is as follows:

	1960	1963	1964	1965	1966	1967
	(million tonnes S content)					
Free World countries	5.65	5.47	5.82	6.17	6.24	6.32
Communist countries	2.48	3.21	3.43	3.62	3.89	4.11
	8.13	8.68	9.25	9.79	10.13	10.43

Of the total world pyrite production of about 23.5 million tonnes product (10.4 million tonnes S) in 1967 only 5 million tonnes (21.4%) was exported, represented by exports of about 3 million tonnes (1.38 million tonnes S) from Western World producers and about 2 million tonnes from Communist countries including about 1.3 million tonnes (0.5 million tonnes S) directed to Western markets.

World Pyrites Trade

('000 tonnes S)

	1963	1964	1965	1966	1967
Western World Exports:	1607.6	1665.4	1638.9	1520.4	1376.7
of which to markets outside W. Europe:	197.1	203.3	206.6	192.6	183.8
Communist exports:	661.6	623.7	687.3	868.1	874.2
of which to markets outside W. Europe:	442.3	337.6	321.4	459.9	335.6
Total Exports:	2269.2	2289.1	2326.2	2388.5	2250.9
of which to markets outside W. Europe:	669.4	570.6	528.0	652.5	519.4

The seven major pyrites exporters identified above exported in 1967 some 213 million tonnes S or 94% of total world pyrite exports. Of the major European exporters Spain exported about 30% of its production, Cyprus 100%, Norway about 60%, Portugal about 45% and Turkey about 90%. In Canada rising production and static exports has resulted in the progressive delcine of the ratio to under 40%. U.S.S.R. exports a growing proportion of its pyrite output - 32% in 1967. Yugoslavia declined sharply in 1967 while production has remained static so that the production/exports ratio has declined from 80% in 1963 to 22% in 1967, without, however, a compensating growth of domestic usage.

The bulk of world trade originates in W. Europe and is directed to markets in W. Europe. Exceptions are as follows:-

1) Canada to U.S.A. (and intermittently to Taiwan) at an annual level of 160/170,000 tonnes S.

2) Deliveries within the Communist Bloc, (notably to E. Germany, Cuba) at an annual level of 300,000 tonnes S.

3) Exports from W. Europe to Africa at an annual level of 10/15,000 tonnes S.

4) Exports to Japan by the Philippines and the U.S.S.R.

"OTHER" SOURCES OF SULPHUR

The principal 'other' forms of sulphur supply are non-ferrous smelter gases, anhydrite/gypsum, spent oxide and hydrogen sulphide, other than that converted to recovered brimstone. In addition there is low grade sulphur ore used tel quel in sulphuric acid production and as soil conditioner, sulphur filtercake, sludge acid arising at oil refineries, ferrous sulphate and the sulphur content of ammonium sulphate recovered as by-product in chemical refining of sulphide ores.

As shown above, other forms of sulphur account for more than one sixth of current Free World production and consumption of sulphur in all forms.

The importance of other forms of sulphur is indicated in the following table which shows the proportion of total sulphur consumption for sulphuric acid manufacture in the main countries concerned.

	Sulphur in other forms as % of total sulphur used in H_2SO_4 production
Austria	47%
Belgium	32%
Finland	86%
France	13%
W. Germany	19%
Italy	9%
Netherlands	8%
Spain	8%
Sweden	11%
U.K.	31%
Australia	23%
Japan	36%
Canada	56%
U.S.A.	13%

Of the total output and use of 4½ million tonnes of sulphur in forms other than brimstone and pyrites, about 87% arises as sulphuric acid and the balance in other forms (liquid SO_2 or SO_2 gas stream, ammonium sulphate, ground sulphur ore). An analysis by the source of sulphur shows the following pattern:

S in Smelter gas (Sulphide Ores)+	52%
S in Sulphates (Gypsum and Anhydrite)	16%
S in Coal (spent oxide, H_2S not converted to brimstone)	4%
S in Sulphur Ore (not produced as or refined to brimstone)	7%
S in Hydrocarbons (other than recovered as brimstone)	5%

Waste Products:	Ferrous sulphate (ex TiO_2 manufacture and steel pickling)	½%
	Sludge Acid (ex Oil refining)	15%
	Waste acid (ex chemical plants)	½%

+ Chemical refining of sulphide ores at present accounts for less than ½%.

Production - Sulphur in other forms

(million tonnes S)

1960	1963	1964	1965	1966	1967
3.52	3.67	3.87	3.93	4.23	4.38
0.55	1.13	1.32	1.40	1.61	1.69
4.07	4.80	5.19	5.33	5.84	6.07

Regional Analysis of Sulphur Production

W. Europe:

The sulphur production pattern in W. Europe has been traditionally dominated by pyrites, although the advent of sulphur recovery from sour natural gas in S. W. France in late 1950's, which more than compensated for the decline of the Italian/Sicilian sulphur ore mining/refining industry, has also given W. Europe a substantial indigenous source of brimstone. This is supplemented by brimstone recovered at oil refineries and from pyrite, which since the Orkla processes ceased to be operated in Norway, Portugal and Spain, is confined to marginal tonnages of sulphur recovered by the Asarco process in Spain and the growing output by Outukumpu in Finland. Also important in the W. European sulphur supply pattern is the production and use of sulphur in other forms, notably of anhydrite/gypsum for sulphuric acid and ammonium sulphate production and of SO_2 in smelter gases which is recovered as sulphuric acid.

Production (million tonnes S)

		1963	1964	1965	1966	1967
Pyrite		3.31	3.46	3.67	3.56	3.51
Brimstone	Lacq	1.42	1.52	1.53	1.52	1.64
	Other	0.43	0.42	0.42	0.38	0.44
Sulphur in other forms		1.62	1.61	1.59	1.60	1.67
		6.78	7.01	7.21	7.06	7.26

It will be seen that during the period under review pyrites accounted for about one-half (ranging from 48% - 51%) of total W. European sulphur production, brimstone for just over one-quarter (27% - 29%) and sulphur in other forms for just under one-quarter (22% - 24%).

North America:

In view of the abundant and varied sources of brimstone, sulphur supply in N. America is predominantly in this form and, in addition to meeting the bulk of domestic demand, N. America is the principal source of brimstone supply to world markets. This applies in particular to the U.S. Frasch industry which until the mid-1950's accounted for over 90% of world exports, but whose share of world trade has progressively declined under the competitive impact of Mexican, French, Canadian and most recently, Polish brimstone exports. The N. American brimstone supply capability is much strengthened by the expanding production capacity of sulphur recovered from sour gas in Canada and to a lesser extent of sulphur recovered from sour gas in the U.S.A. and from H_2S extracted from petroleum fractions at oil refineries. The level of pyrite production in N. America is increasing progressively as the result of the rising use of pyrites in Canada. The entire Canadian output and the bulk of the U.S. output is represented by by-product and co-product pyrite concentrates arising in conjunction with non ferrous metal sulphide ore treatment. Formerly a significant exporter to W. Europe, notably U.K., Canada at present only exports to U.S.A. and intermittently small quantities to the Far East, notably Taiwan. U.S. pyrite production which increased modestly up to 1966 has since then receded.

Production of sulphur in other forms in the U.S.A. in represented primarily by SO_2 in smelter gases which is recovered mainly as sulphuric acid with a small proportion as liquid SO_2, and by acid sludge from oil refineries which is burnt to SO_2 for virgin sulphuric acid production. In Canada the bulk of the output is in the form of SO_2 in metal smelter gases.

Production (million tonnes S)

	1963	1964	1965	1966	1967
Frasch Sulphur	4.96	5.31	6.21	7.06	7.07
Recovered sulphur:					
U.S.	0.99	1.06	1.24	1.27	1.34
Canada	1.35	1.56	1.68	1.83	2.28
Pyrites	0.64	0.67	0.72	0.76	0.80
Sulphur in other forms	1.24	1.30	1.38	1.42	1.38
	9.18	9.90	11.23	12.34	12.87

Brimstone production accounts for an increasing proportion of total N. Americal sulphur supply, having risen from 80% to 83% in the past 5 years. Pyrites production accounts for about 7% and sulphur in other forms about 11-13%.

Latin America:

Except for the production of Frasch sulphur in Mexico, there are no significant sulphur supply sources in Latin America, although there is a substantial potential represented by volcanic sulphur deposits extending the full length of the Andes, which are exploited on a small scale in Columbia, Chile, Argentina, Bolivia and imminently in Ecuador, as well as a number of sedimentary deposits in Central America, e.g. Guatemala, Costa Rica, Venezuela.

Production of recovered sulphur is based on a small sour gas operation in Mexico and a number of oil refinery operations notably in the Caribbean, where large scale expansion is however imminent.

Pyrites production is negligible and confined to a small captive utilization of pyrite concentration at a copper mine in Chile. Potential production in Brazil is however substantial.

Output of sulphur in other forms is represented predominantly by the use of SO_2 in metal smelter gases.

	1963	1964	1965	1966	1967
			(million tonnes S)		
Brimstone:					
Frasch	1.48	1.65	1.50	1.64	1.82
Recovered	0.08	0.08	0.08	0.07	0.08
Native/refined	0.12	0.12	0.12	0.14	0.19
Pyrites	+	+	+	+	+
Sulphur in other forms	0.07	0.08	0.08	0.08	0.09
	1.75	1.93	1.78	1.93	2.18

\+ less than 10,000 tonnes p.a.

Africa:

Except for marginal recovered sulphur production in Egypt and S. Africa, there is no brimstone production in Africa. Production of pyrites in Morocco and S. Africa is substantial and there is relatively small-scale output in Rhodesia and Algeria. Production of sulphur in other forms is almost entirely based on SO_2 in metal smelter gas in South Africa, Zambia and Congo.

	1963	1964	1965	1966	1967
		(million tonnes S)			
Brimstone	+	0.01	0.02	0.02	0.02
Pyrites	0.22	0.26	0.26	0.27	0.36
Sulphur in other forms	0.06	0.06	0.06	0.12	0.16
	0.28	0.33	0.34	0.39	0.54

Asia:

Brimstone production is represented primarily by the Japanese sulphur ore mining/refining industry. The low level of recovered sulphur output at various oil refineries is being boosted substantially by a major expansion of capacity in connection with desulphurisation of fuel oils, as an air pollution abatement measure.

The only pyrites producers in Asia are Japan, Taiwan and Philippines of whom Japan is the second largest producing country in the world next to the U. S. S. R.

The large output of sulphur in other forms is mainly attributable to the utilisation of SO_2 in metal smelter gas in Japan.

Oceania:

The only production of sulphur in this region is in Australia. The small scale brimstone output is recovered at oil refinieries. Pyrite production has declined. Despite the large potential supplies of pyritic tailings arising in connection with metal sulphide ore treatment, pyrite production is relatively small. At the end of 1967 the only West Australian producer ceased production. The nonferrous metal smelters give rise to a significant utilisation of SO_2 in smelter gas.

	1963	1964	1965	1966	1967
			(million tonnes S)		
Brimstone	+	0.01	0.02	0.02	0.02
Pyrite	0.09	0.10	0.09	0.11	0.13
Sulphur in other forms:	0.11	0.12	0.13	0.13	0.13
	0.20	0.23	0.24	0.26	0.28

Communist Countries:

There are no authoritative data available on sulphur production in the U.S.S.R. and China. The production estimates in these two countries take account of the apparent domestic S-requirements and of exports which can be accurately identified.

Brimstone production in the Communist countries of East Europe and the Far East is represented by the large scale sulphur ore mining/refining operations in U.S.S.R. and Poland, and to a lesser extent in China, and the recovered sulphur production based on coke and town oven gas in the U.S.S.R., E. Germany, and, it is believed, in China, on natural gas in the U.S.S.R. and on oil refinery gas in the U.S.S.R. and most E. European countries. Since 1966 the "Frasch" sulphur production in Poland has increasingly contributed to brimstone output and it is reported that this process has recently started to be used in the U.S.S.R.

Pyrites are produced in all Communist countries except Hungary. In the U.S.S.R., the largest producer in the world, the bulk of the output, especially that available for export, is represented by low cupreous fines and flotation concentrates, while cupreous pyrites are considered to be an integral part of the non-ferrous metal industry which gives rise to a substantial output of SO_2 in smelter gases which is recovered as sulphuric acid. With the exception of Yugoslavia and Cuba, none of the other Communist countries have a pyrites export potential. Yugoslavia has pyrite concentrates in excess of domestic demand and in Cuba copper pyrite production is capable of expansion.

	1963	1964	1965	1966	1967
		(million tonnes S)			
Brimstone	1.47	1.76	2.12	2.37	2.70
Pyrites	3.21	3.43	3.62	3.88	4.11
Sulphur in other forms	1.13	1.32	1.40	1.61	1.69
	5.81	6.51	7.14	7.86	8.50

WORLD BRIMSTONE TRADE

Up to the mid-1950's the U.S. Frasch sulphur industry dominated world brimstone trade, accounting for over 90%. With the advent of Mexican Frasch sulphur and soon after, French and W. Canadian recovered sulphur production, the number of suppliers to world markets had increased to four and as a corollary, compeition in the importing countries sharpened, culminating in the "price war" of 1957-1963. Apart from the U.S.A. itself, which rapidly became the world's largest single importing country and the main market for Mexican Frasch and Canadian recovered sulphur, the "Free" World's main importing region was and still is, W. Europe. Imports elsewhere have risen, but the relative importance of the importing regions has not changed much, with the possible exception of Asia, where India's import requirements are progressively making themselves felt. It should be added that the 1967 export pattern is distorted in relation to actual demand, because of the substantial tonnages which were delivered into consumers' stockpiles, notably in India, Taiwan and Australia/New Zealand.

Changes in the world export pattern have been as follows:-

Brimstone Exporters' Share of World Markets

	1960	1965	1967
Total World Exports (million tonnes)	3.85	6.81	7.07
U.S.A.	47%	35%	31%
France	11%	14%	14%
Mexico	32%	24%	23%
W. Canada	3%	20%	24%
Other Free World	3%	*	2%
Communist countries	4%	7%	6%

* less than ½%

Brimstone Exports by Destination

	1960	1965	1967
Total World Exports (million tonnes)	3.85	6.81	7.07
N. America	19%	24%	23%
W. Europe	39%	39%	36%
Australasia	9%	9%	11%
Asia	7%	9%	15%
Africa	6%	7%	5%
Latin America	6%	5%	6%
Communist countries	4%	7%	4%

In the light of new developments of supply sources and demand growth significant changes in world trading patterns are anticipated.

North America

Despite the envisaged increase in brimstone supply in North America nearly 6 million tonnes between 1967 and 1975, the volume of the nett export surplus is only expected to increase marginally from 2¼ to 2½ million tonnes.

W. Europe

Nett brimstone import requirements are expected to increase from 1.4 million tonnes in 1967 to about 3½ million tonnes in 1975. Peak imports of W. Europe were in 1965 when they totalled 2 million tonnes gross, 1.8 million tonnes nett. Of the increased import needs of 2 million tonnes at least one-quarter is likely to be met by Poland.

Asia & Oceania

In 1967 imports reached over 2 million tonnes of which 1.7 million tonnes was actually consumed.

In 1975 nett import needs are estimated at 0.7 million tonnes, i.e. 1 million tonnes less than in 1967.

Rest of World (Latin America & Africa)

In 1967 this arbitrary portion of the world had a nett export surplus of 1 million tonnes (Gross 1.6 million tonnes). By 1975 the export surplus is expected to increase to 1.8 million tonnes and in addition this region (Mexico) will be exporting about ½ million tonnes S in the form of phosphoric acid.

BRIMSTONE EXPORTS

('000 Metric Tonnes)

1966

Importers/ Exporters	U.S.A.	Mexico	Canada	France	E.Germany	W.Germany	Poland	U.S.S.R.	China	Bolivia	Others	TOTAL
W.Europe												
Austria	45.5	-	-	6.4	6.0	7.8	19.3	5.4	-	-	-	90.4
Belgium	152.2	-	11.0	36.0	-	-	-	13.5	-	-	-	212.7
Denmark	3.5	-	-	2.1	-	-	-	-	-	-	-	5.6
Eire	54.8	-	-	19.5	-	-	-	-	-	-	-	74.3
Finland	41.3	-	-	23.9	-	-	4.8	12.3	-	-	-	82.3
France	70.4	129.5	-	-	-	-	-	-	-	-	-	199.9
W.Germany	279.7	18.7	-	114.7	-	-	7.0	-	-	-	-	420.1
Greece	-	-	20.8	41.5	-	-	-	-	-	-	-	62.3
Netherlands	167.1	-	5.2	64.2	-	-	-	-	-	-	-	236.5
Norway	33.4	-	-	10.5	-	-	-	-	-	-	-	43.9
Portugal	6.4	-	-	29.4	-	-	-	-	-	-	-	35.8
Spain	12.6	-	-	38.0	-	-	-	-	-	-	-	50.6

Importers/ Exporters	U.S.A.	Mexico	Canada	France	E.Germany	W.Germany	Poland	U.S.S.R.	China	Bolivia	Others	TOTAL
Sweden	61.6	-	-	62.2	-	-	34.6	-	-	-	-	158.4
Switzerland	38.9	-	-	18.8	-	-	-	-	-	-	-	57.7
U.K.	214.3	208.4	5.1	295.4	-	-	31.0	-	-	-	-	754.2
Italy	20.9	-	10.7	14.9	-	0.6	40.9	-	10.2	-	-	98.2
TOTAL - W.EUROPE	1,202.6	356.6	52.8	777.5	6.0	8.4	137.6	31.2	10.2	-	-	2,582.9
E.Europe												
Bulgaria	-	-	-	-	-	-	-	-	-	-	-	-
Czechoslovakia	24.3	-	15.3	1.4	-	5.1	119.9	37.5	-	-	-	203.5
E.Germany	-	-	-	-	-	-	-	-	-	-	-	-
Hungary	-	-	40.4	-	-	6.9	3.6	60.9	-	-	-	111.8
Poland	-	-	-	-	-	-	-	-	-	-	-	-
Roumania	-	-	-	-	-	2.0	-	2.7	-	-	-	4.7
Yugoslavia	-	-	-	10.8	-	-	-	10.0	-	-	-	20.8
U.S.S.R.	-	-	15.3	-	-	-	-	-	-	-	-	15.3
TOTAL - E.EUROPE	24.3	-	71.0	12.2	-	14.0	123.5	111.1	-	-	-	356.1

Importers/ Exporters	U.S.A.	Mexico	Canada	France	E.Germany	W.Germany	Poland	U.S.S.R.	China	Bolivia	Others	TOTAL
Cuba	-	-	-	-	-	-	76.8	-	-	-	-	76.8
N.Korea	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	76.8	-	-	-	-	76.8
TOTAL - EASTERN BLOC	24.3	-	71.0	12.2	-	14.0	123.5	187.9	-	-	-	432.9
Africa												
Algeria	-	-	-	31.8	-	-	-	-	-	-	-	31.8
Angola	-	-	-	-	-	-	-	-	-	-	-	-
Congo	-	-	-	1.6	-	-	-	-	-	-	-	1.6
Egypt	-	15.2	-	19.2	-	-	-	-	-	-	-	34.4
Ethiopia	-	-	-	-	-	-	-	-	-	-	-	-
Morocco	-	-	-	10.1	-	-	-	-	-	-	-	10.1
Mozambique	-	-	-	-	-	-	-	-	-	-	-	-
S.Africa	-	10.1	81.9	-	-	-	-	-	-	-	-	92.0
Tunisia	46.1	5.2.	-	11.0	-	-	-	-	-	-	-	109.8

Importers/ Exporters	U.S.A.	Mexico	Canada	France	E.Germany	W.Germany	Poland	U.S.S.R.	China	Bolivia	Others	TOTAL
Guinea	-	-	-	0.1	-	-	-	-	-	-	-	0.1
TOTAL - AFRICA	46.1	78.0	81.9	73.8	-	-	-	-	-	-	-	279.8
Asia												
Kuwait	-	-	17.7	-	-	-	-	-	-	-	-	17.7
Syria	-	-	-	-	-	-	0.2	-	-	-	-	0.2
Hong Kong	-	-	0.5	0.1	-	-	-	-	-	-	-	0.6
India	193.6	20.9	61.6	-	-	-	10.6	-	-	-	-	286.7
Indonesia	4.8	-	1.2	-	-	-	-	-	-	-	-	6.0
Iraq	0.3	-	-	0.1	-	-	-	-	-	-	-	0.4
Israel	48.2	-	5.0	-	-	-	-	-	-	-	-	53.2
Japan	-	-	8.2	-	-	-	-	-	-	-	-	8.2
S.Korea	1.2	-	3.7	-	-	-	-	-	-	-	-	4.9
Lebanon	-	-	-	10.6	-	-	-	-	-	-	-	10.6
Malaysia	-	-	-	5.2	-	-	-	-	-	-	-	5.2
Philippines	0.1	-	-	-	-	-	-	-	-	-	-	0.1
Taiwan	24.0	10.0	34.3	-	-	-	-	-	-	-	-	68.3
Thailand	9.1	-	-	1.2	-	-	-	-	-	-	-	10.3

[redacted]

Importers/ Exporters	U.S.A.	Mexico	Canada	France	E.Germany	W.Germany	Poland	U.S.S.R.	China	Bolivia	Others	TOTAL
S.Arabia	1.4	-	-	0.1	-	-	-	-	-	-	-	1.5
Singapore	1.0	-	-	-	-	-	-	-	-	-	-	1.0
TOTAL - ASIA	283.7	30.9	132.2	17.3	-	-	10.8	-	-	-	-	474.9
America												
Canada	138.6	-	-	-	-	-	-	-	-	-	-	138.6
U.S.A.	-	812.1	712.8	-	-	-	-	-	-	-		1,524.9
TOTAL - AMERICA	138.6	812.1	712.8	-	-	-	-	-	-	-	-	1,663.5
C.America												
Costa Rica	-	-	-	-	-	-	-	-	-	-	-	-
Guatemala	-	-	-	-	-	-	-	-	-	-	-	-
Jamaica	1.0	-	-	-	-	-	-	-	-	-	-	1.0
Salvador	3.8	-	-	-	-	-	-	-	-	-	-	3.8
Trinidad	22.2	-	-	-	-	-	-	-	-	-	-	22.2
Honduras	0.1	-	-	-	-	-	-	-	-	-	-	0.1
TOTAL - C.AMERICA	27.1	-	-	-	-	-	-	-	-	-	-	27.1

Importers/ Exporters	U.S.A.	Mexico	Canada	France	E.Germany	W.Germany	Poland	U.S.S.R.	China	Bolivia	Others	TOTAL
S.America												
Argentina	34.5	-	-	-	-	-	-	-	-	-	-	34.5
Bolivia	-	-	-	-	-	-	-	-	-	-	-	-
Brazil	175.2	4.1	-	-	-	-	-	-	-	-	-	179.3
Chile	8.1	10.4	-	-	-	-	-	-	-	17.7	-	36.2
Colombia	-	-	-	-	-	-	-	-	-	-	-	-
Ecuador	-	-	-	-	-	-	-	-	-	-	-	-
Paraguay	0.2	-	-	-	-	-	-	-	-	-	-	0.2
Peru	12.9	-	-	-	-	-	-	-	-	0.3	-	13.2
Uruguay	12.4	-	-	-	-	-	-	-	-	-	-	12.4
Venezuela	1.5	-	-	-	-	-	-	-	-	-	-	1.5
TOTAL - S.AMERICA	244.8	14.5	-	-	-	-	-	-	-	18.0	-	277.3
Australasia												
Australia	164.7	103.1	189.1	-	-	-	-	-	-	-	-	456.9
N.Zealand	130.5	61.4	45.3	-	-	-	-	-	-	-	-	237.2
TOTAL - AUSTRALASIA	295.2	164.5	234.4	-	-	-	-	-	-	-	-	694.1
WORLD TOTAL	2,262.4	1,456.6	1,285.1	880.8	6.0	22.4	271.9	219.1	10.2	18.0	-	6,432.5

BRIMSTONE EXPORTS

('000 Metric Tonnes)

1967

Importers/ Exporters	U.S.A.	Mexico	Canada	France	Finland	W.Germany	Bolivia	Poland	U.S.S.R.	China	E. Germany	Others	TOTAL
W.Europe													
Austria	31.6	-	-	16.3	-	2.2	-	11.1	6.4	-	5.3	-	72.9
Belgium	186.8	-	-	56.7	-	-	-	-	-	-	-	-	243.5
Denmark	2.0	-	-	2.3	-	-	-	0.1	-	-	-	1.9	6.3
Eire	76.8	-	-	21.2	-	-	-	-	-	-	-	-	98.0
Finland	23.7	-	-	18.7	-	-	-	1.4	-	-	-	-	43.8
France	5.1	221.1	-	-	-	-	-	2.4	-	-	-	-	228.6
W.Germany	248.0	-	-	105.8	-	-	-	-	-	-	-	-	353.8
Greece	-	-	14.4	49.9	-	-	-	20.0	-	-	-	-	84.3
Netherlands	195.0	-	-	68.1	-	-	-	-	-	-	-	-	263.1
Norway	26.6	-	-	9.6	-	-	-	-	-	-	-	0.3	36.5
Portugal	-	-	-	18.3	-	-	-	-	-	-	-	-	18.3
Spain	15.0	-	8.2	42.9	-	-	-	-	-	-	-	-	66.1
Sweden	47.9	-	-	69.3	6.7	-	-	7.8	-	-	-	1.2	132.9
Switzerland	18.9	-	-	20.7	-	-	-	0.4	-	-	-	-	40.0

Importers/ Exporters	U.S.A.	Mexico	Canada	France	Finland	W.Germany	Bolivia	Poland	U.S.S.R.	China	E.Germany	Others	TOTAL
U.K.	149.0	298.7	10.2	270.5	-	-	-	1.0	-	-	-	-	729.4
Italy	11.0	-	15.1	37.8	-	2.5	-	-	-	-	-	-	66.4
TOTAL - W.EUROPE	1,037.4	519.8	47.9	808.1	6.7	4.7	-	44.2	6.4	-	5.3	3.4	2,483.9
E.Europe													
Bulgaria	-	-	-	-	-	-	-	-	-	-	-	-	-
Czechoslovakia	5.1	-	15.0	7.2	-	3.7	-	120.0	40.0	-	-	-	191.0
E.Germany	-	-	-	-	-	-	-	-	-	-	-	-	-
Hungary	-	-	40.0	-	-	12.1	-	10.0	65.0	-	-	-	127.1
Poland	-	-	-	-	-	-	-	-	-	-	-	-	-
Roumania	-	-	-	1.5	-	3.0	-	-	5.0	-	-	-	9.5
Yugoslavia	-	-	-	20.1	-	-	-	-	10.0	-	-	-	30.1
U.S.S.R.	-	-	44.1	-	-	-	-	-	-	-	-	-	44.1
TOTAL - E. EUROPE	5.1	-	99.1	28.8	-	18.8	-	130.0	120.0	-	-	-	401.8

Importers/ Exporters	U.S.A.	Mexico	Canada	France	Finland	W.Germany	Bolivia	Poland	U.S.S.R.	China	E.Germany	Others	TOTAL
Cuba	-	-	-	-	-	-	-	-	80.0	-	-	-	80.0
N.Korea	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL - EASTERN BLOC	5.1	-	99.1	28.8	-	18.8	-	130.0	200.0	-	-	-	481.8

Importers/ Exporters	U.S.A.	Mexico	Canada	France	Finland	W.Germany	Bolivia	Poland	U.S.S.R.	China	E.Germany	Others	TOTAL
Africa													
Algeria	-	-	-	24.1	-	-	-	-	-	-	-	-	24.1
Angola	-	-	-	-	-	-	-	-	-	-	-	-	-
Congo Kinshasa	-	-	-	1.8	-	-	-	-	-	-	-	-	1.8
Egypt	-	-	-	42.8	-	-	-	-	-	-	-	-	42.8
Ethiopia	-	-	-	-	-	-	-	-	-	-	-	-	-
Guinea	-	-	-	0.1	-	-	-	-	-	-	-	-	0.1
Morocco	-	-	-	6.1	-	-	-	-	-	-	-	-	6.1
Mauritius	-	-	-	-	-	-	-	-	-	-	-	-	-
Senegal	-	-	-	1.3	-	-	-	-	-	-	-	-	1.3
S.Africa (incl. S.W.Africa)	19.8	30.3	58.9	16.9	-	-	-	10.5	-	-	-	-	136.4
Tunisia	51.5	42.1	-	8.7	-	-	-	10.0	-	-	-	-	112.3
Tanzania	-	-	-	-	-	-	-	-	-	-	-	-	-
Cameroons	-	-	-	0.1	-	-	-	-	-	-	-	-	0.1
TOTAL -AFRICA	71.3	72.4	58.9	101.9	-	-	-	20.5	-	-	-	-	325.0

Importers/ Exporters	U.S.A.	Mexico	Canada	France	Finland	W.Germany	Bolivia	Poland	U.S.S.R.	China	E.Germany	Others	TOTAL
Asia													
S.Arabia	1.2	-	-	-	-	-	-	-	-	-	-	-	1.2
Bahrein	0.1	-	-	-	-	-	-	-	-	-	-	-	0.1
Kuwait	-	-	-	-	-	-	-	10.0	-	-	-	-	10.0
India	217.8	83.9	244.8	30.5	-	0.3	18.9	70.0	-	-	-	-	666.2
Indonesia	1.2	-	1.2	-	-	-	-	-	-	-	-	-	2.4
Iraq	0.2	-	-	-	-	-	-	-	-	-	-	-	0.2
Israel	34.5	6.1	5.1	-	-	-	-	-	-	-	-	-	45.7
S.Korea	6.3	-	72.1	-	-	-	0.4	-	-	-	-	-	78.8
Lebanon	-	-	-	6.8	-	-	-	-	-	-	-	-	6.8
Malaysia	-	-	-	7.7	-	-	-	-	-	-	-	-	7.7
Pakistan	-	-	3.0	-	-	0.5	-	-	-	-	-	-	3.5
Philippines	3.6	-	5.0	-	-	-	-	-	-	-	-	-	8.6
Taiwan	81.1	54.0	68.8	-	-	-	-	-	-	-	-	-	203.9
Thailand	17.8	-	1.5	-	-	-	-	-	-	-	-	-	19.3
S.Vietnam	-	-	11.8	-	-	-	-	-	-	-	-	-	11.8

Importers/ Exporters	U.S.A.	Mexico	Canada	France	Finland	W.Germany	Bolivia	Poland	U.S.S.R.	China	E.Germany	Others	TOTAL
Hong Kong	-	-	-	0.8	-	-	-	-	-	-	-	-	0.8
TOTAL - ASIA	363.8	144.0	411.8	47.3	-	0.8	19.3	40.0	-	-	-	-	1,067.0
America													
Canada	113.2	-	-	-	-	-	-	-	-	-	-	-	113.2
U.S.A.	-	724.4	762.2	-	-	-	-	-	-	-	-	-	1,486.6
TOTAL - AMERICA	113.2	724.4	762.2	-	-	-	-	-	-	-	-	-	1,599.8
C.America													
Costa Rica	-	-	-	-	-	-	-	-	-	-	-	-	-
Guatemala	-	-	-	-	-	-	-	-	-	-	-	-	-
Jamaica	3.6	-	-	-	-	-	-	-	-	-	-	-	3.6
Mexico	-	-	-	-	-	-	-	-	-	-	-	-	-
Neth. Antilles	-	-	-	-	-	-	-	-	-	-	-	-	-
Salvador	4.1	-	-	-	-	-	-	-	-	-	-	-	4.1

Importers/ Exporters	U.S.A.	Mexico	Canada	France	Finland	W.Germany	Bolivia	Poland	U.S.S.R.	China	E.Germany	Others	TOTAL
Trinidad	18.1	-	-	-	-	-	-	-	-	-	-	-	18.1
Honduras	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL - C. AMERICA	25.8	-	-	-	-	-	-	-	-	-	-	-	25.8
S.America													
Argentina	26.9	-	-	-	-	-	-	-	-	-	-	-	26.9
Bolivia	-	-	-	-	-	-	-	-	-	-	-	-	-
Brazil	196.9	-	11.0	15.7	-	-	-	12.0	-	-	-	-	235.6
Chile	4.1	-	-	-	-	-	22.9	-	-	-	-	-	27.0
Colombia	-	-	-	-	-	-	-	-	-	-	-	-	-
Ecuador	0.2	-	-	-	-	-	-	-	-	-	-	-	0.2
Paraguay	0.1	-	-	-	-	0.1	-	-	-	-	-	-	0.2
Peru	16.8	-	-	-	-	-	0.2	-	-	-	-	-	17.0
Uruguay	8.9	-	-	-	-	-	-	-	-	-	-	-	8.9
Venezuela	19.2	-	-	-	-	-	-	20.0	-	-	-	-	39.2
TOTAL - S. AMERICA	273.1	-	11.0	15.7	-	0.1	23.1	32.0	-	-	-	-	355.0

Importers/ Exporters	U.S.A.	Mexico	Canada	France	Finland	W.Germany	Bolivia	Poland	U.S.S.R.	China	E.Germany	Others	TOTAL
Australasia													
Australia	217.4	129.9	208.0	8.2	-	-	-	-	-	-	-	-	563.5
New Zealand	64.2	47.8	78.0	-	-	-	-	-	-	-	-	-	190.0
TOTAL - AUSTRALASIA	281.6	177.7	286.0	8.2	-	-	-	-	-	-	-	-	753.5
WORLD TOTAL	2,171.3	1,638.3	1,676.9	1,010.0	6.7	24.4	42.4	306.7	206.4	-	5.3	3.4	7,091.8

PYRITES TRADE 1956 (million tonnes sulphur content)

	Cyprus	Finland	Italy	Norway	Portugal	Spain	Sweden	Canada	Turkey	Philippines	Yugoslavia	USSR	TOTAL
Austria	–	–	–	–	–	–	–	–	–	–	–	0.01	0.01
Belgium	0.01	–	–	–	0.07	0.02	–	–	–	–	–	–	0.10
Denmark	–	–	–	0.02	–	0.04	–	–	–	–	–	–	0.06
France	0.07	–	–	–	0.01	0.07	–	–	–	–	–	0.01	0.15
W. Germany	0.08	0.02	–	0.18	0.02	0.27	–	–	–	–	0.01	0.05	0.63
Greece	0.02	–	–	–	–	–	–	–	–	–	0.03	–	0.05
Italy	0.12	–	–	–	–	–	–	–	0.04	–	–	0.26	0.43
Netherlands	0.05	–	–	–	0.03	0.02	–	–	–	–	–	–	0.10
Sweden	–	–	–	0.04	–	–	–	–	–	–	–	0.02	0.06
Switzerland	–	–	0.02	–	–	–	–	–	–	–	0.01	–	0.03
U.K.	0.06	–	–	–	–	0.02	0.02	–	–	–	–	0.02	0.12
Egypt	–	–	–	–	–	0.01	–	–	–	–	0.02	–	0.03
Tunisia	–	–	–	–	–	0.02	–	–	–	–	–	–	0.01
U.S.A.	–	–	–	–	–	–	–	0.14	–	–	–	–	0.14
Japan	–	–	–	–	–	–	–	0.01	–	0.03	–	0.11	0.15
TOTAL	0.41	0.02	0.02	0.24	0.13	0.45	0.02	0.15	0.04	0.03	0.07	0.49	2.04

PYRITES TRADE 1967 (million tonnes sulphur content)

	Cyprus	Finland	Italy	Norway	Portugal	Spain	Sweden	Canada	Turkey	Philippines	Yugoslavia	USSR	TOTAL
Austria	–	–	–	–	–	–	–	–	–	–	–	0.01	0.01
Belgium	0.01	–	–	–	0.09	0.01	–	–	–	–	–	0.01	0.12
Denmark	–	–	–	0.02	–	0.04	–	–	–	–	–	–	0.06
France	0.06	–	–	–	–	0.06	–	–	–	–	–	0.02	0.14
W. Germany	0.11	0.01	–	0.15	0.02	0.22	–	–	0.01	–	–	0.08	0.60
Italy	0.15	–	–	–	–	–	–	–	0.05	–	–	0.35	0.56
Netherlands	0.04	–	–	–	–	–	–	–	–	–	–	–	0.04
Sweden	–	–	–	0.01	–	–	–	–	–	–	–	0.05	0.06
Switzerland	–	–	0.02	–	–	–	–	–	–	–	–	–	0.02
U.K.	0.05	–	–	–	–	0.01	0.03	–	–	–	–	0.03	0.12
Egypt	–	–	–	–	–	0.01	–	–	–	–	0.05	–	0.06
Tunisia	–	–	–	–	–	0.01	–	–	–	–	–	–	0.01
U.S.A.	–	–	–	–	–	–	–	0.16	–	–	–	–	0.16
Japan	–	–	–	–	–	–	–	–	–	0.01	–	0.03	0.04
TOTAL	0.42	0.01	0.02	0.19	0.11	0.36	0.03	0.16	0.06	0.01	0.05	0.55	1.97

Balance of Supply/Demand

1963 - 1967

The rapid growth of sulphur consumption in the period 1963 to 1966, which found expression primarily in increased demand for brimstone, was not paralleled by a commensurate increase in brimstone production, in part because of the failure of the Mexican Frasch sulphur industry, in particular PASCO, to fulfil anticipated production and sales plans. In order to meet world-wide requirements, all major brimstone producers, especially U.S. Frasch sulphur industry, made deliveries from stockpiles with the result that world brimstone stocks declined as follows:

End-Year Stocks Held by Major Brimstone Suppliers, 1963-1967

('000 tonnes S)

	1963	1964	1965
US Frasch & Recovered	4836.3	4294.1	3479.4
Mexican Frasch	853.2	575.7	418.4
West Canada	1075.4	998.7	753.8
France, Lacq	660.3	581.2	517.5
TOTALS	7425.2	6449.7	5169.1

	1966	1967
US Frasch and Recovered	2747.6	1985.0
Mexican Frasch	503.2	433.7
West Canada	661.7	659.5
France, Lacq	499.2	466.4
TOTALS	4411.7	3544.6

Prices

After reaching an all-time low in 1963, brimstone prices advanced step by step as world demand outstripped world production in the period 1963-1967. The rise in world market prices was accentuated by the artificial brake placed on domestic prices in the U.S.A. and in France. The following table shows the progress of export prices of U.S. Frasch sulphur which determined the world price level for 75%-80% of deliveries.

U.S. Frasch Sulphur Export Prices*

(1963-1967)

(bright sulphur, $ US/ton, f.o.b. U.S. Gulf)

Year/Period Implemented		List Price
1964	Jan-Nov.	25.00
	December	27.50
1965	January	27.50
	Feb.-March	31.00
	April-Dec.	36.00
1966	Jan.-June	36.00
	July-Dec.	39.00
1967	Jan.-Dec.	39.00

* See also Appendix 2

The balance of deliveries was effected at premium prices, notably in Asian markets and in respect of new demand in a number of other markets, which exceeded delivered prices based on the U.S. Gulf f.o.b. price shown above, by up to $20 and in isolated instances even more.

In this period, pyrites prices (all values f.o.b.) in W. Europe advanced parallel with the delivered price of U.S. Frasch sulphur. In domestic markets outside W. Europe there was practically no increase in the price of pyrites and domestic prices in W. Europe advanced more slowly and not as much as export prices. Notwithstanding the increase in European pyrite price, the cost of sulphur in pyrites, and in particular of cupreous pyrites, compared very favourably with that of brimstone, partly because rising non-ferrous metal prices boosted the value of pyrite residues and more than compensated for the declining iron value which suffered from the weak iron market as the corollary of mounting supplies of low cost high-grade fines iron ores.

Pyrites Export Prices, 1963-1967 *

(Rio Tinto crude fines, basis 48% S, Stg./tonne f.o.b. Huelva)

Year/Period Implemented		Prices
1963	Jan.-Dec.	56/6
1964	Jan.-Dec.	56/6
1965	Jan.-June	62/6
	July-Dec.	68/-
1966	Jan.-June	83/-
	July-Dec.	83/-
1967	Jan.-June	85/-
	July-20th Nov.	85/- (discount of 5/- available)
	21st Nov.-Dec	93/- **

NOTES:

* See also Appendix 2

** Post-devaluation of sterling from £1-$US 2.80 to £1-$US 2.40 on 20th November, 1967

Western World Sulphur-in-all-forms Consumption 1963-1967

(million tonnes sulphur-content)

	1963	1964	1965	1966	1967
Brimstone					
World	11.3	12.5	13.9	15.3	15.5
Western Europe	2.7	3.1	3.5	3.5	3.6
Africa	0.3	0.4	0.4	0.3	0.4
N. America	6.5	7.1	7.8	9.3	9.2
C. & S. America	0.6	0.6	0.7	0.7	0.7
Asia	0.8	0.8	0.9	0.8	1.0
Oceania	0.4	0.5	0.6	0.7	0.7
Pyrites					
World	5.7	5.9	6.0	6.3	6.7
Western Europe	3.5	3.6	3.6	3.6	3.9
Africa	0.2	0.2	0.3	0.4	0.4
N. America	0.6	0.6	0.6	0.7	0.7
C. & S. America					
Asia	1.3	1.3	1.4	1.5	1.5
Oceania	0.1	0.1	0.1	0.1	0.1

	1963	1964	1965	1966	1967
Sulphur in other forms					
World	3.7	3.9	4.0	4.2	4.4
Western Europe	1.6	1.6	1.6	1.6	1.7
Africa	0.1	0.1	0.1	0.1	0.2
N. America	1.2	1.3	1.3	1.4	1.4
C. & S. America	0.1	0.1	0.1	0.1	0.1
Asia	0.6	0.7	0.8	0.9	0.9
Oceania	0.1	0.1	0.1	0.1	0.1
Sulphur in all forms					
World	20.8	22.3	23.9	25.8	26.6
Western Europe	7.8	8.3	8.6	8.9	9.3
Africa	0.5	0.7	0.7	0.8	0.9
N. America	8.4	9.0	9.8	11.4	11.3
C. & S. America	0.7	0.7	0.7	0.7	0.8
Asia	2.6	2.9	3.0	3.1	3.4
Oceania	0.6	0.7	0.8	0.9	0.9

SECTION - 2

NEW SUPPLY (1968 - 1975)

Although the disincentive to develop new sources of brimstone supply or even to explore, resulting from the excess of world brimstone supply and low prices during the seven-year period up to 1964, aggravated the tight supply situation of the past four years, mainly because of the time-lag between the initiation of a new project and the start of new production, the main impetus of new supply has for some time passed from the exploitation of native ore resources by the Frasch and other processes to the recovery of sulphur present in liquid and gaseous hydrocarbons.

The annual Free World output of recovered sulphur between 1955 and 1967 rose by 5 million tonnes, whereas the annual brimstone production from native ores increased in the same period by only 2.6 million tonnes.

The stimulus of rising world demand, coupled with the higher prices of recent years has been reflected in a spate of new projects, mainly based on the Frasch process, which will strongly influence the short term world supply pattern without, however, affecting the underlying long term trend of the increasing role to be played by recovered sulphur, for which new capacity based on the rising supplies of natural gas and oil refinery products has concurrently been built. In respect of the latter, it should be noted that the first major plant projects based on the desulphurization of fuel oil have been initiated. There is a clear limitation to the prospect of a major and continuing expansion of new brimstone production based on the exploitation of native ore deposits. The possibility of large-scale discoveries of native ore deposits amenable to Frasch sulphur processing in the U.S. Gulf region can be virtually ruled out. Discoveries off-shore on the Continental Shelf are circumscribed by the fiascó of the Texas off-shore sulphur leases for which bids totalling $33 million were paid in 1965. Bids in respect of Louisiana off-shore leases are likely to be invited at the end of this year or early next year. Although in deep water - 200 ft or more - there is a statistical prospect of several sulphur domes being identified, the substantially higher capital cost of plants capable of working under such conditions and the attendant technical problems occasion some doubt as to the feasibility of such projects.

In Mexico the identification of viable dome structures can be expected as exploration progresses in view of the extent of probable reserves. Elsewhere in the "Free" World, structures amenable to Frasch processing are known to exist in Iraq and possibly some of the Central American native sulphur deposits, e.g. Costa Rica, may also become realistic projects. The prospect of substantially increased exploitation of all other native ore deposits, where conventional mining methods and ore refining processes have to be employed, is inhibited by the adverse economics of operations, which may however be improved by process development work currently in progress. New process technology - due to be proven within the next 9-12 months by ELCOR Corp. in the U.S.A. - may result in the economic extraction of elemental sulphur from gypsum/anhydrite which would vastly increase the brimstone supply potential, as would also the successful development of a pyritic smelting process or the chemical extraction of elemental sulphur from sulphide ores, notably pyrite and pyrrhotite, on which intensive work is currently being undertaken.

The growth prospects of recovery of sulphur associated with or contained in natural gas, oil and coal are seen in three broad categories:

1) Desulphurisation of a) Sour natural gas
   b) Oil refinery products

2) Sulphur extraction in connection with synthetic crudes

3) Sulphur extraction from combustion gases of major fossil fuel users, notably power stations.

In all instances the motivating factor is not the production of sulphur but either the qualititative requirements relating to the "clean" natural gas and the petroleum product or the social requirements arising out of "clean air" legislation. As a result the volume of future recovered sulphur supply, as it has been in the past, will be largely unrelated to world sulphur demand. Whereas in respect of desulphurisation of sour natural gas, the evolution of recovered supply can be fairly accurately related to the evolution of natural gas consumption, factors influencing oil refinery operations and especially the incidence of "clean-air" legislation is more difficult to anticipate and to measure, especially in the longer term.

In the following section of the study, the evolution of supply up to 1975 has been analysed in some detail, based primarily on developments already in sight. For the period up to 1985, the evolution of supply is subject to many unknown and indefinite factors which have, as far as is possible, been taken into account in arriving at the estimates shown.

SULPHUR SUPPLY

Brimstone Production and Capacity

In the five year period up to the end of 1967, except for the establishment of production facilities at re-steamed domes in Texas and Louisiana which, however, only added less than 200,000 tonnes to the 1967 production total, the production capacity of Frasch sulphur has remained substantially unchanged, and Frasch sulphur output may be said to have conformed to capacity taking account of the water requirements of the sections of the respective dome formations which were exploited. In West Canada additions in the form of new plants to the recovery capacity have been substantial but the output of recovered sulphur has of necessity risen as a function of clean gas sales and not in response to the intensive world sulphur demand. This also applies in the case of the large number of small to medium sized sulphur recovery plants built throughout the world in conjunction with oil refinery operations.

During 1968 Free World brimstone production capacity increased by about 3.8 million tonnes represented by:

Source	Producer	Capacity (t.p.a.)
U.S.A.		
Caminada Dome	Freeport	900,000*
Bully Camp Dome	Texas Gulf	300,000
Lake Hermitage Dome	Jefferson Lake	200,000
Ft. Stockton	Duval	350,000
Pecos County, Texas	Sinclair Oil	100,000
High Island Dome	Pan Am. Petroleum	50,000
Mexico		
Nopalapa	C.E.D.I.	150,000
Canada		
Recovery from sour natural gas, of which :-		1,480,000
Bigstone	Pan Am. Petroleum	109,000
East Crossfield	Pan Am. Petroleum	496,000
Kaybob South No. 1	Hudson's Bay	352,000
Whitecourt	Texas Gulf	218,000**
Rest of Free World		
Recovery from natural & oil refinery gases.		270,000

Operations at the resteamed Bryan Mound of Hooker Chemical Co. ceased and a number of small sulphur ore mines in Sicily and Japan closed. Elcor Chemicals Co.'s plant is reported to have begun start-up operations in the second week of January 1969 and the production programme is expected to be underway in the near future.

Firm projects now under construction or at the design stage are as follows :-

Notes

* Nominal capacity is 500,000 t.p.a.

** Expansion of existing plant.

Source	Producer	Capacity t.p.a.	Due
U.S.A.			
Culberson County, Tex.	Duval	1,500,000	End 1969
Van Horn, Texas	Elcor	350,000	1969
Mexico *			
Texistipec	Texas Gulf	500,000	1970/71
Near East			
Kharg Island, Iran	NPC (1)/AMOCO	198,000	1969
Bandar Shahpur, Iran	NPC (1)/Allied Chemical	503,000	1969
Kirkuk, Iraq	Iraq Nat. Oil Co. (INOC)	143,000	1969**
Mena Abdulla, Kuwait	Amer. Indep. Oil Co.	102,000	1969
Shuaiba, Kuwait	Kuwait Nat. Petroleum Co.	191,000	1969**
Abqaiq, S. Arabia	Petromin (2)	215,000	1969
Canada			
Natural gas & pyrrhotine		1,050,000	by 1971
Japan			
Oil refineries		400,000***	by 1971

Source	Producer	Capacity t.p.a.	Due
Caribbean			
Oil refineries		210,000***	by 1971
West Germany			
Natural gas		380,000	by 1971
Rest of Free World			
Nat. gas/oil refineries & native sulphur		590,000	by 1971

Notes

* International Helium has proposed a project which is not yet firm.
** Completed 1968, but due on-stream in 1969.
*** Does not include capacity already on-stream.

(1) The National Iranian Petrochemical Company (NPC) is a subsidiary of National Iranian Oil Co. (NIOC) and it holds a 50% interest in these two projects.

(2) Petromin has a two-thirds interest in the Abquaiq project, the remaining one third interest being held by Occidental through Jefferson Lake.

Thus, due for completion before the end of 1971 is some 6.3 million tonnes new production capacity.

In addition a large number of projects has been mooted, either for later completion or as yet not specified, or notably in the case of sulphur recovery plants at oil refineries or gas plants the necessary construction of which can be inferred. The total is well in excess of 5 million tonnes but it is expected that at least 2 million tonnes will be built before 1973 and certainly before 1975.

It is seen therefore that new plant capacity already built or building totals 10.1 million t.p.a. and that one may assume with confidence that by 1973 or 1975 at least 2 million t.p.a. more, i.e. 13.1 million t.p.a. new brimstone production capacity will be available. Some of the existing capacity will be closed either due to depletion of deposits or due to adverse economic factors, but in the relatively short period under review, barring a natural disaster, such shut-downs may not reach ½ million t.p.a. of capacity and are unlikely to exceed 1 million t.p.a.

Free World : Summary Tabulation showing Distribution of new Brimstone Production capacity 1968 - 1975
(% of total Free World capacity commissioned)

	1968 Start-up	1969-71 Start-up	1971-75 Start-up
Frasch Sulphur:			
U.S.A. and Mexico	50%	37%	50%
Recovered Sulphur:			
Canada	40%	17%	50%
Near East	-	21%	-
Far East & Pacific zone	.3%	8%	10%
U.S.A. & Atlantic zone	7%	13%	10%
Native Sulphur:	-	4%	-
million tonnes	3.8	6.3	2.0

FERTILIZER CONSULTANCY & MINERALS INDUSTRY STUDIES

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SECTION-3

SUPPLY PROSPECTS 1975-1985

In view of the progressive depletion of most of the native ore deposits currently exploited by the Frasch process and the limited prospect of new deposits of similar magnitude being identified and developed, it is estimated that at best this source of supply will remain static.

The successful development of hotwater process technology now practised in Poland and W. Texas, will, however, permit economic exploitation of a number of sedimentary sulphur deposits which were hitherto not economically exploitable.

The main sources of additional recovered sulphur supply from the desulphurisation of natural gas are expected in:-

W. Canada
Near East
U.S.A.
West Germany

In France no change from the present level of about 1¾ million tonnes is anticipated, whilst some expansion may occur in Italy, and of course from sour gas sources yet to be identified. The increased volumes of sulphur recovered at oil refineries are expected to arise as a result of the rising incidence of sour crudes in the world refinery procurement pattern and more significantly, because of the extension of desulphurisation to heavier products, in particular fuel oil.

In Western Europe the accent on the use of North and West African sweet curdes is likely to delay the greater impact of the need for intensive desulphurization and in the event of a major expansion of oil supplies from Indonesia, this may have a similar effect in the Far East, notably in Japan.

The importance of tar sands and oil shales as a major potential sulphur supply source by recovery in the course of synthetic crude oil production has receded since last year when major oil discoveries were made in Alaska. Previously, the Athabasca Tar Sands especially had been considered as a likely major sulphur source.

The depletion of North American oil reserves had slightly exceeded the additions to new reserves and it was anticipated that, rather than enhancing its dependence on imports from the Near East, the U.S.A. would progressively place greater emphasis on meeting rising oil demand by synthetic crudes. The exploitation of Athabasca Tar Sands which entails the recovery of about 100,000 t.p.a. brimstone per 45,000 barrels per day, synthetic crude production was expected to have priority in the North Central States of the U.S.A. which in any case are not favourably situated in relation to extra-continental oil imports.

With regard to the extraction of sulphur from combustion gases of fossil fuels - coal or fuel oil - notably at power stations, the legislative pressure to minimise SO_2 emission into the atmosphere is mounting in all industrialised countries. In part, the incidence of pollution will be minimised by the use of low-sulphur fuels, of which some may originate from oil refineries where desulphurization is practised. The treatment of effluent gases may, according to the processes favoured at the time, yield brimstone or sulphur in another form, e.g. sulphuric acid, ammonium sulphate. In the following table the estimate for this source of brimstone supply may therefore only be valid in part.

Brimstone Production (million tonnes)

	1967	1975 Probable	1985 High	1985 Low
1. Exploitation of native sulphur ore by Frasch and other processes.	9.5	13.0	15	11
2. Recovered sulphur				
a) Desulphurization of natural gas & oil refinery products	5.8	11.5	21	17
b) Extraction of sulphur in synthetic crude production	+	0.5	8	1
c) Extraction of sulphur from fuel combustion gases	-	1.0	10	6
	15.3	26.0	54	35

+ less than 50,000 tonnes

Pyrites

Production of pyrites in the Western World is expected to advance from about 8 million tonnes S in 1975 to at least 10 million tonnes S. Most of the additional pyrites supply is expected to be in the form of flotation concentrates produced in conjunction with non-ferrous metal concentrates. Sulphur production in other-forms, notably SO_2 in metal smelter gases and the use of waste products such as sludge acid and waste sulphuric acid, will increase at established growth rates, whilst greater use may be made of gypsum both natural and phospho-gypsum, especially in ammonium sulphate production. Production by 1985 in forms other than brimstone or pyrites is expected to exceed 6 million tonnes S.

The Free World supply pattern by 1985 is expected as follows:-

Production	High	Low
	(million tonnes S)	
Brimstone	54.0	35.0
Pyrites	11.5	10.0
Sulphur-in-other-forms	6.5	6.0
	71.0	51.0
Imports from East Europe		
Brimstone	3.0	1.0
Pyrites	1.0	0.5
TOTAL	75.0	52.5

Indeed by 1975 in the event of a same potential sources of recovered sulphur supply not materializing, World sulphur supply could again become tight with a corresponding reversal of the current price trend. Because of the increasing uncertainty and possibility of frequent supply/price fluctuations due to the growing dependence on recovered sulphur supplies, the supply of economically priced sulphur in pyrites is likely to become increasingly attractive, especially to large consumers, because of their relative stability.

Supply/Demand Balance to 1985

Free World consumption of sulphur-in-all-forms in 1985, based on the extension of the present use pattern and allowing for relevant factors influencing the growth of demand of derived products, is indicated at 59 million tonnes S. The margin of error, disregarding major areas of substitution due to new technology or changes in comparative economic viability of products at present dependent on the use of sulphur, is estimated at up to ± 10%.. As indicated above, sulphur supply is expected to expand to at least 55 million tonnes S, whereas maximum sulphur recovery from oil, gas and coal could raise Free World sulphur supply to some 71 million tonnes S. In view of the cost economics of the respective sources of sulphur supply, a continuing excess and mounting of recovered sulphur - of which the real cost would bear little or no relation to that of a primary production, such as Frasch sulphur or to the comparable cost of the use of sulphur in pyrites - would result in the discontinuation of the higher cost of primary sources of sulphur supply.

Pending a clearer emergence of quantifiable trends in recovered sulphur production, especially from desulphurization at oil refineries and from combustion gases of fossil fuels, the evaluation of future supply will remain questionable and there will be a strong possibility of recurring threats of an imbalance between supply and demand.

SECTION - 4

SULPHUR DEMAND

All Forms Consumption

In 1968 total free world consumption of sulphur in all forms is expected to total 27.6 million tonnes S. The long-term historical trend of demand (1950-1968)+ has shown a growth rate of 5.0% p.a. whereas in the past five years Free World sulphur demand has advanced at a rate of 5.5% p.a.

The proportion of brimstone utilization in the Free World sulphur-in-all-forms consumption pattern has advanced slowly, subject to some fluctuations, from about 56% in the late 1940's to 60%, although as the result of the stagnation of demand in the past two years in the U.S.A. a very large and predominantly brimstone consuming market, it has again receded to just over 58%, 1968 Free World brimstone consumption totalling 16.2 million tonnes.

Analysis of world sulphur demand growth by several alternative methods - notably mathematical extrapolation against a number of correlative factors, analysis of growth projects of demand in individual markets and regionally and world wide of individual major end use products, such as fertilizers, plastics and fibre, pigments, etc., indicates the following probable levels of demand.

Free World : Sulphur Consumption 1970-1975
(million tonnes S)

	1970	1973	1975
Sulphur-in-all-forms	31.2	35.8	39.0
Brimstone	19.1	22.7	25.4

+ 5.3% p.a. for the period 1948 to 1968.

The margin between high and low estimates of which the above are median values is less than ±1%. Based on 1968 consumption figures the above estimates correspond to the following growth rates:-

	Cumulative rate of growth (% p.a.)	Total increase million tonnes S
Sulphur in all forms		
1968 - 1970	6.3%	3.6
1968 - 1973	5.4%	8.1
1968 - 1975	5.1%	10.4
Brimstone		
1968 - 1970	8.6%	2.9
1968 - 1973	7.0%	6.5
1968 - 1975	6.7%	9.2

In the period 1963-1968 brimstone demand rose by 5.1 million tonnes or at an annual cumulative rate of 7% p.a. As shown above, the anticipated increase in demand in the period 1968 to 1973 totalling 6.5 million tonnes brimstone, results in a cumulative growth rate similar to that recorded for the preceding five years.

It is evident that the accuracy of the estimate of brimstone demand growth depends as much on the accuracy of the forecast of total sulphur demand as on that of the use of sulphur in forms other than brimstone, namely sulphur in pyrites and sulphur in "other forms" represented by SO_2 in smelter gases, anhydrite/phospho-gypsum, sulphur ore and H_2S converted direct into sulphuric acid, acid sludge, etc. The growth of sulphur-in-other-forms production is largely governed by the increments in smelter acid production and a modest progression of demand is foreseen, although the greater use of phospho-gypsum in ammonium sulphate production and/or the implimentation of several projects for the production of sulphuric acid and cement from anhydrite/phospho-gypsum would significantly increase the use of sulphur in this form at the expense of brimstone demand. The growth prospects of the use of sulphur in pyrites are also conservatively evaluated and in essence these are confined to those projects which are already firm, i.e. under construction or design, which total about 1.1 - 1.2 million tonnes S. The anticipated growth in the use of sulphur in pyrites between 1968 and 1973 is 1.1 million tonnes S (from 6.9 to 8.0 million tonnes S). In this period brimstone consumption is expected to increase from 16.2 million tonnes to 22.7 million tonnes S, i.e. from 58½% to 63½% of world consumption of sulphur in all forms.

Regional Consumption Pattern

The evolution of sulphur consumption forseen for the main geographical regions is as follows.

Free World : Pattern of Sulphur Consumption 1968 - 1975 (million tonnes S)

	1968	1970	1973	1975
Western Europe	9.9	10.8	12.0	12.8
North America	11.2	12.1	13.4	14.3
Latin America	1.0	1.5	2.0	2.4
Asia	3.7	4.4	5.3.	6.0
Oceania	0.9	1.2	1.6	1.8
Africa	0.9	1.2	1.5	1.7
TOTAL	27.6	31.2	35.8	39.0

The main impact of sulphurous raw materials consumption in forms other than brimstone will occur in Western Europe, Japan, Australia and South Africa, although in South America the realisation of some of the projects under consideration could also result in measurable substitution for brimstone in the demand pattern.

Free World : Pattern of Brimstone Consumption 1968 - 1975 (million tonnes S)

	1968	1970	1973	1975
Western Europe	4.0	4.6	5.3	5.9
North America	9.0	9.9	11.1	11.9
Latin America	0.9	1.4	1.9	2.3
Asia	1.2	1.6	2.3	2.9
Oceania	0.7	1.0	1.3	1.4
Africa	0.4	0.6	0.8	1.0
TOTAL	16.2	19.1	22.7	25.4

The evolution of pyrites consumption in the period up to 1975 is expected to continue being influenced by the factors which have determined growth during the past decade. Despite isolated instances where new viable projects are likely to be implemented in major brimstone importing regions, mainly as the result of special local conditions which will make the use of pyrites clearly more advantageous than that of any other sulphurous raw material, the main expansion will inevitably be in the major pyrite producing countries. Even amongst these the intensity of developments is likely to differ appreciably. Quantitatively the largest growth is expected to occur in West Europe, in particular in Spain and Sweden. In Spain, where the development of Huelva as a major centre of sulphuric/phosphoric acid production is already under way, is likely to be the most prominent, whilst in Sweden the present plans for the construction of major sulphuric acid/liquid SO_2 plants based on pyrites are likely to give pyrites use a major boost notwithstanding that present imports from Norway may be supplanted by domestic ore supplies. Rationalization of pyrites roasting facilities will detract from gross expansion of pyrites use in Italy and in France this is likely to cause a further contraction of pyrite use, although the possibility of a new major project cannot be excluded. In West Germany, despite several new plants and projects, overall growth is likely to be small, especially as increasing domestic recovered brimstone supplies will enhance the pressure of the excessive world market supplies. Turkey will emerge as a major new user, based on indigenous ore supplies. Outside West Europe, Japan, the largest consumer of pyrites, is expected to experience a similar although perhaps not as marked development as in West Germany for the same reasons.

<u>Free world pattern of pyrites consumption</u>:-

(million tonnes S)

	1968	1970	1973	1975
WEST EUROPE	4.2	4.5	4.7	5.0
NORTH AMERICA	0.7	0.7	0.8	0.8
LATIN AMERICA	*	*	*	*
ASIA	1.5	1.7	1.8	1.8
OCEANIA	0.1	0.2	0.2	0.3
AFRICA	0.4	0.5	0.6	0.6
	6.9	7.6	8.0	8.5

* less than 50,000 tonnes S.

FORECASTS OF SULPHUR DEMAND

Non Acid Sulphur

Forecasts of non acid brimstone consumption made in 1965 indicated a total consumption of 3.71 million tonnes of brimstone in 1968 and 4.37 million tonnes in 1975.

Results achieved in 1966 and 1967 tie in closely with these forecasts and it is confidently expected that the level reached in 1968 will correspond to the forecast of 3.71 million tonnes. The forecast of non acid brimstone consumption is also considered valid, for 1975.

Non acid uses of sulphur in pyrites in 1975 are expected to total 0.43 million tonnes. Use of sulphur in gypsum for ammonium sulphate production was forecast at 0.7 million tonnes S for 1975. Several new projects of this type are being implemented and the forecast of consumption of 0.7 million tonnes S in 1975 may prove to be too low. As yet there is not, however, enough evidence to warrant modifying it.

Sulphur for Sulphuric Acid

The projections made in 1966 and 1967 of sulphur demand for sulphuric acid in 1968 indicated the range 20.5 - 23.4 million tonnes S. Probable results were expected to lie at the higher end of the forecast bracket. This is being borne out.

Forecasts for 1975 indicated sulphur demand for sulphuric acid in the range 27.1 - 32.6 million tonnes S, reflecting the results of the different forecasting methods used:-

1. Quadratic extrapolation of Free World sulphuric acid production in the period 1950-1964, giving 27.1 million tonnes S for 1975.

2. Extrapolation of historical growth rate 1950-1964, giving 32.6 million tonnes S for 1975.

3. Correlation with G.N.P., giving 28.6-29.6 million tonnes S for 1975.

4. Evaluation of end product trends on a world basis, giving 28.7-33.9 million tonnes S for 1975.

5. Evaluation of demand on a regional basis giving 28.2-33.5 million tonnes S for 1975.

Giving due weight to the various methods, the anticipated level of free world sulphur consumption in all forms, which in 1968 totalled 27.6 million tonnes S, will total in 1975 about 39 million tonnes S:-

End use pattern	1968	1975
Sulphur in various forms for new sulphuric acid.	23.0	33.5
Sulphur in various forms for non-acid uses	4.1	4.8
Gypsum/Anhydrite for ammonium sulphate	0.5	0.7
	27.6	39.0

Sulphuric Acid Product Pattern:-

During the period 1968 to 1975 the pattern of sulphuric acid consumption is expected to evolve as follows:-

	Cumulative growth rate	
	LOW	HIGH
For phosphate fertilizers	4%	7%
For nitrogen fertilizers	4%	6%
For pigments (TiO_2)	2%	4%
For fibres & plastics	5%	8%
For other	4%	6%

Based on 1968 results when sulphur equivalent of sulphuric acid consumed for the above end-uses totalled 23.3 million tonnes S (including re-used sulphuric acid), the following results are given for 1975:-

	Estimate 1975 million tonnes S	
	LOW	HIGH
For phosphate fertilizers	11.0	13.4
For nitrogen fertilizers	4.0	4.5
For pigments (TiO_2)	1.7	2.0
For fibres & plastics	3.2	4.0
For other uses	8.8	10.0
	28.7	33.9

The growth trend of acid use for nitrogen fertilizers manufacture is increasingly becoming a function of growth in the plastics and fibres sector which yields ammonium sulphate as chemical co-product. Amongst other uses the expected growth of sulphuric acid use for metallurgical use notably uranium ore treatment coupled with the continuing growth of detergent and general chemicals output are likely to be the most prominent factors.

During this period agricultural demand for sulphur is expected to be confined to that present in fertilizers, although by the mid-1970's an increasing number of areas is likely to show growing soil sulphur deficiency for which during the subsequent years allowance will have to be made in the demand pattern.

In view of the prevailing trend of supply and prices, it is not expected that there will be very significant new substitution for the use of sulphur. The switch to hydrochloric acid in steel pickling is already an established trend, as is use of the chlorine route in large capacity TiO_2 plant in major industrialized countries. The latter is likely to weaken, largely due to the limitations of rutile supply and the establishment or expansion of small/medium sized operations in developing countries based on sulphuric acid.

The manufacture of fertilizer phosphoric acid on the basis of elemental phosphorus is expected to be deferred to the late 1970's, before when the availability of low cost electricity from atomic poer plants is not likely to show economic advantages over chemical energy sources for the solubilisation of P_2O_5. In this respect the use of hydrochloric acid is likely to curtail some of the growth which other wise would have contributed to greater sulphur/sulphuric acid use.

SUPPLY/DEMAND BALANCE

Having identified the anticipated increase in Free World sulphur demand between 1968 and 1973 at 6.5 million tonnes and between 1968 and 1975 at 9.2 million tonnes, it is evident that the volume of new plant capacity in sight exceeds the anticipated increment in brimstone demand by a wide margin.

However, both in respect of dome productions, several of which already work well below capacity, and even more so in the case of sulphur recovery plants, which as a rule work much below capacity, the evaluation of capacity increments is not as meaningful as the forecast of production and supply. During the period of review this assumes added significance because of the impact on supply pattern of the Free World of the exports of Polish sulphur.

Sulphur Exports from Poland

The successful realisation of hot-water injection techniques by Polish engineers and their establishment in 1966 and 1968 at two major deposits - Grzybow and Jeziorko - has increased Polish sulphur production capacity from ½ million t.p.a. (represented by the Piaseczno opencast mine and refining plant) to over 1.3 million tonnes. The extension of the life of the Piaseczno mine, as a result of the discovery of additional reserves and the development of the new Machow opencast mine with an ore mining capacity equivalent to 800,000 t.p.a. brimstone, which is due on stream in Spring 1969, raises Poland's production capacity to at least 1.6 million tonnes and, if additional planned refining capacity is installed, to 2.1 million tonnes. Moreover the "Frasch" sulphur operations are to be extended to other parts of the vast sulphur deposits, but as yet these plans are not specified.

Exports of Polish sulphur to the Free World have risen from about 250,000 tonnes in 1967 to about 650,000 tonnes in 1968 and although domestic demand in Poland and that of her Comecon neighbours is increasing, the rising level of output points to the export surplus reaching at least 1 million tonnes by 1970 and at least 1.2 million tonnes thereafter. At this point it is not thought realistic to assess Poland's export potential to the West any higher, although the possibility must be borne in mind, especially as brimstone is now designated a major foreign exchange earner. This factor also determines Poland's very high rating as a fierce competitor on Free World markets, to whom disposal of tonnage is more important than considerations of price or market stability.

The following export supply pattern is anticipated.

Poland : Pattern of Sulphur Export Sales to Free World, 1968 - 1975 ('000 tonnes S)

	1968	1969	1970	1971-1975
W. Europe	380	490	630-830	790-900
Africa	90	100	100-120	120-200
Latin America	80	100	100-120	120-150
Asia	70	120	150-180	150-200
Oceania	20	20	20- 50	20- 50
	640	830	1000-1300	1200-1500

Production Forecast

(1) Frasch Sulphur

a) Mexico

From the restricted level of output of 1.65 million tonnes in 1968 production from the three operating domes is expected to increase to 2.0 million tonnes. Whether or not CEDI builds production facilities at the Texistipec dome it is expected that Mexican Government requirements will result in an output of 2.3 million tonnes by 1973 to satisfy domestic requirements of at least 0.7 million tonnes (including FFM) and exports of 1.6 million tonnes.

b) U.S.A.

It has been assumed that Texas Gulf Sulphur and Freeport Sulphur will adjust their production schedules to maintain the level of U.S. Frasch output at about 7.5 million tonnes this year (1969) and at 7.9 million tonnes from 1970 onwards. It has also been assumed that the principals will bring on stream their Culberson County operation early in 1970 and that this will reach the design capacity in 1971 when the restraint on Texas Gulf and Freeport production will accentuate. The severity of this restraint will depend on stock piling policy and any fluctuations in the level of competing deliveries notably of recovered sulphur, Polish sulphur and the principal's sales in the markets in which the two major producers will maintain their presence.

The progression of Free World brimstone output (shown in greater detail in the statistical appendix) is expected to be as follows:-

1968	16.4 million tonnes
1969	18.0 million tonnes
1970	19.8 million tonnes
1971	20.7 million tonnes
1972	21.7 million tonnes
1973	22.3 million tonnes

The attainment of these production levels is not in any doubt as U.S. Frasch producers are capable of substantially greater output than is included in the estimates. Any shortfall in other supplies or any fluctuations in demand could therefore be readily balanced.

(2) Recovered Sulphur

a) Canada

Production in Alberta and British Columbia which in 1968 is just in excess of 3 million tonnes, will continue to expand commensurate with domestic and export gas sales, and will reflect the rising average H_2S-content of crude gas under exploitation. Progressively increasing operations on the Athabasca Tar Sands will add a modest tonnage of sulphur but this is not expected to exceed 150,000 tonnes by 1971 and 300,000 by 1973. It is thought that total output in West Canada will increase to 3.8 million tonnes in 1970 and 4.6 million tonnes in 1973.

b) U.S.A.

Increasing emphasis on the desulphurisation of heavier petroleum fractions at oil refineries coupled with utilisation of more sour natural gas in the energy supply pattern will tend to accelerate recovered sulphur output in the U.S.A. Also included in this category is the Elcor Chemicals' operation which it is expected will start-up early in 1969.

The production level is expected to rise from 1.45 million tonnes in 1968 to 1.95 million tonnes in1970 and 2.2 - 2.4 million tonnes in 1973.

c) France

Small increases in plant capacity are foreseen in 1969 and 1970 to raise production to about 1.75 million tonnes or about 100,000 tonnes more than at present.

d) Near East

During 1969, the start-up year, it is not expected that aggregate production will exceed 350,000 tonnes of which part will be used to establish commercial stocks. During the period 1970-1973 production is expected at best to increase from 0.7 to 1.2 million tonnes.

e) Rest of World

Four major new sources are emerging; Japan, the Caribbean, East Canada and West Germany; the latter based on natural sour gas, the East Canadian operation on SO_2 from pyrrhotine roasting and the other two based on oil refinery gas desulphurisation. In addition a great many oil refineries throughout the world are building or projecting sulphur recovery units. The anticipated level of output is however, evaluated conservatively and from a production level of just under 0.8 million tonnes in 1968 these sources are expected to increase their output to 1.2 million tonnes in 1970 and 1.6 million tonnes in 1973.

Balance of Supply/Demand and Stocks

In 1968 Free World stocks have increased by about 1.1 - 1.2 million tonnes represented by a rise in U.S. Frasch sulphur stocks of 0.7 million tonnes, W. Canada 0.5 million tonnes, Mexico about 0.1 million tonnes and a decrease of 0.1 million tonnes of French recovered sulphur stocks.

As a result end-1968 Free World stocks total about 4¾ million tonnes.

The anticipated supply/demand balance for the subsequent years is outlined in the following table.

Free World: Brimstone Supply/Demand 1969 - 1973
(million tonnes S)

	1969	1970	1971	1972	1973
Production	18.0	19.8	20.7	21.7	22.3
Nett imports	0.8	1.0	1.2	1.2	1.2
Total supply	18.8	20.8	21.9	22.9	23.5
Consumption	17.6	19.1	20.4	21.7	22.7
Producer stocks Increase	+1.2	+ 1.7	+ 1.5	+ 1.2	+ 0.8

The aggregate increase over the five-year period is 6.4 million tonnes which would raise producer stocks to about 11 million tonnes or about 25 weeks consumption.

The two main factors in the progressive build-up of stocks, despite the anticipated production restraint by the U.S. Frasch sulphur industry are the incidence of Polish sulphur exports and the cumulative effect of a wide range of recovered sulphur productions, notably in West Canada.

SECTION 5

Evaluation of factors influencing future pyrites consumption

An analysis of the world consumption of sulphur in various forms (Section 1.) identifies three broad categories of pyrites consuming countries.

Category I: The level of the country's pyrite consumption is influenced in direct proportion to growth of sulphur demand. This occurs only in a small number of pyrites producing countries where either by tradition, by co-ordination of pyrites producer and consumer interests, or as a reflection of Government policy, sulphuric acid production and in some instances also S-use of other industries, e.g. pulp, is predominantly based on pyrites.

They are as follows:-

	Pyrite use as % of Total sulphur consumption
W. Europe:	
Spain	87%
Portugal	87%
W. Germany	57%
Italy	77%
Sweden	51%
Norway	53%
Rest of the World:	
Japan	57%
Morocco	90%

Of these only W. Germany and Italy and, on rare occasions Japan, are importers of pyrites to supplement indigenous pyrite production. Indeed, W. Germany almost does not qualify in this category since, although pyrites accounts for the greater proportion of total sulphur demand and pyrites consumption is promoted by the activities and company links of Duisburger Kupferhutte, there is also a large number of brimstone using plants.

In other pyrites producing countries where a significant proportion of the total sulphur demand is met in the form of brimstone, the level of pyrites consumption and the extent in which pyrites participates in the total sulphur damand growth, is dictated by the amount of captive pyrites roasting capacity controlled by the pyrites producers and the economic advantage of pyrites use compared with that of brimstone which in these countries is mostly imported brimstone.

Most prominent in this category is S. Africa. Others are:

		Pyrites as % of Total S Consumption
West Europe:	Greece	59%
	Finland	55%
Rest of World:	Philippines	77%
	Taiwan	9%
	Australia	14%
	Canada	20%
	Rhodesia	84%

The last category embraces all countries in which the use of pyrites and the establishment of new roasting capacity is determined strictly on the basis of the economic viability compared with brimstone. Most prominent in this category are:

		Pyrites as % of Total S Consumption
West Europe:	Belgium	25%
	Holland	23%
	France	15%
	United Kingdom and Eire	8%
	Denmark	81%
	Austria	7%
	Switzerland	25%
Rest of World:	United States	5%

The future trend of pyrite consumption will be determined absolutely in relation to the growth of total sulphur demand and subject only to available resources of pyrites in all countries in Category 1.

In Category II growth of pyrite consumption will tend to be paralled with growth of total sulphur demand and may in some countries even improve its relative position vis-a-vis other sulphurous raw materials.

In Category III growth will be determined strictly as balancing function of brimstone consumption determined by the competitive cost of pyrites compared with that of brimstone.

The anticipated evolution of world pyrites consumption is based at least to 1975 on presently known technology. If new technology relating to pyrites cinders treatment only were evolved the present pattern is not likely to change appreciably except that at some location the use of pyrites might become more competitive with brimstone.

If however, new technology were developed in respect of the treatment of sulphide ores offering an economic means of separating sulphur from the other constituents, pyrites would become another prime source of elemental sulphur supply and become subject to the same economic and competitive considerations as other sources such as Frasch sulphur, recovered sulphur or native refined sulphur. Such developments, although being persued notably in Japan where a new process showing some promise is reported to be under test, are not likely to affect the situation until the mid 1970's, but if successful by say the early 1970's would undoubtedly influence the world brimstone supply pattern of the late 1970's and subsequent year.

Spain

Consumption of pyrites in 1967 accounted for 88% of total sulphur consumption. No brimstone was used in sulphuric acid production and of the total consumption of sulphur in sulphuric acid production 96% was based on pyrites the balance being represented by "sulphur in other forms", i.e. smelter acid. In the period 1963 to 1967 pyrites consumption increased from 477,700 tonnes S to 614,400 tonnes S, an annual growth rate of 6.5% cumulative.

In the evaluation of future demand growth there are two factors:

1) Increased utilisation of existing sulphuric acid plant capacity which in 1967 was only 72%

2) The installation at Huelva of new large capacity pyrites acid plants either by pyrites producers or as joint projects between pyrites producers and sulphuric acid/ fertilizer manufacturers, both creating captive outlets for local pyrites production. These projects are designed not only to meet anticipated growth of acid or derived products demand in Spain, but are envisaged also to serve as sources of supply to other markets of sulphuric acid and/or derived products primarily of phosphoric acid and P_2O_5 products based on the favourable North African phosphate rock supply capability.

Plants under construction or firmly projected correspond to a requirement of 250,000 tonnes S in pyrites due for completion in 1970/71 and it is expected by 1973/75 projects of at least a further 250,000 tonnes S in pyrites will be completed.

Rationalisation of operations is likely to result in the closure of a number of minor plants now operating but even so it can be expected that pyrite consumption in Spain will advance to 800,000 tonnes S in 1970 and 1.1 million tonnes by 1975. The supply potential in Spain is adequate to meet this and an even greater demand. The bulk of this consumption will be represented by the established arsenical pyrites containing recoverable quantities of copper and zinc and it is probable that besides the established cinders treatment plant at Bilbao a major cinders treatment plant will be established at Huelva.

SPAIN PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non Acid	Total Consumption	Supply Source Over 50%	Supply Source Under 50% (in descending order)
1963	469.7	8.0	477.7	Spain	
1964	506.8	6.8	513.6	Spain	
1965	540.0	8.1	548.1	Spain	
1966	592.9	7.4	600.3	Spain	
1967	609.7	4.7	614.4	Spain	
1968	642.0	5.0	647.0	Spain	

Portugal

Consumption of pyrites accounts for 89% of total sulphur consumption although during the period 1963 - 1965 it receded at times to about 70% when Cia Uniao Fabril operated a brimstone acid plant which was subsequently closed when the cost of brimstone rose far beyond the cost of sulphur in pyrites. Currently 100% of Portugal's sulphuric acid production is based on pyrites.

Pyrites consumption increased from 129,700 tonnes in 1963 to 147,400 tonnes in 1967 corresponding to an annual growth rate of only 3.3% cumulative. The future evolution of pyrite demand which corresponds to total sulphur demand prospects, is expected to advance at an annual rate of about 5%. This relatively higher rate of growth is anticipated in part because the Portuguese domestic economy is expected to expand more rapidly and also because of the competitive position of Portuguese fertilizers in world markets. Consumption is expected to rise progressively to about 220,000 tonnes S in pyrites by 1975 reflecting the construction of new roaster capacity.

Domestic pyrites resources, of which one (Louzal) is captive to a major fertilizer plant (SAPEC) and the other (Aljustrel) supplies the country's largest fertilizer/chemicals complex (Cia. Uniao Fabril), are adequate to meet this increased demand. Portugal may, however, as a corollary withdraw partly or wholly from export markets, as no change is expected in the supply potential of the Portuguese pyrite mines. The development of the major reserve deposit at Aljustrel which has been identified, is not anticipated in the foreseeable future; the scope of increasing production at both existing mines, especially at Louzal, is strictly limited

PORTUGAL PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	129.7		129.7	Portugal	
1964	129.7		130.7	Portugal	
1965	115.5		115.5	Portugal	
1966	133.9		133.9	Portugal	
1967	147.4		147.4	Portugal	
1968	152.0		152.0	Portugal	

West Germany

Consumption of pyrites in 1967 amounted to 890,000 tonnes S, a total which in Europe was only exceeded by Italy. Pyrites consumption accounted for 57% of total sulphur use and of the total of sulphuric acid production 64% was based on pyrites.

The level of pyrites consumption is determined by two factors:

a) Domestic supply originating primarily from the Meggen Mine, the bulk of which is captively consumed by Sachtleben AG and converted into sulphuric acid.

b) The interests and policies of the parties who jointly own Duisburger Kupferhutte, whose pyrite requirements are almost exclusively imported.

a) Domestic production is currently at an annual rate of about 250,000 tonnes S of which about 80% is in the form of Meggen flotation pyrites containing about 42% S, is captively used at the Homburg acid plant. (The balance is represented by Waldsassen, Trene and Meggen crude ore and 48% S concentrates consumed by various W. German sulphuric acid and pulp plants.)

There is a possibility of the Meggen plant being increased by 50% and if so Meggen flotation pyrites production would correspondingly increase, i.e. the expansion would not create a demand for a new supply source.

b) Plants associated with Duisburger Kupferhutte: During the past 5 years the interests and policies of the individual companies which own Duisburger Kupferhutte* (BASF/Bayer/Hoechst 30.97% each, Guilini 2.3%, Ruhrschwefelsäure 2.36%) have changed significantly.

BASF which had up to about 1963/64 persued a 100% pyrites-use policy, abandoned this and has since then progressively favoured more and more the use of brimstone at Ludwigshafen. A disproportionate merit is being attached to the lower capital costs for brimstone acid plants mainly because of the large investment capital requirements of BASF and in the cost comparison with brimstone, pyrite is penalised by the long up-river journey for pyrite from Rotterdam and the corresponding down-river carriage of residues to Duisburg. The development of the BASF two-stage roaster has not significantly caused a policy change although it improved the status and scope for Iberian pyrites. Present capacity at Ludwigshafen is 520/560,000 t.p.a. 100% H_2SO_4 of which about 180,000/200,000 t.p.a. is based on brimstone. The balance is represented by a 400 t.p.d. ordinary BASF fluidized bed roaster, a 150 t.p.d. two-stage BASF roaster and about 180,000/100,000 t.p.d. H_2SO_4 pyrites acid capacity which is obsolescent and will be scrapped by 1970, when a new 200,000 t.p.a. brimstone acid plant based on Polish sulphur comes on stream. Thus, BASF pyrite consumption will decline by 150,000 t.p.a. in about 1970/1971. Although not quite consistant with their policy it is not thought likely that the two fluidised bed plants will be closed and there remains the possibility of the 150 t.p.d. plant being expanded to 400 t.p.d., resulting in an increased demand of about 85,000 t.p.a. arsenical pyrites.

Farbwerke Hoechst: Whereas in the early 1960's there was a strong possibility of pyrites use being severely curtailed or even abandoned, the present policy gives full support to pyrite use. Following the completions of the new 800 t.p.d. plant based on pyrites in 1968, dismantling old pyrites roasting plants was accelerated and is now almost completed. A new 500 t.p.d. pyrites acid plant (BASF two stage roaster) is projected which will augment W. German pyrites consumption by about 170,000 t.p.a., providing an outlet for arsenical pyrite.

Farbenfabriken Bayer: At the company's three works Ürdingen, Dormagen and Leverkusen, rationalisation of pyrites roasting capacity has been in progress for the past 5-7 years coupled with the increased utilisation of by-product ferrous sulphate. The Ürdingen plant which up to 1965 was using Mexican Frasch sulphur in conjunction with ferrous sulphate, now uses Russian low cupreous pyrite at an annual rate of about 120,000 tonnes. The installation of new large capacity pyrite roasters (at least one 450 t.p.d. two stage BASF roaster) will not significantly change the total pyrite requirement and in view of the company's new developments and projects at Antwerp none is envisaged in W. Germany.

Guilini: A new 200 t.p.d. pyrite roaster based on Spanish pyrites and built under procurement contract incorporating a subsidy by the pyrite supplier towards the cost of its construction, is due on stream end-1969. It will replace a brimstone burner.

Ruhrschwefelsäure: The old pyrite based plant at Duisburg has been under sentence of closure for some time and will certainly close if the new project at Bochum-Riemke (replacing the existing plant) materialises. Here a 500 t.p.d. pyrite based plant is projected, based either on Spanish or Russian pyrites.

Sud Chemie: Conversion from brimstone to pyrites was effected last year and in addition to domestic pyrite Yugoslav and Romanian material is used. No expansion is envisaged.

Other pyrite users: Decline in pyrites use by the pulp industry continues and the small use of about 80,000 t.p.a. pyrite by the pulp industry supplied almost entirely by domestic pyrites (mainly Meggen) is receding further. No significant growth is foreseen in the pyrite requirements of Grillo (liquid SO_2 production) which is in part met by Russian pyrites.

To sum up, the scope of expansion of pyrite demand is limited since much of the new projected capacity is in replacement of old capacity. It is estimated that up to 1972 import demand will at best increase by 100,000 t.p.a. pyrites (50,000 tonnes S) over 1968 when it totalled just under 1 million tonnes S.

The pressure for adequate residues supplies to DKH has receded now that the Bayer plant in Antwerp is a new source of about 300,000/350,000 t.p.a. Rio Tinto/ Tharsis cinders. Because of the adverse demand and price trends for non-cupreous residues in W. Germany it must be also expected that all new demand will be represented by pyrites containing copper and/or other recoverable non-ferrous metal values.

WEST GERMANY PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	748.6	71.0	819.6		Spain, W. Germany, Norway, Portugal, Finland, USSR, Yugoslavi Turkey, Cyprus, Canada Greece
1964	787.9	63.0	850.9		Spain, W. Germany, Norway, Cyprus, USSR Yugoslavia, Finland, Portugal, Turkey.
1965	776.5	82.0	858.5		Spain, W.Germany, Norway Cyprus, Portugal, Finlan Yugoslavia, USSR, Turkey
1966	840.1	73.0	913.1		Spain, W.Germany, Norwa Cyprus, USSR,Finland, Portugal, Yugoslavia, Turkey
1967	815.0	75.0	890.0		Spain, W.Germany, Norwa Cyprus, USSR, Roumania, Portugal, Yugoslavia, Finland, Turkey.
1968	850.0	77.0	927.0		

Italy: Europe's largest consumer of pyrites which in 1967 totalled just under 1.2 million tonnes, Italy has increased its pyrites consumption which since 1963 rose at an annual rate of about 9%. This is largely attributable to the installation of the large pyrites acid plant of Montecatini-Edison at Follonica which is fully integrated with the mine production of low grade (35-37%) Maremma pyrites and which yields an up-graded pelletised pyrite residue of about 66% Fe. The large domestic supply of Italian non-cupreous and cupreous pyrites is supplemented by imports from Cyprus and U.S.S.R. as well as from Turkey and Yugoslavia, totalling about 520,000 tonnes p.a. Changes in the fertilizer use pattern - reduced single superphosphate needs - is resulting in the progressive closure of small pyrite based sulphuric acid/fertilizer plants of which there are still over 30 in operation. During the past 4 years and increasingly since 1967 when the Ente Zolfi Italiana ceased its activities and brimstone imports into Italy were liberated, brimstone is being imported for sulphuric acid manufacture. The availability of low-cost brimstone on world markets, especially of Polish and Canadian origin, in the next 3-5 years will tend to encourage some new construction of brimstone acid plants so that only part of the increasing sulphur requirements will be met by the use of Sicilian sulphur ore and pyrites. The latter are expected to be in the form of imported Russian and possibly Turkish material.

ITALY PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	841.3	9.0	850.3		Italy, Cyprus, USSR, Yugoslavia, Turkey, Greece.
1964	921.1	9.9	931.0		Italy, USSR, Cyprus, Turkey, Greece, Yugoslavia, Algeria.
1965	922.8	10.0	932.8		Italy, USSR. Cyprus, Turkey, Algeria, Yugoslavia, Greece.
1966	995.2	10.0	1005.2		Italy, USSR, Cyprus, Turkey, Algeria, Spain
1967	1175.0	10.0	1185.0		Italy, USSR, Cyprus, Turkey, Algeria
1968	1220.0	11.0	1231.0		

Sweden

Consumption of pyrites in Sweden in 1967 totalled 233,100 tonnes S representing about 51% of total sulphur use. In sulphuric acid production some 71% of the output was based on pyrites. The principal driving force in the Swedish sulphur industry is Boliden AB. Since the take-over of Reymersholm AB through which Forenade AB is controlled, Boliden has progressively evolved a policy of intensive integration and of maximisation of the sulphur value of the company's sulphide ore output.

In part this is to be achieved by the progressive increase of captive sulphuric acid consumption for fertilizer and chemicals manufacture and by capturing a greater share of the sulphur market represented by Swedish pulp industry, in part by aiming to secure a dominent position in the European sulphuric acid market. To this end Boliden is establishing large capacity storage facilities in Sweden, the UK and NW Europe as well as long term outlets in order to eliminate as far as possible violent price fluctuations in the sulphuric acid markets. Construction of another new pyrites acid plant at Helsinborg as well as two liquid SO_2 plants based on pyrites will augment the company's captive outlets and at the same time cause progressive elimination of import requirements of cupreous Norwegian pyrites when the Orkasham plant closes in 1970.

Pyrite consumption in Sweden is expected to increase to over 300,000 tonnes S by the early 1970's.

SWEDEN PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source	
				Over 50%	Under 50% (in descending order)
1963	148.7	105.1	253.8	Sweden	Norway
1964	143.5	96.4	239.9	Sweden	Norway
1965	167.8	95.3	263.1	Sweden	Norway, USSR, Morocco
1966	149.8	90.0	239.8	Sweden	Norway, USSR, Spain
1967	153.6	79.5	233.1	Sweden	USSR, Norway
1968	153.0	78.0	231.0	Sweden	

Japan

In 1967 Japan consumed 1.45 million tonnes S in pyrites which next to the U.S.S.R. makes Japan the largest pyrites consumer in the world. In the period 1963 - 1967 consumption increased from 1.23 million tonnes S, at an annual rate of 41%. Traditionally domestic pyrites is the major source of sulphur supply of the sulphuric acid industry, and accounts for 60% of total acid output. Besides pyrites the acid industry uses sulphur ore much of which is mined in conjunction with pyrites and of course large volumes of SO_2 in non-ferrous metal smelter gases. No brimstone is used.

As the result of company links about 70% of the total pyrites consumption can be described as captive. The initiative to promote pyrites use does not however derive only from the linked interests of pyrites producers and consumers, but the Government also strongly supports pyrites use to avoid the import of brimstone and also to strengthen and provide employment in the mining sector of Japanese industry.

The utilisation of pyrites cinders is intensive and according to the qualities arising, cinders are either treated or used as direct blast furnace feed. Although there is no cinders treatment plant comparable with DKH either in size or treatment techniques, the value of residues is maximized. Of special significance is the successful development of a process and since 1967 the operation of a large capacity plant by Kowa Seiko, designed to treat cinders with relatively low non-ferrous metal values by the admixture of calcium chloride and subsequent calcination resulting in the volatilization of non-ferrous metals on chlorides and the agglomeration of the iron constituent.

Consumption of pyrites in Japan is expected to progress at an annual rate of about 4% which can be readily sustained by available pyrite resources. Government control of pyrites prices coupled with the periodic pressure from low cost brimstone on the world market has inhibited the development of new pyrites mines, so that at times supply shortages occurred, necessitating imports, notably from U.S.S.R. This situation could recur especially if the large mining/chemical combines find more profitable employment for their capital and the Government were to encourage imports from U.S.S.R. or China on trade political grounds. There is also an increasing tonnage of recovered brimstone at Japanese oil refineries, which may result in its being used in domestic sulphuric acid production instead of it being exported to world markets which in the near future are oversupplied.

JAPAN PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source	
				Over 50%	Under 50% (in descending order)
1963	1191.1	41.6	1232.7	Japan	Philippines
1964	1260.4	68.3	1328.7	Japan	Philippines
1965	1301.2	77.4	1378.6	Japan	USSR, Canada, Philippines
1966	1315.1	83.5	1398.6	Japan	USSR, Philippines, Canada
1967	1346.2	109.0	1455.2	Japan	USSR, Philippines
1968	1370.0	120.0	1490.0	Japan	

Morocco

The establishment of the sulphuric acid/fertilizer plant of Maroc Chemie in 1965 at Safi was co-ordinated with the exploitation of the Kettara pyrrhotine deposit, where production progressively increased to about 100,000 tonnes S in 1967, as an increasing proportion of the sulphuric acid output was based on this raw material. The resultant residues containing 0.71% copper continue to be stock piled, pending the development of a suitable and economic treatment process. Because of the irregular quality of ore which fluctuates between 26%-31%S, it is now planned to treat the ore by flotation to yield copper, zinc and pyrrhotine concentrates, the latter containing 40%-47%S. This project will be implemented in conjunction with the expansion of sulphuric acid capacity at Safi by 50% which is projected for 1970/71. The possibility exists, however, of pyrrhotine use being abandoned altogether and substituted by the use of Polish brimstone which would be bartered for phosphate rock.

MOROCCO PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	5.4		5.4	Morocco	
1964	6.0		6.0	Morocco	
1965	36.6		36.6	Morocco	
1966	77.4		77.4	Morocco	
1967	97.1		97.1	Morocco	
1968	130.0		130.0		

Greece

Consumption of pyrites in Greece rose steeply in 1966 when new pyrites based sulphuric acid plants were brought on-stream following the establishment of three new fertilizer plants in Northern Greece. Of these one was based on pyrites, one included pyrites roasters as well as brimstone burners, the former being used intensively in 1966 and 1967 due to limitation of brimstone supply, and the third was based on brimstone. Sulphur shortage also caused the conversion of a brimstone burner at the old-established plant on the Piraeus to pyrites, which will boost pyrites consumption in 1970 by about 30,000 tonnes S.

During the period 1963 to 1965 pyrites consumption in Greece fluctuated between 37,000 and 40,000 tonnes S, then sharply rose to 128,000 tonnes S in 1966 but receded in 1967 to 107,000 tonnes S, and again in 1968 to 81,000 tonnes S. The bulk of Greek pyrites consumption of domestic origin is supplied from the Kassandra mine, in the form of non-cupreous but highly arsenical ore, and from Hermione, in the form of cupreous pyrites, both mines being owned by the country's largest sulphuric acid/fertilizer producer, The Hellenic Company of Chemicals & Manures at the Piraeus. In addition, Greece imports up to 20,000 tonnes per annum Kalavassos non-cupreous pyrites and also varying tonnages of Bor concentrates from Yugoslavia. Only the cupreous cinders are valorized and are sold to DKH. Expansion of production capacity at the Kassandra mine, where up to 200,000 tonnes flotation concetrates will become available from 1970 onwards, will adequately meet the increased demand which in terms of pyrites is expected to rise to over 150,000 tonnes S in the early 1970's.

GREECE PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source	
				Over 50%	Under 50% (in descending order)
1963	42.9		42.9	Greece	
1964	38.8		38.8	Greece	
1965	57.1		57.1	Greece	Cyprus
1966	128.1		128.1	Greece	Yugoslavia; Cyprus
1967	112.0		112.0	Greece	Yugoslavia
1968	90.0		90.0		

Finland

Pyrites consumption in Finland falls in two categories: consumption as such, currently only by the pulp industry and the use of pyrite concentrates in the sulphur recovery plant at Kokkola.

Up to 1966 small quantities (12,900 tonnes S in 1963 declining to 2,100 tonnes in 1966) of pyrites were also roasted for the manufacture of sulphuric acid, but from 1967 onwards the only consuming sector is the pulp industry using about 41,200 tonnes S, to which level consumption had gradually declined from about 58,000 tonnes S in the early 1960's. The bulk of this consumption is represented by Outukumpu pyrite concentrates, the residues of which have a high value due to their cobalt content.

The Kokkola plant is based on the use of Pysahalmi pyrite concentrates which are produced in conjunction with copper and zinc concentrates. Of the input of about 350,000 t.p.a. an increasing proportion of sulphur content is recovered as brimstone by the Outukumpu process which also yields SO_2 gases for sulphuric acid manufacture and an agglomerated iron cinder. Initially only about ½ of the S content equivalent to the labile S-atom was recovered, but process modifications have raised S-recovery to an annual level of about 120/140,000 tonnes.

The trend in Finnish S-requirements is rising due to increasing sulphuric acid demand. This will be abated by the decline in the sulphur needs of the pulp industry. The domestic production of recovered sulphur has virtually eliminated brimstone import requirements and, as these are represented by the pulp and rayon industries, it is expected that the pyrite based recovered sulphur production will in future be adequate to meet this demand.

The bulk of the increased sulphur needs for sulphuric acid are expected to be met by the utilization of SO_2 in non-ferrous metal smelter gases. Existing plant capacity appears to be adequate for at least three years and it is expected that subsequent expansion of non-ferrous smelter activities will satisfy the growing sulphur demand.

FINLAND PYRITES CONSUMPTION

('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source Over 50%	Supply Source Under 50% (In descending order)
1963	12.9	48.3	61.2	Finland	
1964	13.6	49.1	62.7	Finland	
1965	13.1	42.8	55.9	Finland	
1966	2.1	40.7	42.8	Finland	
1967	-	41.2	41.2	Finland	
1968	-	40.6	40.6	Finland	

Philippines

Consumption of pyrites has risen from about 22,900 tonnes S in 1963 to 41,000 tonnes S in 1967. Since then it has been further boosted by the requirements of the new sulphuric acid/fertilizer plant of Esso Chemical Co. which is based on pyrites. The entire requirements in the Philippines are met by indigenous flotation concentrates, which are in conjunction with the concentration of non ferrous sulphide ores. There is a large potential export surplus of flotation pyrites and of the total pyritic tailings only a fraction is used, as domestic requirements are limited by existing roasting capacity and sulphuric acid demand, and because exports are small and intermittent.

PHILIPPINES PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (In descending order)
1963	22.9		22.9	Philippines	
1964	23.1		23.1	Philippines	
1965	23.2		23.2	Philippines	
1966	33.9		33.9	Philippines	
1967	41.0		41.0	Philippines	
1968	45.0		45.0	Philippines	

Taiwan

Consumption of pyrites is about 11,000 tonnes S which is due to increase by as much again when a new roasting plant reaches capacity in 1969. The bulk of pyrites requirements are supplied from domestic mines and there are occasional imports from Canada and the Philippines. No further increase in demand is in sight as the ready availability of brimstone, notably from Canada and also from Japan, points to the rising sulphur requirements in Taiwan being met by imported brimstone.

TAIWAN PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	11.3		11.3	Taiwan	
1964	11.4		11.4	Taiwan	
1965	10.8		10.8	Taiwan	
1966	11.3		11.3	Taiwan	
1967	10.7		10.7	Taiwan	
1968	11.0		11.0	Taiwan	

Australia

Consumption of pyrites in Australia has declined from 120,600 tonnes S in 1963 to 103,800 tonnes S in 1967. The latter represented the integrated operation of the mine the output of which is used captively by a group of roasters in Adelaide and the operation of Norseman Gold in West Australia whose output was used by works near Perth. Since then, in 1968, West Australian pyrites use and production have ceased. Pyrites consumption in New South Wales ceased about 1966 as did that in Victoria some years earlier.

This trend will be reversed when a major (420,000 t.p.a. H_2SO_4) sulphuric acid plant in Tasmania comes on-stream in 1970 based on local pyrite concentrates. A similar project in Queensland based on local pyrite concentrates from the Mount Morgan mine has been deferred and two further projects in Tasmania based on by-product flotation pyrites from tin and iron concentration projects are still being evaluated.

Pyrites use in Australia is subsidized by a Bounty which is based on the import price of brimstone. Nevertheless there is no prospect of pyrites playing a major part in meeting Australia's rising sulphur needs, as any new project is contingent on a ready availability of low cost by-product concentrates at a site where there is a large scale outlet for sulphuric acid. At present only the Tasmanian project fulfils this requirements, to the detriment of the other two projects under consideration, and possibly the Queensland project.

AUSTRALIA PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (In descending order)
1963	120.6		120.6	Australia	
1964	111.0		111.0	Australia	
1965	102.7		102.7	Australia	
1966	100.9		100.9	Australia	
1967	103.8		103.8	Australia	
1968	106.0		106.0	Australia	

Canada

Consumption of pyrites in Canada, represented by the activities of two companies Consolidated Mining & Smelting Co. and International Nickel Co. (In co) in co-operation with Canadian Industries Ltd. (C.I.L.), was increased from 116,500 tonnes S in 1963 to 269,700 tonnes S in 1967.

The pyrites are by-product concentrates arising in conjunction with the beneficiation of non-ferrous metals and after roasting the iron content of the residue is supplied to blast furnaces. In the case of Inco operations, SO_2-roaster gas is piped to the liquid SO_2 plant and several sulphuric acid plants of C.I.L. The growth potential of pyrites concentrate use in Canada is determined in the first place by the sulphuric acid of these two companies and secondly by the feasibility of integrating one of the many abundant and not-utilized sources of by-product pyrites tailings with a plant project requiring SO_2. At present a major project is under consideration by Falconbridge Nickel Co. at Sudbury, Ont. which aims to utilize part of the S-content of the roaster gases in recovered sulphur production by new process technology developed together with Allied Chemical Co., and part as sulphuric acid for which there are nearby economically viable outlets.

Because of the volume and the large number of potential pyrites sources and highly specialized factors which would determine the feasibility of large scale utilization of SO_2 in roaster gases it is not possible to make realistic forecasts of future demand growth beyond that indicated by existing plant operations and firm projects. On this basis it is indicated that by 1970 consumption will have increased to about 350,000 tonnes S and that this may further increase to about 400,000 tonnes S in the early 1970's. It should be added that the implementation of any additional projects, e.g. Texas Gulf using Timmins pyrites tailing, would augment consumption by at least 100,000 tonnes S.

CANADA PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source Over 50%	Supply Source Under 50% (in descending order)
1963	116.5		116.5	Canada	
1964	147.8		147.8	Canada	
1965	164.1		164.1	Canada	
1966	190.3		190.3	Canada	
1967	269.7		269.7	Canada	
1968	305.0		305.0	Canada	

Rhodesia

Consumption of about 20,000 t.p.a. S is represented by one plant which is integrated with the pyrites output of the Iron King mine. No change is expected in the foreseeable future.

RHODESIA PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	20.3		20.3	Rhodesia	
1964	23.6		23.6	Rhodesia	
1965	19.1		19.1	Rhodesia	
1966	21.4		21.4	Rhodesia	
1967	21.0		21.0	Rhodesia	
1968	21.0		21.0	Rhodesia	

Belgium

Substitution of brimstone in place of pyrites in the late 1950's and early 1960's is reflected in a steady decline of pyrites consumption, which until 1966 had shrunk to about 110,000 tonnes or little more than one-half of the peak levels attained in the mid-1950's.

Following the closure and dismantling of several major plants, e.g. Union Chimique Belge, Pont Brule, the only plants based on pyrites in Belgium were those of Produits Chimiques de Limbourg, Produits Chimiques de Tessenderloo and those of a number of small sulphuric acid/fertilizer manufacturers, and of one pulp manufacturer, with annual consumption of up to 15,000 tonnes. In addition at a few sulphuric acid plants where the greater part of the sulphur was based on brimstone or SO_2 in smelter gas some pyrites roasting furnaces were being used. Contrary to the general trend, but based on sound market trend evaluation, Produits Chimiques de Limbourg decided in 1964 to base a major sulphuric acid plant on pyrites; this came on stream in 1966 and currently consumes about 100,000 t.p.a. of Portuguese pyrites, the producers of which (S.A. d'Aljustrel and Mines et Industries) engaged in a long-term contract with appropriate price guarantees and escalations in the events of declining sulphur prices.

As a result pyrites consumption has risen steeply from the 1966 low and is currently at a level of about 160,000 tonnes S. As the result of the recent decision of Bayer N.V. to base the giant sulphuric acid project at Antwerp on pyrites, consumption from 1971 onwards will be further augumented by about 200,000 tonnes S, represented by Spanish pyrites, the cupreous cinders from which will be valorized at DKH. Consideration is being given by Ugine Kuhlmann to expand sulphuric acid capacity at Rieme by the addition of pyrites furnaces and the decision will be influenced by the price/cost relationship between imported brimstone and pyrites.

BELGIUM PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption For Acid	Consumption for Non-Acid	Total Consumption	Supply Source	
				Over 50%	Under 50% (in descending order)
1963	126.0	3.8	129.8	Portugal	Cyprus, Spain, USSR
1964	118.9	0.7	119.6	Portugal	USSR, Spain, Cyprus
1965	108.9	1.3	110.2	Portugal	USSR, Cyprus, Spain
1966	108.5	2.0	110.5	Portugal	Spain, Cyprus
1967	137.0	2.2	139.2	Portugal	Spain, USSR
1968	145.0	2.9	147.9		

Holland

The pyrites consumption pattern in Holland is similar to that in Belgium and from a mid-1950 peak of about 220,000 tonnes S, consumption declined to 113,600 tonnes S in 1963 and just under 100,000 tonnes S in 1967. In that year one of the two remaining pyrites acid plants, N.S.M. at Sluiskil closed and currently only the plant Albacid at Pernis remains. This is based on C.M.C. pyrite concentrates containing enough copper to justify their valorization at DKH. No change is anticipated as the cost structure and operational life of the Pernis plant are satisfactory and as no new pyrites acid project appears to be in sight.

NETHERLANDS PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source Over 50%	Supply Source Under 50% (in descending order)
1963	113.6		113.6	Cyprus	Italy, Portugal, USSR
1964	135.3		135.3	Cyprus	Spain, Portugal, Italy, USSR.
1965	126.9		126.9	Cyprus	Spain, Portugal
1966	103.5		103.5	Cyprus	Portugal, Spain
1967	99.6		99.6	Cyprus	Portugal
1968	96.0		96.0		

France

Although not as pronounced as in the Low Countries, there has been a similar trend in pyrites consumption in France during the past fifteen years. From a peak of 400,000 tonnes S in 1951 consumption declined to 298,000 tonnes S in 1963 and 193,000 tonnes S in 1967. In part this decline has been due to substitution by brimstone burners and this is reflected in the sharply reduced share of pyrites in the total sulphur use pattern, by the whole of new construction being based on brimstone, while many mostly small, obsolete and obsolescent pyrites based plants have been dismantled.

Nevertheless, there still remains in France some pyrites based plants, amongst which there are four major plants: Chauny (Pechiney St. Gobain), Wattrelos and Loos (Ugine Kuhlmann), all using imported pyrites, and St. Fons (Pechiney St. Gobain), integrated with captive supplies of Sain Bel pyrites.

The trend of reduced pyrites consumption and fewer plants will be maintained during the next two years as part of the rationalization measures due to be implemented following the merger of the fertilizer interests of Ugine Kuhlmann and Pechiney St. Gobain. As a corollary, imports will decline affecting primarily Iberian pyrites. Captive use domestic pyrites will continue at the annual level of about 30-35,000 tonnes S and, on current indications, the works based on the use of C.M.C. pyrite concentrates, Algerian and Russian pyrites will not be affected.

The use of pyrites at a major sulphuric acid project between Le Havre and Rouen is receiving consideration, but the high cost of residue freights which adversely affects residue valorization, detracts from the likelihood of pyrites comparing favourably with the use of brimstone.

FRANCE PYRITES CONSUMPTION

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	297.9		297.9		France, Spain, Cyprus, Algeria, Portugal, USSR
1964	271.0		271.0		Spain, France, Cyprus, Portugal, Algeria, USSR, Greece, Italy.
1965	200.4		200.4		Spain, France, Cyprus, Portugal, USSR, Algeria
1966	196.8		196.8		Cyprus, Spain, France, Portugal USSR
1967	193.1		193.1		Cyprus, Spain, France, USSR, Portugal
1968	180.2		180.2		

United Kingdom

The realisation of an intensive construction programme of plants based on raw materials other than brimstone in the mid-1950's resulted in pyrites consumption in the United Kingdom rising to a peak of 232,400 tonnes S in 1954. Closure of a number of small to medium size roasting plants, several of which were obsolete anyhow, has caused consumption to decline progressively, so that in 1963 consumption had receded to 141,900 tonnes and in 1967 to 110,000 tonnes S. This consumption is represented almost entirely by the use of flotation concentrates. The only consumer using fines, Synthetic Chemicals Ltd., drew on a Government stockpile of Spanish crude fines which is now exhausted, as a result of which this roaster is examining alternative sources of supply, including conversion to brimstone use.

The consumers, British Titan Products, Courtaulds, Laporte Acids Ltd., and S.A.I., employ Nichols-Freeman flash roasters which although well maintained are approaching obsolescence. This factor determines the short term demand prospects which would only change in the event of one or more new pyrites acid projects being realised. Currently under consideration are the following:

I.C.I. Agricultural & Other Divisions: The imminent closure of the company's anhydrite acid operations at Billingham (Agricultural Division) coupled with the increasing requirements of Mond Division and General Chemical Division, which hitherto relied mainly on supplies from acid plants on Merseyside several of which are already closed as obsolete and others due for closure, and which have been considering a new acid plant project at a Merseyside location for the past four years, have focussed the attention of all divisions on this problem. Already the final date for a decision - end February 1969 - has passed and still alternatives are being weighed. These include not only the project presented to the principals by Sir. Frank Schon, which I. C. I. turned down, but also the joint Bolidens/ Borregard proposal for a pyrites acid plant at Teesside, at or near the Billingham plant, which is combined with a flexible take or supply scheme for sulphuric acid to allow for fluctuation in I. C. I. demand. Other projects relate to brimstone projects, coupled to a greater or lesser degree with phosphoric acid purchases, sulphuric acid purchases from Northern and North West Europe and Canada and combinations of the above.

Others: B. T. P., Courtaulds and Laporte are all considering the possible need to install new capacity. In particular B. T. P. received an approach by Bolidens for a pyrites acid plant at Grimsby with a take or supply option for sulphuric acid surpluses or deficits. There is no indication as yet that any of these companies are giving serious consideration to any one project as their imminent sulphuric acid supply situation is adequate and the cost structure of their sulphuric acid operations satisfactory.

To sum up, while in the short/medium term, pyrite consumption at established plants will decline, there are better than average prospects for the realisation of one or more major pyrites acid plant projects, depending however not only on economic viability compared with brimstone, but also on special circumstances governing individual companies.

U. K. PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	141.9		141.9	Cyprus	USSR, Spain, Canada
1964	133.4		133.4	Cyprus	USSR, Spain, Sweden
1965	111.7		111.7	Cyprus	USSR, Spain, Sweden
1966	111.6		111.6		Cyprus, USSR, Sweden, Spain, Poland
1967	110.0		110.0		Cyprus, USSR, Sweden, Spain, Poland
1968	100.1		100.1		

Eire

For the past seven years pyrites consumption in Eire has been negligible being confined to one small plant at Galway which uses about 1,800 tonnes S p.a. Since the establishment of a liquid sulphur terminal at Dublin and the participation of Freeport Sulphur and Texas Gulf Sulphur companies, together with Goulding Fertilizers Ltd. in Sulphac Ltd., the country's largest sulphuric acid producer, there is little prospect of the greater part of Eire's sulphuric acid output being based on a raw material other than brimstone. The Government-owned nitrogen/complex fertilizer producer, Nitrigin Eireann Teoranta, at Arklow however which at present uses imported brimstone is giving serious consideration to basing a new sulphuric acid plant on local by-product pyrites concentrates which would arise if copper production were resumed at the nearby Avoca mine. In the event of this project not being realised, imported pyrites might be considered, if they proved competitive with brimstone. The potential annual requirements are up to 60,000 tonnes S.

EIRE PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	1.8		1.8	Spain	
1964	1.8		1.8	Spain	
1965	1.8		1.8	Spain	
1966	1.8		1.8	Spain	
1967	1.4		1.4	Spain	
1968	1.4		1.4	Spain	

Denmark

Dansk Svovolsyre og Superphosphat Fabriken, operating three works, is a traditional user of pyrites which is consumed at an annual level of 60-70,000 tonnes S. Consumption is evenly divided between Norwegian (Sulitjelma) and Spanish (Rio Tinto) pyrites, the residues of which are treated and valorized at Hamburger Kupferhutte and at times at Lubeck. Total sulphur requirements are supplemented by the use of domestic and imported brimstone, which rarely exceeds 15% of total sulphur consumption.

No change in the present pattern is expected in that pyrite roasting capacity is employed to the maximum and that there is little prospect for a new sulphuric acid project. In the event of increasing demand for sulphuric acid, competitive supplies are readily available from acid suppliers in Sweden, Norway and possibly also Germany.

DENMARK PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption For Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	65.3		65.3	Spain	Norway
1964	66.9		66.9	Spain	Norway
1965	70.0		70.0	Spain	Norway
1966	63.0		63.0	Spain	Norway
1967	61.5		61.5	Spain	Norway
1968	62.5		62.5		

Austria

Pyrites consumption in Austria has declined slightly in past years and in 1967 totalled 13,100 tonnes S, represented mainly by imported Yugoslav, Greek and Italian pyrites, which are primarily used in the pulp industry. Although the Austrian pulp industry is exposed to strong competitive pressures, little change is expected in the present sulphur use pattern as there is unlikely to be any new investment. For sulphuric acid, increasing use of brimstone is expected to satisfy growing demand.

AUSTRIA PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	-	11.9	11.9		Italy, Greece, USSR, Yugoslavia
1964	-	11.5	11.5		USSR, Greece, Italy, Yugoslavia
1965	-	10.8	10.8		USSR, Yugoslavia, Greec Italy
1966	-	11.3	11.3	USSR	Yugoslavia
1967	0.1	12.3	12.4	USSR	Italy, Greece
1968	0.1	13.0	13.1		

Switzerland

Consumption of pyrites has fluctuated between 18,200 and 16,000 tonnes S over the period represented entirely by imported Italian and Yugoslav pyrites. There are only two plants based on pyrites, a sulphuric acid plant and a pulp mill: for strategic reasons this is not expected to change.

SWITZERLAND PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source: Over 50%	Supply Source: Under 50% (in descending order)
1963	12.5	5.7	18.2	Italy	Yugoslavia
1964	12.5	6.1	18.6	Italy	
1965	12.0	6.8	18.8	Italy	Yugoslavia
1966	10.0	6.6	16.6	Italy	Yugoslavia
1967	10.7	5.0	15.7	Italy	Yugoslavia
1968	11.0	5.0	16.0		

United States

From a peak of 685,600 tonnes S in 1956, pyrites consumption in the U.S.A. has progressively declined to a level of 515,500 tonnes S in 1963 and about 525,,000 tonnes S in 1967. Of this total about 170,000 tonnes S is imported from Canada and the balance is represented almost entirely by captive use in vertically integrated pyrites acid plants of non-ferrous ore mining and smelting companies, now that operations of the Mountain Copper Company in Shasta County, California, have ceased following the cessation of local pyrites acid production.

The Canadian pyrites imports are exclusively directed to plants of Allied Chemical Corp. in the North-eastern States. The domestic pyrites originate and are used locally at plants in Tenessee, Colorado and Arizona. A major (700 short t.p.d. H_2SO_4) new pyrites acid project is under construction at Rico, Arizona, based on local by-product pyrites and the acid will be consumed locally for ore and metal treatment.

Any expansion of pyrites use in the U.S.A. depends on purely local circumstances of matching pyrites supply and sulphuric acid demand. Evaluations by a number of companies, including Freeport Sulphur Co. and Stauffer Chemical Co. to utilize pyrites or pyrites concentrate supplies for conversion into merchant acid failed to show competitive ability compared with brimstone.

U. S. A. PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source	
				Over 50%	Under 50% (in descending order)
1963	490.5	11.0	510.5	U.S.A.	Canada
1964	485.0	11.0	496.0	U.S.A.	Canada
1965	505.0	11.0	516.0	U.S.A.	Canada
1966	505.0	11.0	516.0	U.S.A.	Canada
1967	515.0	10.5	525.5	U.S.A.	Canada
1968	500.0	10.0	510.0	U.S.A.	Canada

Algeria

Small scale pyrites consumption at Algiers of up to 12,000 t.p.a. S is based on local pyrites. Despite the favourable geographic location in relation to Huelva, Spain, future plans for expansion of sulphuric acid capacity are reported to be based on brimstone and anhydrite/gypsum.

ALGERIA PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source	
				Over 50%	Under 50% (in descending order)
1963	3.4		3.4	Algeria	
1964	9.4		9.4	Algeria	
1965	10.7		10.7	Algeria	
1966	7.0		7.0	Algeria	
1967	12.2		12.2	Algeria	
1968	13.0		13.0	Algeria	

Tunisia

Part of the sulphuric acid requirements of the sulphuric acid/fertilizer plant at Tunis are based on pyrites which are consumed at an annual rate of up to 7,000 t.p.a. S. All the pyrites are imported, mostly from Algeria and occasionally from Portugal and Spain. There are no prospects of new acid capacity being based on pyrites in the forseeable future and even the existing operations may cease before long.

TUNISIA PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source Over 50%	Supply Source Under 50% (in descending order)
1963	6.4		6.4	Spain	
1964	5.7		5.7	Spain	
1965	6.3		6.3	Spain	
1966	7.1		7.1	Spain	
1967	6.3		6.3	Spain	
1968	6.4		6.4	Spain	

Egypt

Three plants, located near Alexandria, are based on pyrites. Although aggregate rated roasting capacity is about 86,000 tonnes S, consumption is recent years has been around 50% of rated capacity. All pyrites are imported, in recent years from Spain and Yugoslavia under barter arrangements, mostly against phosphate rock. A part of the increasing sulphur requirements will undoubtedly be reflected in greater use of pyrites, which as heretofore will be imported under barter transactions.

EGYPT PYRITES CONSUMPTION
('000 tonnes Sulphur content)

Year	Consumption for Acid	Consumption for Non-Acid	Total Consumption	Supply Source Over 50%	Supply Source Under 50% (in descending order)
1963	29.6		29.6	Yugoslavia	Spain
1964	35.7		35.7	Spain	Yugoslavia
1965	22.2		22.2	Spain	
1966	43.7		43.7	Yugoslavia	Spain
1967	42.9		42.9	Yugoslavia	Spain
1968	43.0		43.0		

Communist Countries

All the communist countries of East Europe consume pyrites, but only Czechoslovakia, East Germany and Hungary are importers. All others - U.S.S.R., Poland, Roumania and Yugoslavia - are exporters or, as in the case of Poland, have an export surplus. To Czechoslovakia, Hungary and occasionally to Poland the Danube provides a favourably situated transport route from the Balkan pyrites mines, even though in most instances pyrite has to be transferred to rail for onward movement from the Danube port to the consuming works.

East Germany, which imports annually up to 300,000 tonnes S in pyrites, receives the bulk of her requirements from the U.S.S.R. by sea for onward transmission by rail. The intra-East European pyrites trade is transacted wholly within Comecon agreements and pyrites are not considered to be a commodity for which foreign exchange funds are made available. A contributory factor in this concept is the heavy incidence of means of transportation within the framework of which pyrites provide in many instances return cargoes.

Although pyrites continue to account for the greater part of East European sulphur consumption, which promises to continue growing at a rate of at least 5% p.a. and probably nearer 7% p.a., abundant indigenous supplies, especially in Yugoslavia and the U.S.S.R., will obviate the need to look to Western World sources. Under exceptional circumstances, which can be expected to favour the communist country partner, a barter transaction may offer an opportunity to sell pyrites in East Europe.

Price Relationship - Brimstone V Pyrites

Although from the viewpoint of the pyrites producer his product is a raw material, both for the sulphur consuming, notably the sulphuric acid industry, and for the mineral ore processing industries, traditionally the price of pyrites is determined as a sulphurous raw material in relation to brimstone. This price relationship takes account of the value of the metal constituents of the residue, but because of the simplicity and the low capital and operating cost of brimstone based operations, the economic feasibility of the use of alternative sulphurous raw materials, notably of pyrites, depends on a number of favourable factors, the incidence of which diminishes as the prime cost of brimstone increases and conversely this importance is enhanced when brimstone prices decline.

The "favourable factors" which promote the use of pyrites relate primarily to the optimum valorization of residues and to the minimisation of transporation and handling costs of pyrites and residues and are primarily a function of the geographical location of the pyrites consuming plant. In consequence it is not possible to determine, except in very broad terms, a generally applicable price relationship between pyrites and brimstone or between different types of pyrites.

The basic price relationship between brimstone and pyrites is determined by the differentials in capital and operating costs of sulphuric acid plants, which are analysed below. The costs shown are deemed to be currently valid in major W. European industrialized countries and in order to facilitate the comparison, they refer to contact plants to produce 66% acid which are to be built in an industrial region where services are accessible.

Capital Costs

The total investment has been determined by adding to the cost of installations (battery limits), 15% for the cost of off-site facilities plus a further 8% for construction and start up costs. For similar plants erected in North America the investment cost is 8-10% greater and in developing countries at least 30% and often up to 60% greater.

The analysis of brimstone acid plant includes the costs of a melter and filter; in the event of liquid sulphur these would not apply, but provision for liquid sulphur storage would reduce the cost saving to about 90,000-200,000 in the range of plant sizes shown. The raw materials requirement is expressed in terms of solid bright sulphur. For liquid sulphur this may reduce to about 328 Kg/tonne H_2SO_4. Costs do not provide for a steam turbine to utilize steam for electric power generation nor for double catalysis.

For pyrites acid plants the cost analysis includes pyrites and residues transport and storage, but correspondingly no provision for steam turbine or for double catalysis. The cost of the roaster section, which accounts for 44%-48% has been determined on the basis of an ordinary fluidized bed roaster. In the event of the type of pyrites e.g. arsenical pyrites necessitating the installations of more sophisticated roasting systems in order to attain the desired quality of the residues, investment costs for the roaster section would increase as follows:

For a Bolidens type roaster	+ 25%
For a BASF 2-stage roaster	+ 35%
For a rotary kiln with steam recovery	+ 85%
For a multiple hearth roaster	+ 120%

Fixed costs are determined on the basis of a ten year straight line depreciation not including any interest charges on investment or working capital, local taxes, insurance or administrative overheads. It is recognised that this approach tends to reduce the differential in fixed costs between brimstone and pyrites acid plants, whereas the inclusion of such items would tend to exaggerate it, especially if the assumed rate of interest charges and the proportion of the capital costs to which they are applied, are on the high side.

Investment costs for two selected plant sizes are as follows:

	Capacity (tonnes)			Investment	Fixed Costs per tonne H_2SO_4 $	
	per day raw material	per day H_2SO_4	per annum H_2SO_4	Million $	on rated 1.S cap	on 90% rated cap
Brimstone	172	500	165,000	1.75	1.06	1.18
Pyrites*	370	500	165,000	5.2	2.54	2.83
Pyrites+	370	500	165,000	4.75	2.88	3.20
Brimstone	344	1000	330,000	2.75	0.85	0.92
Pyrites*	745	1000	330,000	6.4	1.94	2.16
Pyrites+	745	1000	330,000	7.4	2.24	2.49

* For arsenical pyrites, say BASF 2-stage

\+ Non-arsenical 48% S roasted in ordinary fluidised

Return on Capital

One of the most significant criteria from the point of view of the investor is the appreciably lower incidence on the sulphuric acid cost pattern of the return on the lower capital investment on brimstone acid plants compared with that of pyrites.

At a desired return of 85%, comparable data are as follows:

	500 t.p.d.	1000 t.p.d.
	U.S. $ per tonne H_2SO_4	
Brimstone Acid Plant	$1.59	$1.25
Pyrites Acid Plant (ordinary FB roaster)	3.81	2.41
Pyrites Acid Plant (2-stage FB roaster)	4.32	3.36

Operating Cost:-

These are based on West European conditions indicating the following unit costs:-

Electric Power	¢ 1 per KWH
Cooling Water	¢ 0.9 per m^3
Boiler Feed Water	¢ 6 per m^3
Labour	$ 2 per man hour including overheads

The following requirements are indicated:-

Requirements per tonne:	Brimstone Acid	Pyrites Acid	
		Ordinary Fluidized	Two stage Fluidized Bed
Cooling Water (m^3)	28	63	63
Boiler Feed Water (m^3)	2	2	2
Electricity (KWH)	30	70	75
Operating Labour (per shift)	2	10	10
Supervision expressed as equivalent to operating labour	2	5	5
Maintenance expressed as % of investment cost	5	6	6

The indicated requirement for electricity provides for the use of by-product steam for the blower. Overall requirements per tonne acid reduce by about 10% in the case of larger capacity plants. The labour and supervision requirement shown has to be provided for a 500 t.p.d. H_2SO_4 plant, but is at the same time adequate to operate plants up to about 1200 t.p.d. H_2SO_4.

	Capacity			Operating Cost per tonne H_2SO_4	
	per day raw material	per day H_2SO_4	per annum H_2SO_4	at rated cap.	at 90% rated cap.
Brimstone	170	500	165,000	$ 1.71	1.82
Pyrites *	370			4.83	5.21
Pyrites +	370			5.09	5.49
Brimstone	340	1000	330,000	$ 1.33	1.41
Pyrites *	745			3.44	3.68
Pyrites +	745			3.67	3.93

* Ordinary fluidized bed roaster

\+ Two stage fluidized bed roaster.

Differential

In determining the cost differential between brimstone acid and pyrites acid plants no account has been taken of credits. Steam credit has been disregarded as the amount of by-product steam arising is approximately the same, i.e. 1-1.1 tonnes steam per tonne H_2SO_4. The value of this steam may be said to equal the value of 2.4 million B.T.U. in fuel per tonne steam and range between $1-2.

The above evaluations of fixed and operating costs show the following differentials:

	Plant Capacity	
	300 t.p.d.	100 t.p.d. H_2SO_4
Between brimstone and pyrites acid plant, (ordinary fluidized bed)	$4.60	$3.22
Between brimstone and pyrites acid plant (ordinary fluidized bed) @ 90% operating rate	$5.04	$3.51
Between brimstone and pyrites acid plant (2-stage roaster)	$5.20	$3.75
Between brimstone and pyrites acid plant (2-stage roaster) @ 90% operating rate	$5.79	$4.09

Return on Capital

The differential is augmented as shown below, if full account is taken of the higher return on capital in respect of pyrites acid plant, which is postulated by the greater investment.

Compared with the return on brimstone acid plant investment, that additional return on pyrites acid plants is as follows:

	500 t.p.d.	1000 t.p.d. H_2SO_4
	US $	
Acid plant with ordinary FB roaster	2.22	1.66
Acid plant with 2-stage roaster	2.73	2.11

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SECTION - 6

Sales Potential of Stordø Pyrites

From the above analysis of pyrite consumption in individual countries, it will be seen that the identifiable and significant growth prospects lie only in countries which use indigenous pyrites and are not dependent on imports.

In all other countries the prospects of growth are determined by specially conceived projects. The competitive ability of Stordø washed and flotation pyrites is analysed below in relation to the use of brimstone and "cupreous" pyrites in new projects:-

In the light of the above and with special reference to the potential valorization of residues the consultants conclude that the only regions in which new projects, under present circumstances, could give favourable consideration to the use of Stordø pyrites are:-

1. U.K.
2. Eire
3. Southern Sweden or Denmark

In Northern Germany, the Benelux countries and Northern France large capacity plants based on brimstone or cupreous pyrites substantially show too pronounced economic advantages to warrant them being considered as potential outlets.

In the evaluation of the respective merits of flotation and washed ore, in respect of their use in new projects, the determining factors are the investors' choice of a specific type of roaster and the preference or otherwise of the blast furnace operator for fines or flotation residues. No cash value can be determined nor are there any determinate factors which may be specified independently of the pyrites roaster.

As shown previously, analysing the value of Stordoe washed and flotation residues and the cost of transport of pyrites and residues, it is only in very favourable circumstances that the residues value can cover transportation costs. Residues values range from \$3 to \$6 per tonne pyrites and the cost of transporting pyrites and residues from \$3 upwards.

Nevertheless, in determining the competitive status of Stordø pyrites with that of other supplies of sulphurous raw materials, it is proposed to assume that the f.o.b. netback is represented by the whole of the sulphur value in the pyrites.

see table (next page)

Return on Capital

On the basis of a desired 15% return on capital, the investor would necessarily look to an additional \$2.41 per tonne H_2SO_4 when comparing the investment on brimstone acid plant with that in a pyrites acid plant based on Stordø flotation pyrites and \$2.50 in the case of comparison with a plant roasting Stordø washed pyrites.

The total differential of fixed and operating is in respect of:-

Stordø washed pyrites use	\$4.79 per tonne H_2SO_4
Stordø flotation pyrites use	\$4.73 per tonne H_2SO_4

and if full account is taken of the greater return on capital required in respect of the pyrites acid plants:-

Stordø washed pyrites use	\$7.29 per tonne H_2SO_4
Stordø flotation pyrites use	\$7.14 per tonne H_2SO_4

Adverse Differential Compared with Brimstone

	Capacity (tonnes)			Investment	Fixed Cost per tonne H_2SO_4	
	per day raw material	per day H_2SO_4	p.a. H_2SO_4	million US $	on rated cap.	on 90% cap
Brimstone	170	500	165,000	$ 1.75	$ 1.06	$ 1.16
Stordø (washed)	455	500	165,000	$ 4.5	$ 2.77	$ 2.97
Stordø (flotation)	425	500	165,000	$ 4.4	$ 2.67	$ 3.03

				Operating Cost per tonne H_2SO_4	
				at rated cap	at 90% of cap
Brimstone	170	500	165,000	$ 1.71	$ 1.82
Stordø (washed)	455	500	165,000	$ 4.83	$ 5.21
Stordø (flotation)	425	500	165,000	$ 4.83	$ 5.21

It will be seen that the lower S-content of Stordø pyrites compared with a standard material of 48% S is expressed in an increase of the adverse differential of about $0.49 per tonne H_2SO_4 for washed ore and $0.32 per tonne H_2SO_4 in the case of a 500 t.p.d. H_2SO_4 plant with an ordinary fluidized bed roaster based on non-arsenical pyrites. In the case of a plant with a 2-stage roaster, Stordø pyrites show an advantage (because of the lower capital cost requirements) of $0.64 for washed pyrites and $0.79 for flotation pyrites. Because of the limitation of supply to about 150,000 t.p.a., Stordø pyrites, a comparison for a 1000 t.p.d. H_2SO_4 plant is not relevant.

It must be emphasized that whereas the differential in fixed and operating cost can be determined with reasonable accuracy as shown above - bearing in mind however that these calculations relate to a "basic" sulphuric acid plant and that in the event of the plant incorporating special features such as, turbines for electricity generation, steam towers, etc. the cost differential will alter - the evaluation of the differential return on capital is not clearcut nor can intangibles be readily expressed in terms of dollars and cents. The above differentials for Stordø pyrites are considered to favour slightly the use of pyrites.

Related to a range of brimstone prices, the following values are identified in the case of a 500 t.p.d. H_2SO_4 plant:-

Cost per tonne brimstone delivered plant	$ 25	30	35	40	45
Cost of brimstone per tonne H_2SO_4 (344 kg)	$ 8.60	10.32	12.04	13.76	15.48
1. Stordø washed pyrites - adverse differential $7.29					
Value of S in pyrites per tonne H_2SO_4	$ 1.31	3.03	4.75	6.47	8.19
Value of S in pyrites per tonne pyrites delivered plant	$ 1.76	4.06	6.38	8.68	10.98
2. Stordø flotation pyrites - adverse differential $7.14					
Value of S in pyrites per tonne H_2SO_4	$ 1.46	3.18	4.90	6.62	8.34
Value of S in pyrites per tonne pyrites delivered plant	$ 1.96	4.27	6.57	8.89	11.18

It is evident that if the minimum acceptable f.o.b. netback, determined in relation to production costs of washed or flotation pyrites is of the order of $7 per tonne pyrites, there must be a grave doubt whether Stordø pyrites can remain competitive in present downward cycle of world brimstone pyrites, especially as the costs of residues and pyrites transport can only be covered by the value of residues under favourable circumstances.

This adverse differential may be greater if a shorter depreciation period is postulated for the investment cost of the pyrites acid plant as far as the difference in costs between brimstone acid plant and pyrite acid plant. The last-named postulate in the case of a 1000 t.p.d. H_2SO_4 plant would increase the adverse differential by $1.41 per tonne H_2SO_4.

Similar adverse factors would be the application of interest rates to part or the whole of investment costs, higher labour costs or indeed the evaluation of intangible factors such as comparisons of cleanliness, management problems, etc.

Recognising that in specific instances of comparison will show slightly different results, the following table numerizes the adverse differentials of pyrites V brimstone use:

Brimstone use compared with pyrites roasted in:	Sulphuric acid plant	
	500 t.p.d.	1000 t.p.d.
Ordinary fluidized bed roaster	$ 6.82	$ 4.88
2-stage fluidized bed roaster	$ 7.93	$ 5.86

Related to a range of brimstone prices, the following values for the S-content of pyrites are identified:

Cost per tonne brimstone delivered plant	$ 25	30	35	40	45
Cost per tonne H_2SO_4 (344 kg.)	$ 8.60	10.32	12.04	13.76	16.48

1. Capacity 500 t.p.d. H_2SO_4: ordinary fluidised bed - adverse differential $ 6.82

Value S in pyrites per tonne H_2SO_4	$ 1.78	3.50	5.22	6.94	8.66
Value S in pyrites per tonne pyrites delivered plant:	$ 2.39	4.70	7.00	9.31	11.62

2. Capacity 1000 t.p.d. H_2SO_4: ordinary fluidized bed - adverse differential $ 4.88

Value S in pyrites per tonne H_2SO_4	$ 3.72	5.44	7.26	8.88	10.60
Value S in pyrites per tonne pyrites delivered plant:	$ 4.99	7.30	9.73	11.92	14.22

3. Capacity 500 t.p.d. H_2SO_4: 2-stage fluidized bed - adverse differential $7.93

Value S in pyrites per tonne H_2SO_4	$ 0.67	2.39	4.11	5.83	7.55
Value S in pyrites per tonne pyrites delivered plant:	$ 0.90	3.21	5.51	7.82	10.13

4. Capacity 1000 t.p.d. H_2SO_4: 2-stage fluidized bed - adverse differential $ 5.86

Value S in pyrites per tonne H_2SO_4	$ 2.74	4.46	6.18	7.90	9.62
Value S in pyrites per tonne pyrites delivered plant:	$ 3.68	5.98	8.29	10.60	12.90

Thus at the current level of the U.S. bright sulphur price of $43 per tonne c&f Rotterdam, the corresponding value of sulphur in pyrites would be $12 per tonne with 48% S (roasted in a 2-stage roaster of a 1000 t.p.d. H_2SO_4 plant)

A comparison with the "Verrechnungs Preis" of the West German roasters which at present stands at Pfg. 7.2 per kg sulphur in pyrites c.i.f. Rotterdam, shows that the German roaster pays $6.44 for the sulphur in pyrites per tonne H_2SO_4 compared with $8.93 which is the cost of 344 kg brimstone less the differential of $5.86.

Since the above named "Verrechnungs Preis" is based on current f.o.b. costs of "cupreous pyrites, residues values and prevailing freight charges for pyrites and residues it is evident that at Rotterdam, probably the most favoured location for pyrites roasting, pyrites use enjoys a significant cost advantage over brimstone. A rough analysis of the current residue value and transport costs corroborates the validity of the current price for Spanish pyrites fines. At the current P.R.O. (Pyrites Residues Organisation) valorization for Iron and copper in say Rio Tinto residues, a value of approximately $9 per tonne resdue or say $6 per tonne pyrites is indicated. With Ocean transport costs for pyrites from Huelva-Rotterdam of about $2.50 and residues freight (Rotterdam - Duisburg) of $1 per tonne pyrites, the net metal value equals $2.50 which together with the sulphur value of the "Verrechnungs Preis" of $8.70 equals the current f.o.b. all values price of Rio Tinto pyrites of $11.20.

It is evident that declining world brimstone prices will cause a decline of f.o.b. pyrites prices, Whilst a decline in residues values, notably a decline of the world prices of copper could precipitate this, it is though unlikely that in the foreseeable future the net residue value (after deduction of freights) could drop below $1.50 and it is more likely that its value will remain around $ 2.50.

The decline in world brimstone which, as shown in section X, is now in progress and is likely to continue until the early 1970's can be expected to cause the delivered brimstone in West Europe to drop to $35 and possibly even lower, although it is unlikely that the average price will fall below about $32. At that price the cost of brimstone per tonne H_2SO_4 would be $11 after deduction of the above-analysed differential of $75.86 per tonne H_2SO_4 (1000 tpd H_2SO_4 plant, 2-stage roaster) an equivalent of the sulphur only value of $6.90 per tonne pyrites containing 48% S is indicated.

On the assumption that Iberian and other European 'cupreous' pyrites can, in future, be produced and supplied competitively and profitably at all values f.o.b. prices as low as $7 or possibly even somewhat lower, it is concluded that even at sharply reduced world brimstone prices, sulphuric acid manufacture with established pyrites acid plants would still find it advantageous to continue using pyrites and that at favourable locations some additional new pyrites plants may be established if only to replace obsolescent plant.

In respect of non-cupreous pyrites the limited accpetance and adverse valorization of residues in the continent of Europe severely limits future prospects for this grade, unless it is made available at a very low cost, as is the case for non-cupreous and flotation pyrites imported from the U.S.S.R. Currently on the continent the valorization of the Fe content of non-cupreous residues amounts to about $3.50 per tonne pyrites which in some instances may just cover pyrites and residues transport costs. Although the U.S. valorization of non-cupreous residues of up to $6 per tonne pyrites compares favourable, the incidence of transport costs for both imported and domestic residues is much higher while the scope of the domestic pyrites market has its limitations.

Pyrite Residues

In the evaluation of marketing prospects the valorization of residues is one of the key factors. This valorization attaches, in the case of most small pyrites and flotation pyrites residues to extractable amount of non-ferrous metals and to the iron content of the residues. In non-cupreous pyrites, especially in respect of residues from flotation pyrites the non-ferrous metals content is usually too low to warrant the cost treatment and in consequence from the point of view of valorization of the Fe. content these non-ferrous metal constituents come to be considered as more or less deleterious. This applies especially to arsenic copper and zinc and may apply to T_1O_2, Pb and mineral oxide establishments. As the outlet for the iron content of pyrites residues is the steel industry in the form of blastfurnace feed, the evolution of iron ore supplies and prices has fundamentally influenced the acceptance of pyrite residues.

During the past ten years the availability and use of iron ore fines, originating from Brazil, West Africa, Peru and more recently Australia, has increased very substantially. The attendant expansion of sintering capacity should have improved the marketability of "non-cupreous" pyrite residues, but in fact the abundant iron ore fines supply caused not only a decline in iron ore prices but also a reluctance by the blastfurnace to admix pyrite residue. As a result residues with impurities became almost unsaleable and the value of "purple ore" and of "clean" non-cupreous residues declined year after year.

The impact of these developments on Stordø wasted pyrites residues and flotation pyrites residues is only in respect of price, as neither product has practically any deleterious impurities and is an acceptable for blast furnaces at any plant prepared to use pyrite residues. In this respect should be mentioned that because of rationalization of transport and handling and in order to simplify the procedure to obtain a uniform and homogenous blast furnace burden, an increasing number of steel works now refuse pyrite residues or purple ore altogether. These are mostly in the Ruhr, and also include such major integrated works as Ijminden and Dunkirk. No outlet for residue could be identified in Sweden. An examination of potential outlets shows, however, that practically all small to medium sized steel works will accept Stordø washed pyrite cinders. In respect of the flotation material the acceptance can be said to be conditional in the light of the composition of the burden of the sinter belts or sintering machines. These reservations are thought to be designed to exercise greater price pressure on the residues supplier and may amount to as much as US ¢ 1 per unit Fe though more often between US ¢ 0.25 to US ¢ 0.75 per unit Fe. Although it can be argued that the adverse feature of the flotation material is its greater fuel requirement because of its greater moisture content and finer grain size, no correlation has been identified between various fuel costs and buyers' ideas of discount in the value of flotation residues and roasted fines residues. Indication of the iron value in pyrites residue of a quality corresponding to Stordø residues are as follows:

West Germany:

Pfg. $36\frac{1}{2}$-$37\frac{1}{2}$ US ¢ $9^1/_8$- $9^3/_8$ per metric ton Fe delivered works.

Belgium:

Fr. 3.75-4.15 US ¢ $7\frac{1}{2}$-$8\frac{1}{4}$ per metric ton Fe delivered works

Spain) Italy) Portugal)	nominal indications in a wide range of US £ $7\frac{1}{2}$ to $12\frac{1}{2}$ per metric ton Fe.

It is assumed that by efficient roasting one tonne of Stardò pyrites will yeild the following:

	Washed ore	Flotation ore
Residue per tonne pyrites	715 kg	710 kg
Fe content	57%	60%
Fe content	406 kg	426 kg
S content	39%	42%
Useful S content	360 kg	385 kg
Fe yield per kg useful S content	1.13 kg	1.11 kg

		Per tonne H_2SO_4	Per tonne Pyrites	Per tonne H_2SO_4	Per tonne Pyrites
Fe. value per tonne H_2SO_4 @ US £	$7\frac{1}{2}$	2.77	3.04	2.72	3.20
	8	2.96	3.25	2.90	3.41
	$8\frac{1}{2}$	3.14	3.45	3.08	3.62
	9	3.33	3.66	3.26	3.83
	$9\frac{1}{2}$	3.51	3.86	3.44	4.05
	10	3.70	4.06	3.62	4.26
	11	4.07	4.76	3.99	4.26
	12	4.44	4.87	4.35	5.11
	13	4.80	5.28	4.71	5.54
	14	5.17	5.69	5.07	5.96

Transport of Stordø Pyrites & Residues

Pyrites

Conditions at the port of loading, represented by depth alongside and turning circle, enable vessels of up to 5000 tonnes to be considered although the usual size of vessel is 300-3800 tonnes. Under prevailing loading conditions at Stord of maximum 500 tonnes per hour with an average capability of 300 tonnes per hour, the cost freight is indicated as follows to a range of European deductions:-

UK East Coast	17s - 21s per ton
UK West Coast and Eire	24s - 30s per ton
Hamburg and Antwerp range	19s - 25s per ton
French Atlantic Coast	2s - 35 s per ton
French Mediterranean	3s - 45s per ton

These freight indications reflect the current level of chatering single or consecutive voyages. More favourable terms of up to 40% less should be obtainable if shipowners can be offered continuing regular long-term employment of vessels with a guaranteed volume.

Residues

The cost of transporting the residues from the acid plant to steelworks assumes great importance because like the cost of pyrite transport, it diminishes the f. o. b. netback. There are hardly any established pyrites acid plants in West Europe from which the cost of transport to steelworks is less than $1 per tonne of pyrites and the average is between $2. 50 to $3. In the case of new projects it may be assumed that in the selection of site this factor would be optimized.

APPENDIX A

WESTERN WORLD PYRITES-ACID PLANT LIST.

Country/Company		Location	Capacity*
(A) Western Europe			
(i) Belgium			
	Bataille Freres	Basecles (Hainaut)	15.0
	Engrais Rosier	Moustier	20.0
	Ets. Kuhlmann	Rieme-Zelzate	90.8
	Produits Chimiques de Limbourg	Kwaadmechelen	99.0
	Produits Chimiques de Limbourg	"	132.0
	Produits Chimiques de Tessenderloo	Tessenderloo	132.0
(ii) Denmark			
	Dansk Svovlsyre og Superphosphat-Fabrik	Fredericia	85.0
	Dansk Svovlsyre og Superphosphat-Fabrik	Kalundborg	70.0
	Dansk Svovlsyre og Superphosphat-Fabrik	Noerresundby	85.0
(iii) Eire			
	Thomas McDonogh & Co.	Galway	6.0
(iv) France			
	Bordelaise des Produits Chimiques S.A.	Sete	33.0
	Bordelaise des Produits Chimiques S.A.	Nantes	33.0
	Bordelaise des Produits Chimiques S.A.	Bordeaux	33.0
	Ste. Courrieres Kuhlmann	Harnes	49.5
	Ste. des Etablissements Linet	Grand Quevilly, Rouen	16.5
	Ste. des Fertilisants de l'Ouest (Sofo)	Nantes-Chantenay	27.0
	Ste. des Fertilisants de l'Ouest (Sofo)	Nantes-St. Anne	24.0

Man. des Engrais Nuvo*	L homme-lez-Lille	16.5
Ets. Emile Duclos & Cie.	Supiemes-les-Vallons	16.5
Ste. Marles Kuhlmann	Choques, Lille	33.0
Ste. des Produits Chimiques Pechiney - St. Gobain	St. Fons	109.0
	Toulouse	29.7
Cie. du Phospho-Guano	La Pallice	23.1
Ugine-Kuhlmann	Wattrelos	59.4
" "	Loos-lez-Lille	59.4
Other Plants (Total-4)	Various	33.3

(v) Finland

Rikkihappo Oy	Kokkola	180.0
" "	"	240.0

(vi) West Germany

A.G. fur Chemische Industrie	Gelsenkirchen-Schalke	36.3
Badische Anilin und Soda Fabrik	Ludwigshafen	198.0
Badische Anilin und Soda Fabrik	"	132.0
Chemische Fabrik Th. Goldschmidt A.G.	Mannheim-Rheinau	55.0
Dynamit Nobel A.G.	Leverkusen	26.9
Farbenfabriken Bayer A.G.	Uerdingen	161.7
" " "	"	161.7
" " "	Dormagen	161.7
" " "	Leverkusen	161.7
" " "	"	317.0
" " "	"	150.0
Farbwerke Hoechst A.G.	Hoechst	200.0
" " "	"	313.5
Guanowerke A.G.	Krefeld	23.1
Kali-Chemie A.G.	Mannheim	33.0
Phosphatfabrik Hoyermann A.G.	Nienburg	33.0
Ruhrschwefelsaure A.G.	Bochum-Riemke	128.6
" "	" "	79.2
" "	Duisburg-Wanheim	156.2

* All capacities are shown in 1000 tonnes 100% H_2SO_4 equivalent.

Sachtleben A.G.	Homberg	280.0
" "	"	140.0
" "	"	94.0
Sud Chemie A.G.	Kelheim	49.5
" " "	"	82.5
A.G. fur Zink Industrie	Duisburg-Hamborn	34.3

(vii) Greece

Hellenic Chemical Products	Drapetsuna	91.0
Fertilizers Co. Ltd.	"	66.0
Phosphoric Fertilizers Industries	Nea Kavala	123.8
Chemical Industries of Northern Greece	Salonica	115.8

(viii) Italy

Aziende Colori Nazionale Affini SpA.	Cesano Moderno	39.0
Aziende Colori Nazionale Affini SpA.	Cengio	35.5
Chatillon S.A.	Chatillon	49.5
" "	Ivrea	49.5
Consorzio Agrario Provinciale	Novara	33.0
Consorzio Agrario Provinciale	Bagnolo Mella	33.0
Consorzio Agrario Provinciale	Piacenza	33.0
Cooperativa Cremonese	Cremona	33.0
Fabrica Mantovanna Concomi Chimici	Mantova	33.0
Federconsorzi	Soncrgano	26.4
"	Sonnsiba	26.4
Industria Chimica del Mezzogiorno	Napoli	41.3
Interconsorziale Romagnola	Ravenna	46.2
" "	Prato	33.0
Marchi Figli di Carlo	Florence	33.0
" " " "	Marano-Veneziano	49.5
" " " "	Pascia	33.0

Soc. Mineraria e Metallurgica di Pertusola	Gobone	200
Montecatini-Edison SpA.	Porto Marghera	110.0
" " "	"	460.0
" " "	"	180.0
" " "	Spinetta Marengo	198.9
" " "	Scarlino-Follonica	730.0
" " "	Crotone	64.0
" " "	Apuania	32.0
" " "	San Giuseppe di Cairo	110.0
" " "	Other M-E Units (Total-17)	260.6
Prodotti Chimici Superfosfati	Isola Vercelli	33.0
Rumianca SpA.	Pieve Vergonte	66.0
" "	Avenza	33.0
Soc. Industriale Catanese (M-Edison)	Priolo	256.0
Snia Viscosa	Varedo	46.2
" "	Torviscosa	46.2
Terni Industrie Chimiche	Nera Montoro	19.5
Other Plants (Total-15)	Various	198.4

(ix) Netherlands

Albatros Zwavelzuren Chemie Fabrieken	Pernis, Rotterdam	120.0

(x) Norway

Borregaard A/S	Sarpsborg	200.0
" "	"	25.0
Lysaker Kemiske	Lysaker	39.9

(xi) Portugal

Amoniaco Portugues	Estarreja	80.0
Cia. Industrial Portuguesa	Obidos	18.2
Cia. Uniao Fabril (CUF)	Barreiro	165.0
" " " "	"	93.0
SAPEC	Setubal	33.0
"	"	39.6

(xii) Spain

Abonos Miral S.A.	Salamanca	22.5
Abonos Sevilla S.A.	Sevilla	72.0
Barrau S.A.	Mongat	40.3
Empresa Nacional "Calvo Sotelo"	Puertollano	70.8
Cia. Insular del Nitrogeno S.A. (CINSA)	Telde	95.5
Cia. Insular del Nitrogeno S.A. (CINSA)	Tenerife	82.3
S.A. Cros.	Alicante	40.3
" "	Badalona	185.6
" "	Coruña	49.3
" "	Lerida	23.2
" "	Malino	64.9
" "	San Juan de Aznalfarache	48.4
" "	San Jeronimo	36.0
" "	Valencia	61.4
" "	San Carlos de la Rapita	24.3
	Axpe - Bilbao	196.0
Dow-Unquinesa		
Energia e Industrias Aragonesas S.A.	Sabiñanigo	23.5
Española de Fabricaciones Nitrogenadas S.A.	Luchana-Baracoldo	216.0
Ets. Gaillard S.A.	Mongat	21.7
Hidro Nitro-Española S.A.	Tarragona	25.3
Iberica del Nitrogeno S.A.	Barrus	21.6
Industrias y Abonos de Navarra S.A.	Pamplona	23.8
Industrias y Abonos de Navarra S.A.	Lodosa	55.0
Industrias y Abonos de Navarra S.A.	Lozo	72.6
Industrias Quimicas Canarias S.A.	Zorroza	24.7
" "	Grao, Castellon	25.0
" "	Grao, Valencia	33.4
Industrias Reunidas Minero Metalurgicas S.A.	Asua	38.5

La Industrial Quimica de Zaragoza	Zaragoza	39.9
Productos Electroliticos S.A. (PESA)	Barcelona	54.0
Productos Quimicos Ibericos S.A.	Almeria	24.2
Productos Quimicos Ibericos S.A.	Malaga	43.2
Real Cia. Asturiana de Minas S.A.	San Juan de Nieva	29.3
Refineria de Petroleos de Escombreras S.A.	Cartagena	150.0
Cia. Espanola de Minas de Rio Tinto S.A.	Huelva	243.0
Union Espanola de Explosivos S.A.	La Manjoya	53.4
" "	Luchana	46.2
" "	Cartagena	78.0
Other Plants (Total - 11)	Various	137.0

(xiii) Sweden

Boliden A/B	Halsingborg	120.0
" "	"	175.0
" "	Oskarshamm	45.0
AB Forenade Superfosfatfabriker	Nörrkoping	70.0
Stora Kopparbergs Bergslags A/B.	Falun/Skutskar	60.0

(xiv) Switzerland

Chemische Fabrik Uetikon	Uetikon	35.0

(xv) Turkey

Karabuk Iron & Steel Works	Karabuk	9.0

(xvi) United Kingdom

British Titan Products Co. Ltd.	Pyewipe, Grimsby	46.9
" " " "	" "	51.6
Courtaulds Ltd.	Greenfield	50.3
" "	"	50.3

Scottish Agricultural Industries Ltd.	Sandilands, Aberdeen	50.3
Laporte Acids Ltd.	Castleford	45.7
Laporte Titanium Ltd.	Stallingborough	40.2
Synthetic Chemicals Ltd.	Kottingley	20.1

(D) Africa

(i) Algeria

Ste. Nouvelle Algerienne de Produits Chimiques et d'Engrais.	La Senia	20.0
	Bone	13.2
	Algiers	10.0

(ii) Egypt

Abu Zaabal Fertiliser & Chemical Co.	Abu Zaabal	39.6
Ste. Financiere et Industrielle Egyptien de Kafr el Zaiyat	Kafr el Zaiyat	30.0
	Alexandria	16.3

(iii) Morocco

Ste. Cherifienne d'Engrais et de Produits Chimiques	Keitara	21.8
Maroc Chemie	Safi	215.0
" "	"	215.0

(iv) Rhodesia

A.E. & C.I.	Rodia	62.6

(v) South Africa

Buffelsfontein Gold Mining	Klerksdorp	66.0
" "	"	36.3
Blyvooruitzicht Gold Mining	Carletonville	44.6
Daggafontein Mines	Springs	72.6
Harmony Gold Mining	Virginia	39.6
O'Kiep Copper	O'Kiep	11.6
Randfontein Estates Gold Mining	West Witwatersrand	82.5
Stilfontein Gold Mining	Klerksdorp	72.5
" " "	"	49.5
Transvaal Gold Mining Estates	Graskop	6.0
Western Reefs Exploration & Development	Klerksdorp	72.6
West Rand Consolidated Mines	Pilgrims Rest	18.0
Virginia-O.F.S. Gold Mining	Virginia	108.9
AE & CI	Modderfontein	16.0

(vi) Tunisia

SAPCE	Tunis	19.8

(C) Asia

(i) India

Fertilizer Corporation of India	Sindri	132.0

(ii) Japan

Chisso KK	Minamata	69.3
Ishihara Industries	Yokkaichi	66.0
Kowa Seiko K.K.	Tobata	198.0
" " "	"	115.5
Mitsubishi Petrochemical Co.	Yokkaichi	72.6
Nippon Kokan K.K.	Koyasu	158.4

Nissan Chemical Industries	Nagoya	66.0
Nissan Chemical Industries	Onoda	84.2
Seitetsu K.K.	Befu	66.0
Sumitomo Chemical Industries	Niihama	66.0
Tohoku Hiryo	Akita	105.5
Tohoku K.K.	Matsuo	118.8
Ube Industries	Ube	204.6
" "	"	72.6
Other Plants	(a) Under 33,000 t.p.a. capacity (-100 t.p.d.) Total (21)	393.4
	(b) From 33,000 to 65,000 t.p.a. (100-199 t.p.d.) Total (32)	1,445.4

(iii) <u>Philippines</u>

Maria Christina Fertilizers.	Iligan City	39.6
Resins Inc.	" "	21.8
Esso Standard Fertilizers & Chemicals.	Limay, Bataan	224.4
Atlas Fertilizer Co.	Toledo City	39.6
" " "	" "	39.6

(iv) <u>Taiwan</u>

Taiwan Fertilizers	Keelung	16.5
Kaohsiung Ammonium Sulphate.	Kaohsiung	16.5

(D) <u>Australasia</u>

(i) <u>Australia</u>

Imperial Chemical Industries of Australia & New Zealand (ICIANZ)	Yarraville	21.0
	"	50.0
	"	33.0
	North Birkenhead	20.0
Sulphide Corp.	Cockle Creek	40.0
ACF & Shirleys	Pinkenba	83.0
Sulphuric Acid Pty.	North Birkenhead	100.6
CSBP & Farmers	Bassendean	30.0
" "	Freemantle	15.0

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Cresco Fertilisers	Bayswater	33.5
" "	"	25.1

(E) North America

(i) Canada

Canadian Industries Ltd.	Coppercliff	742.4
Cominco	Kimberley	107.7
"	"	107.7
"	"	80.8

(ii) United States

Allied Chemical Corp.	Denver, Col.	27.0
" " "	N. Clayton, Del.	150.0
" " "	Newell, Pa.	90.0
Kennecott Copper Corp.	Hayden, Ariz.	30.0
Tennessee Copper Corp.	Isabella, Tenn.	57.0
" " "	" "	104.9
" " "	" "	57.0
" " "	Copperhill, Tenn.	206.0
" " "	" "	134.8
" " "	" "	230.0
Rico Argentine Mining	Rico, Col.	60.0
Bethlehem Steel	Sparrows Point Md.	50.0

APPENDIX TWO

Brimstone and Pyrites Export Prices 1950-1969

Mention has been made earlier in this report of the movements of sulphur prices during the 1960's, particularly in respect of brimstone and for reference purposes it is intended to present here a tabulation of export prices of U.S. Frasch sulphur and Spanish pyrites for the period from 1950-1969 so to provide a background framework for the earlier analysis. The particular price series have been chosen because of their major significance during the last 20 years in determining the ruling brimstone and pyrites prices in Western World markets; the U.S. Frasch suppliers have been the brimstone price leaders in the major Western European and Asian markets and, as the principal source of pyrites for importers in Western Europe, the influence of the Spanish suppliers has been unrivalled.

U.S. Frasch sulphur export prices

The data in Table A is presented in respect of listed export prices f.o.b. U.S. Gulf and average realized f.o.b. prices at the same shipping point. The posted prices generally indicate the levels at which brimstone would be available on short term business whereas the realized f.o.b. figures relate to the average return per ton on all shipments and since the greater part of such shipments are made under medium to long term contracts with prices more favourable to the consumer, the realized f.o.b. figures are influenced accordingly.

TABLE A

U.S. Frasch Sulphur Export Prices, 1950-1969
(Bright sulphur, $U.S./ton f.o.b. Gulf Port)

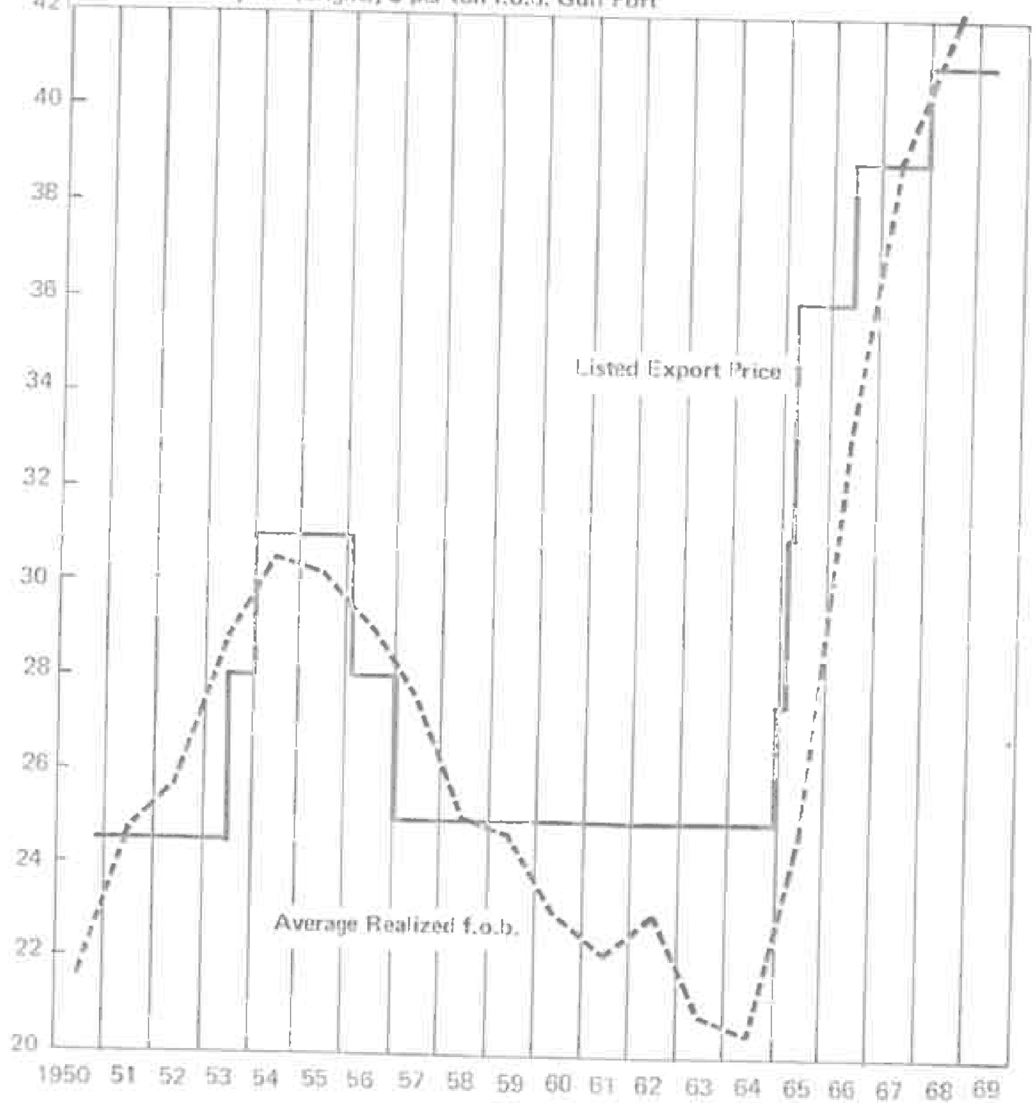
(i) Listed Prices			(ii) Realized F.O.B.	
Year / Date Effective		Price(s)	Year	Price
1950	September	24.50-27.00	1950	21.50
1951		no change	1951	24.70
1952		no change	1952	25.70
1953	June	28.00-30.50	1953	28.80
1954	January	31.00	1954	30.60
1955		no change	1955	30.30
1956	February	28.00	1956	29.25
1957	January	25.00	1957	27.70
1958		no change	1958	25.00
1959		no change	1959	24.75
1960		no change	1960	23.00
1961		no change	1961	22.20
1962		no change	1962	23.10
1963		no change	1963	20.90
1964	December	27.50	1964	20.60
1965	February	31.00	1965	24.50
	April	36.00	1965	24.50
1966	July	39.00	1966	33.30
1967		no change	1967	39.15
1968	January	41.00	1968	42.20
1969		no change	1969	39.00

Applying, as they do, to deliveries to all markets the realized f.o.b. prices in the right-hand column above do not reflect the particularly low 'net-back' which prevailed with regard to exports to major consumers during the period immediately before the onset of limited brimstone availability in 1964 when, as previously stated, f.o.b. prices went down as low as $16-17 per ton.

During the period from 1957 to 1964 when the U.S. Frasch sulphur producers were engaging in intensive competition with the newly emerging sources of brimstone supply in Mexico, West Canada and France, listed prices remained static at $25.00 per ton f.o.b. but effective market prices incorporated a series of variable discounts and freight contributions and these led to the progressive adoption of delivered prices in export markets.

BRIMSTONE EXPORT PRICES

U.S. Frasch Sulphur (bright), $ per ton f.o.b. Gulf Port



Spanish pyrites export prices

The price series for Rio Tinto crude fines is shown in Table B in the quoted sterling currency and in terms of the U.S. dollar for ease of comparison with the U.S. Frasch sulphur price.

In line with the sterling devaluation in November 1967, the pyrites price moved upwards from 85/- to 93/- per tonne and since the producers were granting a discount of 5/- per tonne on the price established in mid-1966 during the second half of 1967, the f.o.b. price in U.S. dollars effectively remained the same before and after devaluation.

TABLE B

Spanish Pyrites Export Prices, 1950-1969
(Rio-Tinto crude fines, basis 48%S, per tonne fob Huelva

Year / Date Effective		Quoted Prices	$U.S. Equivalent
1950		58/-	8.12
1951	January	60/6	8.47
	July	75/-	10.50
1952		no change	
1953	January	84/-	11.76
1954	January	105/-	14.70
1955		no change	
1956		no change	
1957	July	92/6*	12.95
1958	January	82/6*	11.55
	July	77/6*	10.85
1959	January	67/6*	9.45
	October	60/-*	8.40
1960		no change	
1961		no change	
1962		no change	
1963	January	56/6*	7.91
1964		no change	

Year / Date Effective		Quoted Prices	$U.S. Equivalent
1965	January	62/6*	8.75
	July	68/-*	9.52
1966	January	83/-*	11.62
	July	85/-*	11.90
1967		**	
1968	January	93/-	11.16
1969		no change	

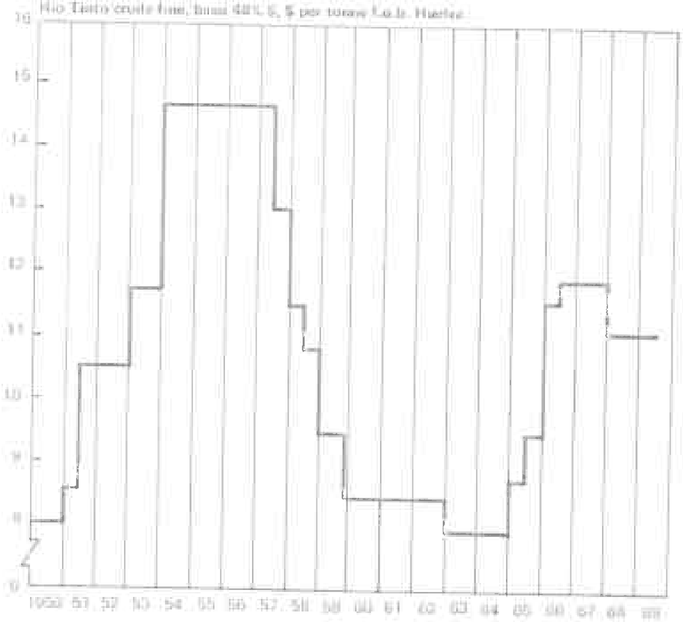
<u>Notes</u>

* Do not include producers voluntary Contributions (cinders credits)

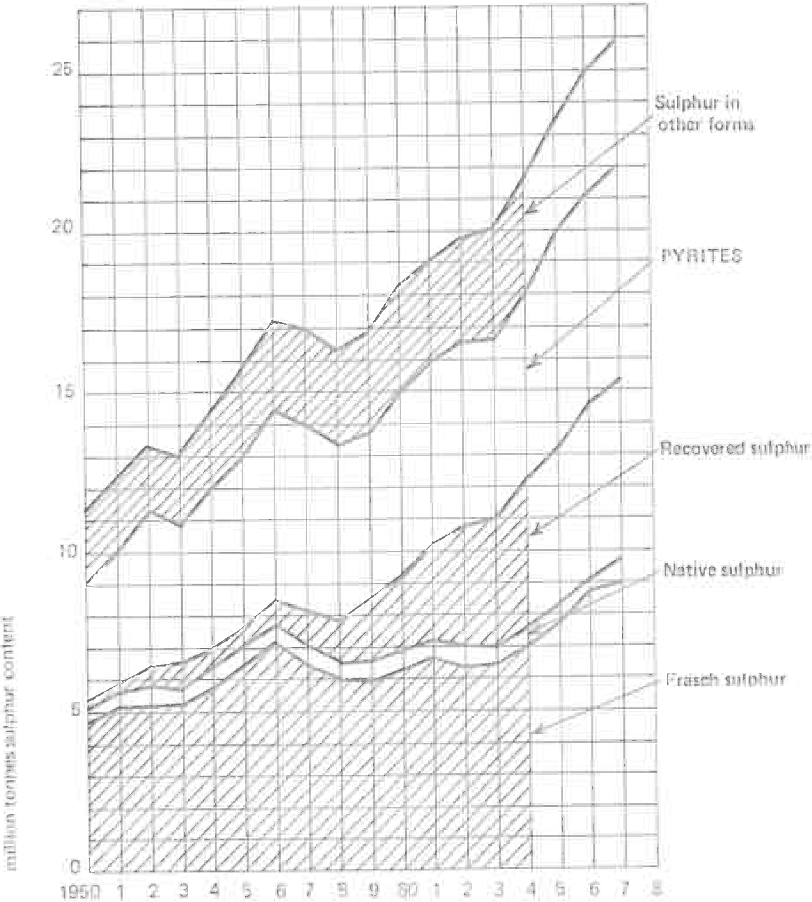
** Price was officially unchanged on July 1966 level up to sterling devaluation on 20th November 1967 but in fact the producers granted a discount of 5/- per tonne on second half 1967 contracts. Post-devaluation price of 93/-($ 11.16) this approximates to a pre-devaluation effective price of 80/- ($11.20).

PYRITES EXPORT PRICES

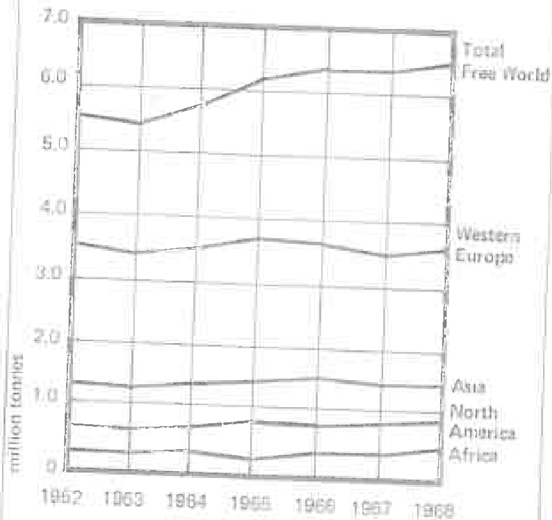
Rio Tinto crude fine, basis 48% S, $ per tonne f.o.b. Huelva



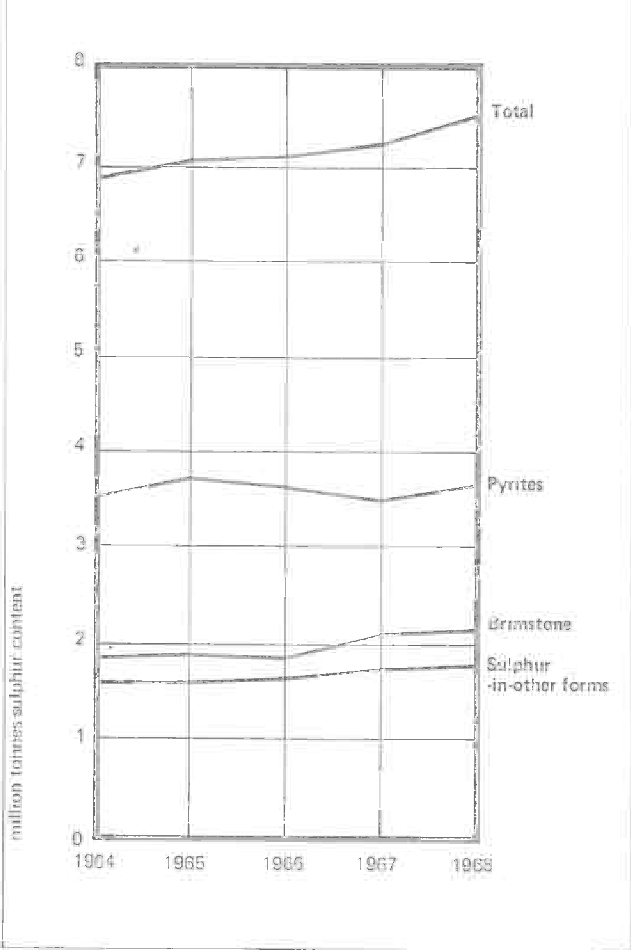
FREE-WORLD SULPHUR PRODUCTION



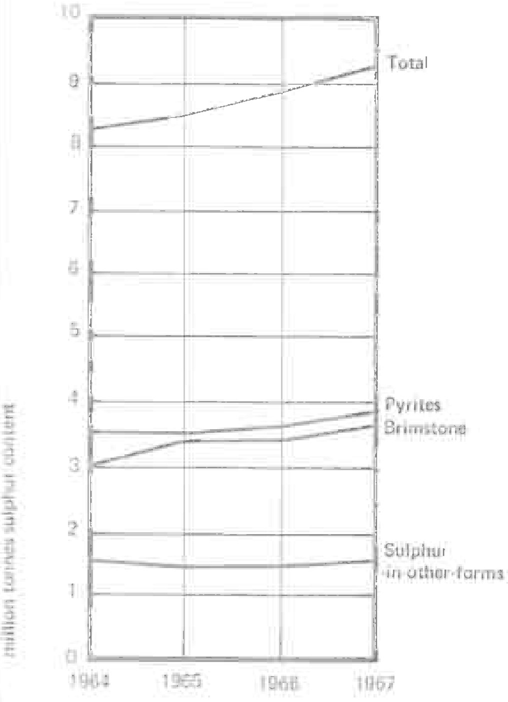
FREE WORLD SULPHUR AS PYRITES PRODUCTION
1962 - 1968

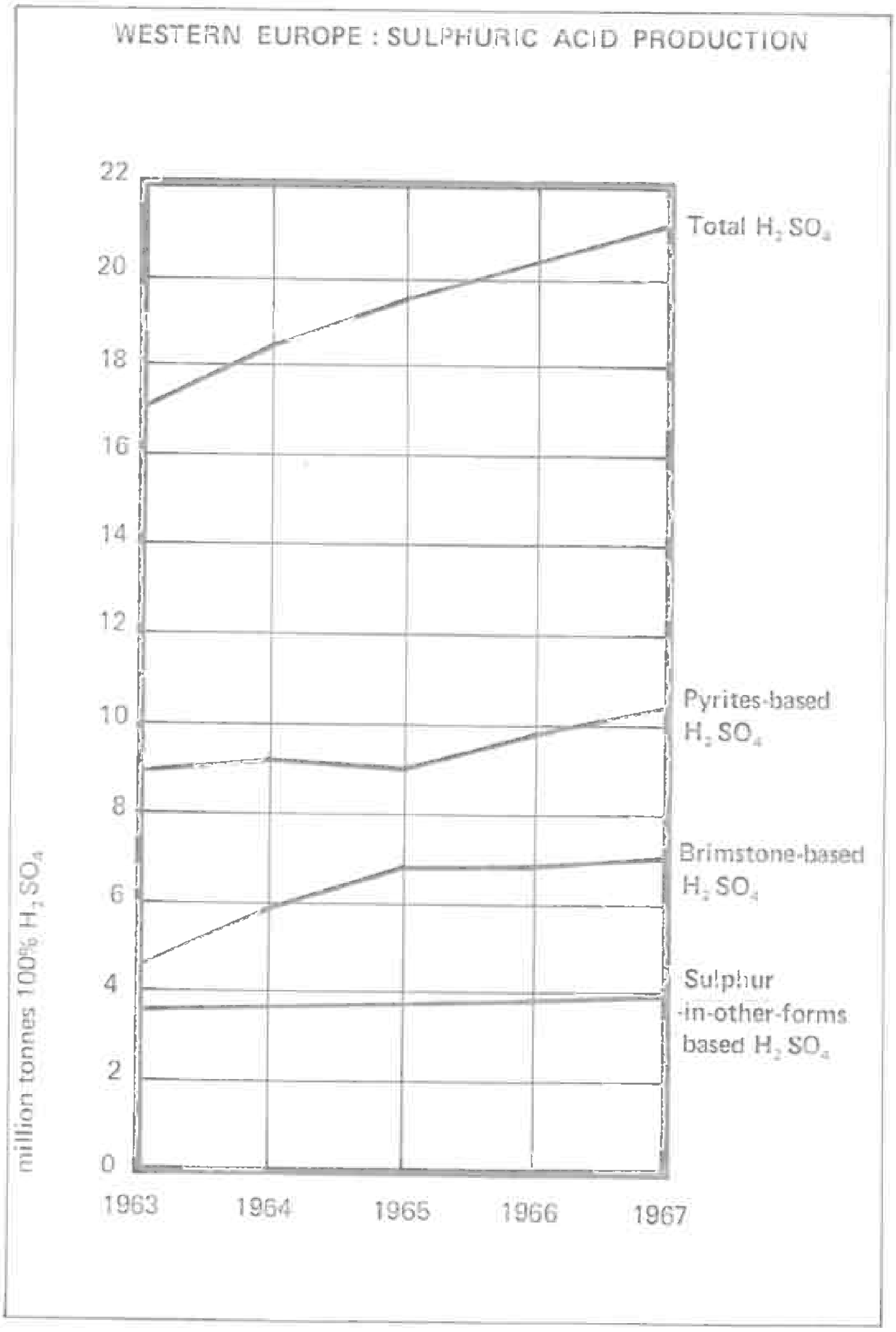


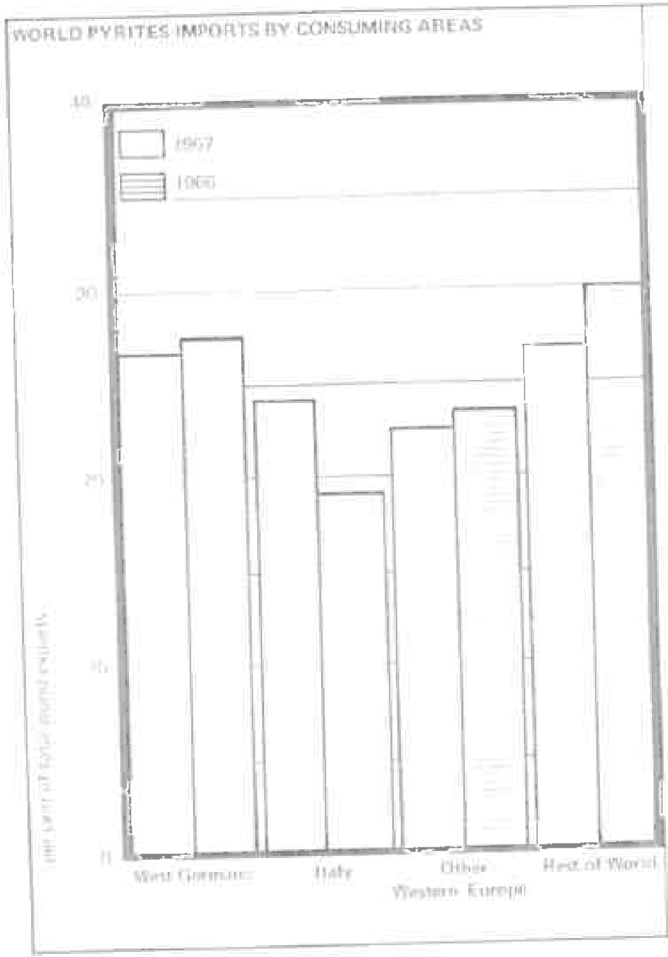
WESTERN EUROPE : PRODUCTION OF SULPHUR-IN-ALL-FORMS

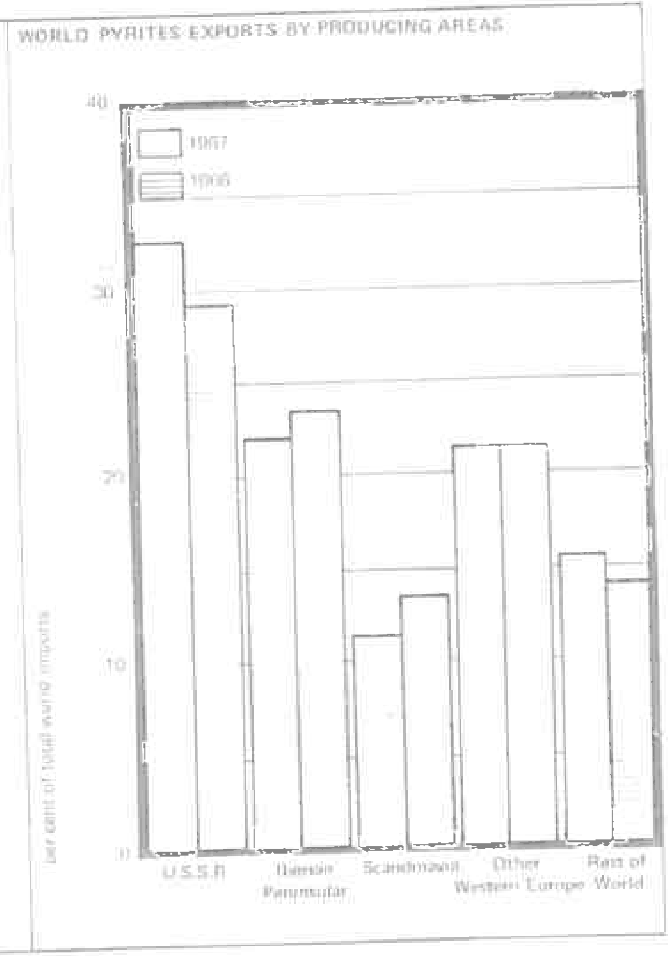


WESTERN EUROPE :
CONSUMPTION OF SULPHUR-IN-ALL-FORMS

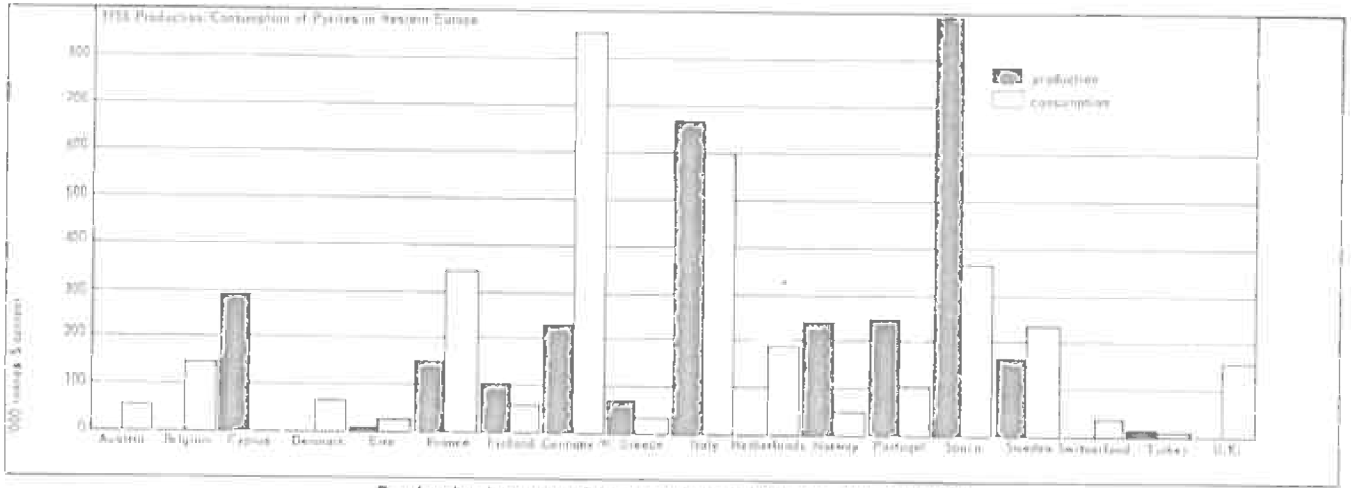



WESTERN EUROPE : SULPHURIC ACID PRODUCTION
22
20
18
16
14
12
10
8
6
4
2
0
1963
1964
1965
1966
1967
million tonnes 100% H_2SO_4
Total H_2SO_4
Pyrites-based H_2SO_4
Brimstone-based H_2SO_4
Sulphur -in-other-forms based H_2SO_4

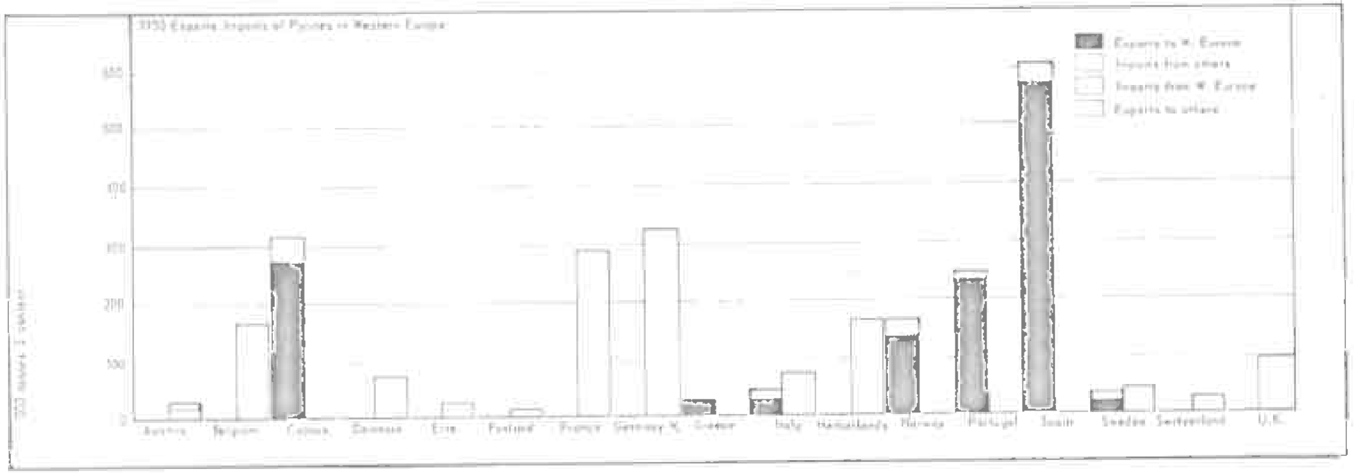

WORLD PYRITES IMPORTS BY CONSUMING AREAS
1967
West Germany
Italy
Other Western Europe
Rest of World


WORLD PYRITES EXPORTS BY PRODUCING AREAS
40
30
10
0
U.S.S.R
Peninsular
Scandinavia
Other Western Europe
Rest of World

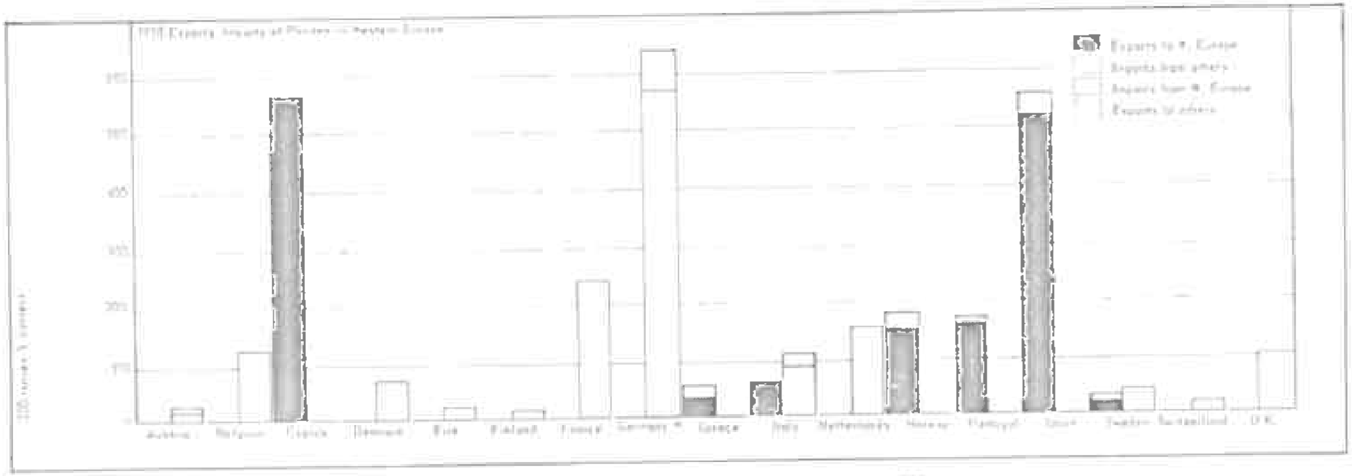
Production/consumption of pyrites in Western Europe, 1950



Production/consumption of pyrites in Western Europe, 1958

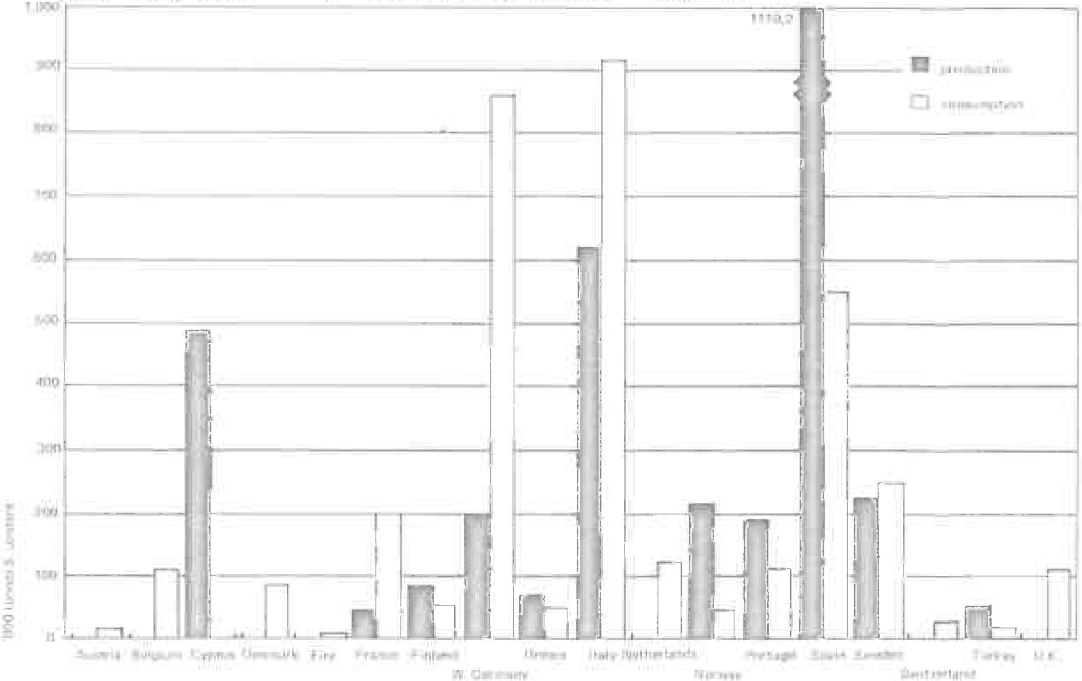


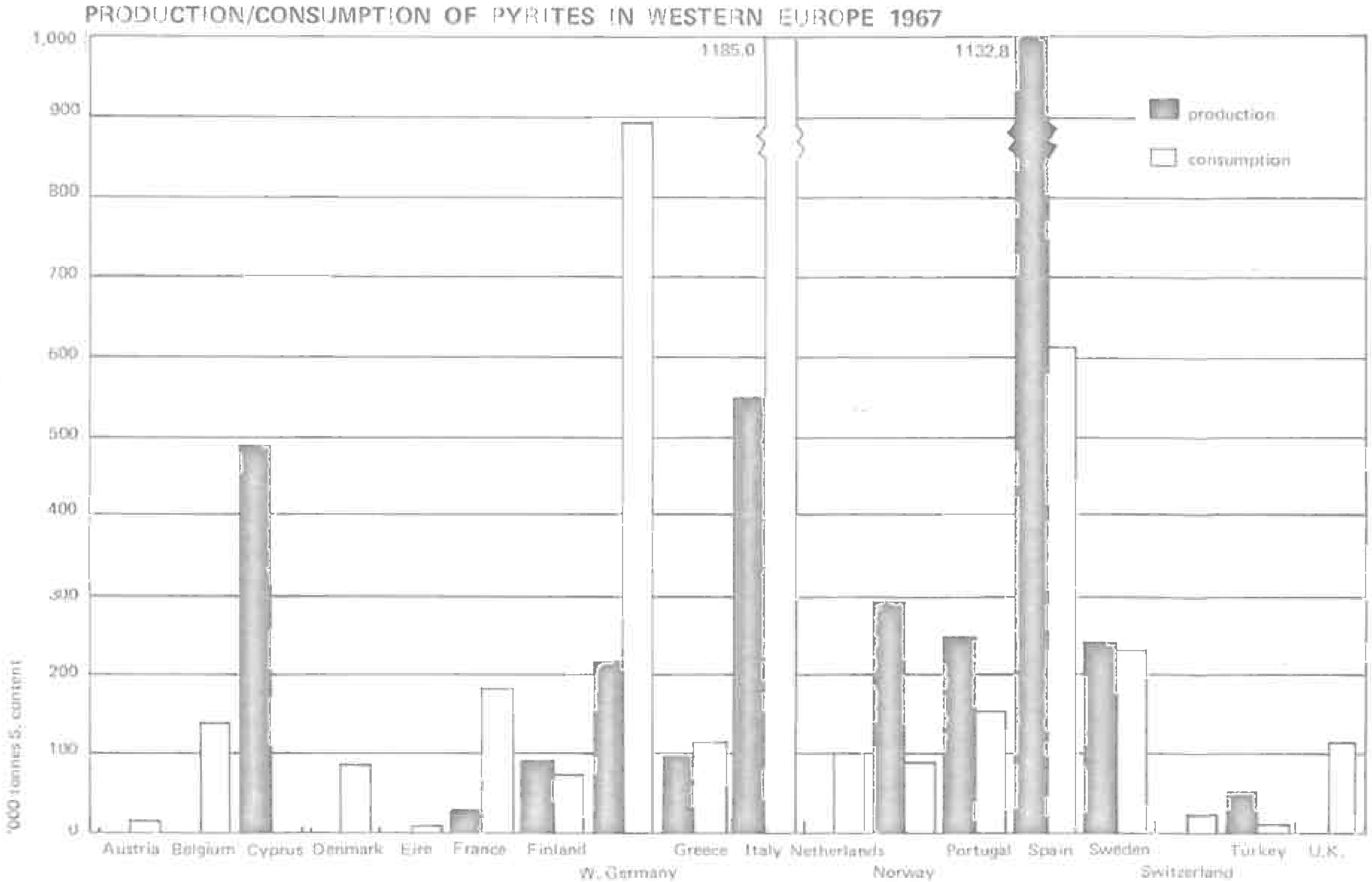
Exports/imports of pyrites in Western Europe, 1950



Exports/imports of pyrites in Western Europe, 1958

PRODUCTION/CONSUMPTION OF PYRITES IN WESTERN EUROPE 1965

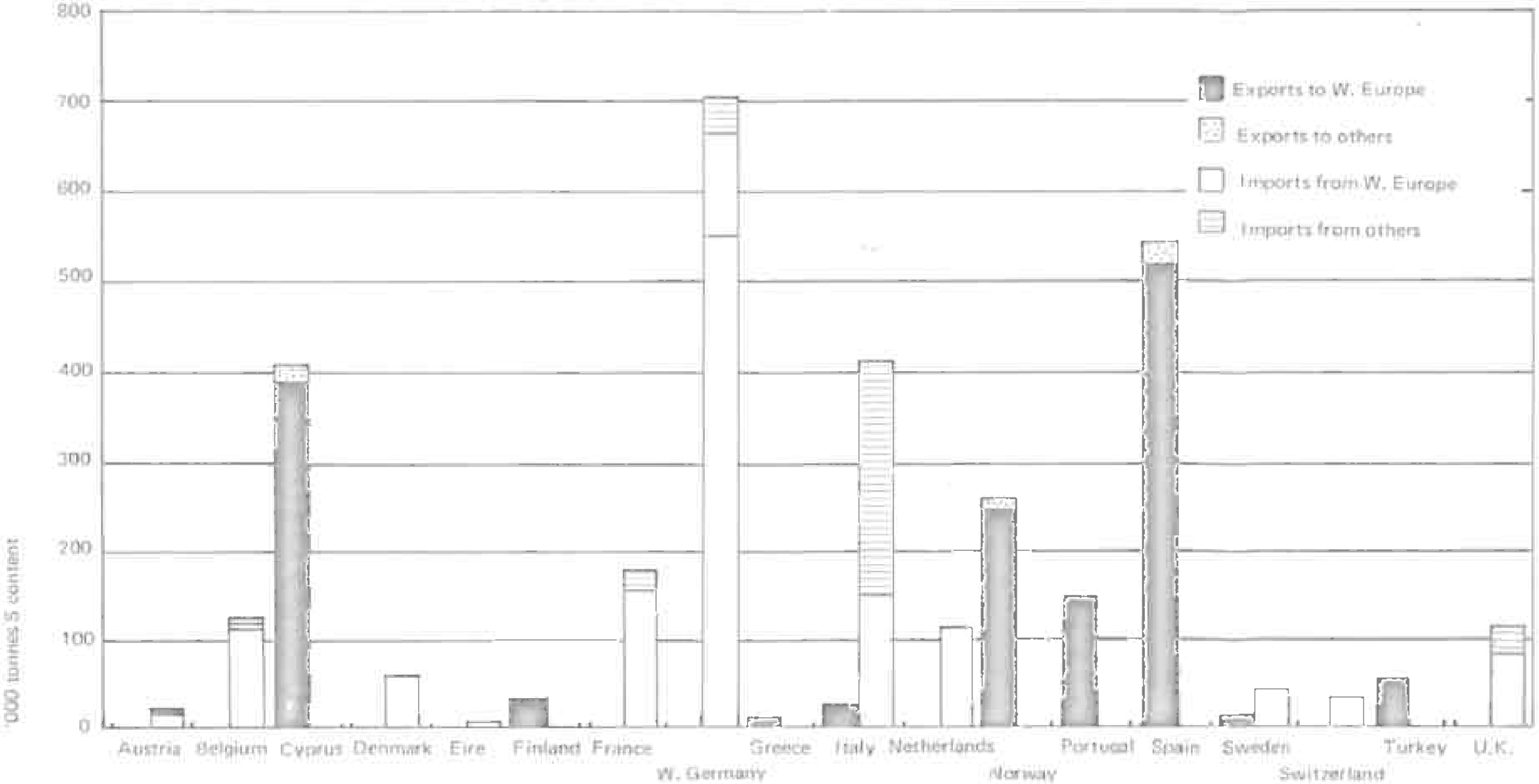




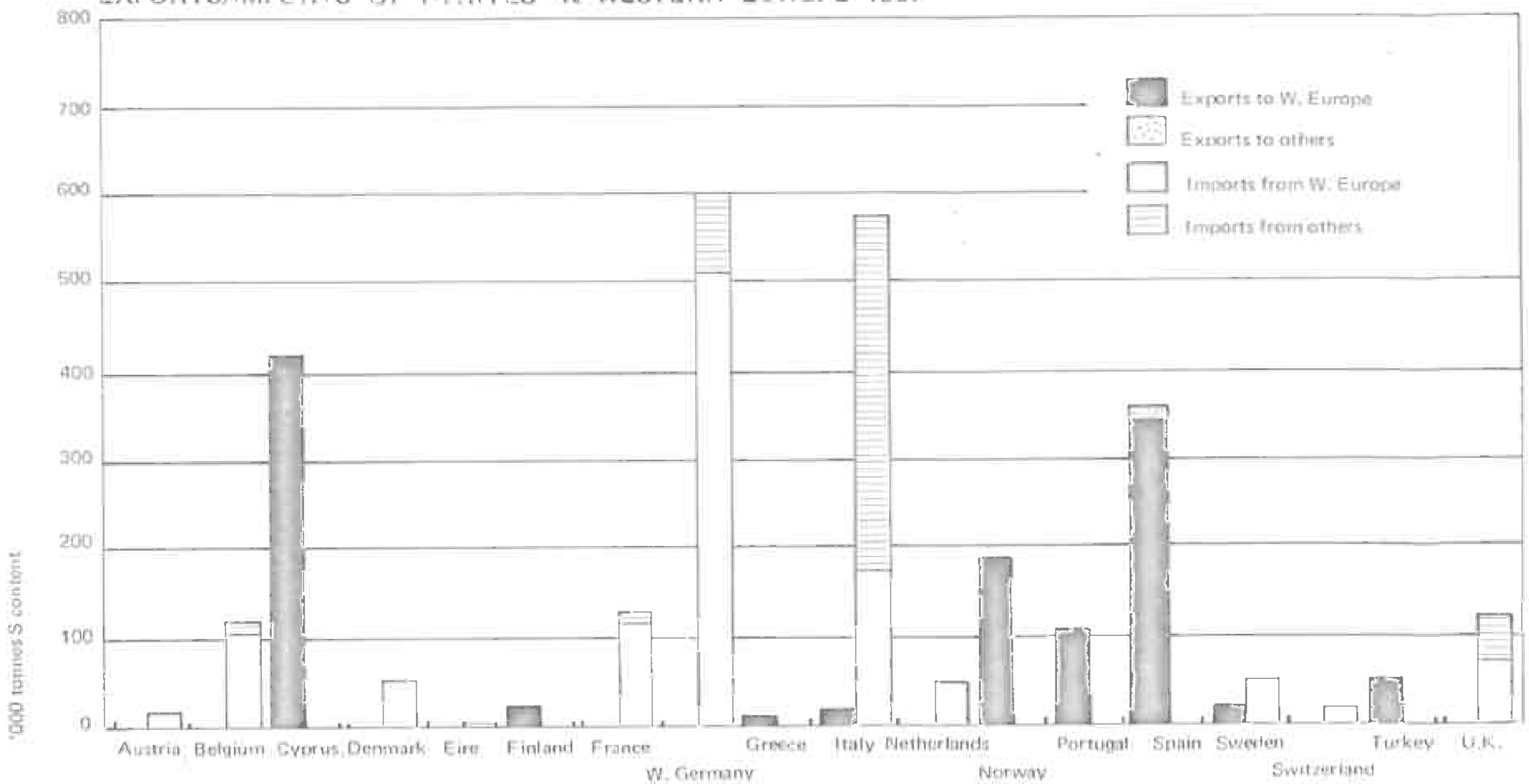
PRODUCTION/CONSUMPTION OF PYRITES IN WESTERN EUROPE 1967
'000 tonnes S. content
1,000
900
800
700
600
500
400
300
200
100
0
1185.0
1132.8
production
consumption
Austria
Belgium
Cyprus
Denmark
Eire
France
Finland
W. Germany
Greece
Italy
Netherlands
Norway
Portugal
Spain
Sweden
Switzerland
Turkey
U.K.

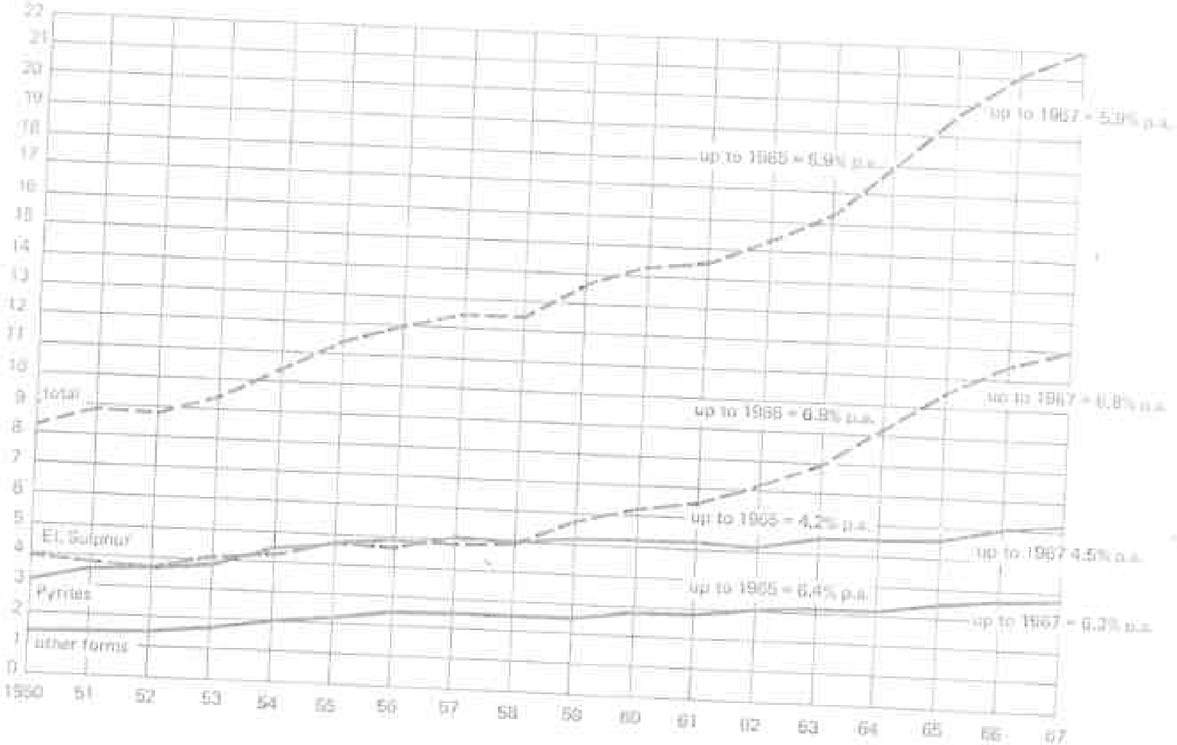
224

EXPORTS/IMPORTS OF PYRITES IN WESTERN EUROPE 1965

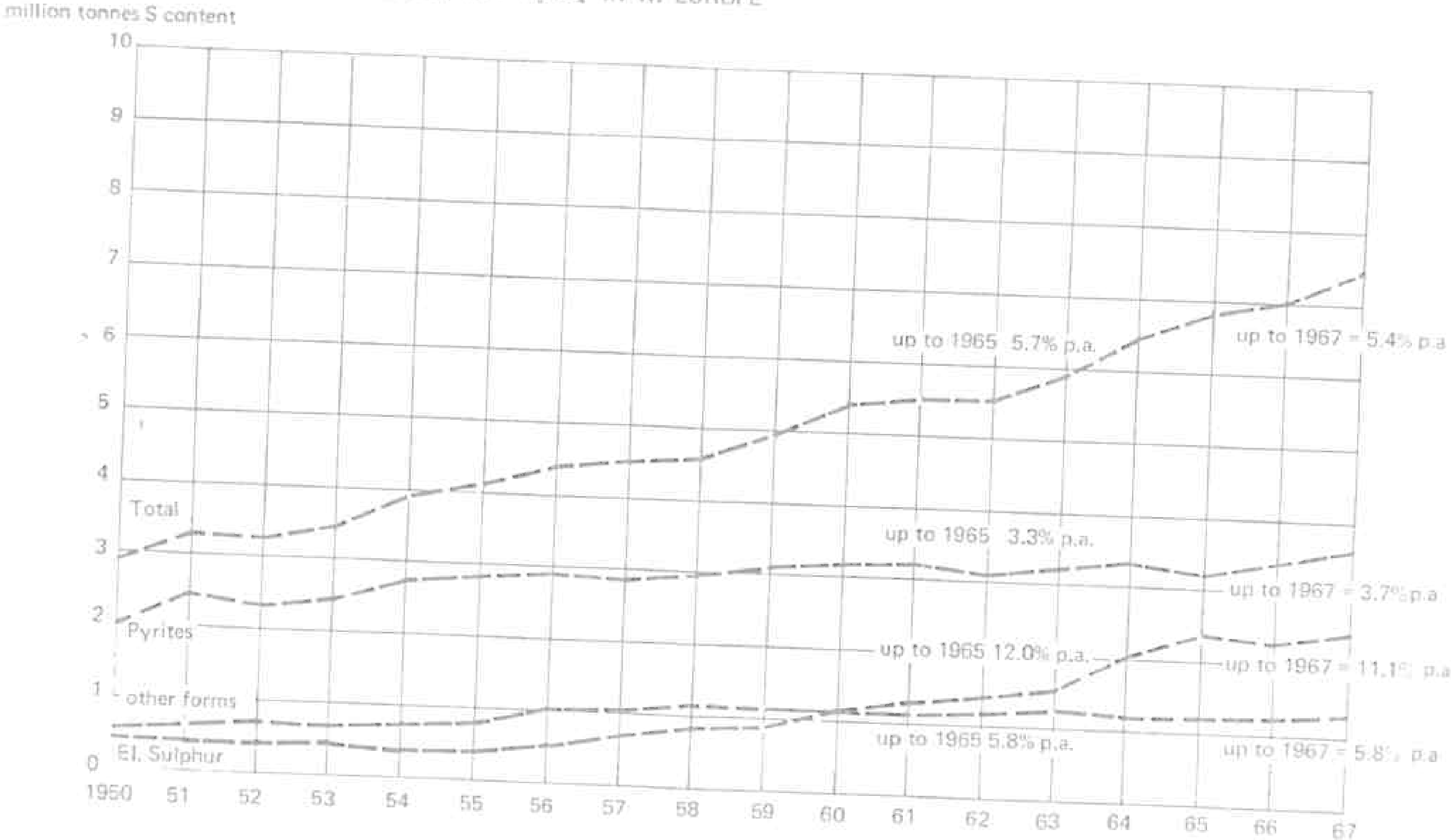


EXPORTS/IMPORTS OF PYRITES IN WESTERN EUROPE 1967




Total
El. Sulphur
Pyrites
other forms
up to 1965 = 4.2% p.a.
up to 1967 4.5% p.a.
up to 1965 = 6.4% p.a.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
1950
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67

CONSUMPTION OF SULPHUR FOR H_2SO_4 IN W. EUROPE



GRONG

PROSPEKTERING

1974 – 1982

Div. materiale