A study of copper consumption in some industrial countries and its relevance to India

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CHANGE has always been a way of life. In the past its rate has often been slow but today changes take place so rapidly that, except in a limited field, it is not possible for one man to keep abreast of modern developments and assess their possible effects. Changes affect every facet of our lives whether political, social or technological and nowhere is this more pronounced than in India. By itself change it not necessarily a solution to all problems and, as an example, has not solved one of the world's most critical problem —the gap between the 'Developing' and 'Industrial' countries. Fundamentally the reason is simple. Where capital accumulates, is invested in research to provide the basis for the necessary technical change and is turned into productive equipment, trade expands and living standards rise.

Change is as much a part of metals as of peoples. It is an intrinsic part of the technological revolution creating new demands on materials and is the concern of all ferrous and non-ferrous metals. It has led to increased competition between metals for the same area of usage with most, in one way or another, being challenged by plastic materials. Copper has been widely used for many years, and despite the advent of the new materials and changes in their relative price, demand for copper has shown a continuous increase although the pattern of its use is changing. The pattern of change also varies both by country and by use and it may therefore be of interest, first, to see how copper is used in some countries other than India and, secondly, to examine the relevance of this use to present Indian conditions. Only certain countries are examined in detail—the U.S.A., Britain, Germany, Japan, France and Italy partly because they are representative of the industrial countries and partly because there is a lack of statistical information on wrought copper and its uses in other countries. The countries detailed, however, account for nearly 80% of the free world's refined copper consumption.

In general terms copper consumption can be related to such economic indices as net income, industrial production and gross national product. But the distribution of this consumption is as variable as the distribution of the world's productive resources and wealth. For instance, less than one-third of the free world's population produces four-fifths of its output and income and consumes over nine-tenths of its copper.

Certain terms which will be used require defining. The free world is taken to exclude Russia and her satellite countries and China. Refined copper refers to copper which has been either refined from primary or secondary material; the direct use of scrap has been excluded and dealt with separately to provide a total known consumption of copper. (When scrap is used directly by manufacturers it is mainly to produce alloy rod and castings.) All tonnages quoted are metric and population figures taken from the United Nations Demographic Year Book, unless otherwise stated.

World copper consumption

The world consumption of refined copper rose from 3 766 000 tons in 1955 to 5 898 000 tons in 1964, an increase of 57% or 6·3% a year (Graph I). Per capita consumption of refined copper rose by 26%, or 2·9% a year (Graph I), a lower rate than the world refined consumption due to the explosive increase in the world's population. It also emphasises that not all the rise in refined consumption is due to the increase in population. The per capita consumption in the world today is 3·9 lb of copper compared to 3·1 lb in 1955 (Graph I).

Free world copper consumption

The free world's refined copper consumption rose from 3 246 000 tons in 1955 to 4 852 900 tons in 1964 (Graph II), an increase of 49% or 5·4% per annum. Per capita consumption of refined copper rose by 22%

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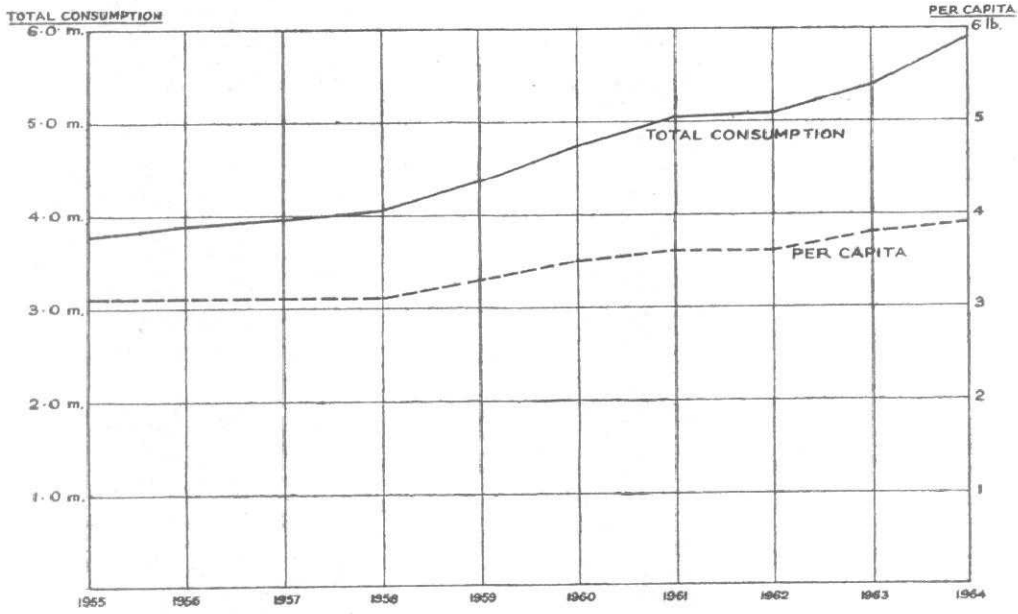

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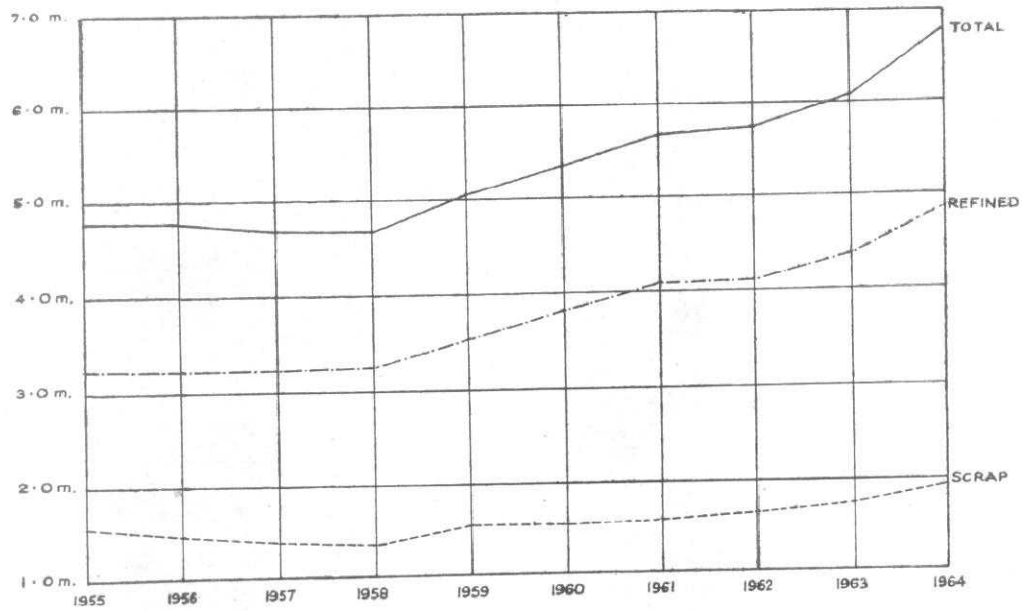
Graph I
World consumption of refined copper (metric tons)

or an average 2·5% a year from 4·1 lb. in 1955 to 5·0 lb in 1964 (Graph III).

The total amount of scrap used in 1964 is assessed by Metallgesellschaft to be 2 697 800 tons or 56% of refined copper consumption. Of this 765 000 tons was used in the production of refined copper and 1 933 000 tons directly by manufacturers (Graph II). The total amount of copper used in the free world was therefore 6 786 000 tons in 1964, a rise of 42% from 1955 or an average of 4·7% a year (Graph II). Per capita consumption rose from 6·0 lb in 1955 to 7·0 lb in 1964, an increase of 17% or an average 1·9% a year (Graph III). The lower rate of total usage is due to consumption of scrap increasing at only about the same rate as the increase in population.

In those countries which have already been named, accounting for some 80% of the free world's refined copper consumption, about 4 391 000 tons go to fabricators of which 1 189 000 tons is the copper content of the alloy production. Of the total one half is drawn into copper wire and 14% into copper tube. A further 7% is rolled into sheet and 3% drawn into rod. An



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Graph II
Free world copper consumption (metric tons)

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Population

Millions

	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
World	2 691	2 737	2 795	2 852	2 905	2 995	3 069	3 114	3 160	3 332
Less U.S.S.R. & Satellites	347	353	364	363	370	374	379	384	388	402
	2 344	2 384	2 431	2 489	2 535	2 621	2 690	2 730	2 772	2 930
Less China	608	621	646	660	670	686	710	740	770	800
Free World	1 736	1 736	1 785	1 829	1 865	1 935	1 980	1 990	2 002	2 130

Source : U. N. Demographic Year Book
1964 estimated

CIDEC : London, Dated 1.2.1966 ; Reference : Schedule II, India

Population by countries

Millions

Country	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
Britain	51·2	51·4	51·6	51·8	52·1	52·5	52·9	53·4	53·8	54·2
France	43·4	43·8	44·3	44·8	45·2	45·7	46·2	47·0	47·9	48·6
Germany	52·4	53·0	53·6	54·3	54·9	55·4	56·2	57·0	57·6	58·2
Italy	48·2	48·5	48·8	49·0	49·4	49·6	49·9	50·2	50·5	50·7
India	386·6	394·2	402·2	410·7	419·6	429·0	435·5	449·4	471·1	481·5
Japan	89·0	90·0	90·7	91·5	92·4	93·2	94·1	94·9	95·9	90·9
U.S.A.	165·9	168·9	172·0	174·9	177·8	180·7	183·8	186·7	189·4	192·1

Source : U. N. Demographic Year Book

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Copper consumption by countries Metric Tons

U. S. A.

	Refined	Per capita lb.	Scrap	Total	Per capita lb.
1955	1 362 600	18·1	800 100	2 162 700	28·7
1956	1 380 200	18·0	734 800	2 115 000	27·6
1957	1 226 600	15·7	671 300	1 897 900	24·3
1958	1 134 600	14·3	631 400	1 766 000	22·3
1959	1 327 200	16·5	768 400	2 095 600	26·0
1960	1 224 600	15·0	655 000	1 879 600	23·0
1961	1 327 100	16·0	636 000	1 963 100	23·5
1962	1 451 200	17·1	699 000	2 150 200	25·4
1963	1 582 400	18·4	758 000	2 340 400	27·2
1964	1 640 900	18·8	864 500	2 505 400	28·7
Growth	+20·4%		+8·1%	+15·8%	

BRITAIN

	Refined	Per capita lb	Scrap	Total	Per capita lb
1955	504 100	21·7	163 600	667 700	28·7
1956	509 500	21·9	133 600	643 200	27·6
1957	515 600	22·0	136 100	651 700	27·8
1958	543 200	23·1	135 400	678 600	28·9
1959	486 500	20·6	156 800	643 300	27·2
1960	560 300	23·5	173 900	734 200	30·8
1961	528 800	22·0	167 000	695 800	29·0
1962	526 100	21·7	138 300	664 400	27·4
1963	558 000	22·9	137 400	695 400	28·5
1964	632 900	25·7	155 800	788 700	32·0
Growth	27·5%		−4·7%	+18·1%	

Source : Metallgesellschaft's "Metal Statistics 1955–1964"

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Consumption copper semis in U.S.A., Britain, Germany, France, Italy and Japan

Thousand metric tons

Year	Copper					Alloy				
	Wire	Tube	Sheet	Rod	Total	Wire	Tube	Sheet	Rod	Total
1955	1 381·8	316·1	272·0	102·1	2 072·0	49·4	163·0	631·9	697·6	1 541·9
1956	1 462·3	307·5	237·7	125·0	2 132·5	54·0	163·1	551·5	614·2	1 382·8
1957	1 489·9	302·8	236·7	113·4	2 142·8	56·3	162·3	452·1	616·6	1 287·3
1958	1 436·7	336·8	222·1	104·6	2 100·2	57·6	157·5	481·9	600·9	1 297·9
1959	1 530·0	453·3	246·4	117·0	2 346·7	45·5	166·7	571·0	706·7	1 509·9
1960	1 660·6	395·5	252·3	125·4	2 433·9	78·4	162·4	585·8	739·2	1 565·8
1961	1 787·7	428·0	266·4	126·5	2 608·6	81·3	173·6	595·9	772·5	1 623·3
1962	1 807·1	462·0	268·1	115·7	2 652·9	78·0	175·2	605·7	770·2	1 629·1
1963	1 901·5	526·2	265·7	112·6	2 806·0	77·1	183·3	613·8	810·1	1 684·3
1964	2 168·9	595·8	298·3	139·4	3 202·4	87·9	187·3	683·9	927·6	1 886·7
Growth	+56·9%	+88·6%	+9·5%	+36·2%	+54·5%	+77·9%	+14·7%	+8·2%	+32·9%	+22·3%

Note : These countries represent nearly 80% of the refined consumption of the free world.

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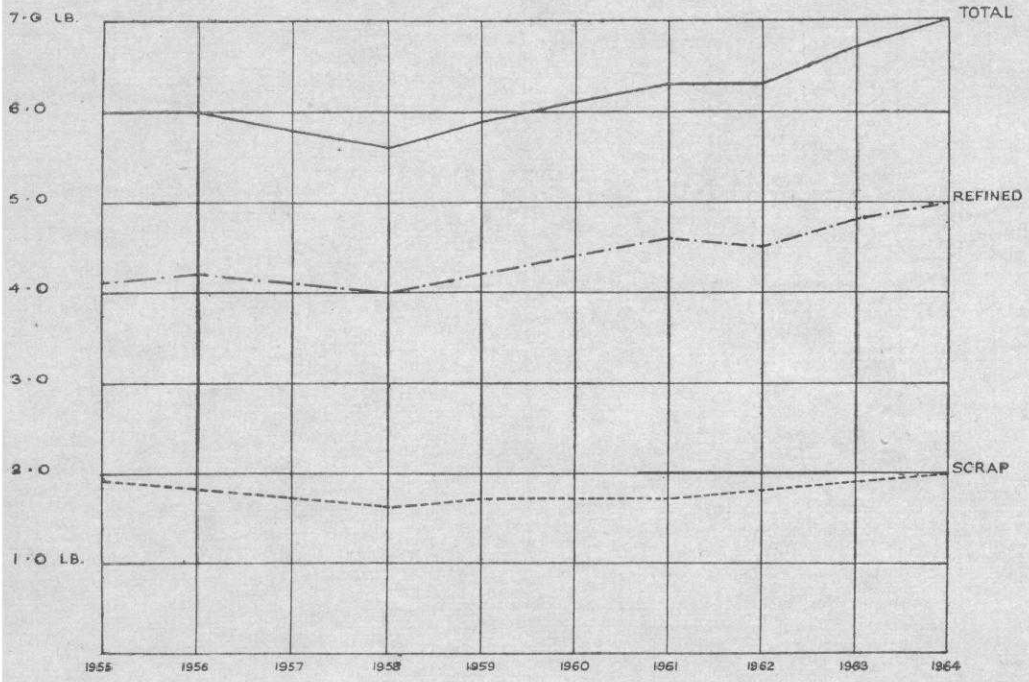
Consumption of copper semi products by industry 1964

Metric tons

INDUSTRY	U.S.A.	Britain	Germany	France	Italy	Japan	Total
Electrical*	1 062 000 (47)	335 000 (42)	331 000 (48)	183 000 (47)	150 000 (55)	434 000 (65)	2 495 000 (49)
Transport	275 000 (13)	65 000 (8)	48 000 (7)	20 000 (5)	25 000 (9)	26 000 (4)	459 000 (9)
Construction	377 000 (17)	124 000 (16)	45 000 (7)	63 000 (16)	25 000 (9)	11 000 (2)	645 000 (13)
General Eng.	526 000 (23)	265 000 (34)	264 000 (38)	125 000 (32)	75 000 (27)	192 000 (29)	1 447 000 (29)
Total	2 240 000	789 000	688 000	391 000	275 000	663 000	5 046 000

Notes : *Includes all wire and cable irrespective of the industry in which the final product is used.
Figures in brackets are percentages.



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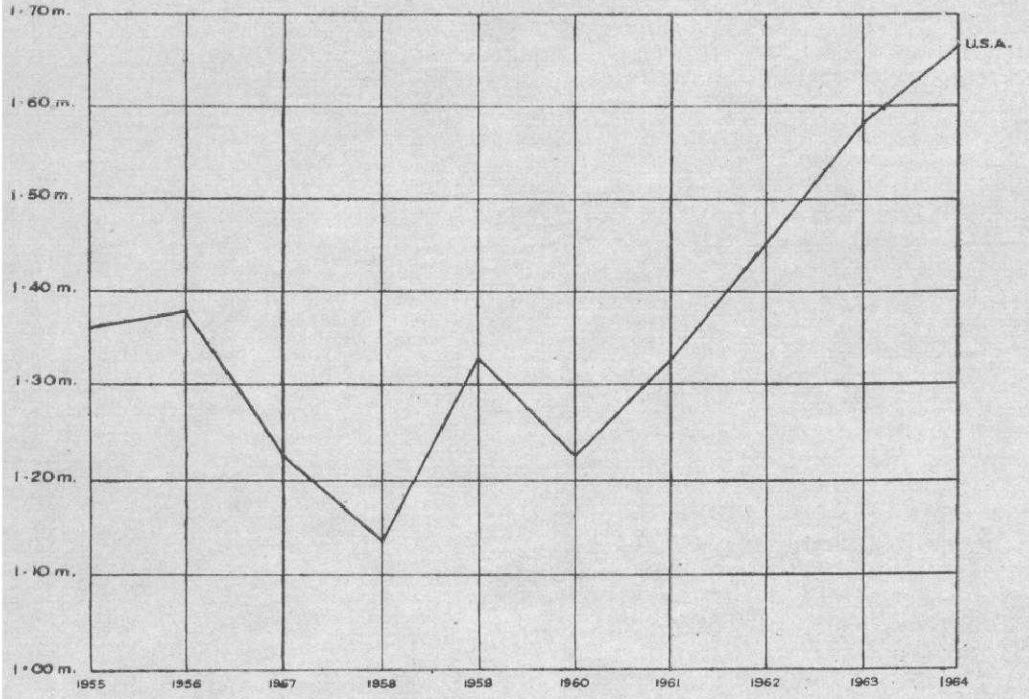
Graph III
Free world copper consumption per capita lb.

additional 13% of the total is drawn into alloy rod and 10% into alloy sheet. Alloy wire and alloy tube make up the balancing 3% (Schedule IV).

Copper semis have risen by 55% and alloy semis by 22% since 1955 making an increase in the total semi fabricated products of 41% or an average of 4·6% a year (Schedule IV). Although copper wire accounts for much the greater tonnage, the growth rate of copper tube has been appreciably higher. In the decade 1955–1964 consumption of copper wire rose 57% and that of tube 89%. Copper rod rose 36% and alloy rod by 33%. Alloy wire increased by 78% and the remaining semi products only marginally (Schedule IV).

The electrical industry consumed nearly one half or



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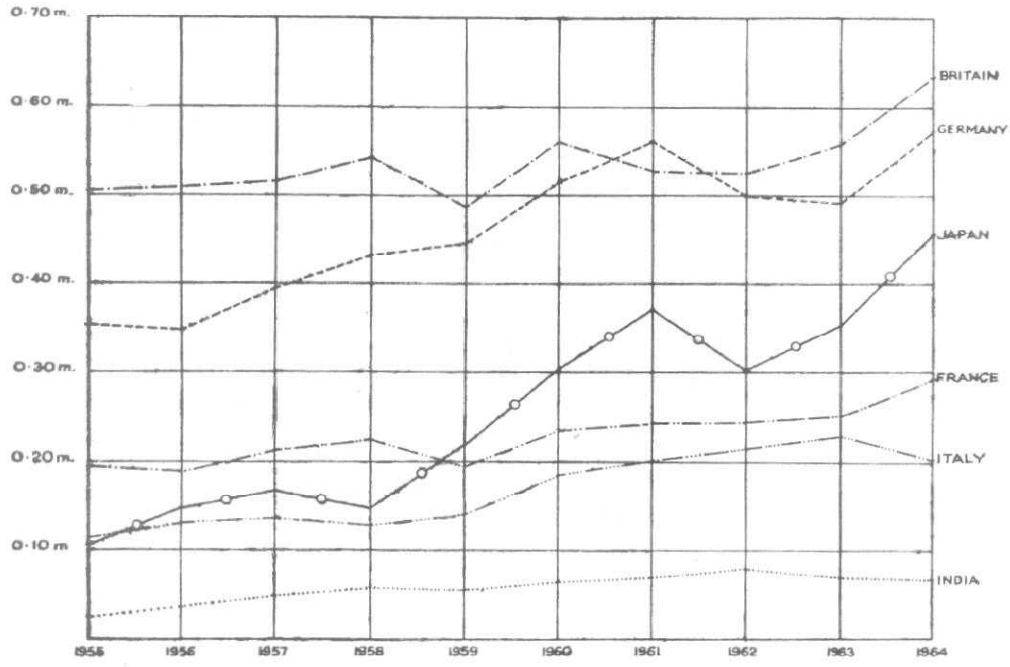
Graph IVa
Consumption refined copper by countries (metric tons)



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Graph IVb

Consumption refined copper by countries (metric tons)

2 495 000 tons and the construction industry 13% or 645 000 tons (Schedule V). The transport industry used 9% or 459 000 tons and general engineering the remaining 29% or 1 447 000 tons (Schedule V). Additionally castings used around 837 000 tons (mainly cathodes, ingots and scrap) and copper based salts such as sulphates and oxychlorides 141 000 tons.

Reasons for growth

The main increase in refined consumption of copper and semi-fabricated products occurred in the second half of the decade 1955–1964. This was due mainly to this period including the formation of the European Economic Community, providing an incentive to raising gross national product, increasing industrial production and raising capital investment in its member countries, rapid economic growth in Japan and the resurgence of the U. S. economy from its period of lethargic growth.

At the same time increased attention was given to raising productivity since a product of expansion was increasing wage and material costs. Such was, and is, the pressure on wages that increasing a country's productivity has become essential to sound economic growth. It is also generally agreed that to raise productivity an increasing use of electrical power per capita is necessary. For example, since 1958 production of electricity in the Common Market countries has risen by 60% or 10% a year, in Europe as a whole by 10% and the O.E.C.D. countries by 8% in total. It is therefore not surprising that consumption of copper wire, which is nearly all used in the electrical industry has increased by 51% or 8·5% a year since, 1958 (Schedule IV).

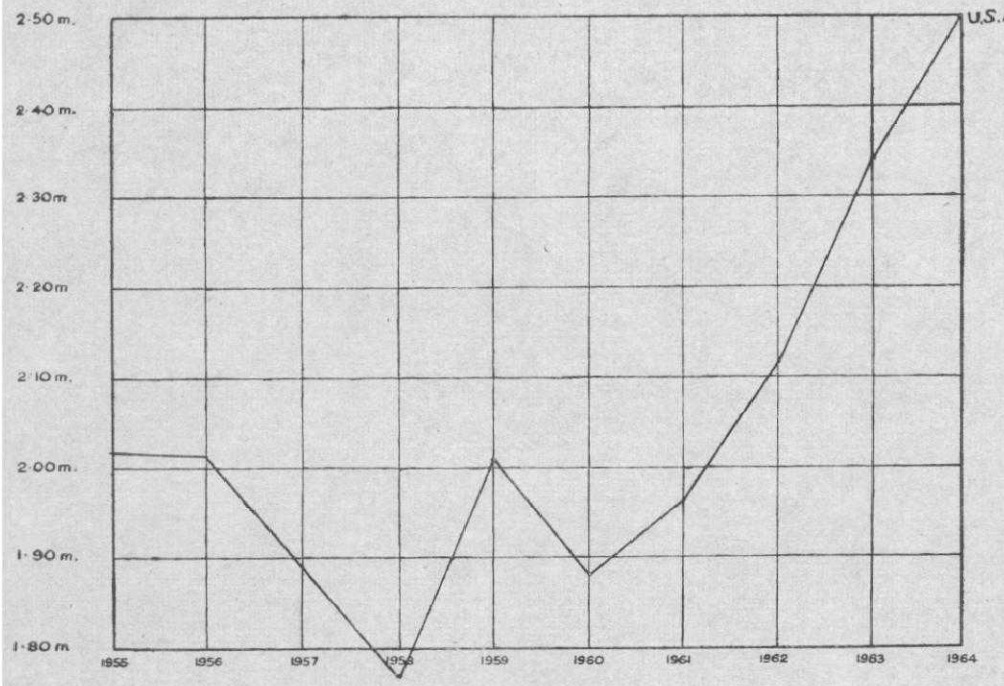
Although the transport industry, in which possibly three quarters of the copper consumed is used in the automobile industry, uses the least tonnage of copper of the four industries mentioned, it is a growth market. The ownership of cars has been found to rise at 2½ times that of real incomes and under any foreseeable conditions up to 1970 real incomes are unlikely to increase by less than 2½% a year in the industrial countries of Europe. Neither is there any likelihood of car ownership approaching the saturation level even in North America where there are 1·4 cars per family. In Britain, for instance, only about one family in two possesses a motor vehicle of any description whether a car, three wheeled vehicle or motor cycle. Production of cars in the free world, has risen from 10·8 million in 1959 to around 16·7 million in 1964, an increase of 55% or an average 11% a year.

The construction industry is another growth market. One aspect of increased incomes and standards of living is that far more people can afford to buy houses and more want and need homes to be provided under welfare state schemes. It is therefore an industry dealing in large numbers and one in which demand generally exceeds supply. Hence there is a growth market in those countries which use copper for water, gas, heating and sanitation service tubes and the ancilliary plumbers' fittings and brassware. In the Common Market countries, for example, completed buildings have risen by 8·3% a year since 1960.

Copper consumption by countries

U.S.A

Consumption of refined copper has risen by 20·4%



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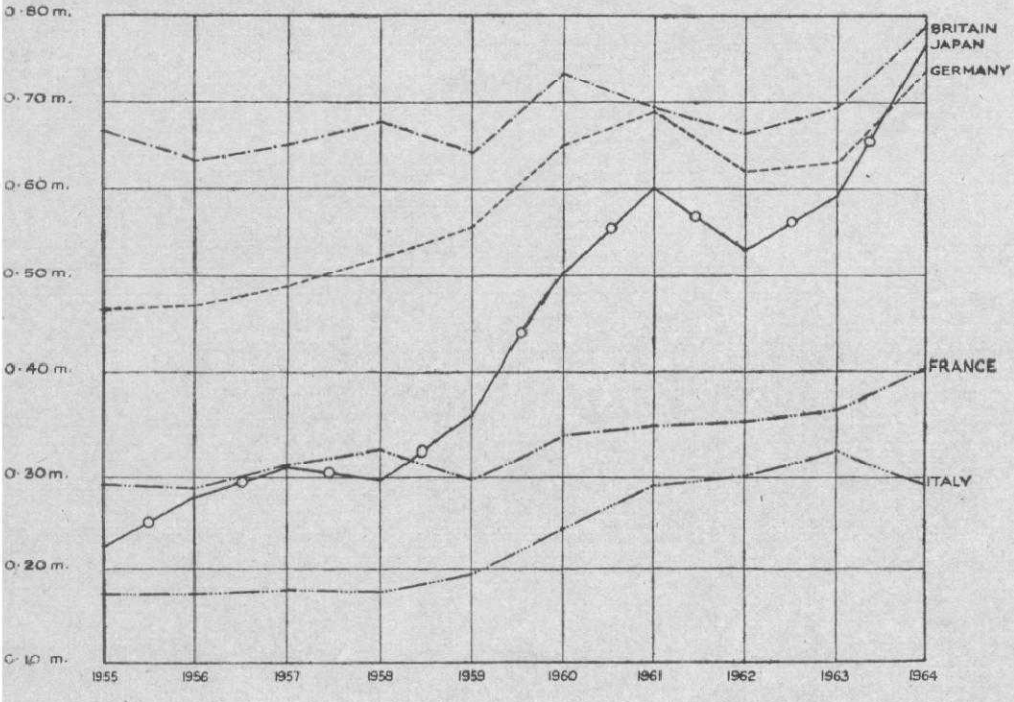
Graph Va
Total copper consumption by countries (metric tons)



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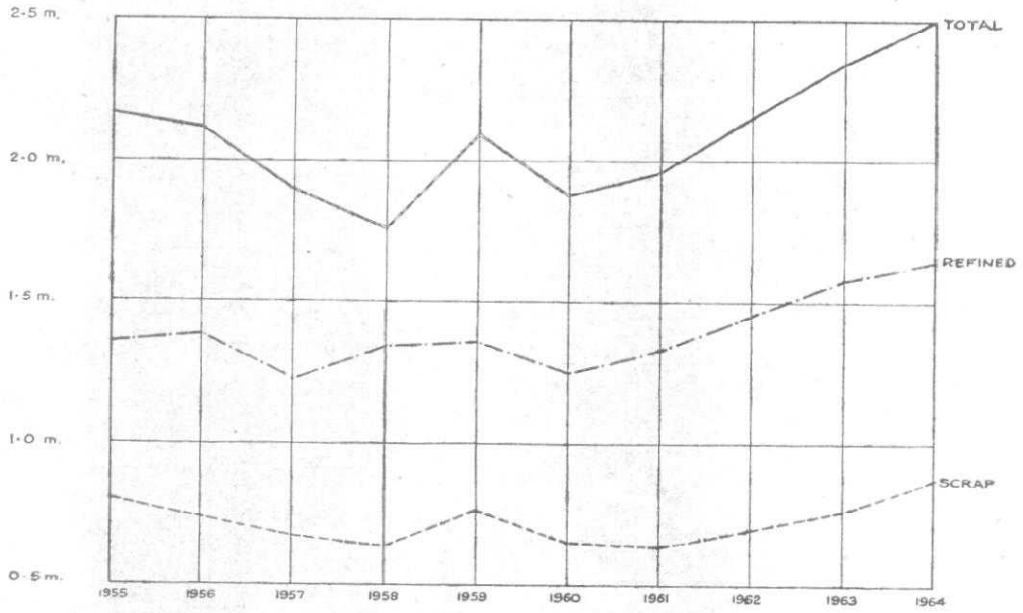
Graph Vb
Total copper consumption by countries (metric tons)



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Graph VI
U.S.A. Consumption copper (metric tons)

since 1955 or an average of 2·3% a year and in 1964 amounted to 1 641 000 tons (Graph VI). The directed use of scrap has risen by only 8% in the same period amounting to 864 000 tons in 1964 (Graph VI). Total consumption of copper therefore amounted to 2 505 000 tons in 1964, an increase of 16% or an average of 1·7% a year (Graph VI).

In the same period per capita consumption of refined copper increased from 18·1 lb to 18·8 lb in 1964 and including the direct use of scrap remained unchanged at 28·7 lb (Schedule III).

Consumption of semi-fabricated products amounted to 2 213 000 tons in 1964. Consumption of copper wire rose by 30% to 912 000 tons in 1964 (Graph XIa) and copper tubes by 82% to 383 000 tons (Graph XV), whilst the use of copper rod rose by only 16% to 63 000 tons. The use of copper sheet fell 12% to 131 000 tons (Graph XIII) and alloy rod also fell by 5% to 338 000 tons (Graph XIXa). In addition both alloy sheet and alloy tubes fell by 9% (Graph XVIII) and 20% (Graph XXa).

The per capita consumption of semi-fabricated products in 1964 was as follows :

	Lb.	
	Copper	Alloy
Wire	10·5	—
Rod	0·7	3·9
Sheet	1·5	3·6
Tubes	4·4	0·8

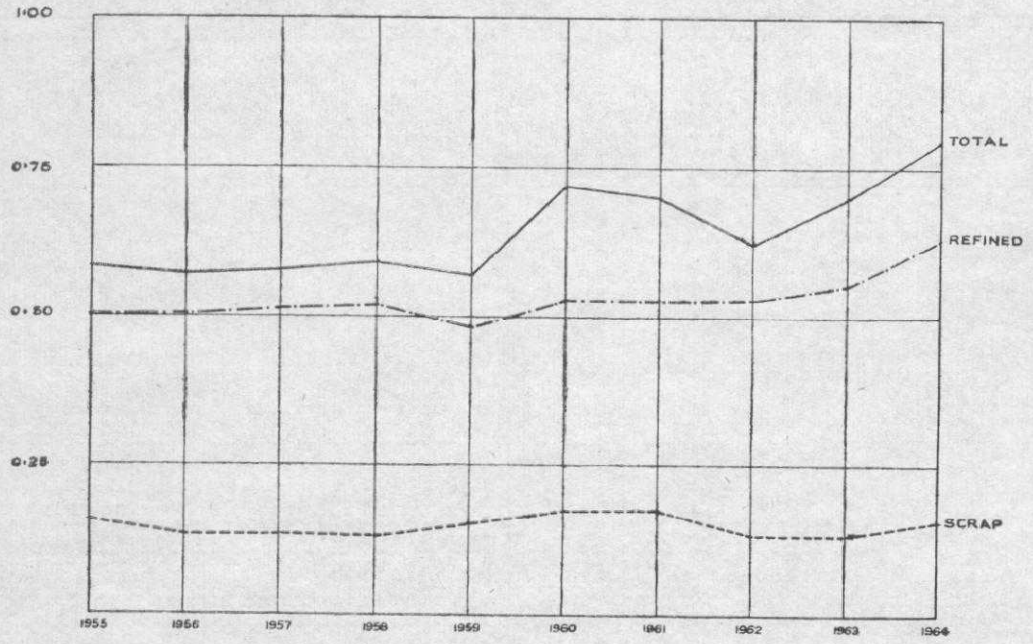
The electrical industry consumed 47% of copper semi products. The breakdown by industry was as follows :

	Tons	% Total
Electrical	702 000	47
Transport	275 000	13
Construction	377 000	17
General Engineering	526 000	23
Total	2 240 000	100

(Schedule V)

The moderate growth rates shown above are due mainly to a lack of economic growth during the period 1955–1964. Gross national product at constant prices rose by an average 3·6% a year since 1955. Since 1960 economic growth has accelerated with G.N.P. and industrial production rising by 4·3% and 5·5% a year respectively. This development largely originated with the expansionist policies of the late President Kennedy which included reduction in personal tax, large slum clearance and urban development.

In the same way since 1960 refined copper consumption rose by 34% or an average 8·5% a year (Graph VI), copper wire consumption 32% a year or an average 8% a year (Graph XIa), copper sheet 43% or an average 11% a year, (Graph XIII), copper tubes 63% or an average 16% a year (Graph XV) and so on.



Graph VII
Britain copper consumption (metric tons)

In tonnage terms the rise is more remarkable with an increase of 416 000 tons (Graph VI) in refined copper consumption since 1960 or nearly the entire equivalent consumption of Japan. With a market the size of the U.S.A.'s average annual increase of 8·5% over four years is a remarkable achievement.

Britain

In Britain consumption of refined copper rose by 28% or 3·1% a year since 1955 amounting to 633 000 tons in 1964 (Graph VII). The direct use of scrap fell 5% during this period to 156 000 tons. Total consumption therefore amounted to 789 000 tons, an increase of 18% or an average 2·1% a year since 1955 (Graph VII). Per capita consumption of refined copper rose by 2·2% a year to 25·7 lb in 1964 and total consumption by 1·3% a year to 32·0 lb (Schedule III).

The use of copper wire has increased by 43% or an average 4·8% a year since 1955 and has risen from 199 000 tons in 1955 to 284 000 tons in 1964 (Graph XIb). Consumption of copper tubes has risen by 109% or 12% a year from 44 000 tons in 1955 to 92 000 tons in 1964 (Graph XIV). Consumption of other semi-manufactured products like copper rod, sheet and wire and alloy products rose only marginally and in fact the use of alloy sheet fell by 19% (Graph XVIII), and alloy tubes (Graph XXb) remained constant.

The per capita consumption of semi-fabricated products in 1964 is summarised as follows :

	Lb.	
	Copper	Alloy
Wire	11·5	0·8
Rod	0·8	7·1
Sheet	2·4	4·5
Tubes	3·8	0·7

In 1964 the electrical industry consumed 42% of the total copper semi fabricated products as follows :

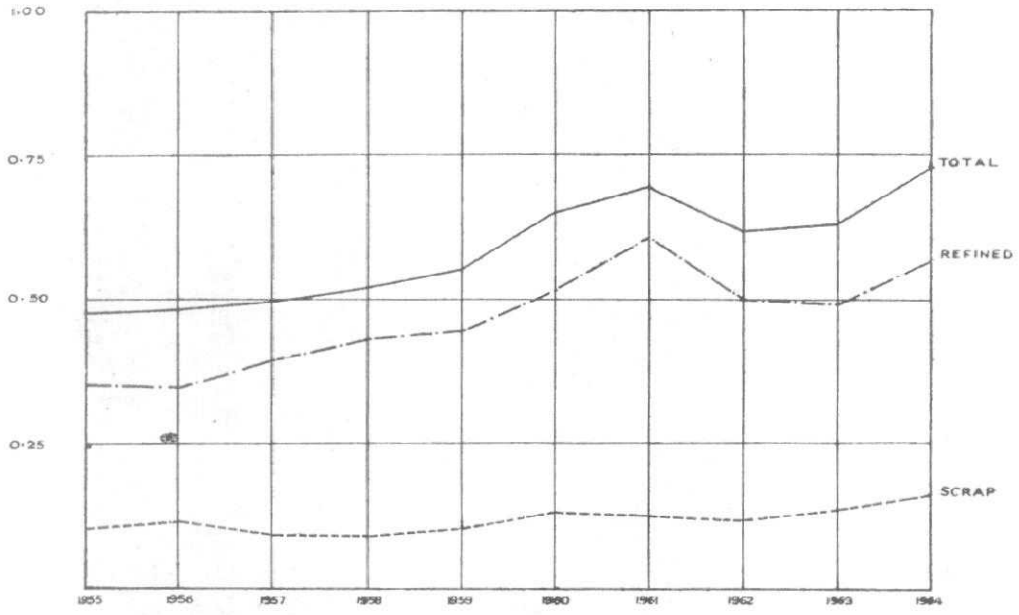
	Tons	% Total
Electrical ...	335 000	42
Transport ...	65 000	8
Construction ...	124 000	16
General Engineering ...	265 000	34
Total ... (Schedule V)	789 000	100

The reason for Britain's relatively slow overall increase in copper consumption is that during this period economic growth has also been slow. Industrial production increased by an average 3·2% a year compared with the U.S.A's 4·1%, Canada's 5·5%, Sweden's 4·5% and Germany's 8·5%.

On the other hand, in the last ten years electrical energy has increased by an annual rate of 8½% and this rate is expected to continue up to 1970. Since 1955 copper wire consumption has increased by 4·8% on average a year (Graph XIb) but due to increased substitution, will probably only slowly increase up to 1970.

Germany

Since 1955 consumption of refined copper in Germany has increased by 62% or 6·9% a year from 354 000 tons in 1955 to 573 000 tons in 1964 (Graph VIII). The



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Graph VIII
Germany consumption (metric tons)

direct use of scrap has risen by 52% to 163 000 tons and total consumption of copper by 60% or 6·6% a year from 461 000 tons in 1955 to 736 000 tons in 1964.

Per capita consumption of refined copper has risen by 5·1% a year from 14·9 lb in 1955 to 21·7 lb in 1964 (Schedule III) and total consumption by 4·9% a year from 19·4 lb in 1955 to 27·9 lb in 1964 (Schedule III).

Consumption of semi-fabricated products amounted to 688 000 tons in 1964. Copper wire increased by 91% or 10·1% a year since 1955 amounting to 306 000 tons in 1964 (Graph XIb). Copper tubes rose by nearly 200%, with the main increase occurring since 1959, from 13 000 tons to 40 000 tons in 1964 (Graph XIVb). Consumption of alloy wire almost doubled totalling 26 000 tons in 1964 (Graph XVII), whilst alloy rod increased by 8·2% a year to 122 000 tons in 1964 (Graph XIXb). Alloy sheet and alloy tubes rose by 29% and 73% respectively to 84 000 tons (Graph XXIII) and 44 000 tons (Graph XXb) each. Copper rod only rose fractionally.

The per capita consumption of semi-fabricated products in 1964 was as follows :

	Lb.	
	Copper	Alloy
Wire	11·6	1·0
Rod	0·8	4·6
Sheet	1·6	3·2
Tubes	1·5	1·7

The electrical industry consumed 48% of the total semi-fabricated products in 1964. The breakdown by industry for 1964 was as follows :

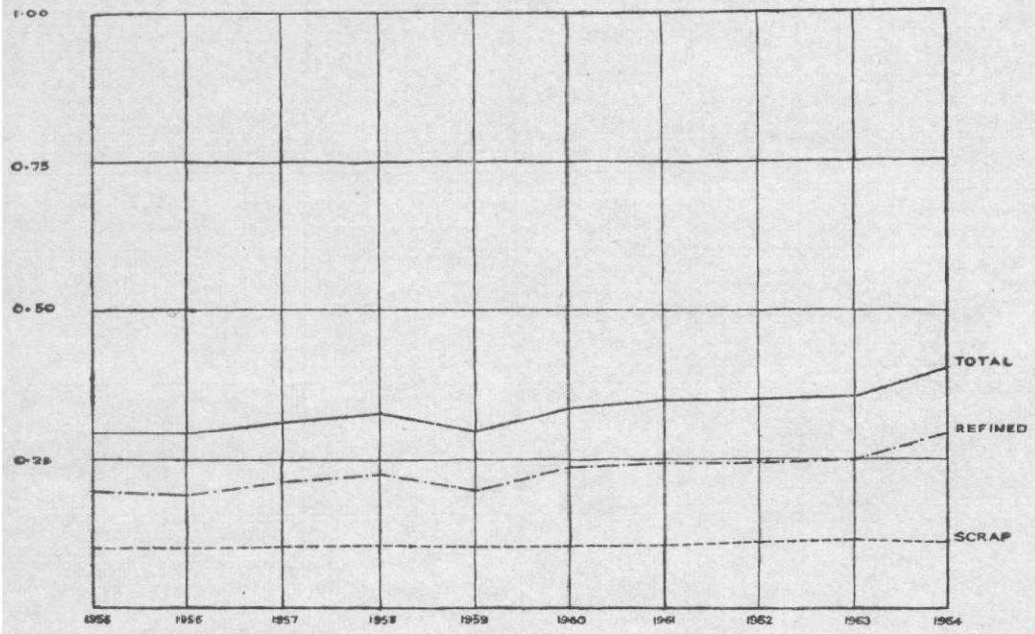
	Tons	% Total
Electrical ...	331 000	48
Transport ...	48 000	7
Construction ...	45 000	7
General Engineering ...	264 000	38

(Schedule V)

Germany's economy has been one of the most consistently expansive in the world. Its growth has been based mainly on a high level of exports and capital investment enabling domestic demand, first, for capital equipment and, secondly, for consumer goods to increase proportionately. Since 1955 industrial production has risen by an annual average of 8·6% a year, Gross National Product by 8·2% a year and Gross Fixed Investment by 11·1% a year. More particularly since 1955 output of electricity has more than doubled ; production of cars increased by nearly 250% and exports by 164% or 18·3% a year.

Japan

Consumption of refined copper in Japan jumped by



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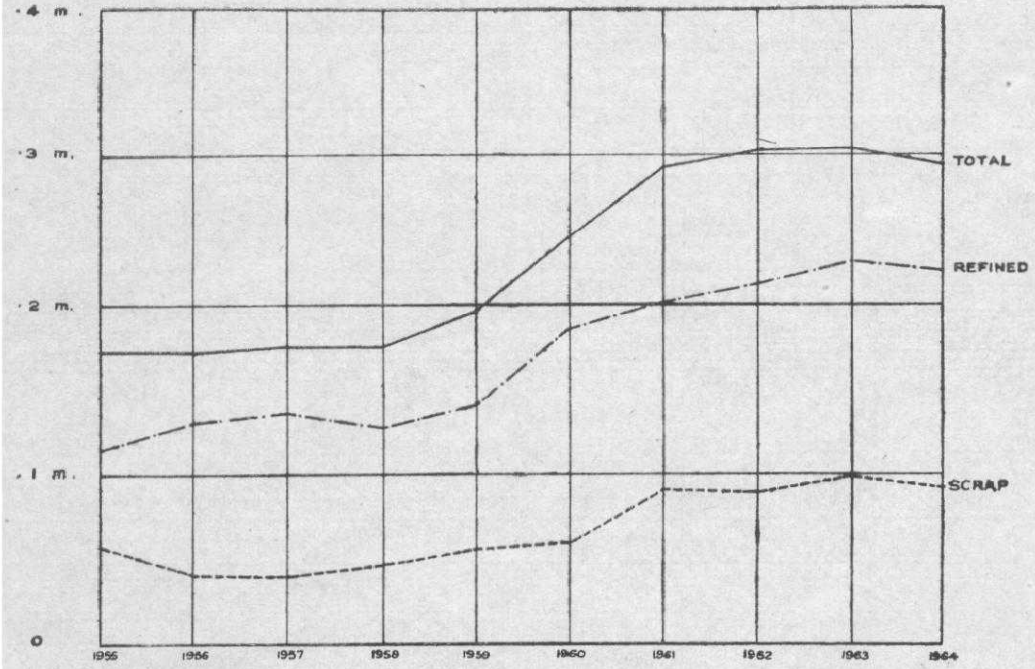
Graph IX
France copper consumption (metric tons)

334% or 37% a year from 105 000 tons in 1955 to 45 8000 tons in 1964, (Graph X). The direct use of scrap climbed by 158% to 310 000 tons and the total use of copper by 240% a year to 786 000 tons in 1964 (Graph X). Per capita consumption of refined copper has risen by equally impressive rates. Refined consumption has jumped from 2·6 lb in 1955 to 10·4 lb in 1964 and total consumption from 5·6 lb to 17·5 lb in 1964 (Schedule III).

Consumption of semi-fabricated products totalled 720 000 tons in 1964 of which 368 000 tons consisted of copper wire, having risen by 349% or 39% a year since 1955 (Graph XIb). Copper rod has increased from 1 000 tons to 15 000 tons in 1964 (Graph XVIb), copper sheet from 12 000 tons to 41 000 tons (Graph XII) and copper tubes have risen by 363% to 30 000 tons in 1964 (Graph XIV). The alloy products have increased similarly with consumption of alloy rod



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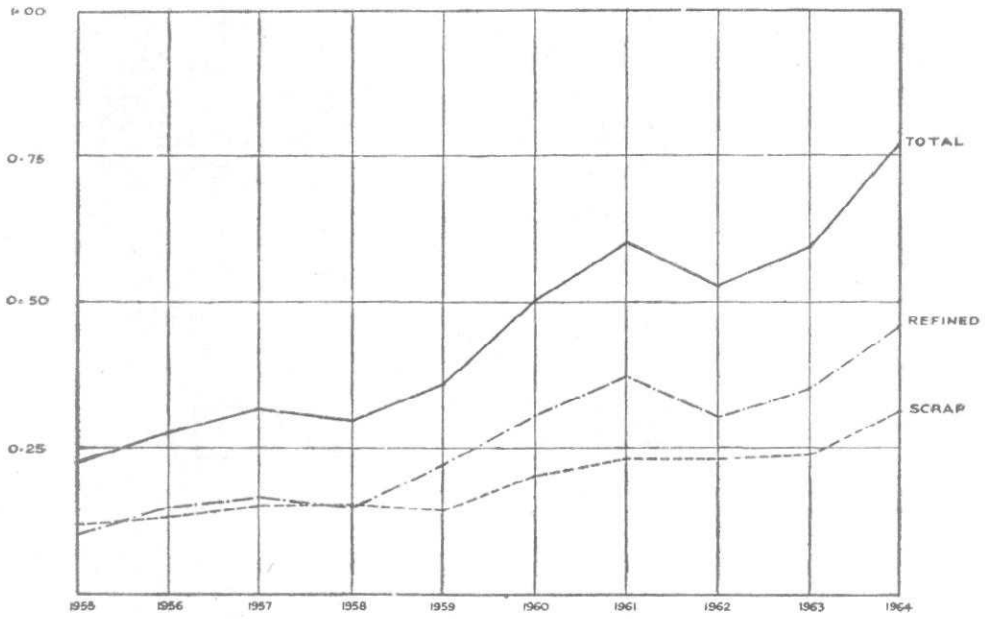
Graph IXa
Italy copper consumption (metric tons)



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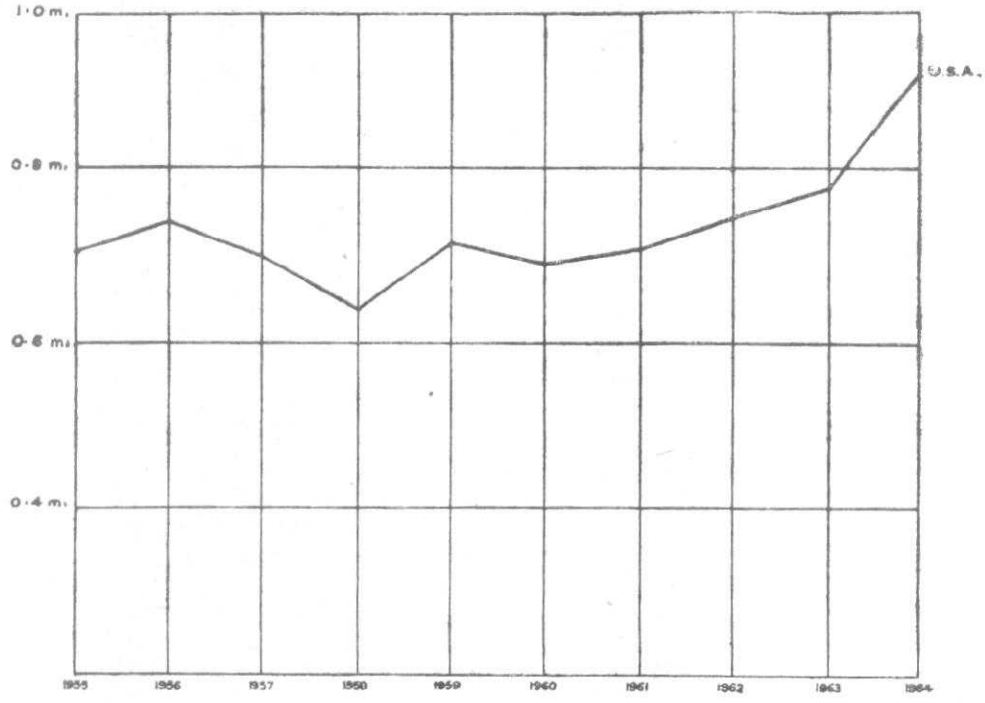
Graph X
Japan copper consumption (metric tons)



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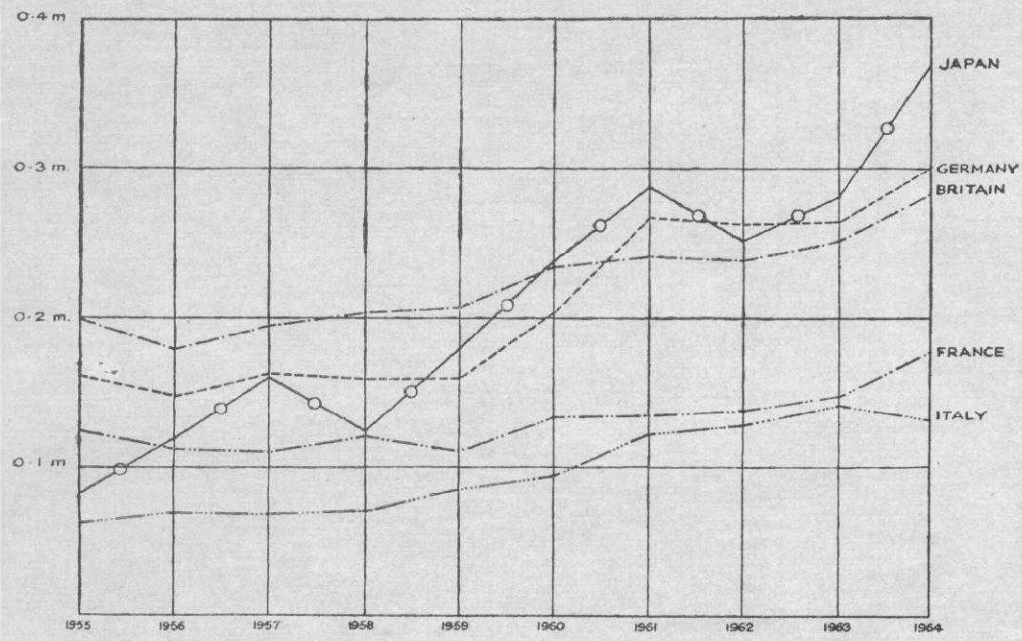
Graph XIa
Consumption by semis, copper wire (metric tons)

rising by 364% to 116 000 (Graph XIXb) whilst alloy sheet has risen 149% to 97 000 tons (Graph XVIII) and alloy wire by 147% to 29 000 tons in 1964 (Graph XVII).

The per capita consumption of semi-fabricated products in 1964 was as follows:

	Lb	
	Copper	Alloy
Wire	8·4	0·7
Rod	0·3	2·6
Sheet	0·9	2·2
Tubes	0·7	0·5



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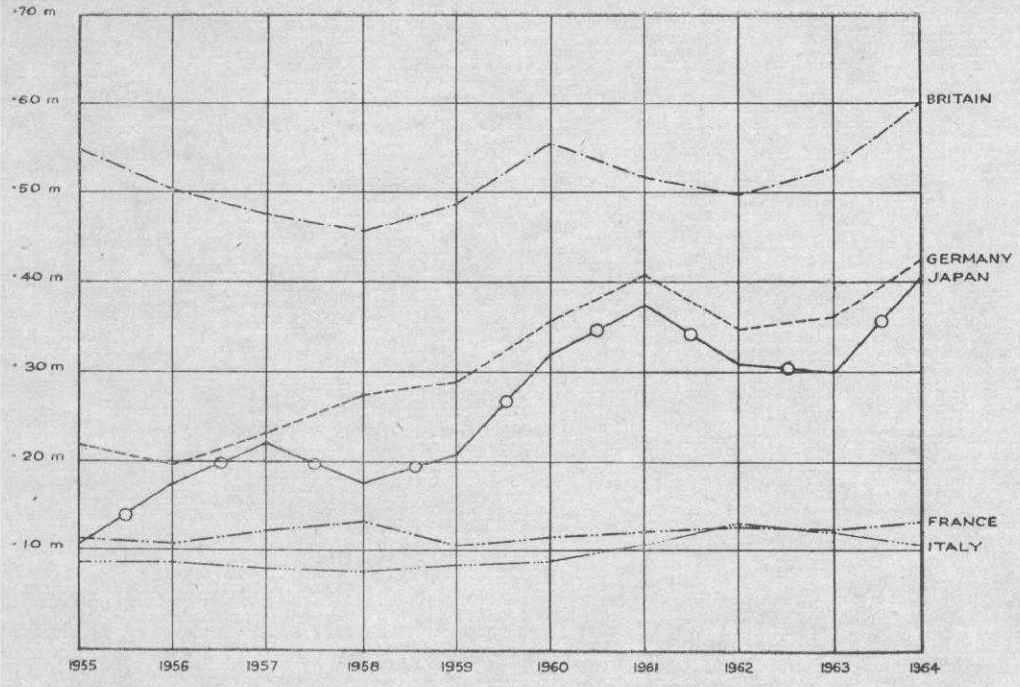
Graph : XIb
Consumption by semis, copper wire (metric tons)



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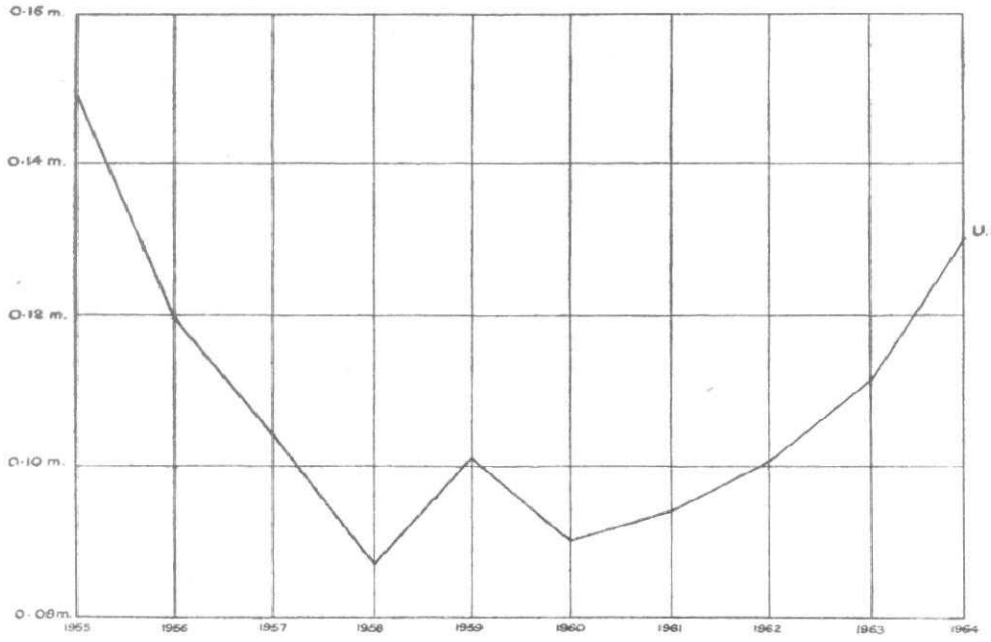
Graph XII
Consumption by semis, copper sheet (metric tons)

The electrical industry consumed as much as 65% of total semi-fabricated products. The breakdown by industry for 1964 was as follows :

		Tons	% Total
Electrical	...	434 000	65
Transport	...	26 000	4
Construction	...	11 000	2
General Engineering	...	192 000	29

The remarkable increases in the use of copper in Japan are the direct result of economic growth enabling Japan to grow from having a relatively small consumption of copper in 1955 to being the third largest consumer in the free world in 1964. During this period



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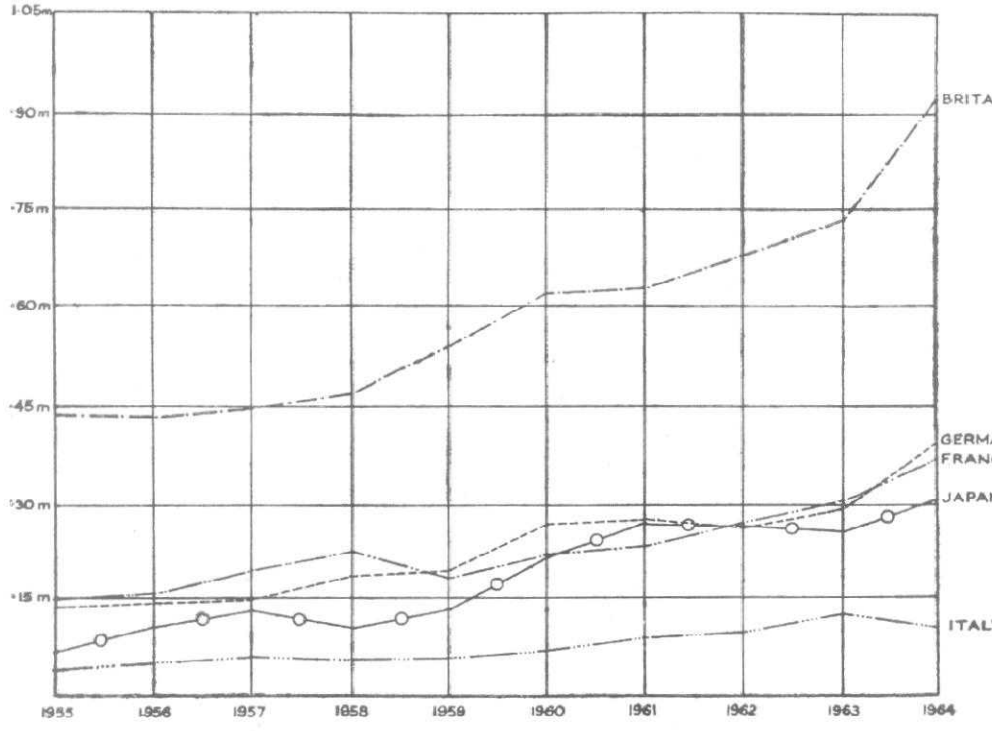
Graph XIII

Consumption by semis, copper sheet (metric tons)



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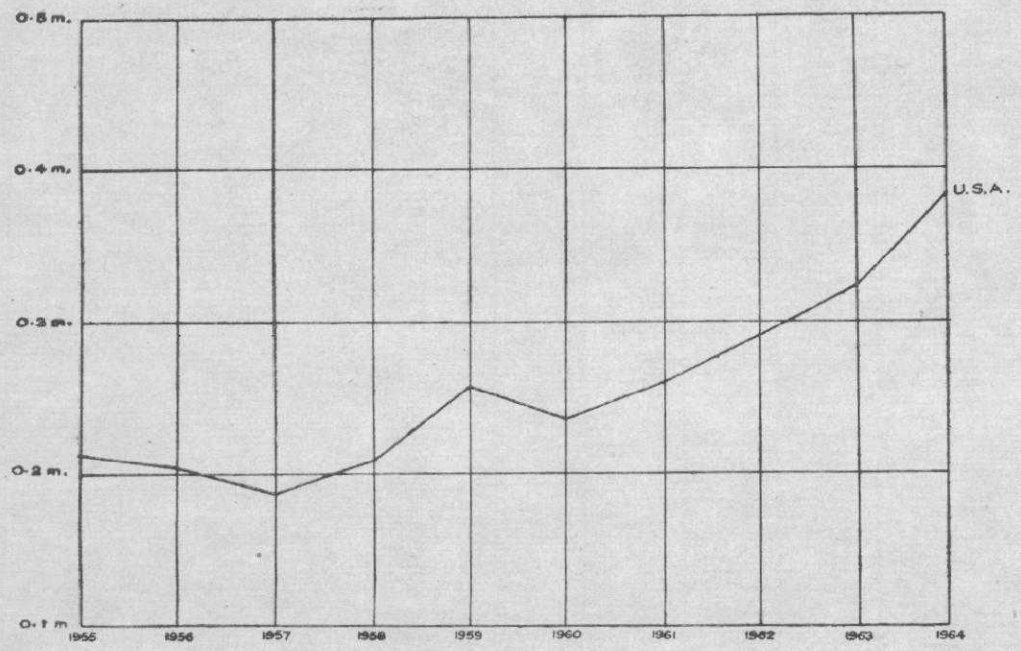
Graph XIV

Consumption by semis, copper tubes (metric tons)



Graph XV
Consumption by semis, copper tubes (metric tons)

industrial production rose by as much as an average 28% a year and gross national product by 15% a year. Exports have jumped by an average 26% a year and investment by as much as 35% a year.

Japan, however, uses substantially more copper wire in relation to its total consumption than any other country. Nearly two-thirds of the copper which fabricators receive in Japan is used to produce wire and excluding that the amount used to produce alloy products is as much as 80%.

There are three main reasons for Japan's large consumption of copper wire which in tonnage terms is second only to the U.S.A. First, Japan's incredible economic growth has been based mainly on industrialisation requiring an increasing use of electrical energy. Copper wire was therefore needed for the underground high voltage transmission and distribution cables, wiring of houses, offices and factories, transformers, generators, switchgear and other plant required to generate, transmit and distribute the electrical energy. In the five-year period 1958–1963, for example, the electrical industry expanded output by 300% and in 1963 its gross production of £1 500 million equalled that of Britain and Germany. In fact one-third of the country's production of machinery was electrical products and appliances.

Secondly, the improved standard of living, which was a product of economic growth, was accompanied by enormous social changes—working hours were reduced and labour saving appliances reduced the hours required for household tasks. Leisure time was therefore increased and brought with it "the home electrical boom". For instance, 83% of Japanese homes now have television sets, only the U.S.A. has more, over 70% have radios, 53% washing machines, 35% refrigerators and 25% vacuum cleaners.

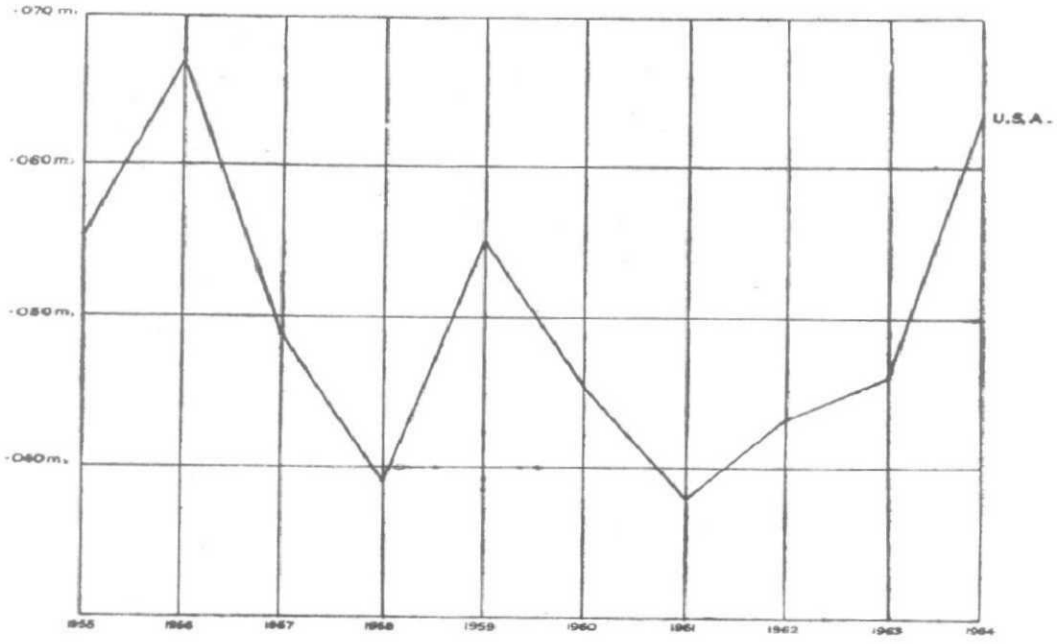
Thirdly, exports of electrical equipment and appliances have expanded and now account for 10% of total exports. Despite this growth record the use of electrical power in Japan is still relatively low. Present per capita consumption is 1 218 kwh, which is about half that of Britain.

In other industries expansion has been no less rapid. In the construction industry, for example, the number of buildings completed has grown by about 20% a year and production of cars and commercial vehicles has grown from 69 000 in 1955 to 1 702 000 in 1964.

France

Consumption of refined copper increased by an average 5·6% a year from 194 000 tons in 1955 to 292 000 tons in 1964 (Graph IX). Total consumption of refined copper increased from 9·9 lb in 1955 to 13·2 lb in 1964, and total consunption from 15·0 lb to 18·3 lb in 1964 (Schedule III).

The use of copper wire rose by 4·1% a year amounting to 168 000 tons in 1964 (Graph XIb) representing 43% of the total consumption of semi-fabricated products. Consumption of copper tubes rose by an average 13·1% a year to 38 000 tons in 1964 (Graph XIV) and alloy wire by 6% a year to 7 000 tons (Graph XVII). Consumption of alloy rod rose by 9·4% a year to 105 000 tons (Graph XIXb) and alloy sheet by 3% to 42 000 tons (Graph XVIII). Consumption of alloy tubes rose 4% a year to 7 000 tons in 1964 (Graph XXb). The use of copper rod fell and copper sheet rose fractionally.



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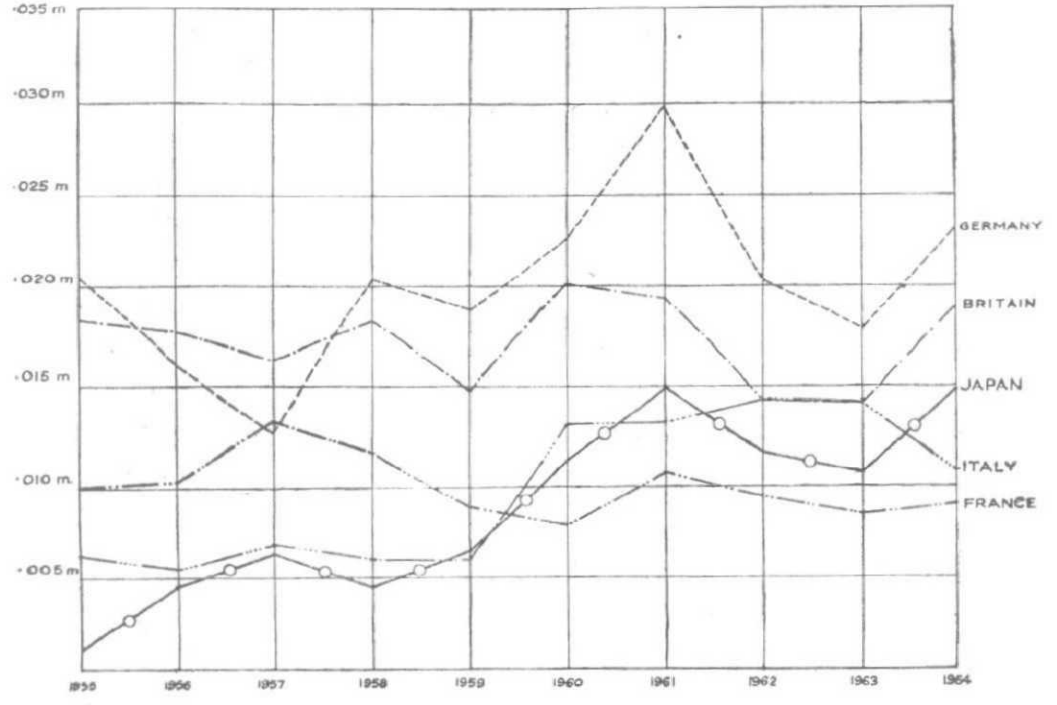
Graph XVIa

Consumption by semis, copper rod (excluding rod drawn into wire) (metric tons)



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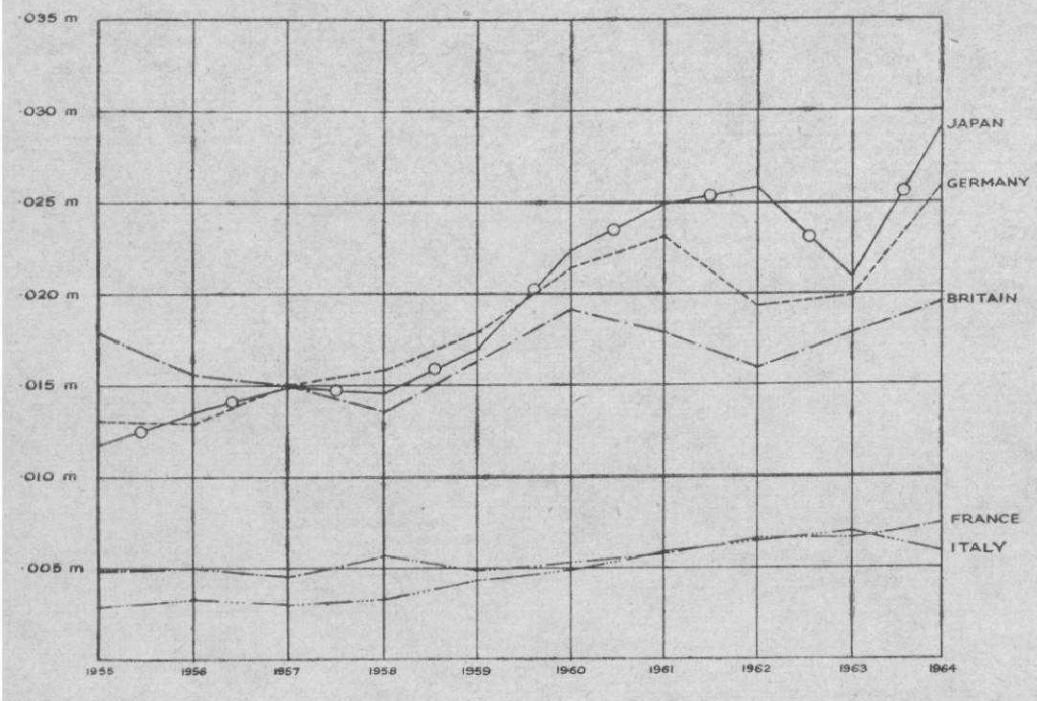
Graph XVIb

Consumption by semis, copper rod (excluding rod drawn into wire) (metric tons)



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Graph XVII
Consumption by semis, alloy wire (metric tons)

The per capita consumption of semi-fabricated products for 1964 was as follows:

	Lb.	
	Copper	Alloy
Wire	7·6	0·3
Rod	0·4	4·8
Sheet	0·6	1·9
Tubes	1.7	0.3

The electrical industry used 47% of the total semi-fabricated products in 1964 and the breakdown by industry is as follows:

	Tons	% Total
Electrical ...	183 000	47
Transport ...	20 000	5
Construction ...	63 000	16
General Engineering ...	125 000	32

(Schedule V)

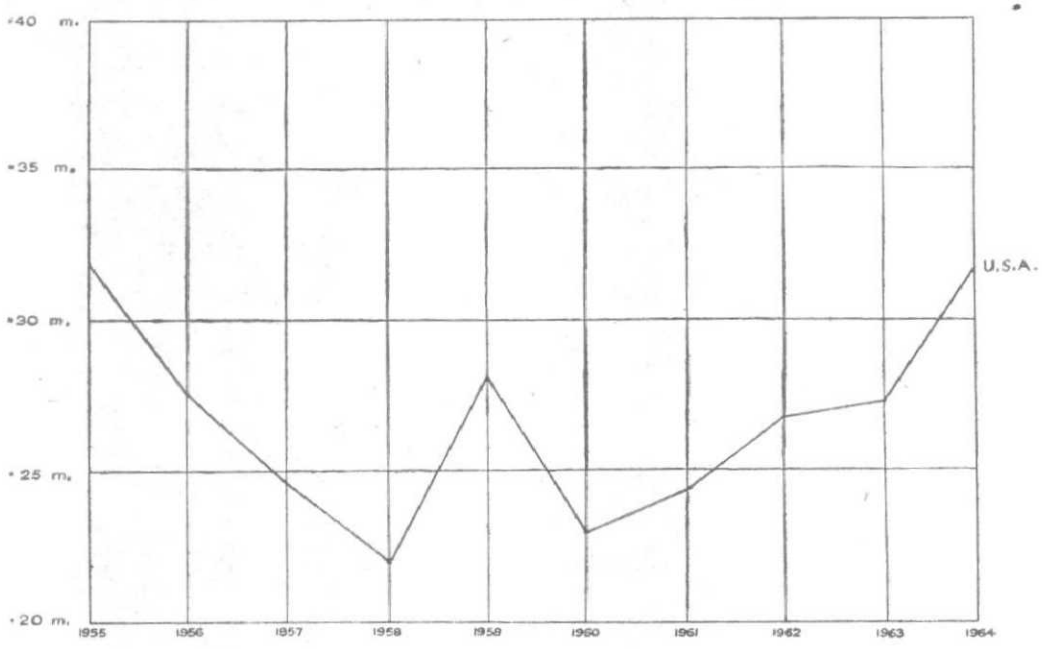
In the period 1955–1964 one of the main characteristics of the French economy has been the increasing concentration of investment in industry as opposed to agriculture in order to give the economy a broader base. Capital investment rose by an average 10·3% a year and industrial production by 9·6% a year. The construction industry was particularly strong rising by 11·1% a year since 1955.

Italy

Consumption of refined copper rose by an average 8·1% a year from 114 000 tons in 1955 to 202 000 tons in 1964 (Graph IXa). The direct use of scrap rose by 6·9% a year to 93 000 tons and total consumption by 8·1% a year since 1955 to 295 000 tons in 1964 (Graph IXa). Per capita consumption of refined copper rose from 5·2 lb in 1955 to 8·8 lb in 1964 and total consumption from 7·8 lb to 12·8 lb in 1964 (Schedule III).

1964 was, however, a recessionary year and as such demand for copper was at a much lower level. In 1963 for instance, the per capita figures were 10·0 lb and 14·3 lb respectively.

Consumption of copper wire amounted to 131 000 tons in 1964 (Graph XIb) representing 48% of total consumption of semi-fabricated products, having risen by 12·7% a year since 1955. Copper rod and copper sheet rose by 8·2% (Graph XVIb) and 27% (Graph XII) respectively totalling 11 000 tons each. Despite Government legislation prohibiting the use of copper tubes for drinking water services, consumption of copper tubes have risen from 4 000 tons in 1955 to 10 000 tons in 1964 (Graph XIV), showing an increase of 180%.



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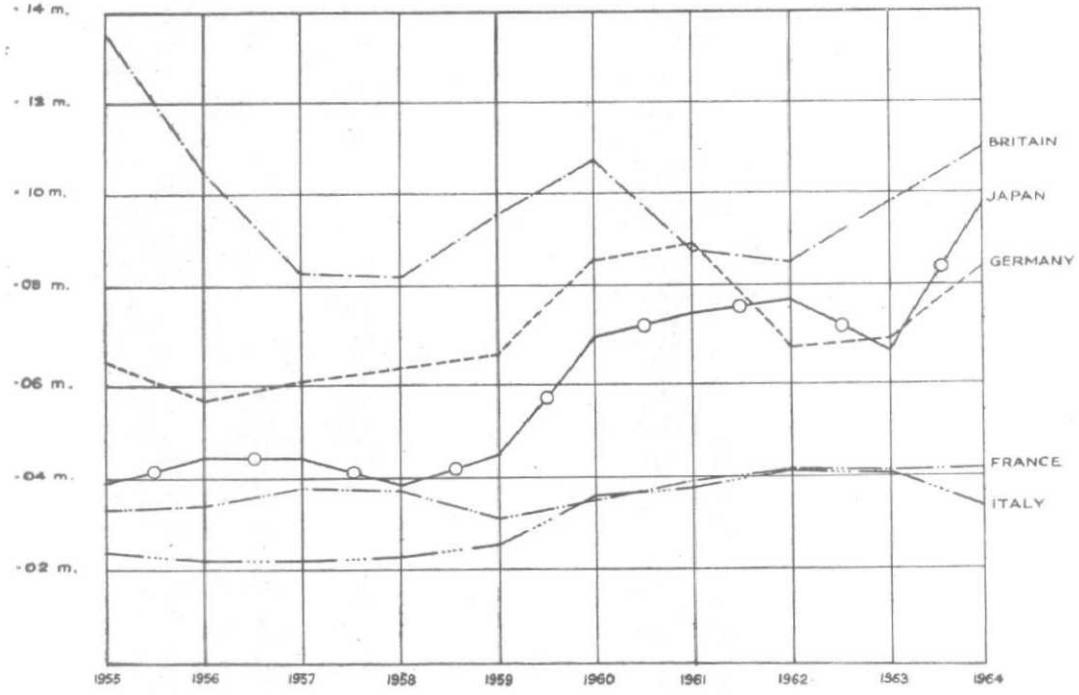
Graph XVIIIa
Consumption by semis, alloy sheet (metric tons)



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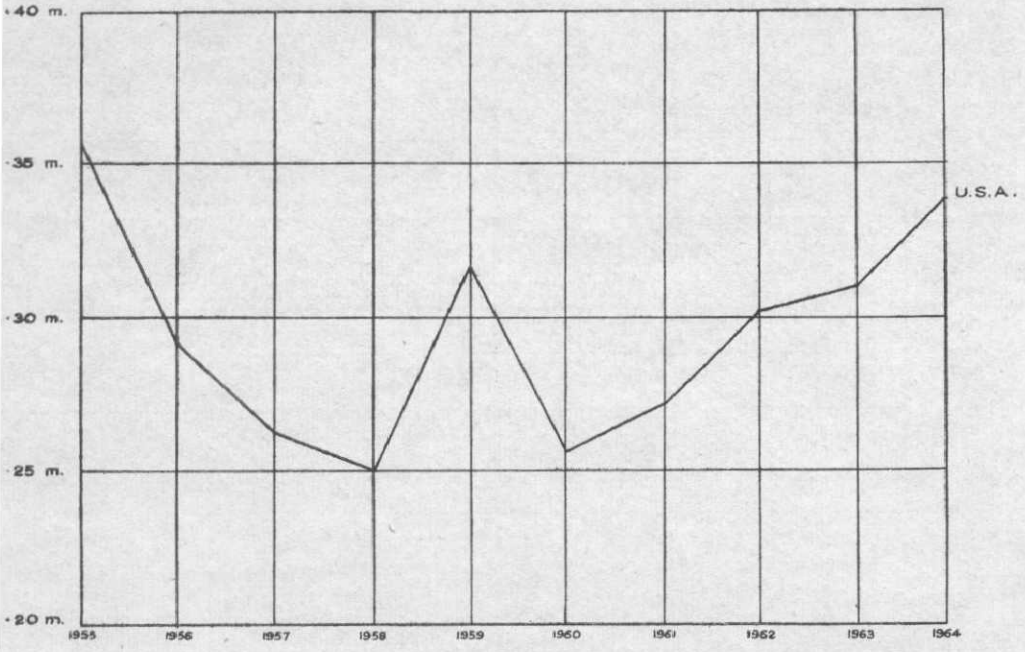
Graph : XVIIIb
Consumption by semis, alloy sheet (metric tons)



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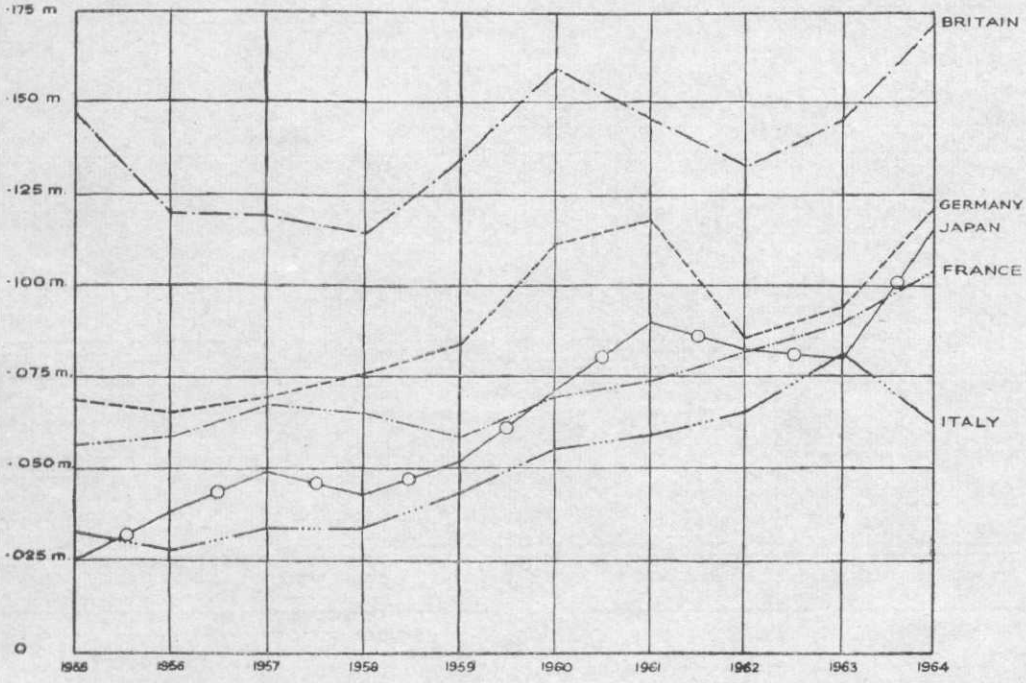
Graph IXXa
Consumption by semis, alloy rod (metric tons)



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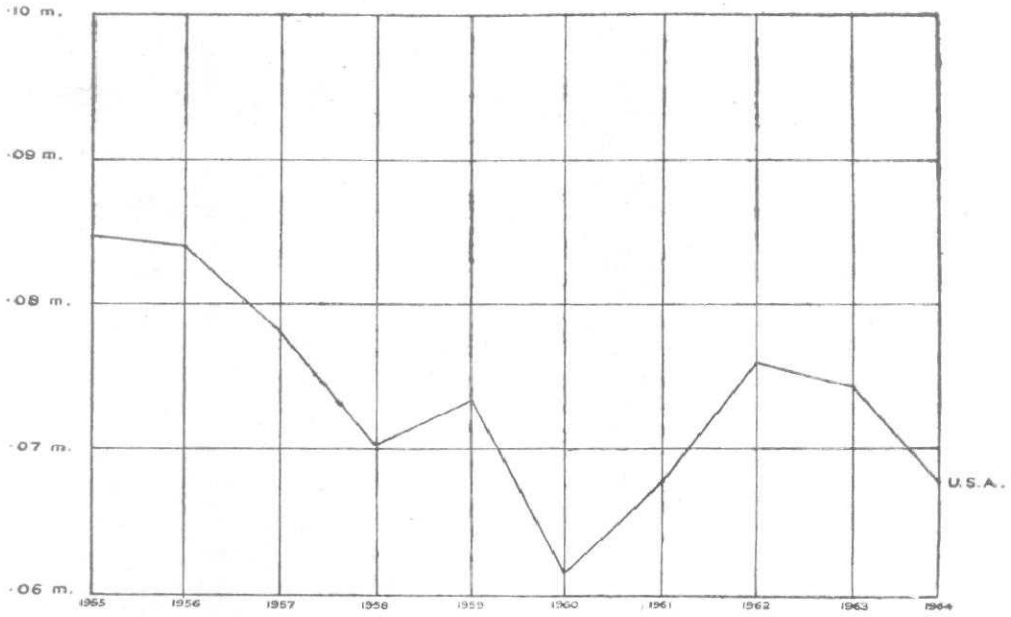
Graph IXXb
Consumption by semis, alloy rod (metric tons)

The use of alloy wire has doubled amounting to 60 00 tons in 1964 (Graph XVII) and alloy rod has risen by 11·8% a year to 62 000 tons in 1964 (Graph XIX b). Alloy sheet and alloy tubes have increased by 38% (Graph XVIII) and 42% (Graph XXb) respectively during this period amounting to 33 000 tons and 9 000 tons each.

Per capita consumption of semi-fabricated products in 1964 was as follows :

	Lb.	
	Copper	Alloy
Wire ...	5·7	0·3
Rod	0·5	2·7
Sheet	0·5	1·5
Tubes	0·4	0·4



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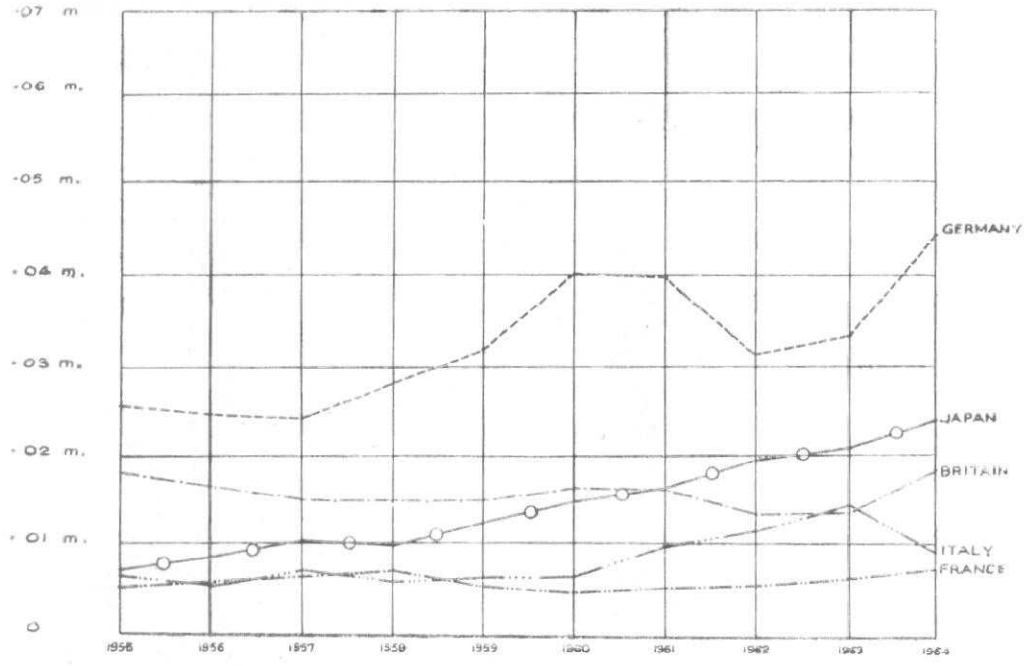
Graph XXa
Consumption by semis, alloy tubes (metric tons)



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Graph XXb
Consumption by semis, alloy tubes (metric tons)

The electrical industry consumed as much as 55% of total copper semi products in 1964. The breakdown by industry for that year is as follows :

The Italian economy has been, and is, in the process of industrialisation particularly the development of the rural and low incomed South. Industrial production has risen by an average 11·8% a year and capital investment by 8·8% a year (1963–11·1%). This development has been made possible by a high level

		Tons	% Total
Electrical	...	150 000	55
Transport	...	25 000	9
Construction	...	25 000	9
General Engineering (Schedule V)	...	75 000	27

of exports, increasing by an average of over 25% a year, and in this way Italian industry has been able to largely pay for its industrialisation.

Conclusions

Out of this rather indigestible digest of detail a number of facts stand out.

First, increase in consumption of copper, whether as refined or as a semi-fabricated product, follows economic growth. It will have been seen that those economies which have expanded most have most increased their use of copper. Japan, Germany, Italy and France are, in the context of this paper, the obvious examples. In each case growth has been based mainly on industrial development requiring an increasing output of electrical energy and has been made possible by a high level of exports from which came the investment for growth. It is unquestionably true to add that those economies that have expanded most rapidly were the most successful salesmen.

The second is the dominant use of copper in the electrical industry averaging 49% in those countries discussed and ranging from 42% for Britain up to 65% for Japan. Britain's lower use is probably due to the more complete substitution which has taken place there in low voltage underground cables than in other countries. Despite substitution, its use per capita of 11·4 lb is only a point below that of Germany's which is the highest in the free world.

Thirdly, although copper wire represents the biggest tonnage consumer, copper tubes were the fastest growing market. In Britain and the U.S.A. the use of copper tubes for water, gas, heating and sanitation services, which probably accounts for two thirds of the copper tube consumption, has been accepted for sometime. But in other countries like France and Germany copper plumbing has only started its rapid expansion in the last few years. In the U S.A. and Britain, for example, the use of copper tubes per capita was 4·4 lb and 3·8 lb respectively in 1964, whilst in Germany, France and Japan it was only 1·5 lb, 1·7 lb and 0·7 lb.

Fourthly, copper sheet, strip or plate has in total only risen marginally although in Japan and Germany its use has increased appreciably.

Fifthly, alloy rod has risen by only 3·7% a year in total. This relatively slow increase was due mainly to the declining use in the U.S.A. and only a marginal increase in Britain although its use per capita of 7·0 lb is considerably higher than any other country. In other countries, the rise has been quite rapid compared with Britain.

Sixthly, although in quantitative terms the U.S.A. is the largest consumer of copper in the world, since it has a population of over 192 million fed by probably the most sophisticated and modern industry in the world, in per capita terms Britain, Germany, Switzerland and Sweden use more copper and this is probably indicative that the saturation level has not yet been reached in the U.S.A.

For comparison the per capita consumption of semi-fabricated products for 1964 in the countries discussed is shown :

	Lb.		
	U. S. A.	Britain	Germany
COPPER			
Wire	10·5	11·5	11·6
Sheet	1·5	2·4	1·6
Tubes	4·4	3·8	1·5
Rod	0·7	0·8	0·8
ALLOY			
Wire	—	0·8	1·0
Sheet	3·6	4·5	3·2
Tubes	0·8	0·7	1·7
Rod	3·9	7·0	4·6
COPPER			
	France	Italy	Japan
Wire	7·6	5·7	8·4
Sheet	0·6	0·5	0·9
Tubes	1·7	0·4	0·7
Rod	0·4	0·5	0·3
ALLOY			
Wire	0·3	0·3	0·7
Sheet	1·9	1·5	2·2
Tubes	0·3	0·4	0·5
Rod	4·8	2·7	2·6

The role of copper in India

Section I has shown how and where copper is used in the world as a whole and in a number of countries other than India. The important question is the significance of this information to India. No material is indispensable, but in some cases substitution can only be accepted as a long term solution if all industrialised countries accept the same limitation. The fact that while under strong competition from other materials such as aluminium, stainless steel, plastics, etc. a large tonnage of copper is used in other countries indicates the need for extreme care when studying what changes should be made under the existing Indian conditions.

Experiences show that no country can be self-contained under modern conditions of world trade, and a developing country with increasing industrialisation must export part of its production to obtain foreign exchange. If equipment is to compete in an export market, then not only must it be competitive in cost, but in many cases it must comply with international standards which are much more widely used now than few years ago. India has a close association with the International Organisation for Standardization (I.S.O.), the Commonwealth Standards Conference and the International Electro-Technical Commission (I.E.C.) and to comply

with a number of these standards it is necessary for copper or its alloys to be used. Dr Lal C. Verman in his article in the Eastern Metals Review dated 13th December, 1965, has stressed the importance of standardization in the following words :

"For an under-developed country, co-ordinated development of industries, conservation of resources and achievement of high level of productivity are of paramount importance. At the same time, there is a need to boost exports to earn adequate foreign exchange to provide for the growing needs of importing capital equipment which is so essential for initial development. Standardization, therefore, is a primary need for development of countries which have taken the road of conscious planning leading to economic and industrial betterment."

Apart from standardization, the competitive position is unlikely to be realised if in complex equipment copper is designed out solely to reduce the initial capital cost, regardless of any other considerations. It is difficult to isolate any one market today, for this is an era of international activity and interdependence in trade. Technical isolation is equally dangerous and can turn what at first seems a capital saving into an overall loss. Experience amongst industrialised nations has shown that in most instances exporting must be based on a sound home market and that as far as possible the design and manufacture of the item for home consumption and export has to be the same if the benefits of mass production are to be achieved.

The basic index of the industrial activity in any country and its development is the production and consumption of various metals. Industrialisation is fairly new to India and it is no wonder that Indian figures are very low compared to those of other developed countries in the world. Per capita consumption figures for refined copper for India and some of the developed countries are given below :

Countries	Per capita consumption in lb
U.S.A.	18·8
U.K.	25·7
Japan	10·4
India	0·34

If the consumption figure has to improve, the indigenous production or the supply position has to be stepped up to match the population explosion. The installed capacity for the production of fire refined copper in India is about 9 600 tons per annum and the actual production has reached almost the full capacity. The Development Council for non-ferrous metals has estimated the requirement of copper at 170 000 tons by 1965–1966. Domestic production meet only a small part of the requirement and even with substitution, it is not possible to fill the gap that would result, if copper is not made available for relevant use. It is estimated that India would be able to produce about 35 000 tons copper by the end of the Fourth Plan period but by that time the demand also would have arisen to about 238 000 tons. As in most countries self-sufficiency is never possible and production has to be supplemented with imports or if imports are not possible, progressive substitution will have to be considered.

In a number of products copper can be replaced by other materials without serious loss of efficiency. In others the price to be faced is often a reduction of efficiency either in terms of the input/output relationship or expensive maintenance not necessarily the cost of the repair, but the consequential cost resulting from the failure. These consequences can often react against the initial reason for making the change and react against the conservation of both plant and materials, both of which are vital.

The theory of substitution has now become an accepted fact in many countries particularly after the advent of the second world war. But as pointed out by Dr B. R. Nijhawan in a recent article, it is rather a very controversial subject, in that a number of factors like ease of fabrication, economics and acceptability of the material have to be considered before actual substitution is carried out. It has also become imperative that a country should be mostly export oriented, if they have to avoid the tight foreign exchange position that India is facing now. In exporting engineering items it becomes imperative to cater to consumer specifications. If traditional materials are substituted without proper schooling, the resulting loss in trade might defeat the purpose itself. For instance, copper finds application directly or indirectly in many items of export from electrical equipment, machine tools, etc. to textile and ferro-alloys. Some time back the Indian textiles industry tried to substitute the dyeing and printing copper rolls with aluminium or stainless steel rolls. The results with aluminium were very discouraging due to the chemical reactions of the roll material with dyes. Subsequent substitution with stainless steel proved to be very uneconomic.

Shri Faiz A. A. Jasdanwalla in his presidential address to the Indian Non-ferrous Metals Manufacturers' Association on the 3rd November, 1965, has stressed the need to export manufactured goods and the need to provide for the continuous replacement of raw materials. If sufficient raw materials cannot be provided due to lack of foreign exchange, manufacturers might find it possible as a temporary measure and if Government approval was forthcoming, to negotiate with copper fabricators in other countries to supply certain semis or semi-finished copper components on a toll basis where the items were to be included in equipment which was finally to be exported : the copper semis being paid for after the equipment was sold. Clearly such a scheme would only be justified if the final exported article contained a considerable amount of Indian workmanship so as to bring a reasonable return of foreign exchange to the country.

Present copper consumption

Information supplied by the Indian Non-ferrous Metals Manufacturers' Association shows a copper consumption in 1964 of 86 000 tons used in the manner shown below :

		Metric Tons
1.	Consumption of Scrap Copper in 1964 :	8 300
2.	Consumption of Copper in 1964 :	
	(a) Electrial Industry ...	30 000
	(b) Transport ...	7 000
	(c) Construction ...	4 000
	(d) Mechanical Engineering ...	7 000
	(e) General Engineering ...	17 000
	(f) Others ...	21 000
	Total ...	86 000
3.	Consumption of Semis in 1964 :	
	A. COPPER :	
	(i) Wire	22 000
	(ii) Rods, bars and sections	600
	(iii) Sheets, strip and plate	4 100
	(iv) Tubes	910
	B. COPPER ALLOY :	
	(i) Wire	260
	(ii) Rods, bars and sections	4 300
	(iii) Sheet, strip and plate ...	25 900
	(iv) Tubes	1 650
	Total (A+B) ...	59 720
	C. (i) Miscellaneous use (6% of A+B)	3 583
	(ii) Production Reserves (8% of A+B)	4 777
	(iii) Repairs and Maintenance	1 000 (Approx.)
	(iv) Increase in incomplete production	1 000 (Approx.)
	(v) Foundries ...	15 000
		85 080

Note :—Figures given against item C, sub-items i, ii, iii and iv are estimated on the basis of the article written by Mr P. C. Jain in The Eastern Metals Review—February 1965.

Substitution and retention

In general the reason that copper and copper alloys are used so widely is not for any one of their properties but several. Copper and its alloys have a unique combination of properties—high electrical and thermal conductivity, adequate mechanical properties, high resistance to many types of corrosion, high scrap value, easily joined and amendable to many forms of fabrication. In general, substitutes have only one or two of these properties.

Copper is a traditional material in many industries, and the processes of change referred to earlier have naturally tended to take away some of its markets. This has mainly been due to the relative price of these materials and copper. Substitution had to be practised during World War II but in many cases the industries reverted to the use of copper and its alloys when these materials became freely available again.

There are some general lessons that have been learnt on substitution and which, although obvious, are not always given due attention. Designs with substitute materials have very often in the past been precise copies of the copper product, whereas the substitute materials called for a complete redesign if trouble was not to result. Very often, short term tests were given to new materials and troubles only developed after say, a year in service. Substitution, which is perfectly satisfactory in one industry, is not necessarily suitable in another, although the application at first sight may appear the same, and what is satisfactory in one part of the world, may also be unsatisfactory in another. Although obvious, due attention has not been paid to the necessity of closely analysing the overall long term results of changing from copper to another material. It is not possible in this article to give a detailed list of where substitution can and cannot be practised, but a few general examples are given.

Aluminium can and has, for example, replaced copper in almost all types of overhead power line. The trend for this E.H.V. lines was clear in 1930 and for medium and low voltage lines since about 1950. Contact wire for railway electrification is a case, however, where copper and copper alloy are still vitally essential. In underground insulated cables up to 33 kV aluminium conductors are now in wide use in many parts of the world, including India. For cables above 33 kV the position is not so clear cut. In many cases high voltage cables in copper are beginning to reach the limit of the physical size which can be easily made transported and installed. The use of a conductor material with a lower conductivity such as aluminium increases these problems. Again, for flexible cables—particularly for quarrys and mines, copper conductors are advisable and copper alloys retained for plug pins, connectors and sockets.

Aluminium can be used to replace copper in low voltage distribution transformers and is economic at certain ratios of copper/aluminium price, but in the largest power transformers, difficulties begin to arise and most transformer designers are not yet prepared to change away from copper on a large scale. In rotating electrical machinery there are some places in which aluminium can be used to replace copper without serious difficulties, but there are others such as in the stator windings of large machines which pose considerable problems and would almost certainly incur increased losses. It should be remembered that usually this large type of equipment is expected to last for many decades and not only do these losses present a continual cost problem, but they are using power which is needed elsewhere. The third annual Electric Power Survey of India, recently published, indicates that India will be doubling her installed generating capacity from 7 350 megawatts for 1965 to 16 527 megawatts for the years 1968–1969. Despite this increase the power deficit, when expressed as the difference

between firm capacity and peak load, is expected to have increased during the same period from 2·8% to 9·5%. Clearly, in evaluating substitution the effect of any possible increased losses affecting the availability of power elsewhere will need serious consideration.

Again in many types of electrical equipment fine enamelled wire have to be used and in these cases it is dubious if there is any effective alternative to copper, although in the larger sizes aluminium may be substituted either by conventional round wire or rectangular section or in the form of foil.

Trouble-free performance is an essential requirement in any industrial process and it is in this connection that the manifold properties of copper and its alloys perform to the best advantages. In most parts of the world copper alloys are used in the majority of steam condensers in fossil fuel and nuclear power stations. The importance of trouble-free performance in a power plant needs no emphasis and this is another area where any contemplated change from copper alloys should be very thoroughly examined and tested for each individual situation.

It should be remembered that in the case of a power station, for example, which will operate at high efficiency with materials which have been developed along with the other items to achieve this efficiency, it does not necessarily follow that if some of these items are changed to something less satisfactory, the efficiency of the remainder of the installation is unaffected. A particular example is the modern boiler. This plant item in a power station cannot stand repeatedly leaking condenser tubes. If there is a shortage of power, there is a tendency to continue to run the set when the saline content of the condensate is reached and perhaps passing the threshold value. If this happens the whole boiler installation may be out of commission for many months. On the other hand, if materials such as stainless steel or titanium are used for condenser tubes, then a very high level of technical competence is necessary in their construction. It is not without interest that in the USA where stainless steel technology is as advanced as anywhere, there have been a number of such failures in power producing plants. As far as titanium is concerned, there is very little experience and clearly it would have to be taken slowly and long experimental period used before such tubes could be installed into commercial power plants with real security. The same remarks apply to condenser tubes in ships.

As an alternative to copper for a tube supplying water to a complex piece of equipment, the use of plastic coated steel might be considered, but this, although capable of giving satisfactory results in some cases, has to be designed with great care. Some plastic coatings on steel pipes are excellent, but the possibility of a portion coming loose and blocking the pipe cutting off the water may easily cause a critical condition. Many pump cases, impellers and valves are normally made of copper alloys, but in some cases these might be replaced with cast iron or other materials, although in general, renewal may be more frequent, posting the consequential difficulties which arise when important plant has to be taken out of commission for repair and maintenance.

Copper, phosphor bronze and brass are conventional materials for use in paper making machinery and in these applications, apart from mechanical reasons, the fungicidial problems of copper and its alloys are of considerable importance.

There has been a recent move to replace copper and brass in the utensil manufacturing industry which is estimated to consume about 33 000 tons of metal per annum. The consumption is expected to increase so that about 72 000 tons of brassware would be made by the end of the Fourth Plan period. This is a field of limited substitution—limited due to consideration of health hazards and aesthetic values—where technical problems may not be serious. Without educating the house-wives and without improved economics, the danger of total substitution cannot be over emphasised. The small scale industries producing consumer curio will be hard hit if substitution of copper is envisaged, as this is not only potential employer but also a variable foreign exchange earner.

In India, as in other countries, aluminium has been used to substitute many metals in short supply. If a good proportion of copper is to be substituted, as envisaged, it would be worthwhile analysing the availability of aluminium metal, ignoring the economical aspect. The estimated domestic production of aluminium for 1965–66 is about 70 000 tonnes, whereas the total requirement is estimated at 120 000 tonnes for the same period. The requirement also considers substitution of copper by aluminium in the bare copper conductors to the tune of about 2 750 tonnes. During this period, the import of this metal would be about 38 000 tonnes. Unless the production of primary metal is improved, aluminium will have to be imported even for the manufacture of traditional items, leave alone substitution. Development in the power generation alone will help in expansion of the aluminium industry, which again depends on the use of copper for its economic production. It must be borne in mind that aluminium is expected to substitute not only copper, but also zinc, tin and stainless steel. The requirements of aluminium will therefore have to be computed on the basis of substitution of all these metals and alloys and also for export. The export of aluminium ingots represented 59% of the total exports of 1964.*

There are many cases in which economies can be made in the use of copper and its alloys, and before change to another material, consideration should be given to techniques such as copper cladding, copper plating or copper spraying. Savings can also be effected by the correct choice of copper alloy for the particular application and by improving the design technique of casting. In other areas printed or laminated circuit wiring may be used to replace conventional wiring techniques.

* Figures available from a paper 'Non-ferrous Metal Industry in India' by P. C. Jain, published in The Eastern Metals Review dated 8th February, 1965, pp. 89–99.

No apology is made for referring to agriculture in this Symposium since agriculture and industry must develop together, and copper salts can play a large part in increasing food production where copper in the soil as a trace element is absent. For example, in the Allahabad Farmer for May 1963, it was reported by K. S. Yawalkar, S. Kokde and Vijay Kumar that as far as rice was concerned in certain areas, the application of copper increased the production by about 83%.

'Among all the trace elements, copper has been tried extensively, resulting in good response in several parts of the country. Application of copper sulphate gave yield increases in rice, wheat, sorghum and cotton in different areas in India (Tables I and II). Soil application of copper sulphate to paddy seed-bed (or one lb per acre of transplanted paddy) at 14 lb per acre increased the grain yield from 37 to 83 per cent over control (Table I) in Konkan and Poona regions in Maharashtra, where soils are naturally low in copper content. Substantial increases in paddy yields were also obtained in experiments at Bangalore (Mysore), Coimbatore (Madras), and Warangal (A.P.). Soil (5 lb) and spray (one lb) application of copper to wheat enhanced the yield by 16·6 and 14·5 per cent respectively at I.A.R.I., New Delhi (Table II). Similar significant responses of wheat were obtained at Poona. Considerable yield increases due to soil application of copper sulphate were also obtained with sorghum (52 to 58 per cent) at west Khandesh district (Mahrashtra) and with cotton (16 per cent) at Indore (M.P.).'

India is just emerging from a totally importing country to a gradually exporting one. The exports are very meagre indeed, consisting of only semis. The aim of earning more foreign exchange is therefore nullified because in return the raw materials have to be purchased. It is essential to manufacture items where metals can be used technically intelligently, at competitive prices. This calls for efficient technical skill and knowledge and reasonable governmental incentive. The planning should be such as to avert difficulties due to underutilisation of installed capacities and shortage of raw

TABLE I Crop responses to soil application of copper sulphate under field conditions in Maharashtra

(Grain yield in lb per acre)

Crop	Location and District	Grain yield in lb per acre			Dose lb/acre	Ref.
		Yield				
		Control	Copper Treated	Per cent increase		
Rice	Alibag (Kolaba)	1579	2178	37·9	14·0	12
	Alibag* (Kolaba)	1625	2222	36·7	14·0	
	Murdi* (Ratnagiri)	988	1811	83·3	14·0	
	Palghar* (Thana)	1712	2601	51·9	14·0	
Sorghum (Jowar)	Taloda W. Khandesh)	941 (without O&M)	1433	52·3	56·0	13
		1656 (with O&M)	2778	67·8	56·0	

*Experiments conducted on cultixators' fields.

TABLE II Effect of Micronutrient treatments in the yields of wheat and maize at I. A. R. I., New Delhi

Micronutrient treatment and dose per acre	Wheat (1953–54 to 1955–56)		Hybrid maize (1960)
	Soil application	Foliar application*	Soil application
N P K (control)	1428	1502	1529
N P K + Cu @ 5 lb.	1665 (16·6)**	1721 (14·5)**	...
N P K + Mn @ 10 lb.	1861 (30·3)	1599 (6·4)	...
N P K + Zn @ 5 lb.	1599 (12·0)	1744 (16·1)	1909 (24·9)
N P K + Mg @ 10 lb.	1726 (20·8)	1782 (18·6)	...
N P K + Cu + Mn + Zn + Mg	1805 (26·4)	1655 (10·1)	2013 (31·7)

*Dose for foliar application was 1 lb of each element.

** Figures in bracket indicate percentage increase over N P K in respect of soil treatments and over N P K + water spray in case of foliar treatments. Average of three (1953–54 to 1955–56) seasons' data for wheat and of one (1960 season's data for hybrid maize).

Ref. No. 15 for wheat and No. 1 for maize.

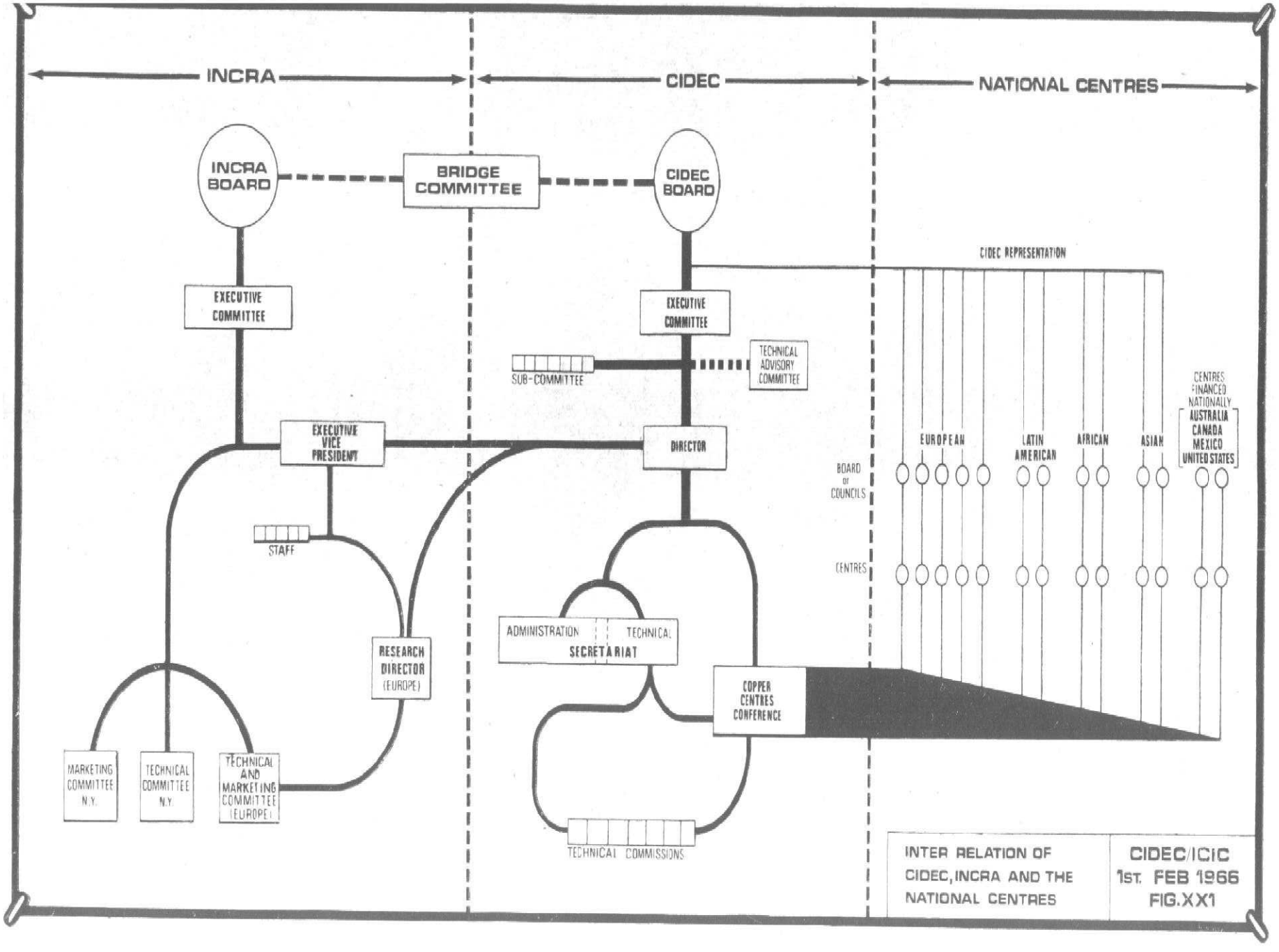

Fig. XXI *Inter-relation of CIDEC, INCRA and the National Centres*

material. As per recent survey many industries run much below their rated capacities, in spite of which quite a few licences are granted for such industries. For instance, the utilisation capacity in the copper pipes and tubes industry is only about 16% of the installed capacity, as also in the copper rods and section where the utilisation is about 55% of the total capacity. This is generally true for all non-ferrous metals industry, and if the production capacities are allowed to grow unsystematically, the production cost increases and the product becomes uncompetitive in the world market.

The other problem interlinked with under-production is the allocation of raw materials. The basis of allocation of the base metals for various units is as per their performance in 1963. While this might be helpful to some industries installed much earlier than 1963 and emerged successful after their teething trouble, new units might face shortage of raw material consequent to their initial low production pattern. A recent survey conducted by the Indian Non-ferrous Metals Manufacturers' Association shows that the allocation of copper to relevant industries is only 44% of their actual requirements. The licensing system is such that any increase in metal market price lowers the quantity of metal to be imported (the basis of import is governed both by value and tonnage of the metal). The resulting shortage may hold up production of finished goods constituting a large bulk of exportable items. Added difficulties arise due to frequent changes in governmental policies, in regard to the excise duties, procedures, etc., when a practical approach to the problem would alleviate a number of grievances. The largest sufferer—as indicated—is the electric cable and wire industry where excise duties have been on constant upward revision, resulting in the extra burden to the consumer.

Only a few of the examples of the need for using copper and its alloys have been mentioned. Generalising it would seem advisable that the use of copper and its alloys should be retained in uses where international competition has to be met in the export market and in all items of equipment for home use where long term efficiency is at stake. In particular this would apply to telecommunication equipment, large generators and motors, large power transformers, switchgear parts, steam condensers in power stations, certain items of chemical plant, heat exchangers, and all cases where the possible substitute material would give a shorter life in plant where stoppages for any reason would react on production as a whole.

The experience which has been gained in other parts of the world on the technical and economic use of copper will be available through the recently formed Indian Copper Information Centre of which Dr Vaidyanath is the Manager. This centre exists to supply technical information on the economic use of copper and its alloys in all its many forms. Through the International Copper Development Council this centre can draw not only on the knowledge of 19 other such centres throughout the world, some of which have been established for over 30 years, but it can forward problems where experimental work or research work is necessary to determine the result. Associated with these bodies is the International Copper Research Association, which sponsors research work throughout the world on copper and its alloys. At present it is financing some 60 research projects. An organisational chart showing how these various centres and associations are interlinked is shown in Fig. 21.

In the past labour was used to save materials and today materials are being used to save labour. This may seem irrelevant to some as far as India is concerned, but the shortage of skilled labour is probably as acute in India as in the rest of the world. At the same time industry has been caught between the conflicting forces of having to sell its products at increasingly competitive and generally lower prices and having to pay continuously higher wage bills. This situation has led to much more emphasis being placed on the more economical use of material and it is in these more onerous service conditions that copper's intrinsic qualities show their true worth.