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05280

Distr.
LIMITED

ID/WG.146/112
17 August 1973

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Third Interregional Symposium
on the Iron and Steel Industry

Brasilia, Brazil, 14 - 21 October 1973

Agenda item 8

CO-OPERATIVE RESEARCH IN ITALY, A COUNTRY WITH A RECENTLY DEVELOPED STEEL INDUSTRY: TECHNICAL AND ORGANIZATIONAL PROBLEMS AND POSSIBILITIES FOR INTERNATIONAL COLLABORATION[1/]

by

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id.73-5758

S U M M A R Y

The paper begins by tracing the basic stages in the development of an iron and steel industry. It describes the structure of the fundamental consumptions, together with steel consumption data, and gives some details relating specifically to western Europe.

The stages in the organizational development of research in the iron and steel field are considered, and there is an evaluation of the present size of research activity in the industry as compared with its size and structure.

The Italian example in then discussed in detail, in relation to the development of the world iron and steel industry.

Since the recruitment and training of engineers suitable for research organizations is a crucial problem, especially for developing or recently developed countries, consideration is next given to the past and present status of university teaching of metallurgical subjects, and an outline is given of the general problems in teaching metallurgy.

The origin, manning, and buildings of the Centro Sperimentale Metallurgico in Rome are next described. This leads on to a section on the organization of research in CSM, with investment and operational costs.

Special attention is paid to the participation of CSM in joint research programmes sponsored by the European Community, and to the meaning and importance of co-operation at regional level.

There are three appendices, detailing plant and equipment installed and in operation at CSM.

Section 1

The background, the objectives, the structure, and the motivation of the Centro Sperimentale Metallurgico in Rome may be of some general interest to this Symposium, largely by reason of the fact that Italy, having recently joined the ranks of those countries for whom the iron and steel industry is an important factor in their economic and industrial structure, can be taken as an immediate reference point by those countries that are in the process of passing through the initial stage of development.

A centre for applied research and its problems may be described and assessed in various ways. Straightforward technical data can only be of interest, if at all, to a limited number of specialists. However, taken in the broad context of their industrial sector it is possible to consider their importance in relation to the development of their industry, and this is of much greater interest for this Symposium, and especially for this Eighth Session.

In this section an attempt has been made to bring together certain relationships, of greater or lesser importance, which can be established between data relating to research and to the development of the iron and steel industry on the one hand and certain parameters of a more general nature relating to this industry at different stages of its development. It is by no means the intention to construct from these relationships any reference models against which every country can set up its own iron and steel research policy; it is intended, on a more modest scale, to offer to colleagues some themes worthy of consideration and to draw out their considered reactions, whether favourable or otherwise.

As a first observation, let us repeat something that has been expressed many times before, namely that apparent per capita steel consumption (defined in the accepted way) is a significant index of the degree of economic development of different countries.

Figure 1 shows graphically the figures achieved in the years indicated over the period 1913-1970 by regions and for typical countries which in 1970 were at the stage of major world consumers (Sweden), average-major consumers (ECSC countries, Japan), consumers with over 200 kg per capita (Italy, Spain) or at present nearing this level (Argentina. Brazil, Mexico, Venesuela). The importance of a consumption of about 200 kg per capita is shown in the three diagrams on Fig. 2. For three countries that are geographically neighbours and which have a generally similar socio-economic structure (and also with supply practices that are sufficiently comparable), such as France, Italy, and Spain, the situation that formerly obtained (high consumption of farinaceous materials, low apparent consumption of steel) is compared with the present situation : a per capita consumption of 200 kg comes at the intersection of the two curves for all three countries. The three economies have obviously been transformed, at various dates (1952 - 1958 - 1967), from predominantly agricultural to predominantly industrial. This general critical level corresponds, in western Europe, to the entry into operation of national co-operative iron and steel research organizations - IRSID in France (192 kg in 1949), CNRM in Belgium (201 kgin 1949), BISRA in the UK (287 kg in 1949), CSM in Italy (267 kg in 1963), so far as those countries, the structure and history of whose iron and steel industries is roughly comparable, are concerned.

The origins of these coincidences becomes clear if one analyses the distribution of consumption in the various user sectors in relation to the increasing totals.

Figure 3 shows a diagram taken from a UN publication which illustrates graphically the dynamics of development by type of consumption. This figure will be interpreted with the same reservations expressed in the publication from which it derives, namely that the composition of consumption is, to variable extents, influenced by the industrial specialisation of the country concerned, and therefore at an early stage of development the discrepancies in relation to average operations are larger and more frequent. However, even with these reservations, at a per capita rate of consumption of 200 kg there is a change in the rate of investment consumption and obviously an increase in more diversified consumption, in which it is not only the basic physico-mechanical properties that determine the choice of steel but also a more 'scientific' correspondence of the material with the specific service requirements.

The relationships between apparent steel consumption and gross national product have been analysed broadly and now constitute the basis of forecasts of total consumption. Less attention has been paid to the relationships which derive for the most part from these basic correlations; in the same way that the major iron and steel consumptions can be defined and characterized, so it is necessary to identify the priority objectives for research, which means that the essential problem for those responsible for research is to concentrate the forces and skills that are necessarily limited at the outset, and can grow only slowly, on a few important problems.

It would appear logical to assume that those countries that wish to tackle the development of their iron and steel industries with an adequate level of research activity should solve problems relating to the following :

1. the preparation of an initial nucleus of qualified personnel;
2. study of the most suitable raw materials and energy sources;
3. the production of essential finished products which meet the typical requirements of the country's steel market;
4. selection and optimization of processes and equipment in the light of the local labour situation and local raw-materials and energy possibilities;
5. the introduction of user industries which favour the most rapid achievement of economic stability and which are characterised by low specific investment costs, simple transformation cycles, and the possibility of gradual replacement of existing craft activities.

After having collaborated in the choice of process and location of the production complex and after having contributed to the resolution of problems relating to the start-up and adjustment of the production cycles which are successively installed, it is up to the research organisation to define the best characteristics of materials that have to be supplied to meet the current market applications that are gradually set up.

Section 2

In the same way that it is today possible, based on past experience, to forecast for the iron and steel industry the initial moment for a more specific activity, it is equally possible in the field of applied research to predict the developments in research activity as productive capacity gradually increases. In other words, the decision to establish an applied research organization should not only lay down the extent and the initial methods of the innovative force but should also be orientated on the basis of the rational development of the industry in the immediate future.

It is appropriate to dwell a little on this concept, because the real difficulty in taking the decision to set up a research organisation is not merely that of realising the first phase but, more important, that of visualising the size and the capabilities in a proper perspective, in relation to the stabilizing size of the sector. The steel industry is accustomed to this type of of long-term planning in its production departments; however, forecasting for a research organization is linked with a still greater degree of uncertainty. It is considered that a research organization needs a period of between five and ten years to begin to become productive in terms of knowledge and innovation after its establishment; the structure planned at the outset will thus begin to reveal its efficiency in the areas originally laid down between its fifth and tenth years. It will therefore be necessary to carry out certain logical changes, by reducing or increasing, in the structure of the organisation, between the third and the fifth years, thereby anticipating probable changes in the field of operation that may come about between the eighth and thirteenth years, and so on. The periods indicated should not be regarded as excessively long; however, they cover the training of personnel, identification of problems of a specific nature, acquisition and/or construction of suitable equipment, all of which involves decisions that are fraught with risk, anticipation, and good sense, but above all in close contact with the organisations and individuals responsible for the overall development of the sector.

In countries with a long-established tradition, iron and steel research developed first at the works themselves, in laboratories orientated towards immediate problems, whilst at the same time, in some universities, in a sporadic way and for reasons that were above all due to situations or individuals, problems of a more general nature began to be tackled.

The works laboratories then became identified with research workers better suited to deal with medium-range problems, and so this was followed by the establishment of laboratories removed from the production units, with tasks of a wider nature, and with certain links with the universities, which had meanwhile set up specialized laboratories.

A later stage is represented by the establishment of co-operative research centres, some of these as a result of state initiative, especially when the companies concerned are numerous and of low or medium capacity.

The ultimate stage of this evolutionary process is the establishment of continuous and effective links between the various similar centres in a single economic region and of the different countries themselves, resulting in the development of common research programmes and eventually in the exchange of research workers.

Numerical data on iron and steel research which are valid when comparing different countries at varying stages of development are not easy to come by; as a first systematic attempt at comparative study one may quote the one whose results were brought together in an OECD publication of 1969 (2). On the basis of this and other published reports (11, 17, 33, 41, 45), on the significance of which one must express considerable reservations, it is possible to construct diagrams which give an idea of the costs and the number of research personnel in certain of the more advanced iron and steel industries, collected at various stages of their development.*

Figure 4 shows research costs related to progressive national steel production figures, between 5 and 120 million tons per year, over the period 1955-1972. The single points appear to describe a rate of progression characterised by - up to a production of 30-40 million tons a year - an initial stage, in which the unit cost per 1000 t increases almost linearly and a succeeding phase in which the cost rate decreases until it reaches a maximum level. From this attempts are made to establish similar correlations between the number of graduate research workers (per million tons of steel) and the total production (see Fig. 5) : there is growth during the first stage (similar to that shown in Fig. 4), while for higher productions there seems to be a reduction in this parameter. Comparing

* The author would be grateful to those who could supply data that are more complete and more up-to-date than those shown in the diagrams.

Figs. 4 and 5 leads to the conclusion that above a certain total production the major costs are absorbed by ancillary personnel and by equipment.

When research expenses are calculated in terms of sales, it is noteworthy that - in the USA, for example - the iron and steel industry ranks low among the manufacturing industries.

In 1970, in fact, by comparison with a general average of 2.2% (between maxima of 5.1% for the optical instruments, surgical, and photographic industries and minima of 0.4% for the food and kindred industries and that of wood and its derivatives), the iron and steel industry achieved only 0.7% (0.75% in the same year for Japan).

It is evident, however, that these indices represent average values in the countries concerned and in general in the more developed countries there exists an industrial structure that has achieved a balance between its various components. In developing countries it can be seen that, where there is satisfactory local availability of raw materials (iron ore and coal) and of energy sources (oil, natural gas, hydroelectric power), iron and steel industry development becomes, at least for a certain time, an essential, if not the sole, component of economic development.

The data below (from Table 1) show that the proportional total contribution to industrial production of coal, iron ore, pig iron, and steel have - for the countries selected from among the more developed - been of roughly the same value during the three-year period 1936-1938, and that whilst pig iron and steel have maintained their very high values, those of coal and iron ore have significantly decreased. It can be seen that if a minimum production of 1% of the world production of the four materials

Average 3-year period	Coal %	Iron ore %	Pig iron %	Steel %
1936-1938	82.9	81.5	89.6	89.5
1952-1954	79.2	80.4	82.0	82.2
1962-1964	59.3	62.8	82.0	82.2
1970-1972	55.6	52.6	80.7	80.3

Table 1. Development of coal and iron ore mining and of pig iron and crude steel production in 10 industrialised countries and in the world

(1000 t)

Material	Average triennial period	Benelux	France	F.R. Germany	Italy	UK	Sweden	Japan	USSR	USA	Total	World
	1936–1938											
Coal		42247	45360	130493	1082	235663	449	45248	117396	416099	1,033,950	1,250,000
Iron ore		6145	34772	8924	960	13132	13377	664	26982	50575	15,553,511	189,000
Pig iron		5137	6681	15871	864	7781	635	2293	14472	29233	82,957	92,500
Crude steel		5091	6950	18520	2145	11910	1033	5832	17333	42906	111,720	123,000
	1952–1954											
Coal		29539	55753	155686	1077	228700	-	44080	248000	417576	1,130,411	1,483,000
Iron ore		6884	42823	14356	1450	16123	16449	1062	58859	99493	257,524	319,333
Pig iron		7392	9091	14824	1231	11442	996	4200	27486	59479	136,141	157,400
Crude steel		7729	10497	18991	3853	17796	1777	7456	38018	91341	204,495	224,583
	1962–1964											
Coal		21316	51047	147898	582	198756	-	52452	259248	424260	1,155,559	1,946,000
Iron ore		6805	62355	13718	1754	15756	24252	2460	137192	76752	341,044	542,866
Pig iron		11059	14696	24780	3622	15430	2052	20562	58777	68002	218,980	266,600
Crude steel		12067	18189	33833	9902	23449	3960	32948	80522	103547	318,437	395,733
	1970–1972											
Coal		4567	36983	117049	284	148188	-	36515	289140	511452	1,143,975	2,052,000
Iron ore		4881	56239	6423	1010	11508	33012	1620	202200	86892	403,765	764,066
Pig iron		15814	18813	31873	8784	16132	2808	71616	89211	79516	334,567	413,265
Crude steel		18581	23557	43019	18200	25902	5305	92926	120824	119223	467,537	582,166

Sources: EEC – Luxembourg – Annual Statistics – Iron and Steel 1966
Bi-monthly Statistics – Iron and Steel 1/1973
Energy Statistics – Annual – 1960–1971
Bi-monthly Energy Statistics 1/1973
National territory in the period under consideration

Stahl u. Eisen – 75 (1955) No. 5 – 10.3
United Nations – Statistical Office of the United Nations, N.Y. – Monthly Bulletin of Statistics

referred to is assumed to be an index of a sufficiently high industrial activity, the number of countries that attain this level present certain aspects that are undoubtedly interesting and significant. The following tabulation shows the number of countries that have exceeded 1% of the average production of coal, iron ore, pig iron, and steel in the two end periods considered in Table 1 and also the number of countries which in the period 1970–1972 exceeded 1% of pre-war production :

Period	Coal	Iron ore	Pig iron	Steel
1936–1938 No. of countries with production >1% of world production	13 (= 12.5 Mt)	12 (= 1.89 Mt)	11 (= 0.92 Mt)	12 (= 1.24 Mt)
1970–1972 No. of countries with production >1% of world production	13 (= 21.2 Mt)	17 (= 7.63 Mt)	18 (= 4.13 Mt)	16 (= 5.82 Mt)
No. of countries with production >1% of world production 1936–1938	14 (= 12.5 Mt)	32 (= 1.89 Mt)	30 (= 0.92 Mt)	30 (= 1.24 Mt)

To the largely unchanging structure of the coal industry there has been added, over the period of time covered – a little more than 30 years – a considerable degree of proliferation in the other sectors connected with this entity; this diversification can lead either to the use of a substitute source of energy instead of coal, using appropriate production cycles, or to the breakdown of the link between the location of raw materials and the installation of iron and steel plants, which has been in evidence since World War II. It is to this basic fact, as is well known, that one may attribute the enormous increase in sea transportation of iron ores, which is shown diagrammatically in Fig. 6 and in quantitative terms in Fig. 7.

To put iron and steel research into a proper perspective, and one which corresponds to one of its essential roles, that of economically optimising available raw materials supplies to the limit that is technologically possible (the other essential role being the economic optimisation of the contribution of compositional elements up to the limit of their physico-mechanical properties), it is worth briefly considering the present and future availability of energy sources which can in one way or another be utilised in the iron and steel industry.

First of all, let us bear in mind that, as far as [illegible] are concerned, the situation can be represented as shown in Table 2. Table 3 shows the position regarding proved reserves of various primary energy sources. Table 4 gives a comparison between the present crude steel production rates and the predictable available reserves of energy. The imprecision of such data is recognized and it is moreover obvious, in view of their inadequacy in terms of analytical basis, that they must be based upon a detailed and up-to-date knowledge of the local situation. However, taking into account the great mass of past research and, most likely, of future research, they will find their inspiration in the data collected in this table.

Section 3

It is appropriate at this point to deal, for the particular case of the Italian iron and steel industry, with the basic directions that iron and steel research must follow, and the frame of reference within which the development of the Italian iron and steel industry has taken place - and will presumably continue in the future.

Table 5 gives the essential data relating to the development of Italian production over the past forty years, from which may be deduced the following figures relating to the percentage of world production :

Year	Coal	Iron ore	Pig iron	Steel
1929-1931	<0.1	0.3	0.8	1.8
1936-1938	"	0.5	0.9	1.8
1952-1954	"	0.5	0.8	1.7
1962-1964	"	0.3	1.3	2.6
1970-1972	"	0.1	2.1	3.1

On the basis of investments declared by companies to the EEC, as laid down by Articles 46 and 47 of the ECSC Treaty, it is possible to construct the predictable development over the 1966-1975 decade of pig iron and steel production, their location, and the breakdown into different fabrication processes (Table 6). The following results emerge :

a. the LD process has become the predominant one, passing the electric furnace in the three-year period 1971-1973;

b. the LD converters will be located almost exclusively at coastal sites, supplied with imported coal and iron ore used for pig iron production;

Table 2. World iron ore reserves, by geographical areas
(Situation, January 1966)

Geographical areas	Measured, indicated, or inferred reserves			
	Million tons		P (%)	
Western Europe	20034		8.07	
Eastern Europe	104331		42.03	
Total Europe		124365		50.10
North America	52895		21.32	
South America	41767		16.82	
Total America		94662		38.14
Africa		12606		5.08
Far East and Middle East		8406		3.39
Oceania		8152		3.29
Total World		248191		100.00

Reserves measured, indicated and inferred are defined as mineral mass considered exploitable for usable material under existing economic and local conditions. The term "Reserves" is used only to refer to specific areas on which enough geological work has been done to ensure with some degree of accuracy the physical existence of ore.

"The World Market for Iron Ore"

Source: United Nations publication Sales No. F.69.II.E.10 (ST/ECE/STEEL/24)

Definition of Geographical Areas

Source: United Nations Standard Country Code, Statistical Office of the United Nations, Statistical Papers, Series M, No. 49 - New York 1970

Table 3. Assured Reserves of Different Primary Energy Sources and Consumption for 1969

Total Energy Consumption 1969: 32.[illegible] x 10[illegible] kcal
(World Total, Excluding Socialist Economy Countries)

	Solid fuels (coal and lignite)	Crude oil	Natural gas	Uranium for reactors: Thermal: Heat equivalent of kWh produced	Uranium for reactors: Thermal: Developed heat energy	Uranium for reactors: Fast: Heat equivalent of kWh produced	Uranium for reactors: Fast: Developed heat energy
a) Unit Measurement (UM)	t	t	Nm^3	kg			
b) Assured reserves (UM x 10^9)	a) 420 b) 2300	65	32	0,645)[c]			
c) Energy equivalent, Coal/UM	d) 7,4 e) 4	10	8,2	95	316	2850	9500
d) Energy content of reserves, 10^{15} kcal	a) 2600 b) 14900	650	262	61	204	1840	6150
e) 1969 consumption 10^{15} kcal	8,2	17,4	6,2	-	-	-	-
f) Ratio d/e = no. of years consumption for each source	a) 320 b) 1700	37	42	-	-	-	-
g) Ratio d/world energy consumption = no. of years reserves (considered as sole energy source)	a) 98 b) 430	20	8	1,9	6,2	55	190

Note: a = Measured reserves

b = Measured reserves + estimated reserves

c = Ores with extraction cost lower than $ 10 per lb. U_3O_8

d = Coal

e = Lignite

Source: BELLANO, W., "Metallurgical Coal in the Seventies" (I.I.S.I. Conference, Paris, 1970) - E.N.I., "Energia idrocarburi nel 1969"

Table 4. Crude Steel Production and Iron Ore Reserves and Power Reserves Expressed as Percentages (World Totals, Excluding Socialist Economy Countries)

Year 1969	North America	Japan	ECSC Countries	Remainder of Western Europe
% of world steel production	31.6	20.2	26.5	11.2
% of world iron ore reserves*	32.85	0.3	6.07	12.04
% of solid fuel resources	65	0.4	13.5	8.0
% of crude oil resources	8.0	-	0.30	0.25
% of natural gas resources	28.4	-	10.5	4.8
% of uranium resources	57.2	0.3	5.7	2.7

* Situation 1 June 1966

Source: BELLANO, W., "Metallurgical Coal in the Seventies" (I.I.S.I. Conference, Paris, 1970) - E.N.I., "Energia e idrocarburi nel 1969".

The world market of iron ore - ONU, Marché mondiale du minéral de fer - New York 1968.

Table 5. Development of Italian Iron and Steel Production

1929-1972

Period	Crude iron ore (000 t)	Pig iron (000 t)	Crude steel (000 t)	% of special steel	by process (%)				
					Basic Bessemer	Open Hearth	Electric	LD	Acid Bessemer
ø : 1929/31	665	622	1,758	(6.9)	-	87.8	12.0	-	0.2
ø : 1936/38	1,010	873	2,145	(12.0)	-	74.6	25.3	-	0.1
ø : 1952/54	1,450	1,250	3,850	14.8	7.3	49.3	43.4	-	-
ø : 1962/64	1,750	3,600	9,300	12.0	5.7	50.9	41.0	2.4	-
ø : 1970/72	1,010	8,760	18,200	14.8	-	23.6	40.6	35.8	-

Source: Relazione Banca d'Italia - Economia Italiana - 1931-1936, Vol. II - Rome
Commission Economique pour l'Europe - Nations Unies - 1968 - Doc. ST/ECE/STEEL/22 - No. F.58.II.E.4
EEC - Luxembourg - Annuario statistico "Siderurgia" 1966-1968-1970 - Bollettino bimestrale No. 6, 1972
ASSIDER - Industria siderurgica italiana nel 1972 (Milan 1973)

NB. ø = triennial average
() = estimated

Table 6. Development of Iron and Steel Production Capacity in Italy (1966-1975)

Region	1966	1967	1968	1969	1970	1971	1972	1973*	1974*	1975*
	1	2	3	4	5	6	7	8	9	10
PIG IRON										
Coastal %	93.6	94.3	93.8	92.7	93.5	94.5	95.2	95.7	95.6	95.9
Other %	6.4	5.7	6.2	7.3	6.5	5.5	4.8	4.3	4.4	4.1
Total Mt	7.8	8.6	8.7	9.6	10.7	11.9	12.5	14.0	16.0	17.0
PIG IRON/STEEL RATIO										
Coastal %	79.4	78.6	79.4	83.1	90.9	92.6	85.6	84.3	87.4	86.3
Other %	0.6	0.58	0.6	0.72	0.68	0.58	0.56	0.55	0.63	0.60
Total %	44.6	45.7	44.4	47.2	50.5	52.9	50.8	52.2	55.9	55.9
STEEL										
Coastal %	52.6	54.8	52.0	52.7	51.9	54.2	56.5	59.5	61.2	62.2
Other %	47.4	45.2	48.0	43.2	48.1	45.8	43.5	40.7	38.8	32.8
Total Mt	17.5	18.8	19.6	20.3	21.2	22.5	24.6	26.8	28.6	30.4
OPEN HEARTH										
Coastal %	21.2	20.7	19.9	18.7	16.5	12.0	10.9	10.0	9.1	8.6
Other %	13.7	12.8	12.3	12.3	11.8	9.7	8.9	7.1	5.2	2.9
Total Mt	6.1	6.3	6.3	6.3	5.9	4.9	4.9	4.6	4.1	3.5
ELECTRIC STEEL										
Coastal %	3.4	3.7	3.0	3.9	2.3	2.6	2.8	3.0	2.8	2.6
Other %	33.7	32.6	35.7	35.0	35.9	35.2	33.4	32.5	32.9	34.3
Total Mt	6.5	6.8	7.6	7.9	8.1	8.5	8.9	9.5	10.2	11.2
LD STEEL										
Coastal %	28.0	30.0	29.1	30.1	33.1	39.6	42.8	46.3	49.3	51.0
Other %	-	-	-	-	0.4	0.9	1.2	1.1	0.7	0.6
Total Mt	4.9	5.7	5.7	6.1	7.1	9.1	10.8	12.7	14.3	15.7

* Forecasts

Source: EEC-ECSC - Investments in the coal and steel industry of the Community - July 1972 - Doc. 8393

c. electric furnaces, whose level of production keeps Italy in absolute terms in fourth place in the world and, in relative terms (together with Sweden), in first place, are, by contrast, located almost exclusively inland (and supplied with either internal arising scrap or imported scrap);

d. the production of special steels has varied in percentage in relation to overall Italian production around fairly constant levels over the past twenty years (data from before 1953 are not strictly comparable with those from the later period) and seems to have settled at the average percentages that also apply in F.R. Germany and France. However, unlike these two countries, carbon steels (in the special steel grades) predominate over alloy steels.

It would thus appear logical to lay down that, once the conditions that enable a research centre to be set up have been achieved, the latter should, in the case of Italy, orientate its activities so as to give preference to the following essential objectives :

a. study of the behaviour of ores available on the world market and recommend the selection of materials most suitable, in terms of costs, method of transportation, preparation, storage, and stocking, for the operations and the production further along the production cycle;

b. reduce to the lowest possible limit the coke consumption in the blast furnaces and the reduction load, replacing high-cost coal by lower-cost but suitable in terms of coking. An alternative and complementary method is to reduce coke consumption to the quantity needed merely to maintain permeability in the reduction column and for the final carbonisation required totally or in part by reducing gas mixtures, suitably prepared and injected, in the task of reducing iron oxides;

c. bearing in mind that the maximum energy yield possible in typical conditions are of the order of 89% for the LD converter, 73-75% for the electric furnace, and 32-37% for the open-hearth furnace, it is obvious that for the converter there will be above all possibilities for automatic control and regulation, for the electric furnace there are still possibilities of improvement in the supply of power and materials, whilst the open-hearth furnace will disappear gradually as in the older plants the advantages of the low degree of amortization are nullified;

d. so far as carbon steels are concerned, it is evident that control of the metallographic structure and of impurities - now more possible than in the past through either technological processes designed to obtain materials with constant properties or improved methods of research and control - has opened the way to the manufacture of steels with better and more uniform properties of resistance to various types of attack and stress.

For alloy steels, the basic research problem, under Italian conditions, is still that of replacing expensive alloying elements and those that are in scarce supply with other more convenient elements and, as much as possible, with micro-alloyed steels and/or those which have been suitably heat and mechanically treated.

There is particular interest in Italy in the problem of corrosion, either purely chemical or more complex; in addition to better knowledge of the specific role of additions and of alloy elements and of the results that can be derived from these in terms of new or improved materials, the trend is spreading of completing more traditional production lines with coating lines, using non-ferrous and, at times, non-metallic materials.

To summarize, it can be stated that in the modern iron and steel industry production cycles are operated by means of which materials acquire the most suitable properties for specific predetermined secondary working and end-uses, whilst iron and steel research does not itself make prototypes of typical manufactured products in those sectors that are most vulnerable to the competition of other materials.

Section 4

Although it does not come explicitly into the subject matter of the sessions of this Symposium, it is felt that in this paper at least some allusion should be made to the training of graduate research workers. This will by no means exhaust the subject of the training of research personnel, but will be limited to some indications of the means of setting up the founding nucleus referred to in Section 1.

It is evident that when it is a question of proposing - as we are doing on the basis of our experience - the establishment of a research centre, which is rational and commensurate with the local conditions and possibilities, from the outset it is necessary to concern one's self with starting the basic training of those who, put into suitable technical and general surroundings, must gradually insert the research organization into a process of general modernization and innovation.

Thus if the industrial research worker requires a mentality different from that of the university investigator, the basic cultural training must of necessity be similar, and both must have a strong innovatory imagination : the former should be directed towards precise and concrete objectives whilst the latter should be freer and subject only to self-discipline.

At the present time, the university training of future metallurgists is undergoing, even in the European countries with the oldest tradition, a a stage of profound reorganization. The author of the present paper has been able to learn from experts in many countries the difficulties that university education are undergoing in this field.

The present system that applies in Italy and other countries about which detailed information is available may be summarised as follows. In the Italian universities, metallurgy has been treated primarily as coming in the field of "materials" in general education, such as engineering, industrial chemistry, or mining; only in the first decade of this century was there any separate first course.

Nowadays, following an unsuccessful attempt to set up a post-university metallurgical school, metallurgy and the science of metals are very diffused educationally.

The university student in Italy nowadays has a wide variety of choice of materials for study; in the case of engineering it is possible to graduate in chemical or mechanical engineering with a metallurgy bias, but there is no degree in the metallurgical branch proper.

In the USA and the UK there are university courses which cover solid-state physics and the physical chemistry of phases from the outset and introduce the student to metallurgy, allowing them to proceed after three to four years to a higher diploma in this discipline, with opportunities to proceed to higher levels with at least one year of study (master) or two years (doctor).

In the Federal Republic of Germany there are two levels of degree - Diplom-ingenieur after five years at university and Doktor-ingenieur after a longer period of study, with possibilities for specializing in metallurgy (43).

The system in France is similar to that in Italy, except that there are the Grandes Ecoles, with old traditions and considerable renown which ensure a certain degree of specialization.

The problem that has to be resolved for metallurgical degrees has two aspects, concerned with the employment of the young graduate and the state of metallurgical development of the country.

If one considers the branches of metallurgy, it is possible to distinguish the following :

a. extractive metallurgy (based on physical chemistry)
b. process metallurgy (linked with engineering, heat technology, electro-technology, etc.)
c. science of metals (linked with physical chemistry and solid-state physics).

It would appear somewhat doubtful whether it would be possible to have graduates equally versed in the three branches; it would seem more reasonable to envisage graduates specializing in a. + b. or b. + c., that is to say, graduates in metallurgical processes and metallic materials.

The university will be able to supply experimental means for the study of equilibria, structures, plasticity, etc., but not for the study of processes; there is thus an opportunity for collaboration with industrial centres equipped with pilot plants.

For developed countries which annually absorb some hundred graduates into the metallurgical industry, there is a justification for graduate courses of this type, whereas in a less developed country a specialised degree of this kind does not seem to be appropriate. There is no need to disregard the axiom that specialized education requires teachers and laboratories that have been specially prepared and, moreover, this must be justified with an adequate number of students.

For countries of this kind it would be more appropriate to have a general degree course (mechanical engineering, chemistry, etc.) followed, however, by a cycle of specialization in metallurgy which can be obtained abroad in centres already in operation, or by sending young men for training in foreign universities in order to take a degree in a sector of specific interest for the country, which wishes to proceed with all speed with a special type of operation. These are the most immediate solutions and easy to put into operation, in that they do not require the establishment of a course for the selection of teachers or the setting up of elaborately equipped laboratories.

On the other hand, the more developed countries are already offering collaboration by means of national or para-national organizations in terms of finishing courses for technical cadres from developing countries. In this connexion, so far as Italy is concerned, one must recall the work of the Istituto per la Ricostruzione Industriale (IRI), which announces finishing courses annually, including the iron and steel sector.(18)

It should be pointed out that in the industrially advanced countries an international finishing course or an iron and steel technological school, to which the best teachers of the region would gravitate, with adequate equipment, could be useful in producing young technologists who could be introduced into the industry with a profound and up-to-date training (an example of this type is the Centre d'Etudes Supérieures de la Sidérurgie - CESSID, established in France at Metz).

Section 5

The Centro Sperimentale Metallurgico is a limited company set up on 18 March 1963. Its capital at 31 December 1972 was distributed as follows : Soc. Finanziaria Siderurgica Finsider (IRI Group) 75%, Fiat 10%, Acciaierie e Ferriere Falck 5%, Snam Progetti (ENI Group) 5%, Soc. Finanziaria Meccanica Finmeccanica (IRI Group) 2.5%, Nazionale Cogne (EGAM Group) 2.5%.

Building of the administrative and research complex at Castel Romano began on 15 June 1966, and research work began in the new laboratories in the first half of 1968.

The writing of this paper thus coincides with our first five-year period of operation, and we are at the end of the period that has been taken as the running-in period for an organization of this type.

What have been the events in the short history of CSM that can be of interest to those outside and can be considered to be of value to those about to carry out a similar organizational exercise ?

So far as financing is concerned, attention should be drawn to the linking of steel-producing and steel-consuming companies.* In the case of CSM this has resulted in a beneficial coincidence of interest which has been of advantage in the establishment and in the work of the Centre. Specialists, possibilities, and innovations in production processes have been brought into close contact those belonging to the largest and most advanced steel-user sectors (heavy engineering, automobile industry, petrochemicals).

The choice of the headquarters - one of the first problems posed by the multiplicity of associated companies - was made largely in the light of two criteria : the location of the Centre in the most central position in relation to the areas where it was likely to be operating, and a site for it close to the decision-making centres of the industries concerned and of the organizations responsible for research policy.

It was considered that the centre of gravity of the Italian iron and steel industry (in terms of pig iron and steel) was located in 1966 in central Italy, with a tendency to move even further southwards (Fig. 8), and so there was no practical alternative to Rome. Specifically, CSM was located 23 km south-east of the city, in a zone designated by the General Control Plan (Piano Regolatore Generale) for light industries and industrial

* The steel producers associated with CSM produced in 1972 99.9% of Italy's pig iron and ferroalloy output, 68.7% of the total steel output, and 63.6% of the special steels.

research laboratories (Fig. 9). Another initial problem was the professional training of the young research workers at CSM. In the first place the associated companies made available a certain number of research workers already working in their laboratories, and from Finsider in particular a nucleus from the pre-existing Finsider Iron and Steel Institute in Genoa moved to Rome.

To make up the complement of graduate research workers, some 35 well qualified young men have been recruited, by means of a scholarship competition, usually biennial; they are sent for training to Italian and foreign laboratories (in Belgium, France, F.R. Germany, UK, Switzerland, and the USA). Since 1968 15 further graduates have been taken on at the Castel Romano laboratories, following an internal course, lasting on average 18 months, consisting of lectures, training, and gradual integration into the research activity.

As far as possible for those on foreign scholarships and in all cases for those on internal courses, the training is orientated towards specific subjects, which constitute current or likely research projects.

For qualified technicians a scheme for pre-selection and final selection has been set up and operated in association with IFAP (Istituto Formazione Addestramento Professionale del Gruppo IRI), which has led to the nomination of 40 technicians (16 chemists, 10 electrical and electronics technicians, 9 mechanical engineers, and 6 metallurgical and mineralogical technicians), who have attended a twelve-months course, divided into three stages - general metallurgy, specialization, works or laboratory practice).

An inter-works metallurgical experimental complex, large in size and therefore suitably structured, must meet certain requirements in terms of function and flexibility, imposed by the dynamic which distinguishes, on a time scale, the work of applied research. The various groups of buildings, in which the groups are distributed, must be connected, but there must be wide open spaces to provide for subsequent expansion.

To realise a centre based on these premises, it is necessary to tackle not insubstantial planning and constructional problems, which in our case were more critical because of the need to reconcile the general character of the area chosen for CSM, located as it is in an impressive corner of the Pontine countryside, with that of a necessarily functional style of architecture.

From the assessment of this factor and that of necessity there arose the need to have recourse to a plan that involved the use of a number of groups, each dedicated to a particular speciality.

To a study carried out by a firm of architects from New York (Haines, Lundberg and Waehler), well known for a number of important research centres of a similar size) was added in October 1963 the duty of general and functional planning. To translate the functional schemes so obtained into architectonic solutions that were valid in the special local conditions, the assistance was sought of a qualified group of Italian engineers and architects (Donato, Matteoli, Piroddi, Sterbini, Valeri). Finally, the execution of the project, the budgeting, the programming, and the management of the construction were entrusted to Società Italiana Impianti (IT), a member of the Finsider Group.

Co-ordination of the different activities, checking of the conformity of the project to the real requirements, and finally the equipping of the Centre were carried out by an internal working group (the Technical Services and the heads of the various research groups).

This collaboration led to the choice of buildings, layouts, and materials.

The arrangement of the various buildings on the ground and in relation to the sun, the plans of the laboratories and offices and the layout of the services were worked out rationally (Figs. 10 - 12).

The laboratories are centred in two buildings, each with four working floors, the last being used for services, with horizontal ducting for the main networks and vertical for the secondary ones. Heavy equipment and apparatus that is sensitive to vibration could thus be installed on the ground floors or basements (Figs. 13 and 14).

For the construction a steel network structure was adopted, with, for safety reasons, reinforced concrete blocks at intervals for staircases and to support elevators and hoists.

For the facing, the following materials were adopted : patinating steel (Cu-P-Cr) for the columns and stainless steel (Cr-Ni-Mo) in the panels and fasteners.

The plan of the laboratories consists (Fig. 14) of a corridor that is asymmetrical with respect to the axis of the building; the laboratories are arranged on one side of the corridor, equipped with all services, whilst on the other side are disposed offices or laboratories for which normal air circulation is adequate, without the need for extraction hoods (Figs. 13 - 15).

To decide upon the areas required, a maximum depth of about 7 m was decided upon for the laboratories and 4.50 m for the offices, for which a normal occupation by two people was assumed. The longitudinal axis was worked out to be about 3.50 m (the sum of dimensions of benches, the space occupied by one person per bench, and the walkways).

On the basis of these criteria, a constant unit module of of 1.20 m was established.

The repetition of this module determined the location of the external and internal columns of the building and of its various services. This modular arrangement made possible the standardisation of the constructional elements and also the possibility of their being prefabricated, with the intrinsic advantages of this form of construction : reduction in costs, high and constant quality, speedy delivery, and easy adaptability of the laboratories to other uses.

The last-named factor is very important in the case of partitions, since it is possible by adding or removing these to achieve a dynamic plan.

A more detailed description of the technical equipment is given in three appendices (I: General equipment; II: Centralized control equipment; III: Pilot plants).

Section 6

At 31 December 1972 there were working at the Castel Romano complex 530 people, of whom 86% were employed directly or indirectly in research and development activities and 14% in managerial, administrative, and ancillary functions. Of the research personnel, 5.5% represented those in charge of various levels of research groups, 25.3% were graduate research workers, 22.2% were technologists, and 47% were technical and operating assistants.

To illustrate the internal organization of CSM it will be sufficient to explain that the research groups - which are characterized either by common basic or instrumental disciplines or by common interests in certain parts of the iron and steel making cycle or by certain typical products (e.g. the chemical metallurgy group and the steel-making group, respectively) - are co-ordinated by assistant directors who are responsible for a given area of research - primary metallurgy, steel-making - refractories - plastic working, materials, general technologies) or for an ancillary activity (industrialization, technological forecasting).

Attention should be drawn to the fact that the Centre carries out for its company members research projects that can cover one or more companies and that, for multi-company projects, an advisory technical committee, consisting of qualified representatives of the companies, works with the CSM management to identify the most promising and useful lines of research. For every project mixed (company + CSM) working groups periodically follow the development of the project, recommending where necessary changes, additions, modifications, standstills, and final closure.

At 31 December 1972 CSM had in progress 118 research projects, divided as follows (according to the operating assistant director's office) :

Primary metallurgy (coals, ores, blast furnace and reduction, foundry, and physical chemistry)	28
Secondary metallurgy (steel-making, refractories, heat technology, plastic working)	22
Materials (heat-treatment steels, weldable steels, cold-working steels, corrosion-resistant steels, physical metallurgy)	61
Technology (plant and equipment, instrumentation, analytical chemistry	7

Of these, 48 were general-interest projects and 70 were company-sponsored (single or multiple companies).

Among the so-called ancillary activities, particular attention has been paid to the subject of documentation. It is well known that every day the numbers of papers that appear in the technical journals throughout the world is large and growing (for metallurgy alone in 1972 some 50,000 are estimated to have been published) so that it is becoming increasingly difficult to index these in such a way that they can be easily and quickly referred to. The existence of indexes or of abstracts and the classification of publications according to the more traditional systems does not completely solve the problem. For this reason, in an attempt to establish a coherent international method of metallurgical documentation and effective methods of retrieval, CSM has published a metallurgical thesaurus containing some 1600 key-words, and has worked out using a computer a memory system for the characteristic terms contained in the different articles and their more complex combinations. (4)

Using the abstracts of The Iron and Steel Institute (London) since 1965 some 60,000 bibliographical references have been collected. The CSM system enables the research worker to obtain titles and summaries of those articles relating to his specific subject; the answer can be obtained in less than an hour and usually achieves a high level of relevance.

To summarize and complete this information, the following technical survey of CSM containing essential data as at 31 December 1972 has been prepared :

Land area	527,000 m^2
Covered area	18,000 m^2
Floor areas	
Laboratories	12,700 m^2
Pilot plants	5,500 m^2
Services	6,100 m^2
Management, administration, documentation, computer centre, etc.	8,150 m^2
Water supply, with well up to 100 m deep	200 m^3/day
Water cleaning plant capacity	1,000 m^3/day
Electricity supply	
Input voltage	150,000 V
Working voltage	180/220 V
Capacity	1,500 kW

Average annual consumptions

Drinking water	70,000 m^3
Industrial water	30,000 m^3
Electrical power for lighting	600,000 kWh
Electrical power for drives and heating	4,000,000 kWh

Library

No. of books	26,000
Collection of journals	1,200
No. of journals received	650
CSM Technical-scientific publications	520
CSM research reports etc.	1,600
CSM patents in Italy	56

At this point it may be of interest to give some details of the operating and investment costs in one year (1972) which may be considered to be adequately representative of the current situation.

The situation regarding investments, expressed in UdC (1 UdC = 625 Italian lire), is as follows :

<u>Investment costs at 31 December 1972</u>

		UdC x 1000	%
a.	Land	1,600	6.2
b.	Buildings (including civil engineering)	16,000	61.6
c.	Equipment and instrumentation :		
	For laboratories	(5,000)	(19.2)
	For pilot plants	(2,530)	(9.7)
		7,530	28.9
d.	Auxiliary technical equipment (office machinery, furniture, vehicles)	870	3.3
	Totals	26,000	100

The operating costs, divided into a small number of essential groups, are as follows :

<u>Summary operating balance 1972</u>

a.	Labour costs (5,000 for research and development)	6,240	65
b.	Materials and energy	960	10
c.	Depreciation and taxes	2,400	25
	Totals	9,600	100

In order to permit some comparison with similar structures in other countries, the figures given above can be converted to unit values. The following relationships can be derived for personnel :

Graduate research worker	Technologist	Technical assistant	Others
1	0.37	1.85	0.64

The investment and operating costs related to the whole CSM personnel, only to those concerned with research, and only to graduate research workers, give the following values (in 1000 UAC) :

	Unit costs	
	Investment	Operating
Entire CSM personnel (530)	49.0	18.1
Research workers alone	57.0	21.0
Graduate research workers alone	224.1	81.7

Section 7

In a congress such as this one, which is interregional in nature, it may be of especial interest to give some information about CSM's participation in the research projects carried out with the financial support of the Commission of the European Communities, Brussels.

As is well known, Article 55 of the ECSC Treaty, which has since come within the competence of the European Community, lays down that the Community encourages the carrying out of technological research of interest to the iron and steel industry by means of a special fund. From the coming into force of the Treaty until the present day the Community has made available (after suitable investigation for every single project) funds that amounted on 31 December 1972 to more than 61 million UAC. The lesser part (24%) was to support research activities or ancillary aspects of permanent or long-term researches of general interest (AIRBO, ASELT, International Flame Research, blast-furnace gas injection, etc.). The major part (76%) was to support research programmes based on specific agreements between the Community and the company or companies.

It is interesting that, in the nearly twenty years of this activity, these research contracts have increasingly become collective ones; it has passed from an initial period, when it was difficult to identify projects objectively and co-operatively, to the present stage, when most projects are large ones, requiring a distribution of duties and specializations. From a statistical point of view the agreements reached in the period in question can be divided according to degree of collaboration :

	1955–1965	1966–1969	1970–1972
Agreement with 1 firm	47.0%	44.0%	30.0%
" " 2 firms	26.7%	20.0%	15.0%
" " 3 firms	11.3%	3.5%	15.0%
" " 4 firms	15.0%	32.5%	40.0%
Number of agreements	19	29	40

From a growing belief in the value of this type of collaboration there arose in 1968 the Association Européenne pour la Promotion de la Recherche Technique en Sidérurgie (AEPRES), which is starting a systematic study of all the objective possibilities for Community research and on their feasibility.

This Community activity have gained new impetus from the entry of the new members. CSM has supported it wholeheartedly and has thereby been enabled to enter rapidly into a circle with specialized capabilities and to compare its proposals and experience, at a high international level, with those of the other countries.

It would be presumptuous to close this report with indications to which a general validity needs to be given. The experience of CSM is too short, and the conditions under which it was set up and is operating are those peculiar to a certain type of iron and steel industry and to a certain type of growth; moreover, in general terms, the industrial and economic development of Italy has shown in recent years evolutionary and involutionary tendencies that are not to be encountered elsewhere.

In spite of these reservations, however, it is possible to emphasise certain aspects which are closer to those of a developing country :

a. The initiation in Italy of co-operative industrial research. Whilst there were already in Italy laboratory and research centres at company level, it was with CSM that inter-company (and, in our case, inter-sector) discussion on research began. This has precedents enough but, in Europe at least, it has represented the concluding phase of a consistent policy of public intervention in research, of active participation by university research in industrial problems, of a general tendency - throughout professional, scientific, and technical associations, their meetings and publications - to a fairly open exchange of information and experience. The other centres were set up in countries with an older tradition of industrialization in a close network that formed gradually when individuals and research entities had already given numerous convincing proofs of their indisgensability for the development of the sector. In Italy the rapid growth has not allowed the development of the iron and steel industry to be the result, albeit slow, of the achievements of research; CSM was immediately confronted with technological panoramas that are rapidly changing and by foreign centres of capability that were well qualified and against which they had to measure themselves.

b. The lack of a tradition of university education of established worth in the sector obliged CSM to acquire from abroad basic indispensable knowledge in both physical chemistry of the processes and research on materials. Lacking a precise frame of reference for the directions to be studied, we soon found the need to look ahead and had quickly to acquire advanced research techniques at the same time as we learned about their applications to specific problems.

c. The introduction of a research organization, which had no company responsibility, into the industrial patchwork, is always a delicate operation. It becomes especially delicate when it is a matter of an industry, such as iron and steel, which is, in the western European countries at any rate, adding a 'scientific' dimension to the existing base, which was largely founded on empiricism and respect for technological tradition.

d. However, a combination of abilities and equipment, already strong in absolute terms but the more so when related to the local situation, was a natural source of attraction to the member companies and also for the solution of specific and contingent problems.

It is necessary that the co-operative research centre should work in close contact with the concrete problems of production and so it is an indispensable condition for its development that it should obtain the complete trust of the better qualified operators, but it is at the same time obvious that the centre should operate in the course of its activities a judicious choice between short-, medium-, and long-term commitments. Also, if contingent circumstances lead it to assume a role which, within limits, replaces that of company laboratories or basic research laboratories, it may need to pursue with tenacity and realism the fundamental aim of ensuring for the industry a mechanism that is capable of producing innovations that are useful to it, continually improving the competitive position of the sector in which it operates.

e. It is clear that for both developing countries and those, like Italy, which have already passed through the first stage of industrialization, resources and technologists are not available in sufficient quantity to cover, even in relatively narrow sectors, the whole field of possible innovatory contributions. This means that it is necessary to select priorities and it is of value to establish international and interregional collaboration to which the contributions of individual members can be mutually integrated or exchanged, cancelling out or reducing in this way the debit side of the technological balance of payments.

Section 8

The definition of the functions of a research centre - this is the essence of the five-year experience of CSM that the author of this paper is bringing to the Symposium - is the basic aspect of the planning of such a centre. It is said - and rightly so - that industrial research is itself an industry with a high degree of risk (and often highly capital-intensive). It should, however, be added that the risk is not only that which is inherent in the production process that is optimized with timely and valuable innovations but also that which can result from missing the opportunity to create a consumer market for the innovations.

Between the moment of creativity and innovation, which is the task and responsibility of the production organization, there is a broad zone of time, of work, and of costs, which correspond to the creation of the prototype in which the meeting-clash of the two organizations and the two mentalities can come about.

In highly industrialized countries this intermediate area, this "no man's land" is gradually filled with systems that are different but, in general, efficient. In the developing countries and those with a centralized economy it is usually the political authority which - having laid down the development objectives in advance - generally ends up as arbitrator in the case of disagreement.

Those countries which have already gone through the first stage of industrial development or those with a mixed economy must, however, on each occasion work out their model of conduct and optimize it in terms of the local situation, seen with courageous realism in a wide perspective which, without disregarding the data relating to the present, project it into the future that it is desired to attain.

The author wishes to thank Professore E. Hugony, Ing. M. Gervasoni, and Ing. C. Mellere for their valuable collaboration in the collection of data and basic information.

APPENDIX 1 : GENERAL PLANT

1. Conditioning Plant

A centralized installation; primary materials, generated in two central equipments in the service building, are :

- water cooled to 5.5°C (from a cooling centre with a capacity of 3 million refrigeration units per hour)
- saturated steam at 10.5 atm (from thermal centre with a capacity of 8,200 kg of steam per hour).

These liquids are distributed to the different buildings, where they are used either direct from the central conditioners or, if required for process use, through mains that are steam delivery/condensate return or cooled water/water at 12.4°C respectively. The flows to each building are basically controlled by the buildings themselves.

2. Electricity Plant

Power comes from the national grid by means of a 7.5 km 150 kV line. It is transformed at the CSM sub-station by two transformers of 150/6 kV, [illegible] kVA each, which can work in parallel.

From a metal-clad panel located in the sub-station itself, which can be equipped with 14 outlets, the medium-voltage (6 kV) power is distributed to the different buildings of the Centre.

There are 6000/380 V transformer rooms in the buildings for electric drives and illumination :

Building	Number	Individual capacity kVA	Total capacity kVA
Laboratory A	2	500	1,000
Laboratory B	2	500	1,000
Management	2	500	1,000
Technical services	2	750	1,500
Pilot plant A·	2	500	1,000
	1	250	250
Pilot plant B	2	500	1,000
	1	250	250
TOTAL			7,000

· For pilot plant A there is additionally available a direct supply at 6 kV (for about 5,000 kVA), used for running large motors (e.g. for the rolling mill) and for the electric furnaces.

The services building is also supplied by a [illegible] kV line for running the synchronous motors of the cooling group (c. 1,000 kVA).

3. **Water Plant**

The water supply to the Centre is from three wells, from which can be continuously drawn 10 mc/h, the maximum yield of the water table below.

Since this yield is inadequate to meets the demands of the Centre, a recovery plant has been installed to recover all the discharged water (black, acid, industrial) : all the treated water is used for industrial purposes. The recovery plant can treat in total 1250 mc/day.

There are three distribution networks :

- drinking water with 400 mc reservoir and electric autoclave delivery pumps totalling 36 mc/h, plus an emergency motor pump;
- industrial water with 1,000 mc reservoir and autoclave delivery pumps for a total of [illegible] mc/h, with an emergency motor pump;
- water for fire-fighting purposes with 500 mc reservoir and both electric and motor pumps for 150 mc/h.

4. **Gas Plant (LPG)**

The gas needed for use in the CSM pilot plants is distributed from a central storage plant. The storage capacity is 50 mc, with a maximum delivery rate of 300 Nm^3/h.

5. **Compressed Air**

The compressed necessary for the laboratories and pilot plants is supplied by two compressors, each with a capacity of 350 Nm^3/h at a pressure of 8 atm.

6. **Other General Equipment**

CSM is equipped with the following general services :

- a standard telephone system
- an emergency telephone system
- a radio system for staff location
- a central electrical timekeeping system.

APPENDIX II : CENTRAL CONTROL PLANT

The central control plant is located in the CSM services building.

It can be considered as a co-ordinated complex of several supervisory and alarm control equipments, by means of which it it possible to control and oversee all the general equipment in the Centre, operating from a single synoptic board, surmounted by a general alarm board on a supervisory system.

The general synoptic board comprises 14 panels, as follows :

- 4 panels for the 150/6 kV substation and 6 kV distribution system
- 3 panels for the cooling plant (one for each cooling group)
- 3 panels for the the thermal station
- 2 panels for the water plant and water treatment and circulation system
- 1 panel for the combustible gas plant
- 1 panel for the compressed-air plant.

At the centre of the general synoptic board there is a Selectographic equipment, which enables all the conditioning plant in the Centre to be controlled and supervised at a distance, by visualization, as required, of photograms of the technological layout of these plants.

For the supervisory alarm board, any unusual functioning of every plant or equipment in the Centre is reported optico-acoustically, which causes the operator to intervene, either by means of the general synoptic board or at the equipment itself. The equipment can supervise 216 units.

Five years' operation of the Centre has shown that the centralised equipment described above is a complex which enables all the general plant at CSM to be controlled and operated by a single person.

APPENDIX III : PILOT PLANTS

The pilot plants are located into two industrial buildings, constructed in metal and located a convenient distance from the laboratories, to which they are linked by a pneumatic line for the rapid transfer of specimens for analysis.

These buildings are equal in height but vary in size and internal arrangements.

The first is 21.60 m broad, with a covered area of about 2,000 m^2. It is divided into twelve longitudinal bays, each 7.20 m, and is served by an overhead travelling crane of 15 t. It can be considered to be divided, throughout its whole length, into two parts, one 14.60 m wide for the installation of high equipment and the other 7 m wide for intermediate structures of heights varying between 4 and 8 m.

The second is 24 m wide, with a covered area of 2,200 m^2. It is served by a 5 t overhead crane. Throughout its length this building can be divided into two perimeter zones, each 7 m wide, by means of moveable partitions. This enables the maximum flexibility to be obtained for setting up very diverse types of plant.

Each building is provided with main services (drinking and industrial water, gas, compressed air, electricity), running horizontally along the two sides, with modular offtakes every 7.20 m. Figure 16 shows a diagrammatic section though one of these buildings.

Between the two buildings there is an open space of some 5000 m^2 which is used for stocking of raw materials and for subsidiary plant (stores, ore-preparation plant, gas producers, etc).

This open space is closed at its southern end by a bridge joining the tops of the two buildings, and in which are located the offices and services for those operating the pilot plants and the elctrical control cabins for these plants.

At the present time these buildings are 90% occupied. The different equipment installed includes :

- equipment for crushing, handling and screening of iron ore and coal
- two closed-cycle equipments for ore grinding
- equipment for forming and roasting of pellets
- two rotary kilns for drying and roasting of ores or pellets
- experimental plant for treatment of iron ores in special reducing atmospheres

- equipment for classification of coal and coal
- plant for experimental fluidised-bed production of semi-coke
- rotary furnace for hot testing of coke
- two plants for agglomeration tests of ores
- vertical kilns for roasting and reduction tests on agglomerates
- a small experimental foundry with sand preparation plant
- a 3.5 t electric arc furnace
- two induction furnaces of 500 and 1500 kg
- a vacuum degassing apparatus
- a group of vacuum induction furnaces for casts of 50-100 kg
- various heat-treatment furnaces with quenching tanks
- a 290 mm double duo rolling mill
- a 450 mm three-high rolling mill
- welding equipment of various types for studying the weldability of steels
- a machine for compression tests (500 t) on metal structures
- a press for tests on drawing, extrusion, etc. (250 t)
- a 4000 t machine for tensile testing of large welded structures (under construction)

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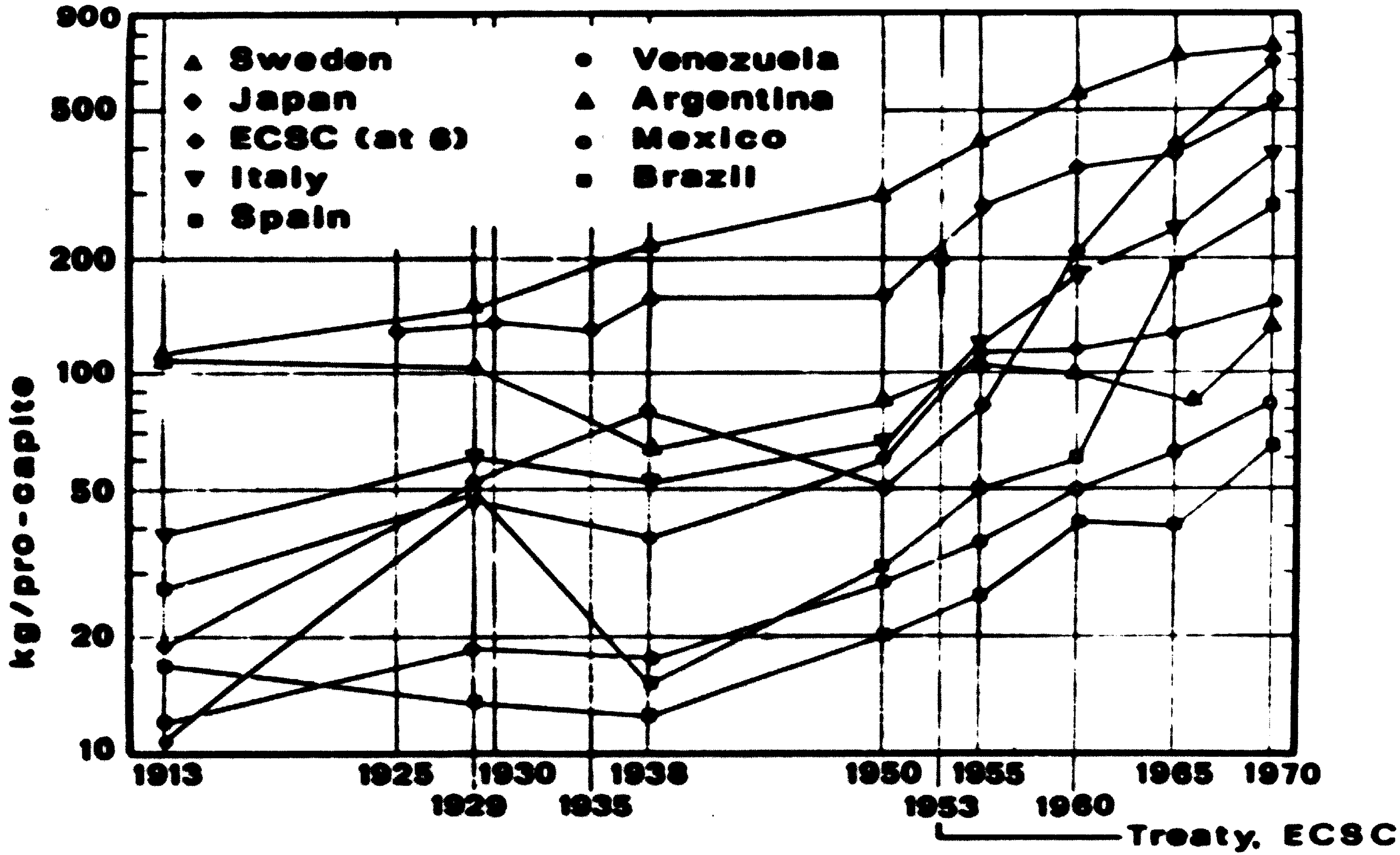


Fig. 1 Growth of per capita apparent steel consumption in some countries with varying degrees of industrialisation between 1913 and 1970 [21, 32, 37, 44]

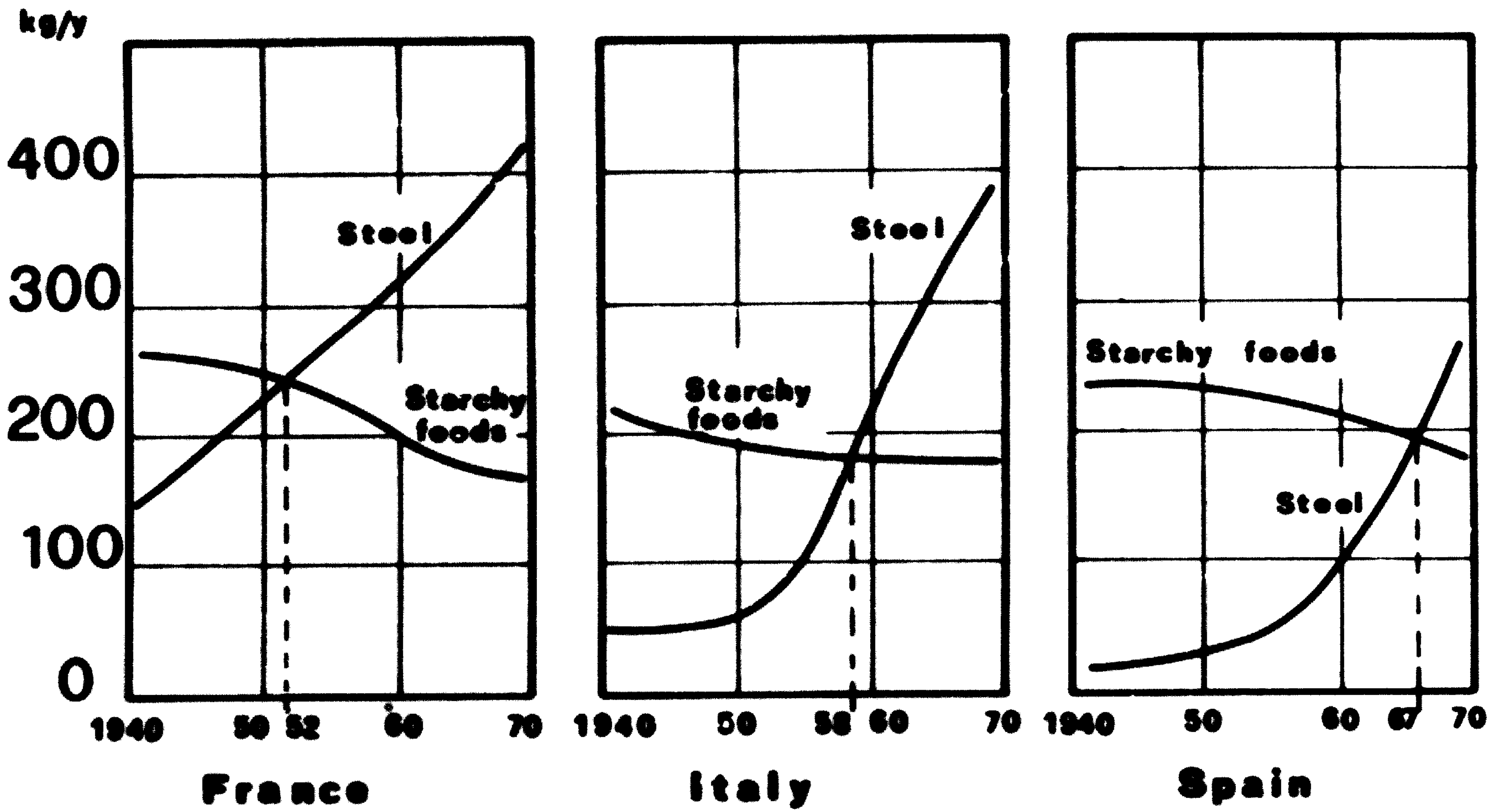


Fig. 2 Consumption of steel and starchy (farinaceous) foods in France, Italy, and Spain between 1940 and 1970 [3, 7, 27, 32]

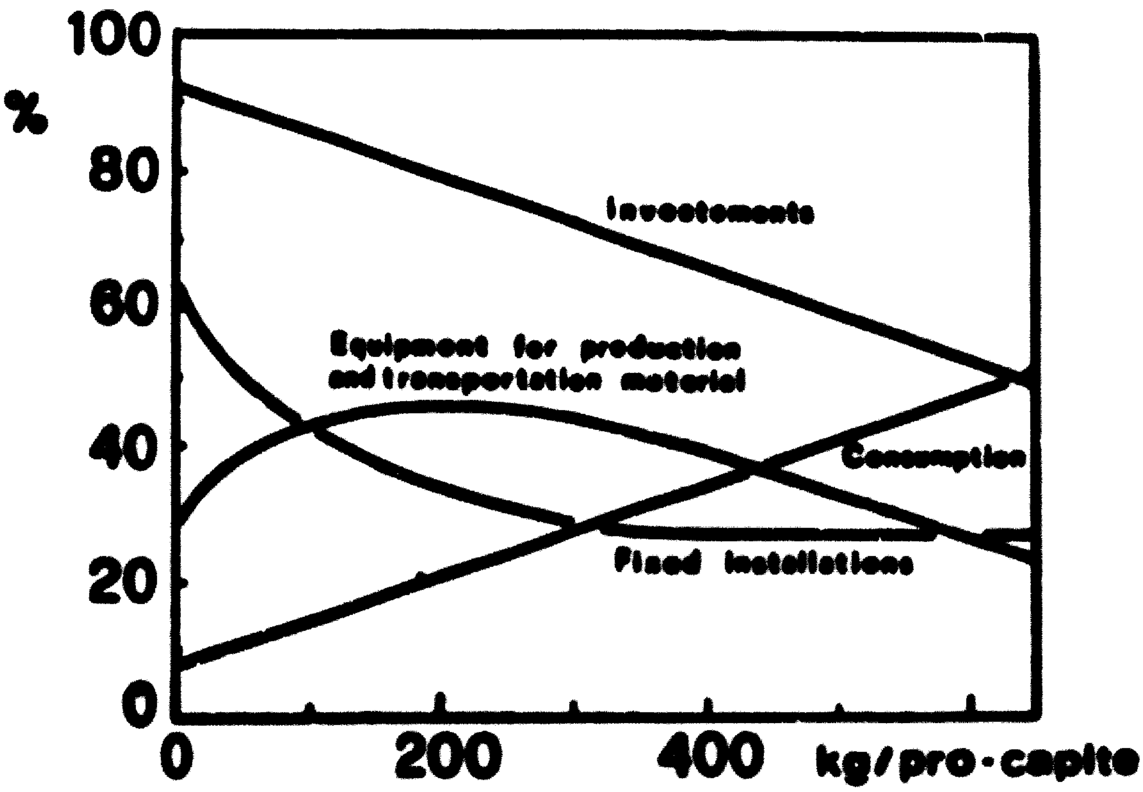


Fig. 3 – Development of main types of steel consumption in relation to the progressive increase in unit steel consumption

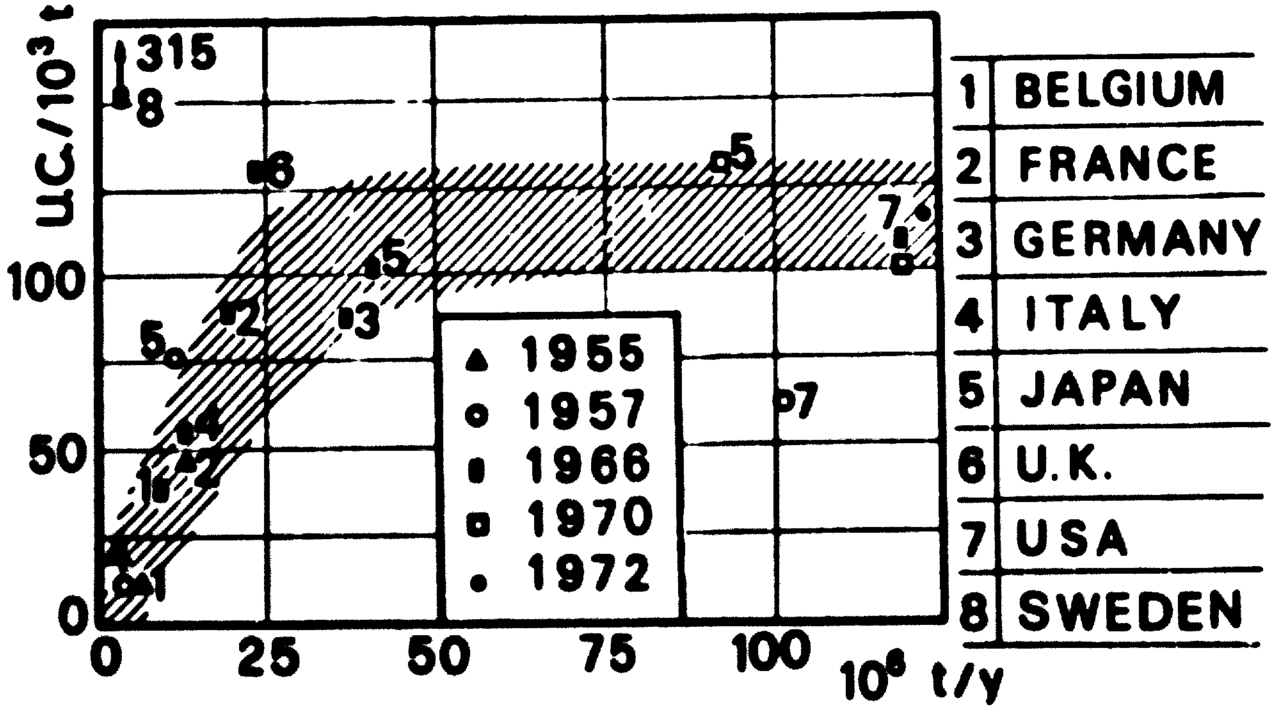


Fig. 4 - Units costs of research and development in the iron and steel industry per 1000 t of steel and total production in several industrialised countries [11, 17, 25, 33, 41, 45]

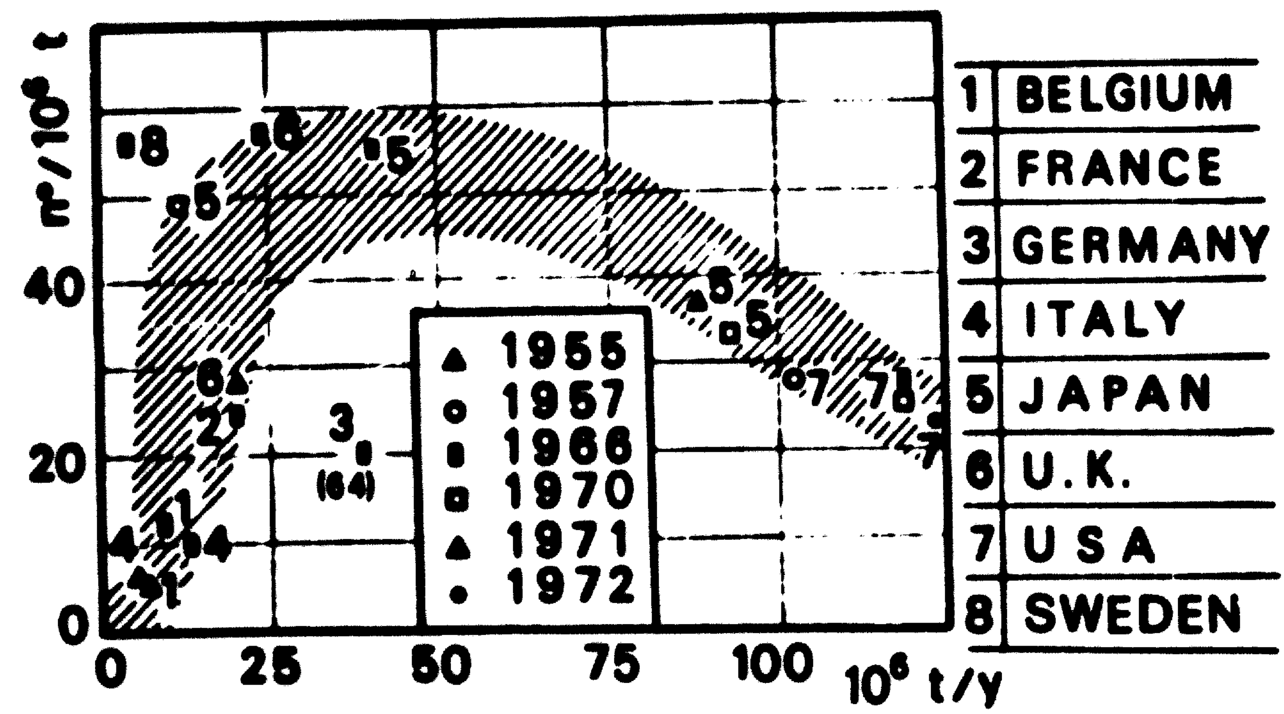


Fig. 5 - Number of graduate research workers in the iron and steel industry per 10^6t of steel and total production in several industrialised countries [11, 17, 25, 33, 41, 45]

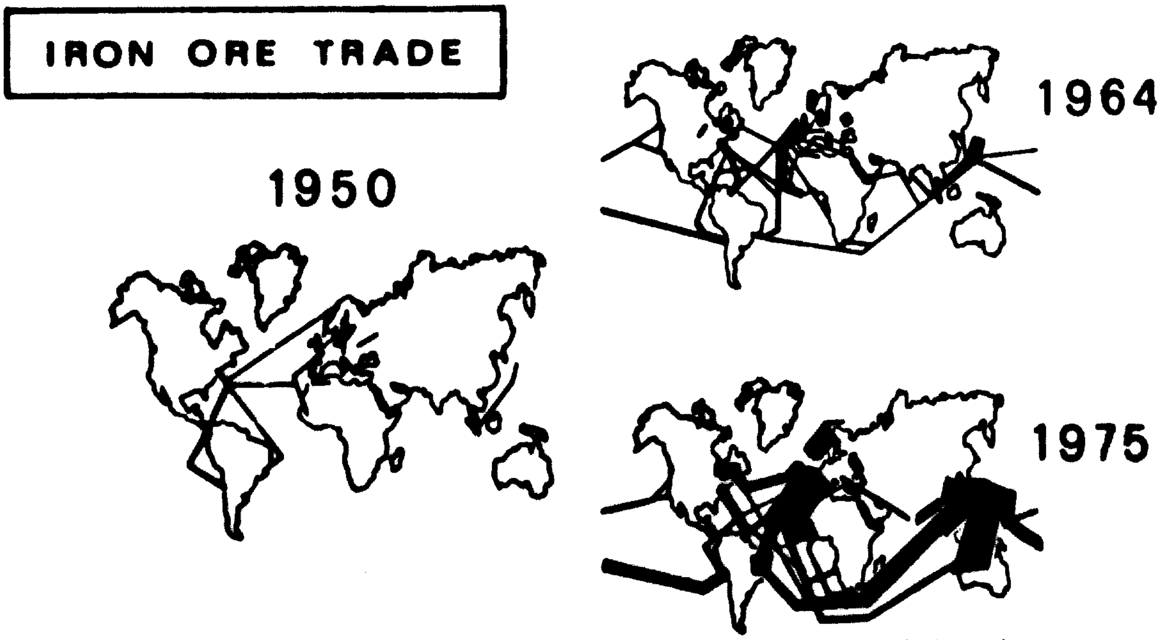


Fig. 6 - Increase in iron-ore trade from exporting countries to iron and steel user countries [26]

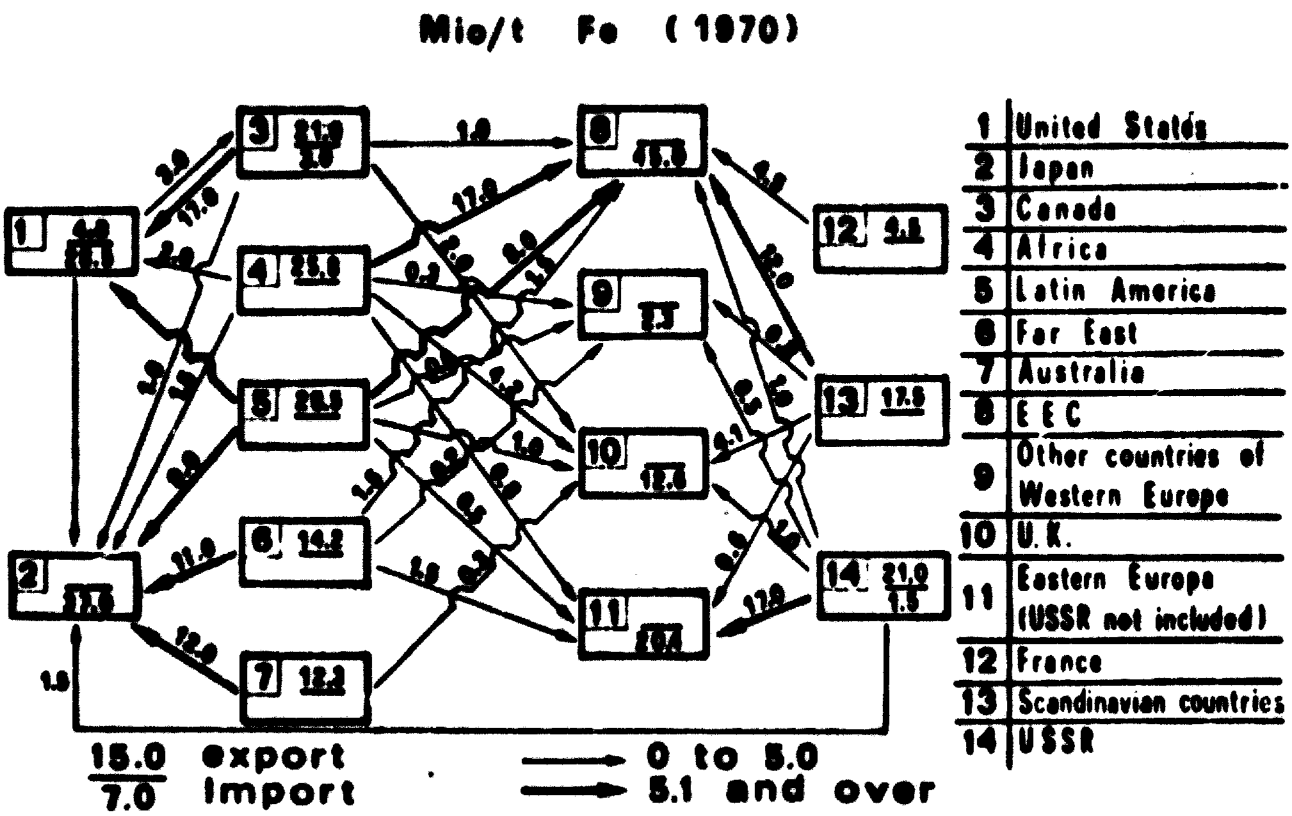


Fig. 7 - Quantitative diagram of iron-ore movements between producing countries or regions and iron and steel industry countries or regions [24]

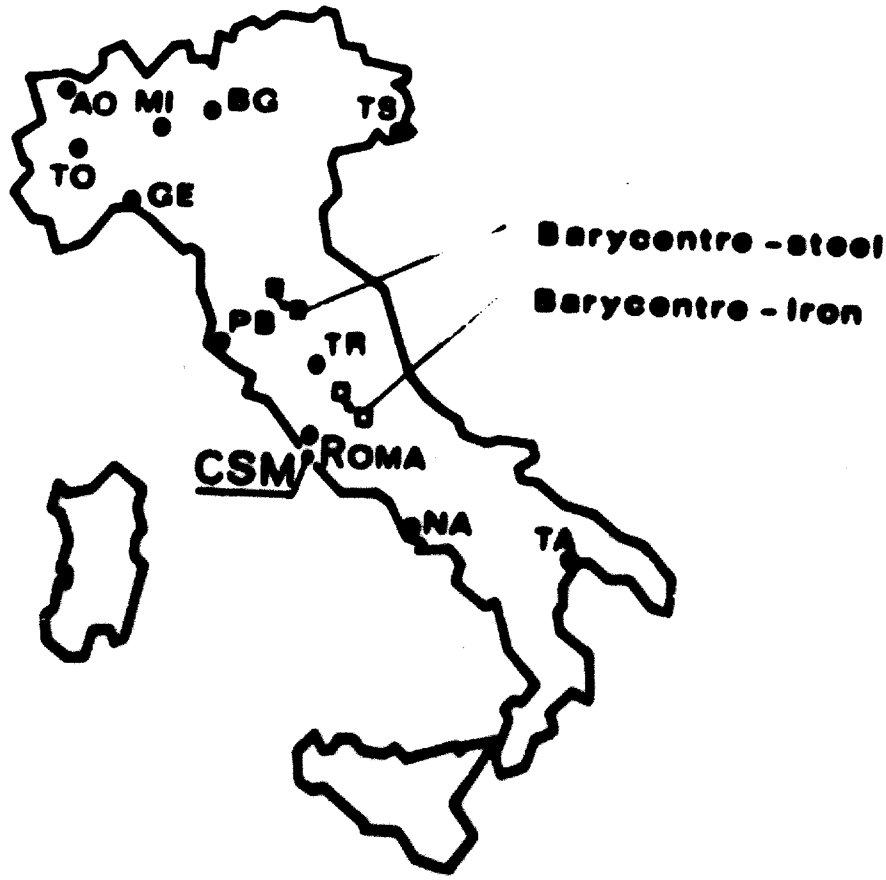


Fig. 8 - Location in Italy of iron and steel works belonging to CSM member companies and relative baricentres for the production of iron and steel, 1966-1971 [5]

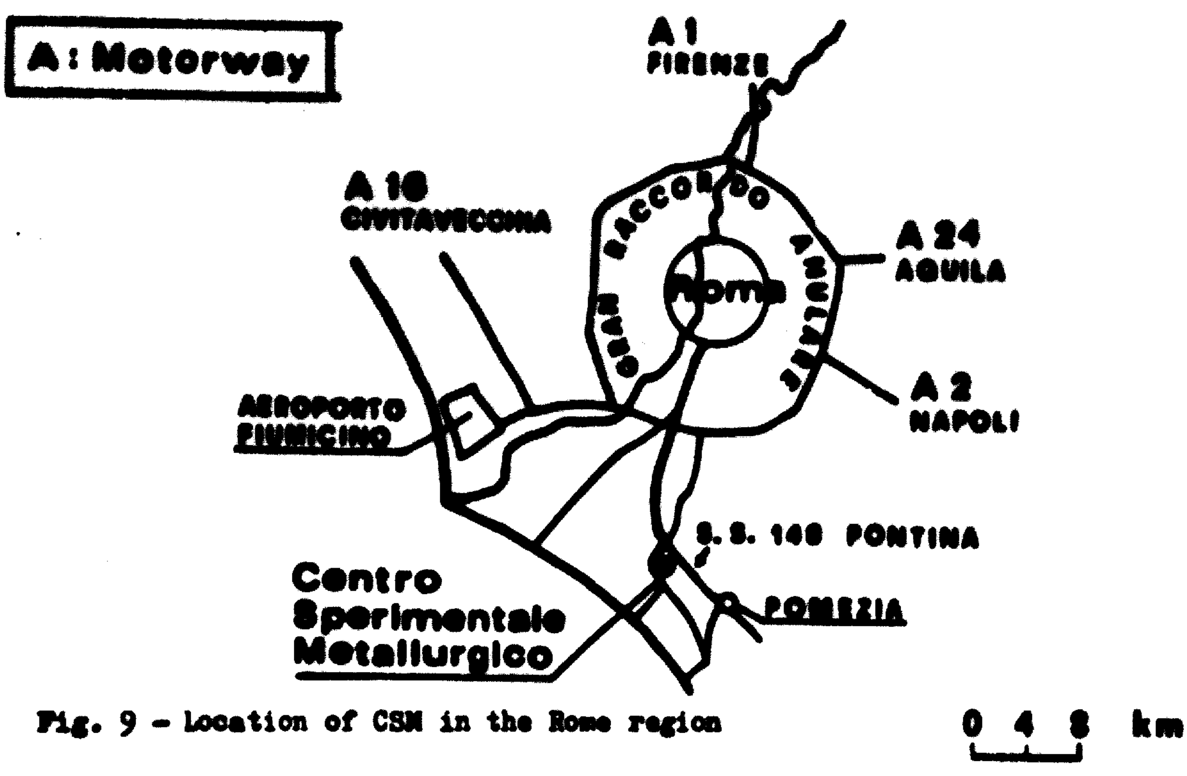


Fig. 9 - Location of CSM in the Rome region

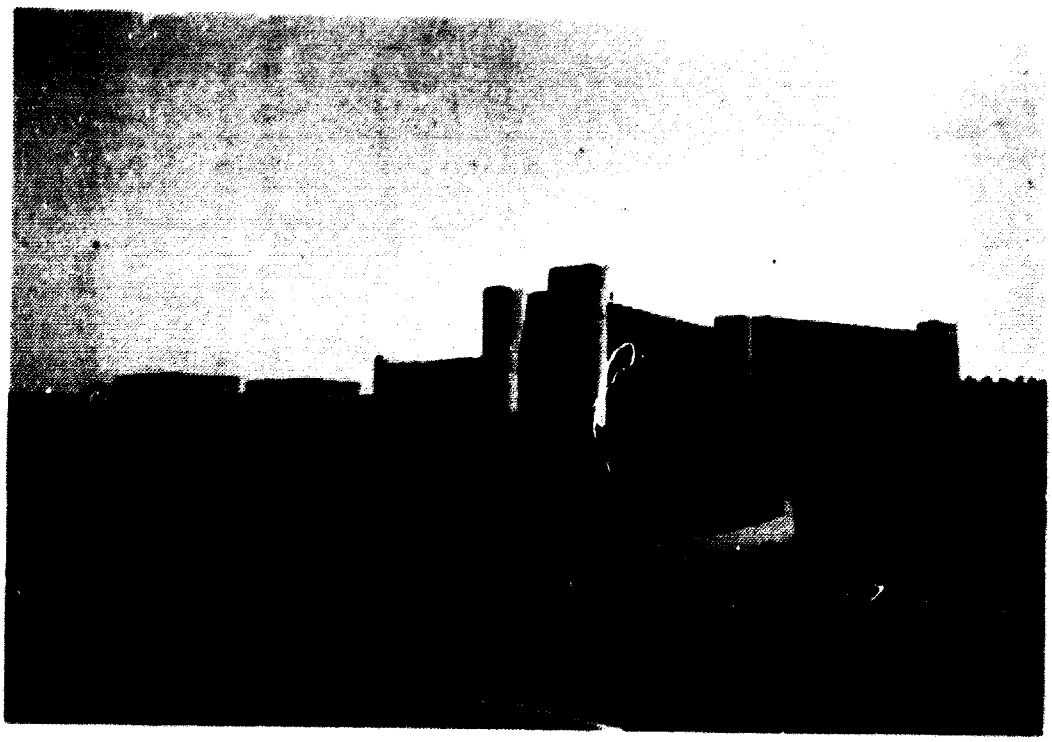
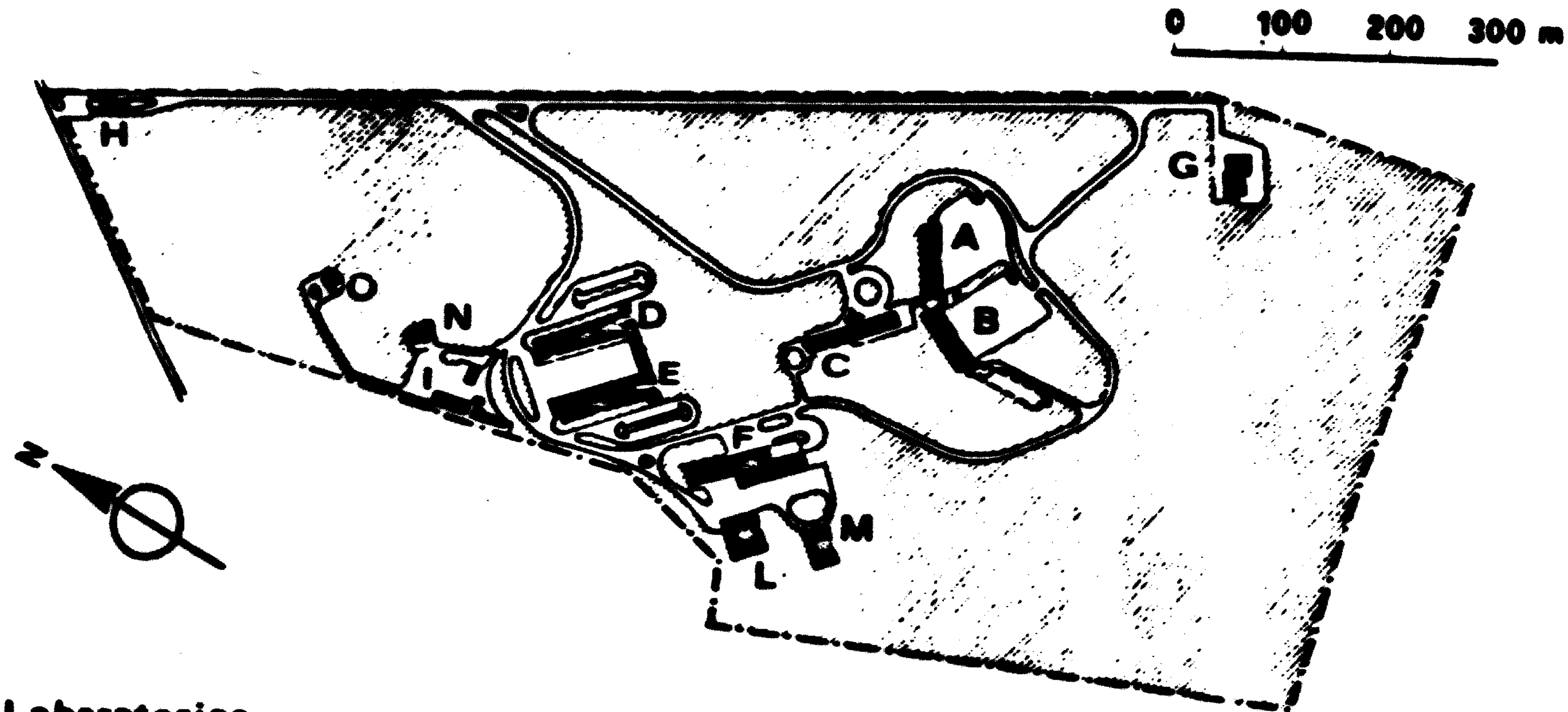


Fig. 10 - The Centro Sperimentale Metallurgico : main nucleus (laboratories, managements and administration offices, documentation and computer centres) and pilot plants



A Laboratories
B Laboratories
C Direction management
D Pilot plants
E Pilot plants
F Technical services
G Cafeteria
H Gate
I Water-treatment plant
L Electric sub-station
M LPG tank
N X-rays laboratory
O High energy laboratory

Fig. 11 Layout of CSN and location of various buildings

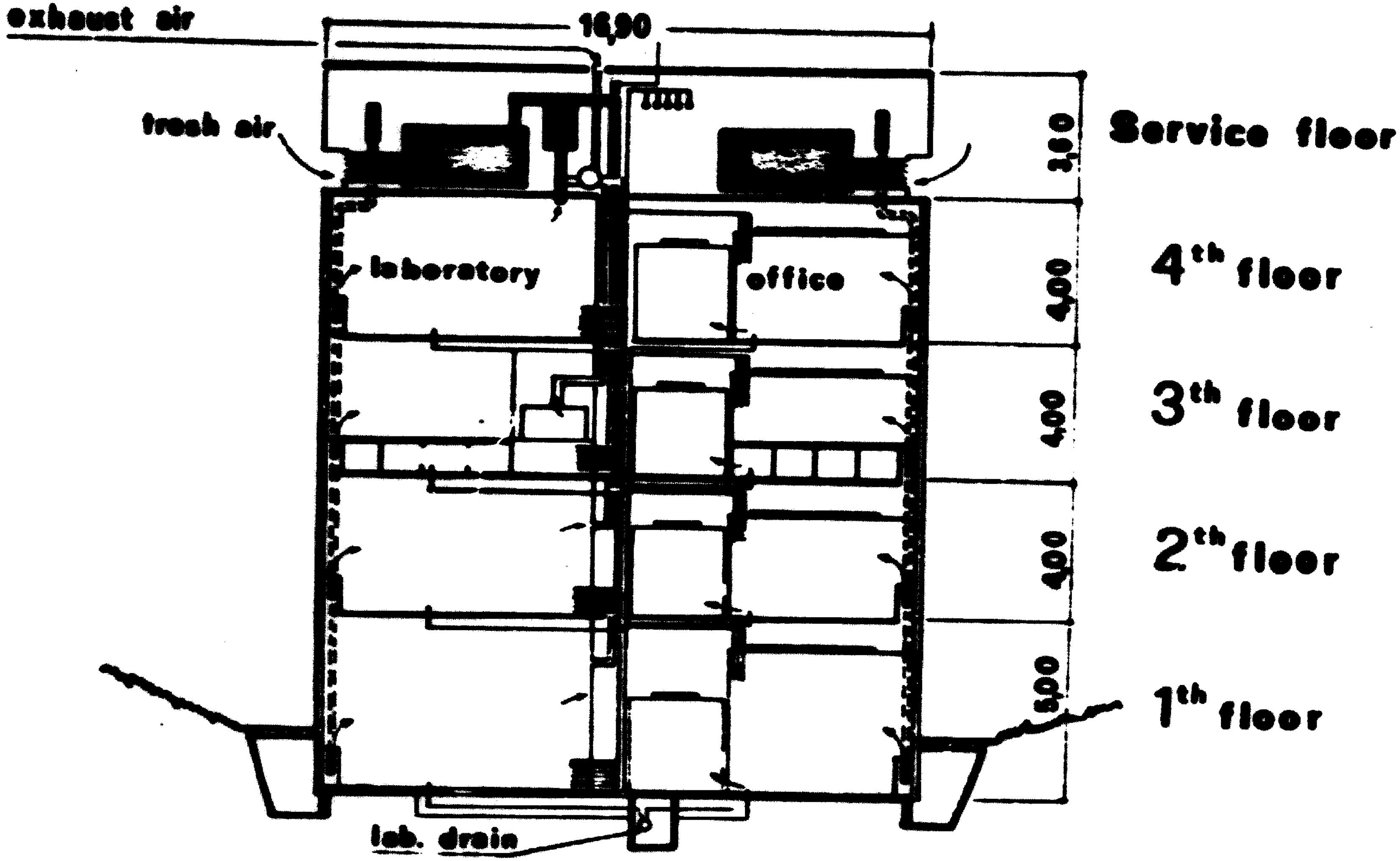


Fig. 12 CSN laboratories : typical section

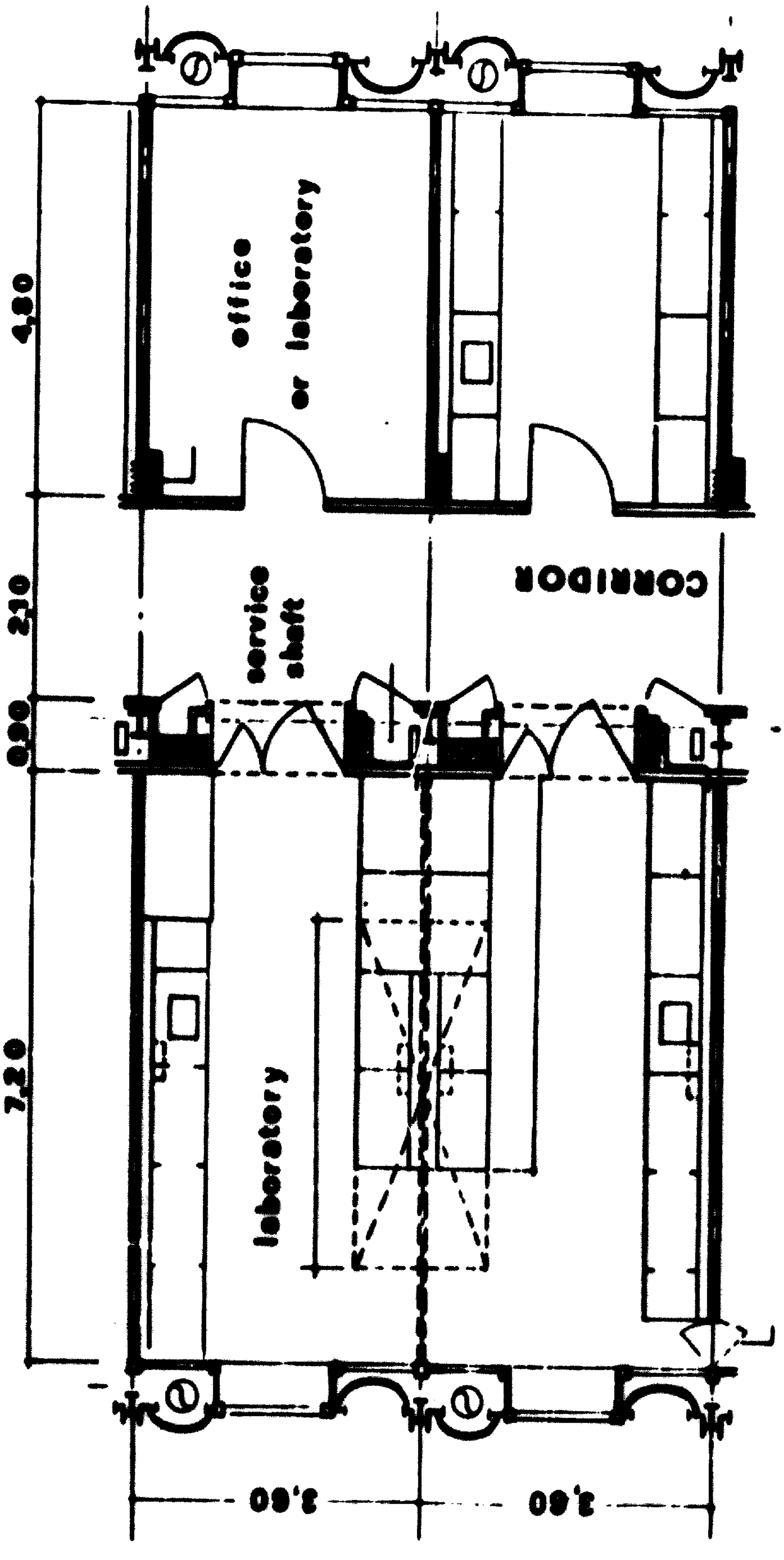


Fig. 13 CERN laboratories : typical plan

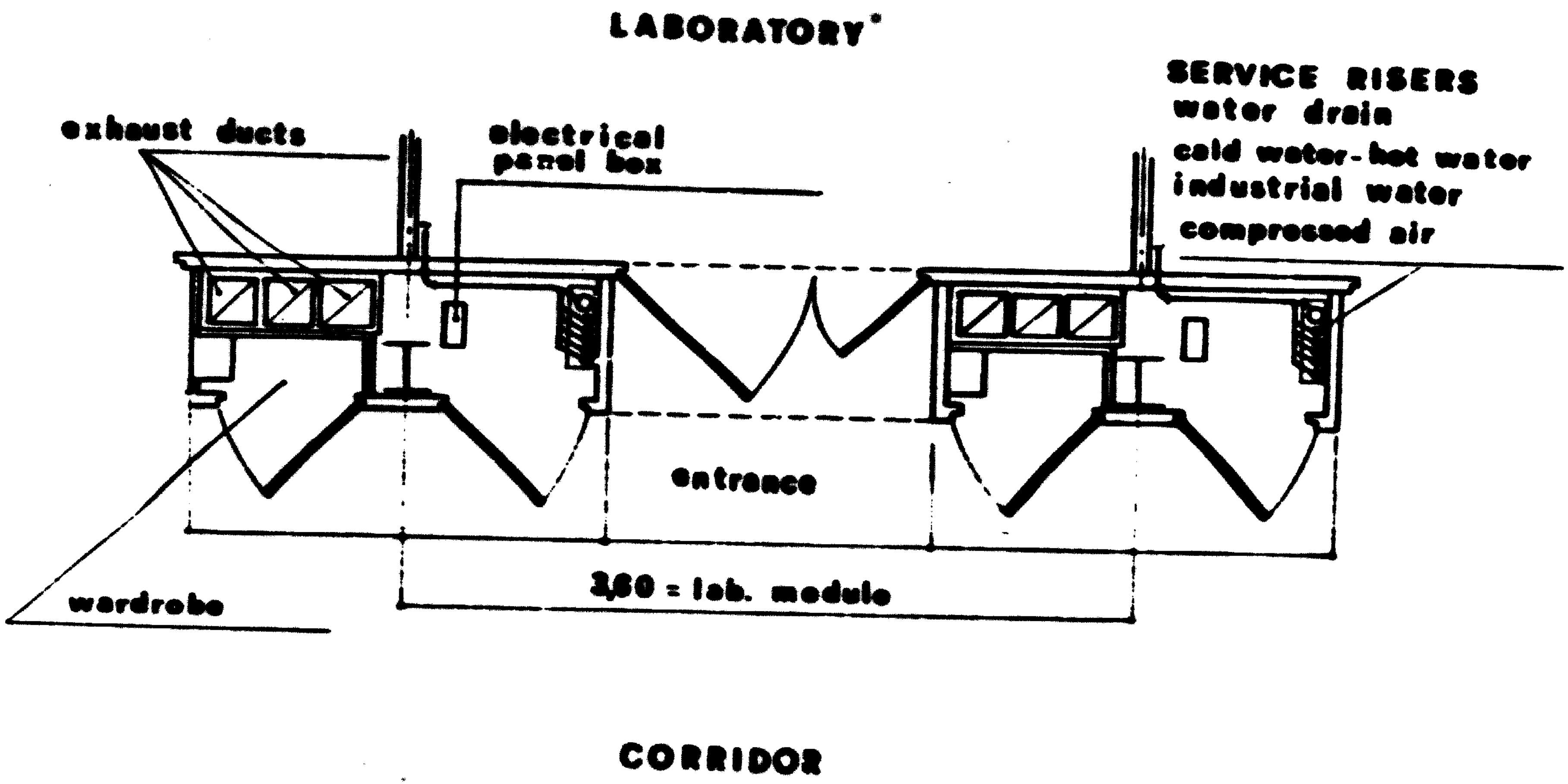


Fig. 14 Detail of entrance area to a laboratory with services plant

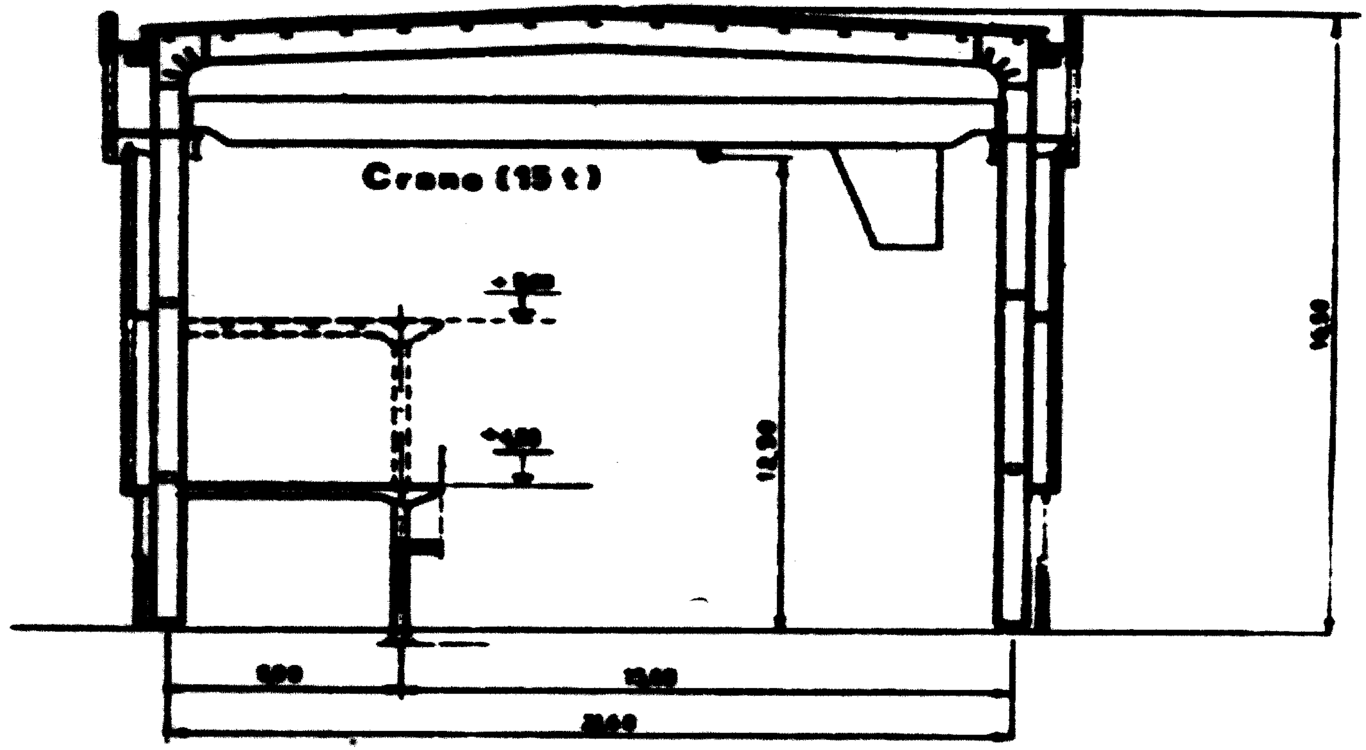


Fig. 15 CEN pilot plants : typical section

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LIMITED

ID/WG.146/112 Corr.1
4 October 1973

ENGLISH ONLY

United Nations Industrial Development Organization

Third Interregional Symposium on the Iron and Steel Industry

Brasilia, Brasil, 14 - 21 October 1973

Agenda item 8

CO-OPERATIVE RESEARCH IN ITALY A COUNTRY WITH A RECENTLY DEVELOPED STEEL INDUSTRY; TECHNICAL AND ORGANIZATIONAL PROBLEMS AND POSSIBILITIES FOR INTERNATIONAL COLLABORATION

by

Oscar Masi
Centro Sperimentale Metallurgico
Italy

Corrigendum 1

Page 8, table at foot of page — Line 2 should read :

1952-1954 79.2 80.4 86.4 87.7

Page 11, table — Line 1 should read :

1929-1931 <0.1 0.3 0.8 1.8

Page 25, line 3 — Should read : "... a maximum depth of about 7.20 m".

line 4 — Should read : "... and 4.80 m for the offices ..."

line 6 — Should read : "... to be about 3.60 m ..."

Page 27 — In table at foot of page, the total floor areas should be shown as totalling 32,450 m^2 (omitted in original). The water cleaning plant capacity should be corrected to 1250 m^3/day, the working voltage to 380/220 V, and the electricity supply capacity to 3420 kW.

Page 29 — The items in the table at the end of Section 6 should be as follows :

For each employee (530)

For each research worker (456)

For each graduate research worker (116)

Page 34

In the table, the following correction should be made to the fourth item :

Technical	2	750	1500
services	2	100	200

The figure for total capacity should therefore be amended to 7200 kVA.

3. 9. 74.