

COMMISSION OF THE EUROPEAN COMMUNITIES

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MEMORANDUM

on the implementation of an iron and steel
research programme, with a view to obtaining
financial aid under Article 55 (2) (c) of
the ECSC Treaty

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M E M O R A N D U M

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I. I N T R O D U C T I O N

The ECSC programme of research and development on iron and steel for 1982 presented in this memorandum consists of projects that have been selected from a total of 200 proposals that were submitted to the Commission of the European Communities requesting aid under Article 55, 2(c) of the ECSC Treaty. After detailed examination of the requests by the services of the Commission in collaboration with the Iron and Steel Technical Research Committee, 81 proposals have been selected as first priority and included in this programme.

In an effort to concentrate the ECSC resources on those projects that correspond most closely to the criteria outlined in the medium-term orientation for steel research (1981-85)* priority has been given to proposals having the following overall objectives:

- to improve industrial competitiveness by reducing production costs and improving the product and
- to promote steel as an engineering and structural material through studies of the service properties and utilisation of steel.

The technical scope of the proposed programme covers various aspects of process-oriented and product-oriented research and the level of funding for the different fields is as follows:

ironmaking 9,9 %; steelmaking 21,2 %; rolling mills and mechanical working 18,2 %; measurements and analysis 15,8 %; properties and service performance 29,5 % plant availability 4,6 % and miscellaneous 0,8 %.

The achievement of economic benefits through the reduction of operating costs, enhancing productivity and energy saving are major objectives of the proposals in the production and processing parts of the programme.

The research in blast furnaces, for example, is directed at improving and refining present control procedure to raise productivity and lower fuel requirements. In the casting and solidification of steel, all six projects concentrate on further development of the continuous casting process with its attendant higher metal yield (greater than 10 %) and energy savings in comparison with conventional ingot casting. The objectives of this work are to improve product quality, broaden the applicability of the process

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and obtain further energy economy based on greater continuity between the steelworks, casting machine and hot rolling mill. Progress in this area is particularly important for the Community's industry since some 40 % of steel production is now continuously cast and this will increase considerably in the future.

Other projects on production include future studies of charge preheating in electric furnace steelmaking using waste gases, the direct utilisation of unfired refractories and the development of heat exchanges for rolled products all of which are concerned with energy saving.

In rolling mill technology, research aimed at reducing both investment and operating costs is proposed by developing a rolling and continuous annealing line in which strip pickling is eliminated. Also there are projects dealing with the improvement in the quality and mechanical properties of mill products.

A major part of the research on measurements and analysis deals with quality assessment and inspection as well as the demand for higher quality standards particularly with regard to the shape and surface finish of long and flat products. Also, to achieve better control of production operations further work will be undertaken to improve the accuracy, speed and reliability of chemical analytical methods.

Research and development in the field of service properties and utilisation has the important task of promoting steel in the user sector and creating new market opportunities. As a consequence of the wide variety and diversity of steel products the projects in this sector of the programme cover a range of subjects from the weldability and formability of steels to alloy and special steels. The concern for energy is again evident in the projects on the fracture behaviour of gas transmission pipelines and the study of high temperature steels used in power generation plant. Also studies are proposed on non-oriented electrotechnical steel strip for electrical engineering applications.

Finally, in the field of plant availability attention is drawn to the high utilisation of continuous casting plant and the heavy demands placed on engineering reliability. As a consequence maintenance has become an item of major importance in plant operation and research will be undertaken to reduce its significant cost.

The financial aid for the 81 research proposals below amount a total of 18.750.000 ECU. To this is added 250.000 ECU for ancillary costs and dissemination of information, giving a total financial commitment of 19.000.000 ECU.

II. THE RESEARCH PROJECTS

II.1. ORE REDUCTION

II.1.1 Sinter

The three projects have the following aims:

- increased reducibility of high-grade ore sinter with low degradability when hot (P1103)

- examination of factors affecting the formation of the cohesive zone with a view to optimizing the sintering process (P1116)
- use of coal/water slurries for firing in the ignition hood of a sintering plant. Where fly ash is not a problem, gas and oil will later be replaced by coal/water slurry in the entire plant. .

P 1103: High reducibility of sinter with low degradability

Research will be carried out on improving the reducibility of the sinter and reducing its degradation. The following parameters will be examined:

- amount of solid fuel in the mixture
- height of bed and density of the sinter mixture
- ignition conditions (duration, temperature, quantity of heat).

The results will be assessed in relation to:

- sinter quality (reducibility, cold and hot strength)
- productivity
- Energy-saving

Tests will be run first of all on a pilot plant (40 cm x 40 cm) at the CSM and then on an industrial plant with a downdraft area of 400 m² at Italsider in Taranto.

Applicant: Italsider - Genova
Budget: 588.000 ECU
Duration: 3 years

P 1116: Factors determining the cohesive zone in grate sintering of high-grade ores

A fluid phase, originating from the fines, is formed during sintering and takes the iron oxides into solution. The effects of this fluid phase on sinter operation will be examined. Although a high content of fines promotes the formation of the fluid phase, it has a negative effect on permeability. Attempts will be made to restrict the width of the cohesive zone and to bring it into a temperature range where rapid dissolution of the iron oxide can be expected.

The tests will be carried out in the sintering pan on high-grade ores with high and low phosphorus contents. The following parameters will be varied:

- particle sizing and type of fluxing agents
- additions determining the micropelletization of the fines.

Applicant: CRM - Liège
Budget: 401.000 ECU
Duration: 3 years

P 1265: Flames of coal/water slurry

The ignition hood of a sintering plant will be converted for firing with coal/water slurry (ratio 70:30). Two problem areas will be studied:

- the combustion characteristics of the slurring (flame length, shape and intensity, type of coal, ignition stability, burner operation, waste gas composition)
- the handling of the coal/water slurry (dry grinding, wet grinding, stability during pumping, distribution and control).

Studies on the transport properties of the slurry will determine whether a central grinding plant should be built for the entire steelworks.

Applicant: Estel Hoogovens - Ymuiden
Budget: 322.000 ECU
Duration: 3 years

II.1.2. Blast furnace

Projects P 1101 and P 1137 are designed to improve and refine blast furnace control. In the first project the descent of the charge will be included in the control model and in the second the control of the silicon content in the metal.

In P 1115 coal combustion with superheated blast in a plasma medium will be studied on a pilot plant.

The final project P 1231 is designed to study a new method of measuring the rates of descent of coke and ore by means of electrical conductivities.

P 1101: Correlation between profile and reduction of energy consumption in modern blast furnaces with bell-less top

A blast furnace control model will be developed which takes into account the horizontal profile of the burden and the radial gas distribution. To this end, a probe attached to the side of the blast furnace in the radial direction will be used to determine the temperature in the blast furnace, the gas composition and the gas throughput. Temperature and material distribution will be determined for different charging programmes. The correlation between a specific charging programme and distribution of the burden over time will then be established. Finally, charging conditions will be established which guarantee a good, uniform flow through the burden and hence minimum energy consumption.

Applicant: Italsider - Genova
Budget: 656.500 ECU
Duration: 2 1/2 years

P 1137: Model to predict the silicon content in the metal in the blast furnace

Studies will be carried out in three phases:

- Development of a mathematical model to describe the silicon exchange between metal, slag and gas phase (SiO). The model will take account of the counter-flow conditions in the blast furnace.
- Experimental physical and chemical studies of silicon transport in the blast furnace. The thermodynamic and kinetic data will be determined in melting experiments in the laboratory (induction and resistance furnaces).
- Incorporation of the model into an existing control model for the blast furnace.

This will be completed by an economic analysis, which will also include the subsequent conversion of the pig iron into steel.

Applicant: IRSID - St. Germain-en-Laye
Budget: 492.000 ECU
Duration: 4 years

P 1115: Coal combustion with superheated blast in a plasma medium. Simulation of blast furnace conditions

The kinetics of coal combustion will be studied. This includes the following parameters:

- particle sizing, type of coal
- blast temperature (up to 2000 ° C) and
- oxygen content of the blast (up to 25 %).

Tests will be carried out in a pilot furnace and conditions in the blast furnace at the tuyeres will be simulated.

Applicant: CRM - Liège
Budget: 261.000 ECU
Duration: 2 years

P 1231: Method of determining the burden material in a blast furnace shaft measuring electrical conductivity

A measuring technique will be developed and tested in order to monitor:

- (a) the distribution of ore and coke near the blast furnace wall, and
- (b) the rate of descent.

The measuring technique is based on the different electrical conductivities of coke and ore (or reduced ore). The initial phase of this project will consist solely of laboratory tests (outside the blast furnace), including:

- measurement of the electrical conductivities of various burden mixtures
- selection of electrode materials and construction of electrodes
- development and construction of the electronic measuring device
- processing of the measurement results so that they can be applied to an existing blast furnace model.

Applicant: Thyssen - Duisburg
Budget: 364.000 ECU
Duration: 2 years

II.2. STEELMAKING

II.2.1. Casting and solidification

In the near future the integration of steel plant, continuous casting machine and rolling mill in a single line without reheating will be one of the main aims in the efforts to save energy in steelmaking. Projects P1096 and P 1118 pursue this aim for two different applications.

In projects P1140 and 1117 a technology is to be developed for the continuous casting of extra-mild steel grades. These are grades which have up to now been cast solely as rimming steel in ingot form.

Projects P1141 and 1238 are designed to improve the surface of a continuously cast product. Both will investigate the formation of reciprocation marks and the surface defects they cause. Process modifications and metallurgical methods will be used to reduce the incidence of such defects. Above all, the need for subsequent mechanical surface dressing is to be eliminated for aluminium-killed steels with a low carbon content and for austenitic stainless steels.

P 1096: Development of direct strand reduction for steel

This is the continuation of the work described in the memorandum of 26 February 1980 under P 889.

It will be recalled that the research work described under P 889 was to be financed in three stages. This is the second stage (20 % of 2.852.000 ECU).

Applicant: Krupp - Essen
Budget: 2.880.000 ECU
Duration: 3 years

P 1118: Energy conservation by incorporating steelplant, continuous casting and rolling mill in a single hot line

First of all a mathematical model for the warm and hot input of slabs will be built.

Then practical experiments will be carried out in a steelworks having an annual production of 1 million tonnes (100 % continuous casting). At first 5 % and later up to 25 % of the slabs will be used hot.

The research programme concentrates on the following:

- change in enthalpy of the slabs between continuous casting and reheating furnace
- correlation between casting conditions and surface quality
- operation of the reheating furnace.

Applicant: CRM - Liège
Budget: 744.500 ECU
Duration; 4 years

P 1140: Improvement of continuous casting for extra-mild steel grades with a low content of deoxidizing elements

The following programme is planned.

The molten steel will be deoxidized in vacuum with carbon.

After deoxidization, denitriding with titanium or zircon, also in vacuum, will be carried out. The most recent ladle technology will be used for the melts.

Then plant on a semi-industrial scale will be used to cast 105 mm square

billets and later slabs of 200 x 800 mm.

The casting will be done with covered hot metal. An optimum covering slag will be used. During the solidification process electromagnetic stirring will be used to improve the solidification structure.

The experiments will be carried out on a semi-industrial scale.

Applicant: IRSID - St. Germain-en-Laye
Budget: 556.500 ECU
Duration: 4 years

P 1117: Development of a low-silicon and low-aluminium grade steel for continuous casting

Here too the aim is to produce an extra-mild steel. The following experiments are planned and will be coordinated with project P 1140.

A steel that is only very slightly over-oxidized will be produced by combined blowing in an industrial converter. The refining process will therefore be stopped with a higher final carbon content than usual.

After refining, vacuum treatment will be carried out in which the residual carbon will first act as a deoxidant so that only very small quantities of deoxidizing agents (Si, Al, etc.) are necessary. The aim is to obtain a mild steel suitable for continuous casting.

At the same time there are plans for laboratory experiments that will serve as a guide for the industrial tests that follow them.

Applicant: CRM - Liège
Budget: 519.000 ECU
Duration: 4 years

P 1141: Control of the formation of reciprocation marks and associated defects

The factors affecting the formation of reciprocation marks are to be investigated both in industrial operation and on a laboratory scale.

The following variables will be investigated in the works: oscillation frequency and amplitude, pouring speed, properties of the lubricants (casting powder, oil), steel grade, overheating and the movement and convection of the hot metal.

On a pilot scale various mould materials will be tested with a view to varying the heat transfer and surface tension between the mould and the hot metal. It is planned to use copper alloys, mild and stainless steels, cast iron and also ceramic materials and graphite as mould materials.

Applicant: IRSID - St. Germain-en-Laye
Budget: 407.000 ECU
Duration: 4 years

P 1238: Reduction of reciprocation marks by high-frequency vibration of the continuous casting mould

In this project the following technological measures will be taken in an effort to eliminate reciprocation marks:

- high-frequency (20 - 100 Hz) and low-amplitude (approximately 1 mm) movement of the mould
- longitudinal oscillation in the direction of withdrawal, preferably at resonant frequency.

The research programme consists of three parts:

1. Design and construction of the vibration equipment
2. Production of billets from:
 - (a) low-carbon aluminium-killed steels
 - (b) stainless steels
3. Metallurgical examination of the surface and grain structure of the products.

Applicant: BSC - London
Budget: 192.000 ECU
Duration: 2 years

II.2.2. Steelworks: metallurgy

The aim of this project is to prevent slag from running out during tapping in large LD converters (300 t). To this end, a method of measuring which can detect slag residue near the converter mouth will first be developed. Suitable measures will then be developed to retain the slag.

P 1239: Development of improved slag detection and retention in BOS vessels and the effect of certain aspects of steel quality

Three aspects will be studied in this project:

1. A technique of rapid slag detection will be developed, and, to this end, the suitability of electromagnetic coils or electric cells will be examined.
2. In the second stage of the project, rapid-action methods of retaining the slag will be developed, both mechanical rapid-action systems and pneumatic methods being studied.
3. The third part of the project is designed to show the improvement in the quality of the steel obtained, especially in respect of the low level of sulphides and oxides present.

Applicant: BSC - London
Budget: 226.000 ECU
Duration: 2 years

II.2.3. Steelworks: technology

The aim of the project is the preheating of scrap in the electric arc furnace by means of waste gas. Two previous projects backed by the ECSC dealt with continuous preheating processes whereas this particular case (P1138) involves a discontinuous process in which the scrap is preheated up to about 500 ° C either directly in the cage or in a specially designed preheating chamber.

P 1138: Preheating of scrap with electric furnace waste gas from the combustion chamber

The process, which will be tested as part of the project, requires the following components: a combustion chamber connected to the electric furnace with the main purpose of regulating the waste gas temperatures, the actual preheating device, in which the scrap, where possible, can be put into charging cages, plus an exhaust system and gas cleaning.

The investigation will be in three stages.

1. First of all, the amounts of waste gas and energy will be determined as a function of the operating method of the electric furnace (with and without additional heating with oxy-fuel burners). In addition, the optimum heat exchange between waste gas and scrap will be established.
2. This will be followed by experiments on 7 t pilot furnaces, with about 10 experimental melts.
3. The third part of the investigation will be carried out on an industrial arc furnace. Some 40 experimental melts are planned, during which the amount and composition of the waste gases, operating parameters and dust will be determined.

Applicant: IRSID - St. Germain-en-Laye
Budget: 398.500 ECU
Duration: 3 years

II.2.4. Special processes

The project described below involves a special application of electroslag remelting. An earlier project, likewise based on electrodes made from metal powders, produced bimetallic cylinders, whereas this project is designed to produce hollow cylinders.

P 1165: ESR production of hollow ingots from metal powders using tubular electrodes

Three investigation phases are planned:

- In the first phase the remelting plant will be designed and constructed. Mould and mandrel will each be made up of two component parts, the lower part being of water-cooled copper components, and the upper part, containing the melts, of refractory material.
- The electrodes will then be produced in the second phase. These consist of two concentric thin-section tubes with the interspace filled with metal powder mixtures of the required composition. Industrial-size electrodes will then, if necessary, be heated up to 1.000 - 1.200 ° C in order to sinter the powder.
- The third phase consists of the production of hollow ingots. Both the operational parameters of remelting and the quality of hollow ingots obtained by this method will be determined.

Applicant: CSM - Roma
Budget: 469.500 ECU
Duration: 3 years

II.2.5. Refractories

Depending on the steelmaking method, refractory consumption in Community countries is between 14 and 18 kg refractory/t crude steel. Both of the following projects are designed to reduce the cost of refractories.

Firing is a major cost factor in the production of refractory bricks, the firing energy being between $1 - 3.5 \times 10^6$ Kcal/t refractories. A large part of this energy will be saved (P1080) by using dried (or annealed) bricks instead of fired bricks, which are then "fired" during operations.

Project P 1242 will attempt to combine the technical and economic advantages of the acid lining (low heat conductivity, low weight, low costs) with the metallurgical advantages of basic lining (lower endogenous steel contamination through O_2 and S).

P 1080: Energy saving by using unfired refractory materials

The possibilities and limits of energy-saving with low-energy brick will be determined.

The performance of these bricks will then be tested under operating conditions in torpedo and casting ladles.

Finally, the advantages and disadvantages of these bricks will be quantified in comparison with the bricks formerly used.

The project provides for laboratory and industrial experiments to determine the chemical, physical and mineralogical behaviour. The main aspect in the industrial experiments will be performance with slags of differing CaO/SiO_2 composition.

It is planned to examine highly aluminiferous materials (45 - 90 % Al_2O_3) and aluminiferous materials with the addition of $ZrSiO_4$.

Applicant: Estel Hoesch - Dortmund
Budget: 641.000 ECU
Duration: 3 years

P 1242: Application of thin basic facings to steel ladles

Experiments will be carried out on a 4 t test ladle. The basic ladle facing will be about 20-30 mm thick and applied both after cold spraying (aqueous suspension) and hot spraying (oxy-fuel burner).

The main factors to be investigated are

- contact time with molten steel and slag;
- slag composition;
- effect of temperature cycles on adhesive strength.

The melts will be stirred with inert gas. Aggressive desulphurization slags (70 - 80 % $CaO + 20 - 30$ % CaF_2) will be used. The experimental conditions will be based on practice as regards duration and temperature.

Applicant: BSC - London
Budget: 166.000 ECU

Duration: 2 years

II.2.6. Theoretical metallurgy

The projects deal exclusively with theoretical research on slags, with the aim of

- making maximum use of reaction slags,
- selecting the optimum slag composition,
- regenerating slags to the maximum in order to reuse components that are not exhausted, and
- reducing dumping costs.

P 1189: Thermodynamic research on slags and recirculating materials

The project is divided into two parts:

1. Optimization of slag composition for post-refining desulphurization and dephosphorization as a function of composition, oxygen activity and reaction temperature.
2. Determination of thermodynamic data in problem materials of iron and steel production for the systems Fe-O-X, where X = Cd, K, Na, Pb, Sb, Sn and Zn.

The studies will be carried out at the 'Max-Planck-Institut für Eisenforschung' and at the 'RWTH Aachen'.

Applicant: VDEh - Düsseldorf
Budget: 488.500 ECU
Duration: 3 1/2 years

II.2.7. Energy in steelindustry

The aim of project P 1192 is to recover the energy stored in rolling stock.

P 1192: Improvement of energy utilisation by heat exchangers for cooling or preheating rolling stock

The following studies are planned:

- Development and preheating of rolling stock
- Flow tests on cold and hot models plus tests on the type of heat transfer with regard to the form of the rolling stock
- Construction and testing of a pilot plant

Applicant: VDEh - Düsseldorf
Budget: 861.000 ECU
Duration: 3 1/2 years

II.3. MECHANICAL WORKING

II.3.1. Reheating furnaces

The market share of microalloyed steels has been steadily increasing in

recent years. If full advantage is to be taken of the mechanical properties of these steels, they must be worked under precisely controlled conditions.

The aim of Project P 1166 is to adapt furnace control to the requirements of these steels. The control model to be built will take into account parameters such as austenitic grain size, the state of the precipitates and scaling.

Project P 1191 is intended to improve control technology for reheating furnaces in general. The control of reheating furnaces is to be improved by incorporating microcomputer technology with the aim of saving energy.

P 1165: Analysis of microstructural and oxidation processes in rolling-mill reheating furnaces and their incorporation in optimum process control

A control model for an industrial slab reheating furnace is to be produced. The following preliminary work is planned:

1. Analysis of the microstructural evolution of C-Mn steels and microalloyed (Nb, V, Ti) low-carbon steels.
2. Analysis of oxidation phenomena, morphology and technological properties of the scale.
3. Development of an automatic control system taking into account:
 - heat exchange patterns under different operating conditions
 - automatic adaptation of the model to the prevailing conditions
 - the need to minimize fuel consumption
 - the need for on-line temperature control in various areas of the furnace.
4. Testing of the complete model on an industrial reheating furnace with a production of 200 t/h.

Applicant: CSM - Roma
 Italsider - Genova
Budget: 598.500 ECU
Duration: 3 years

P 1191: Investigation of energy conservation potential in reheating and heat-treatment furnaces with the use of modern control procedures

The following research stages are planned:

1. Design and construction of an experimental furnace and its instrumentation
2. Building of the dynamic furnace model in the form of equations of state
3. Connection of a microcomputer to the experimental furnace
4. Programming and implementation of the control principles and algorithms
5. Testing of the complete installation to verify the structure of the dynamic furnace model
6. Experiments to ascertain energy consumption with various control algorithms, if necessary varying the quality criterion to minimize energy consumption
7. Evaluation of the results.

Applicant: Wuppertal University - Wuppertal
Budget: 299.500 ECU
Duration: 3 1/2 years

II.3.2. Hot rolling mills - bars and sections

The research aims in this sector are as follows:

- computer-aided system for automatic roll pass calculation and design, and calculation of the material flow according to the theory of plasticity (P 1126)
- the search for a correlation between specific surface defects (cracks, exposed and enclosed pores), rolling parameters (degree of deformation, pass sequence and design) and surface quality (P1145)
- investigation of the most suitable way of making high-strength cable wires ($\sigma_B = 2000 \text{ N/mm}^2$), involving a comparison between the production cycles "continuous casting/hot rolling/controlled cooling" and "direct wire drawing" (P 1167)

The aim of project P 1246 is to establish the areas of application of computer-aided manufacture and robotics which can be applied in existing rolling mills.

P 1126: Integrated computer-aided system for roll pass design

The following work is planned:

- Adaptation of computer-aided design to the problems of grooved rolls. The model should allow the designer to display his draft so that he can assess the pass design visually, thus obviating the need for costly rolling tests. This should reduce design time by a third.
- Development of a simulation model on the computer for deformations in roll passes using a non-linear programme of finite elements.

Applicant: Arbed - Luxembourg
Budget: 679.000 ECU
Duration: 4 years

P 1145: Changes in surface defects during the rolling of bars and sections

Research into the transfer of surface defects will be carried out on the finishing stand of an industrial wire mill. The defects will be tagged with radioactive substances at the first stand. In some cases typical defects will be produced artificially.

Laboratory research will be carried on at the same time to investigate the parameters affecting the changes in defects by means of simulation tests on plasticine (rolling speed, contact pressure and tension). The roll pass parameters will also be studied (shape and rounding).

In addition to the tests with plasticine, a limited number of trial rolling operations on an experimental rolling mill are planned.

To conclude the work, a mathematical model of the material flow will be built using the method of finite elements.

Applicant: IRSID - St. Germain-en-Laye
Budget: 478.000 ECU
Duration: 3 years

P 1167: Improvement of the mechanical properties of eutectoid wire rod suitable for direct drawing, made from cast billets

The following research programme is planned:

- Experimental vacuum-cast ingots of 100 kg will be prepared so as to obtain steel with the desired mechanical properties. Steel of traditional composition (C = 0.80 % and Mn = 0.80 %) will be used as a starting point and the alloying elements Si, Cr, V and B will be added.
- Segregation and undesired structures will be investigated.
- Industrial melts (about 90 t) of the two or three best steels will be made. These will be followed by controlled cooling in a Stelmor installation.

A limited number of rod coils will be drawn into fine wire in a modern wire drawing plant, the main aim being to ascertain the drawability of these steels.

Applicant: CSM - Roma
Budget: 574.000 ECU
Duration: 2 1/2 years

P 1246: Computer-aided manufacture and robotics in rolling mills

The aims are to establish (a) those areas where computer-aided manufacture and robotics can be applied in existing rolling mills and (b) a concept of a future mill with a fully integrated system. The results are intended to provide guidance in the short and medium term for the definition of research projects in this field.

The project covers bar and rod mills, billet mills, narrow strip mills (hot and cold) and cluster mills of the Sendzimir type.

Applicant: BSC - London
Budget: 128.000 ECU
Duration: 2 years

II.3.3. Hot rolling mills - flat products

Although initially the hot strip mill served mainly to produce mild steel coils for subsequent cold rolling, it has recently been used more and more to produce high-strength steel grades (up to X70) for direct fabrication (e.g. longitudinally and spirally welded pipe). This calls for much more accurate temperature control during the rolling process.

Consequently, P 1114 is intended to optimize control of the rolling process with a view to microstructure.

Project P 1146 has a similar aim. It will investigate the suitability of existing coiling systems for thermo-mechanical treatment of the steels, taking into account the mechanical, metallurgical and thermal aspects.

Continuous casting plants operate most economically for long production runs

of very wide products. However, the hot strip mill requires varying slab widths. To operate a continuous hot line it is therefore essential to find ways of obtaining large width reductions between the continuous casting machine and the hot strip mill. This is the aim of Project 1200.

P 1144: Metallurgical optimization of rolling conditions in the continuous hot strip mill

The research programme covers high-strength structural steels and high-strength grades for longitudinally and spirally welded pipe. The following parameters affecting the quality of the finished product will be quantified:

- reheating temperature of the slabs (solution of precipitates)
- rolling in the roughing stand (distribution of deformation work, austenitic grain size, temperature of the individual passes)
- rolling in the finished stand
- cooling of the strip, coiling temperature and cooling during coiling.

These data will be processed in an existing mathematical model which will be tested in industrial conditions. The research will be carried out partly on a hot twisting machine, partly on pilot rolling mills and cooling equipment in the laboratory and partly in industrial operation.

Applicants: IRSID - St. Germain-en-Laye

Usinor - Dunkerque

Budget: 478.000 ECU

Duration: 3 years

P 1146: New coiling procedures on the wide strip mills

For the purposes of thermomechanical treatment, coiling will be carried out at temperatures of 200 - 800 ° C in an industrial hot strip mill. The following four points will be investigated:

- mechanical aspects of coiling
- metallurgical aspects at low temperatures
- metallurgical aspects at high temperatures
- thermal aspects.

Applicant: IRSID - St. Germain-en-Laye

Solmer - Fos sur Mer

Budget: 541.000 ECU

Duration: 3 years

P 1200: Development of methods of obtaining high drafts in the production of wide strip

For the purpose of developing new width reduction procedures, the following methods will be investigated:

1. Central edging. Here the slabs will be locally deformed in the vertical direction but not at the ends. The bulges formed will be levelled out again by a subsequent horizontal pass. This method might be suitable for cases in which the slabs subsequently have to be cut.

2. Simultaneous reduction of width and height. A uniform end configuration can be obtained by simultaneous vertical and horizontal deformation. Several passes would be used.

Applicant: BFI - Düsseldorf
Budget: 989.500 ECU
Duration: 3 1/2 years

II.3.4. Cold rolling mills

In project P 1119 an attempt will be made to produce cold strip from hot strip without prior pickling.

P 1119: Continuous control - rolling without prior descaling

In this research project, to be carried out in industrial operation, the scale will be removed from the hot strip by mechanical methods alone. The coils will immediately be cold rolled and then continuously annealed (in a reducing furnace atmosphere).

In this procedure, the following points will be investigated more closely:

- the surface quality of the cold strip
- the thickness tolerances of the strip
- roll wear
- removal of scale from the rolling lubricant
- formation of deposits on the furnace rollers
- monitoring of furnace atmosphere

Applicant: CRM - Liège
Budget: 753.500 ECU
Duration: 4 years

II.3.5. Miscellaneous

Starting with experimental data, project P 1245 will investigate the theoretical principles for the straightening of flat products and sections. The results should help to improve both the product and the manufacturing process.

P 1245: Studies of straightening and levelling operations for plate

The research is divided into a theoretical and an experimental section.

(a) Theoretical research

- Calculation of the temperature pattern on the product and the resultant residual stresses
- Calculation of the initial state on entry into the straightening and levelling machine and the effect of differentiated cooling on thermal stresses
- Advance calculation of the final geometrical state

(b) Experimental work

- The theoretical research will be backed up by experiments:
- measurements on the straightening and levelling machine (stiffness, forces)
- measurements of temperature distribution
- determination of material properties

Applicant: BSC - London
Budget: 156.500 ECU
Duration: 2 years

II.4. MEASUREMENTS AND ANALYSIS

In line with the approach adopted in recent years, the main aims of the selected projects are to improve quality and increase profitability.

In considering the quality criterion, a distinction must be drawn between the intrinsic quality of the product and the quality of assemblies and structures; different methods of assessment are called for and, in the latter case in particular, account must be taken of the safety factor, which has considerable economic implications.

The continuous research effort required here is mainly due to changing requirements (standards and specifications) concerning acceptability criteria but also to some extent to Japanese domination. It is not only in technological investment that Japan is outstripping the Community, but also in the speed with which it derives practical applications from its research results, leading to the use of new methods and apparatus.

A further factor of general interest to the steel industry is that most of the results, whether they concern non-destructive inspection and testing, metrological and dimensional aspects or analyses of all kinds, are also an essential basis for the automation of plant.

P 1168: Hot ultrasonic inspection of slabs to optimise shearing

The shearing of a slab in the part containing the shrinkage cavity is at present an empirical operation involving successive approaches by a skilled operator.

In order to make the operation more efficient it is essential to be able to ascertain the exact position of the shrinkage cavity. This is the aim of the research project. The CSM in Rome has already developed and constructed an ultrasonic probe operating dry by impulse pressure under an earlier ECSC-aided research project No. 7210-GA/413.

There will be a special detection system and the probe will be protected against heat to allow observations at temperatures around 1200 ° C.

The thickness inspected will not be more than 600 mm and the minimum defects observed will be around 5 mm.

A network of probes will examine an area 600 mm wide by 300 mm long. The system will have an electronic unit to interpret signals and consideration will be given to automation.

Applicant: CSM - Roma
Budget: 404.000 ECU
Duration: 3 years

P 1208: Development of ultrasonic analysis of steel structure

This project has two objectives, one of which is to examine and analyse the microstructure of steels and the other to develop an ultrasonic probe with wide coverage to avoid scanning movements.

The work will be based on results obtained in two previous ECSC-supported research projects consisting of comprehensive theoretical and experimental studies in single-phase microstructures. The aim of the project will be to extend the scope to the characterization of multi-phase structures (pure perlite, ferrite-perlite, bainitic-ferrite, etc.).

Furthermore, an ultrasonic probe will be designed and constructed so as to obtain reflection curves without moving the apparatus. This electromagnetic ultrasonic transducer will operate dry, without coupling liquid, which will make it insensitive to temperature effects and to the surface state of the materials under examination (see ECSC project 7210-GA/118). Measuring frequencies should reach at least 20 MHz. Once these two objectives have been attained, industrial trials will be carried out with a view of adapting the method and equipment to the requirements of an industrial site.

Applicant: Institut für zerstörungsfreie Prüfverfahren - Saarbrücken
Budget: 337.000 ECU
Duration: 2 1/2 years

P 1261: Quality control by automatic ultrasonic inspection of plate quality in the production line

This project is a logical technical follow-up to project No 6210-GA/1/102 which yielded excellent results in industrial operation.

It is designed to make use of the experience gained with the proven ultrasonic method and the aims are as follows:

(a) To gain wider experience of the computerized evaluation system developed during the previous project:

- long-run tests under actual conditions to study a wider range of steel grades; comparison of the results obtained by automatic inspection and data-processing, manual inspection, laboratory measurements using focus sensors and destructive testing.

(b) To include in the system and to test other specifications:

analysis of the evaluation parameters concerned
formulation of general evaluation guidelines
conversion into computer programmes

comparative evaluation

(c) To optimize the evaluation system on the basis of the experience gained:

evaluation of results
speeding up of data flow for higher inspection speeds
analysis and correction of interference signals.

Applicant: **Institut für zerstörungsfreie Prüfverfahren - Saarbrücken**
Budget: 195.000 ECU
Duration 1 1/2 years

P 1150: Continuous measurement of the shape of hot-rolled bars and sections

In the rolling of bars and sections, as indeed in other fields, the ability to keep to closer dimensional tolerances is a competitive advantage, a quality factor and helps to save energy and raw materials.

The aim of the project is to develop a cross-section measuring method and to design apparatus. It is based on recent successes in shape monitoring in the field of robotics. A laser beam directs a spot of light onto the surface of the product and the beam is swept over a plane so as to provide an image of part of the contour to be studied.

The programme to construct a gauge of this kind will be broken down into four successive parts:

1. Construction of a measuring system having a source and two receivers with processing of the associated signal
2. Testing of the system in the laboratory and then on a bar mill to assess its metrological performance and its behaviour in an industrial environment
3. After any modifications that prove necessary, construction of a multi-sensor gauge that can describe a full cross-section
4. Experiments on rolling mills at various stages, roughing, finished products

Applicant: **IRSID - St. Germain-en-Laye**
Budget: 493.500 ECU
Duration: 3 years

P 1155: Non-destructive monitoring of surface decarburization

A monitoring method using sampling, or even better covering 100 % of production, obviously provides a way of detecting production hitches and thus avoiding the finishing and dispatch to customers of defective products. It is also a way of improving production; although the economic aspect is confined to the reduction of costly disputes, there are also obvious psychological advantages.

Two electromagnetic methods of defining surface decarburization will be compared:

- (a) use of the Barkhausen effect;
- (b) use of eddy currents.

In order to restrict the scope of the research, the work will be focused on

products of large cross-section.

After several series of tests and inspections, the parameter or parameters representative of the depth of surface decarburization will be identified and the characteristics of a sensor and electronic measuring system capable of carrying out this monitoring operation will be defined.

Applicant: IRSID - St. Germain-en-Laye
Budget: 287.000 ECU
Duration: 3 years

P 1206: Digital image processing and automatic image evaluation in radiation testing

A research project on the radiographic inspection of steel is already under way (ECSC Agreement No 7210-GF/301). The project described here offers the advantage of complementary technical work.

The aim is to replace the human eye by an automated computerized system for the examination and interpretation of industrial radiographs.

The work will cover four fields:

1. Optimization of radiograph processing to improve contrast, clearness of outline and compensation for darkening
2. Computerized image processing
3. Establishment of a classification of defects so as to identify them by image analysis
4. On-line monitoring using high resolution image converters - examination by TV monitors and video tape recorders.

The technique developed must be versatile enough to be used for the inspection of all steel castings and welded assemblies.

Applicant: BFI - Düsseldorf
Budget: 537.000 ECU
Duration: 3 years

P 1197: Research into the principles of high-pressure hot cutting in the production of semis

High-speed grinding has both technological and economic advantages in the production of semis. The wide range of possibilities for its use call for extensive research and development work. The main purpose of this project will be to study:

- Fundamental technical interactions in high-pressure grinding, in particular the effect of different pressures, grinding wheel width, traverse and cross feed, wheelhead angle, cutting rate and temperature of the tool on the grinding result, the stock removal ratio, chip removal rate and the driving power required.
- Technical laws governing cutting by hot grinding, in particular the effect of the cutting rate, cut distribution, tool temperature and travel speed over the surface.
- Deformation under static and dynamic loading of a high-pressure grinding wheel and of hot cutting machines depending on the machining process.

The research as a whole will make it possible to design and construct a reliable industrial prototype.

Applicant: VDEh - Düsseldorf
Budget: 421.000 ECU
Duration: 2 years

P 1262: Development multi-purpose automatic spraymarker system

In most steelworks, especially modern rolling mills, marking is still carried out by specialized workers on a rule of thumb basis. The purpose of this project is to discover a method and to design equipment to make this operation more straightforward, easier and less laborious for the operator.

The firm Estel Hoogovens has already acquired substantial experience of computer-controlled spray-marking systems used in hot rolling mills. It now wants to exploit this experience by using a robot for this purpose, paying special attention to protection against heat and dust, and to the effect of high temperature on certain mechanical parts.

The work programme is as follows:

1. Analysis of the various tasks involved in manipulating a spraymarker for product identification (continuous cast slabs). Preliminary evaluation of the viability of the equipment.
2. Development of software and special hardware.
3. Technical evaluation of the system and possible modifications.
4. Final design for construction of a prototype.

Applicant: Estel Hoogovens - Ijmuiden
Budget: 340.000 ECU
Duration: 3 years

P 1123: Rapid method for determining metallic aluminium in steels

A precise knowledge of metallic aluminium contents is particularly important in continuous casting. It is essential to avoid inadequate deoxidation as this could give rise to subcutaneous blow holes and even surface pitting. The results of analyses must be obtained very rapidly so that corrections can be carried out in time.

To perform these corrections, the steelmaker must know both the total aluminium content and the metallic aluminium content. CRM has devised this research project in order to meet the need for a rapid method of determining aluminium during steelmaking.

The method is based on the following principles:

- Taking local remelting of part of the sample
- Screening of the top surface and spectrum analysis
- Design of a system for industrial use of the process
- Testing of the method and apparatus required under industrial inspection conditions in a continuous casting installation.

Series of industrial tests will be carried out on 250 - 300 melts. The range of contents to be investigated will be:

Metallic aluminium	0.010 - 0.080 %
Total aluminium	0.010 - 0.200 %

Applicant: CRM - Liège
Budget: 167.500 ECU
Duration: 3 years

P 1202: Optimization of methods of assessing nitrogen content in steel structures

The nitrogen content in steel is extremely important to the manufacturing, fabricating and user industries since the properties of the material can be considerably modified by nitrogen additions.

In this project the nitrogen content will be determined by a method to be developed. Quantitative determination will be carried out not only on large samples but also in the steel microstructure by micrographic analyses.

The detection limit and accuracy of the methods of analysis will be studied (electron microprobe and Auger electron spectroscopy) and applied to the determination of nitrogen in the various phases of the steel microstructure.

The research will also include:

1. Preparation of test pieces for the calibration of measurement signals
2. Calibration between nitrogen content and the measurement signal using series of measurements
3. Examination of test pieces taken from ordinary production runs
4. Quantitative determination in steels having phases containing nitrogen
5. Quantitative determination in the surface layers of nitrided steels
6. Comparison of processes.

Applicant: VDEh - Düsseldorf
Budget: 338.000 ECU
Duration: 3 years

P 1169: Dynamic control of the heat regime of a cold tandem mill

This project will involve developing and testing, on a 5-stand tandem strip mill, an integrated temperature control and work-roll bending system. The aim is to set up and maintain the optimum total roll crown throughout the entire rolling campaign, in order to maximize productivity whilst complying with shape and surface finish constraints.

The work programme will be organized as follows:

- Installation of a thermal control system based on predictions about the hot strip profile
- Determination of the optimum ground cambers for the various stands
- Adaptation of the equipment in the mill
- Development and installation of a self-regulating control system
- On-line tests.

Subsequently the essential elements will be combined to obtain an effective temperature control system for the mill without direct hot profile measurement.

Applicant: CSM - Roma
 Italsider - Genova
Budget: 660.500 ECU
Duration: 3 years

P 1207: Development and industrial use of an inspection system for detecting surface defects

At present firms are deterred from adopting automated surface inspection systems by the fact that there is no versatile equipment on the market, designed to detect and examine all types of defect.

The research proposed by the Betriebsforschungsinstitut of Düsseldorf aims to meet this need, by means of research and development work on a method which should lead to the design of suitable equipment. Opto-electronic processes will be used as well as laser probing. Processing of signals will be carried out without a calculator since highly integrated analog and digital circuits will be developed. The equipment designed will subsequently be constructed in the form of a prototype, the cost of which will have to be relatively low if it is to have a wide market.

Applicant: BFI - Düsseldorf
Budget: 576.000 ECU
Duration: 3 years

P 1124: Internal geometrical survey of the refractory lining of torpedo ladles

Production of pig iron has been increasingly concentrated in optimum production units so as to set up integrated works on a regional basis. As a result, pig iron has to be transported in torpedo ladles over distances of up to several kilometres.

The purpose of this research is to create a tool to monitor the rate of wear of the refractory lining of torpedo ladles in service, in order to define the optimum internal geometrical form for the lining on the basis of service life, safety of use and heat losses. A measuring method based on laser and thermographic techniques will be used to ascertain the state of wear of ladle linings, the test parameters being the geometrical form of the refractory lining, the quality of the bricks and the thermal insulation layer.

The work programme is planned in five successive stages:

- (1) Development of the measuring method
- (2) Trials and adjustments in the works
- (3) Trials on ladles in service
- (4) Finalization of the energy calculation model
- (5) Industrial operation, several months of trials

Applicant: Arbed - Luxembourg
Budget: 191.000 ECU
Duration: 2 years

II.5. SERVICE PROPERTIES AND PERFORMANCE

II.5.1. Weldability

The research proposed on weldability concerns two products and two different welding techniques that are equally important for the improvement of the quality/cost ratio in the finished product. One is the welding of heavy plate and the other the welding of steel sheet, especially in the motor industry.

One of the difficulties in welding in heavy plate is to obtain proper homogeneity of the different zones in order to retain all the mechanical properties, such as rupture strength, of the selected steel grade. Consequently, it is important in multipass welding to monitor as precisely as possible the grain structure in the fusion zone and in the heat-affected zone. With electron beam welding, a technique now gaining ground, these disadvantages can be avoided since there are far fewer passes and the heat effect is more localized. This technique is bound to have a great future with the increase in robotics and plant automation, but we need to know much more about its performance and conditions of use.

In the sheet sector, too, manufacturers are anxious to supply their customers with a product suited to its intended use. Sheets are assembled together to make, for example, a motor car, which will be subjected to very specific stressing conditions throughout its life. Its fatigue behaviour is obviously affected by the choice of materials, the design of components and also by the strength of the connections assembling them.

All these subjects of concern are reflected in the proposed research.

P 1081: Survey of the present state of automation and advanced technology fusion welding in the European Community and Japan

The development of advanced technologies has led to the wider use of fusion welding techniques. At the same time the development of industrial robots is enabling some industries to improve their productivity. Welds in heavy plate can now be required in conventional welding. This obviously saves time and energy, but the weld quality is also much higher.

As it is in Japan that this technology is most advanced at present, a survey of the methods used there will be valuable.

Applicant: Welding Institute - Cambridge
Budget: 35.000 ECU
Duration: 1/2 year

P 1105: Metallurgy and mechanical properties of multipass submerged-arc weld metal in carbon-manganese and low-alloy constructional steels

In several branches of the metal industry various steel grades, even with a yield strength of over 800 Newton/mm², are welded for economic reasons by the submerged-arc welding process.

However, practical experience shows that welding plates with increasing strength properties and/or thickness in this way frequently gives rise to considerable problems in meeting the fracture toughness requirements. Previous research has clearly demonstrated that the fracture toughness properties of submerged-arc weld metal for two-pass technique applications can be improved by a proper

selection of the wire-flux combination in relation to the parent plate composition.

In the proposed investigation attention will be focused on the following aspects of multipass submerged-arc weld metal:

- (a) A study of the influence of oxygen and nitrogen on the microstructure and fracture toughness behaviour of multipass submerged-arc weld metal in C/Mn and low-alloy-steel.
- (b) An evaluation of the welding wire impurity level and the role of certain deoxidizing elements such as: aluminium, silicon, zirconium and titanium on the fracture toughness properties of weld metal.

Applicant: Metaalinstitut TNO - Apeldoorn
Budget: 312.500 ECU
Duration: 3 years

P 1156: High-productivity welding of heavy plate

The heavy plate fabricating industries are constantly endeavouring to improve productivity, especially in welding. The conventional methods call for numerous passes. For example, 130 passes are needed to join two 200 mm plates using automatic welding under solid flux with narrow grooves. This is equivalent to three days of welding to make a straight 4 m weld.

Two methods are of particular interest as they allow single-pass welding whatever the thickness. These are vertical electro-slag welding with consumable guide and electron beam welding. Going back to the above example, the time required is reduced to 5 hours for consumable guide welding and one hour for electron beam welding.

The advantages of the consumable guide process are:

- low capital cost
- ability to handle welds of complex geometry

The advantages of the electron beam process are:

- particularly high productivity
- very low deformation in the weld connections.

The main obstacle to the industrial development of these processes lies in the properties of the connections, as regards both the internal soundness of the welds and their service characteristics.

The aim of the proposed research is to study and improve the conditions for the use of these processes on structural steels for applications such as:

- welded structures (hydraulic engineering, frameworks, structural steelwork, etc.)
- pressure vessels.

Applicant: Creusot Loire - Le Creusot and Firminy
 IRSID - St. Germain-en-Laye
Budget: 319.000 ECU
Duration: 3 years

P 1171: Fatigue behaviour of motor vehicle parts of spot-welded sheet;
influence on material selection

In designing mechanical components which are subjected to heavy dynamic loads during their lifetime, the choice of materials must be made with due regard to fatigue strength considerations.

Fatigue is a local phenomenon which occurs preferentially in areas containing discontinuities or welds and wherever a stress concentration exists. To be valid from a fatigue standpoint, therefore, any comparison between alternative materials must be made under structural conditions similar to the mechanical duties imposed on the component in question.

This is particularly true in the case of thin sheet-steel components, which are usually joined together by spot-welding and whose weakest link from the fatigue standpoint is in general the weld.

The object of the proposed research programme is first to define the geometrical parameters that influence the fatigue strength of spot-welded lap joints and then to determine (i) how the fatigue test modalities and the geometrical characteristics of simple lap-joined components can be used for establishing reliable new criteria for comparing the fatigue behaviour of different materials and of different types of welded joints; (ii) if, and how, the new criteria can be extended to cover the wealth of data collected up to now on welded joints of different geometry (and, therefore, not directly comparable) and/or on joints of limited practical interest.

Applicant: CSM - Roma
Budget: 187.500 ECU
Duration: 2 years

II.5.2. Corrosion and surface protection

Surface condition, especially of steel sheet, is a constant problem for producers. In the successive operations on the sheet, production techniques and plants (for example rolling mills) leave traces, often in the form of surface inclusions, which cause difficulties for the user in finishing operations such as painting (by spoiling the appearance).

The need for surface cleanliness also arises in another application which is bound to develop: the bonding of sheet. This is a technique derived from the aircraft industry which in many cases can simplify the design of parts while ensuring that the whole loses nothing of its robustness. It is well worth studying the development potential of this technique which is now being applied to steel sheet.

P 1157: Bonding of galvanized products

Assembly by bonding was developed in the aerospace industry for aluminium materials. This technique is starting to spread to other industrial sectors such as the construction of motor vehicles, railway rolling stock and other transport equipment, shipbuilding and the manufacture of domestic appliances and office equipment.

This assembly technique has probably not yet become as widespread as it could for steel products because most of them can be assembled (much more

easily than aluminium) by other methods (welding, seaming, bolting, rivetting). It would be a pity not to extend to steel and galvanized products the advantages that bonding can offer, such as tight joints, elimination of galvanic cells when different metals are placed in contact and thus reduction of corrosion, maintenance of the integrity of the parts (no drilling or heating), good fatigue strength, possibility of joining materials. Bonding also allows new parts to be designed by new techniques such as the honeycomb system and this should produce new uses for steel by reducing the weight of structures.

The aim of the proposed project is to show the possibilities of the bonding of galvanized products and to identify the best conditions.

From the technological aspect, the aim will be to provide users with information on the most suitable surface preparation and bonding methods for galvanized products and to ascertain the limits to the use of the assemblies.

From the scientific aspect, the aim is to contribute towards the study of chemical bonds between metal substrates and organic polymers, which will have a spin-off in other fields such as the adhesion of paints and varnishes.

Applicant: IRSID - St. Germain-en-Laye
Budget: 239.000 ECU
Duration: 4 years

P 1247: Effects on cold-rolled and annealed sheet surface cleanliness:
particulate and oil residues

The objective of the proposed research is to evaluate factors affecting surface cleanliness of finished cold-rolled and annealed strip.

In particular the particulate and oil contaminants in rolling emulsions which result in surface residues will be studied along with the steel base chemistry and surface roughness, the annealing conditions and surface oil reactions during annealing resulting in amorphous carbon or graphite formation.

Surface cleanliness of steel sheet intended for autobody construction has a significant effect on the adhesion of paint and the subsequent corrosion resistance of the painted product. The cleanliness is influenced by:

- (a) the amount and nature of the contaminants generated by cold rolling of the steel
- (b) reactions at strip surfaces during annealing whereby very adherent carbonaceous deposits can be formed.

Applicant: BSC - London
Budget: 163.500 ECU
Duration: 2 years

P 1273: Improvement of the cleanliness of sheet surfaces

This research project is designed to improve the cleanliness of cold-rolled sheet by investigating the reactions between the steel surface and rolling emulsions and annealing gases, and also to further develop measuring systems for industrial monitoring.

This should make it possible to identify the characteristic factors affecting strip cleanliness. The factors found to be appropriate will be incorporated in industrial monitoring and quality control and the necessary measuring systems will be developed.

Residuals from preceding mechanical working stages always remain on the surface of flat products. They may stem from chemical reactions or be entirely of mechanical origin. This applies to any changes, even of a local nature, in the chemical composition of the steel surface as a result of pickling, greasing, rolling, cleaning, annealing, cooling, storage or contamination.

Under the heading of strip cleanliness, analytical checks are normally carried out depending on the intended use of the product.

As far as possible methods of on-line analysis are to be developed. In order to do this, laboratory research must be accompanied by identification and classification of the process-induced chemical parameters in the process itself. An attempt will also be made to simulate individual physico-chemical steps on a laboratory scale and to interpret the results. Only after that will it be feasible to sort through the results and incorporate them in an automatic process control system. It is conceivable that a process can then be controlled according to the initial chemical compositions determined.

Applicant: Estel Hoesch - Dortmund
Budget: 707,500 ECU
Duration: 3 years

II.5.3. Cold forming

The conditions under which cold forming operations are carried out, whether on steel sheet (for example in the motor industry) or on bars and sections for cold upsetting (mechanical parts) have a great influence on the performance of the finished product. The fabricator must also know the optimum conditions for carrying out these operations so that he can avoid excessive wear and tear on his plant.

The research effort made two years ago for steel sheet must be continued since the main user, the motor industry, is still one of the vital sectors for our economy. Everything relating to this product, and especially coated sheet, needs to be studied in order to demonstrate the quality criteria of the finished product.

The idea of quality is also important in the production of parts by cold upsetting. Parts may be rejected because of surface defects that can withstand surface cleaning operations. In the study of these effects, the research conducted must take into account the existence of such defects so as to define an acceptability limit.

P 1120: Weldability and formability of coated steel sheet

Because of the need to save fuel the motor industry has to tackle the problem of reducing the weight of vehicles. One possibility is to use thinner sheet or plate for the body work and chassis. This calls for a thorough review of corrosion, and especially resistance to the salt used on the roads, an economic argument appreciated by customers in view of the increase in

purchase prices.

These conditions provide an incentive for the wider use of coated sheet.

In the not too far distant future the Japanese motor industry is planning to use about 100 kg of coated steel per car, around half of which will be high-strength steel sheet. European manufacturers are also planning to use a high proportion of this type of product.

If the use of these steel-based products, such as sheet that is electroplated, hot-dip galvanized or galvanized and annealed to obtain an iron-zinc alloy on the surface and zincrometal (an organic coating zinc) is to be promoted, it must be possible to use them economically. This depends partly on the weldability of the products and partly on their formability and the behaviour of the assemblies.

The proposed project will be limited to a type of welding that is particularly important for steel sheet: resistance welding.

The problems to be examined concern the quality of the welded spots, in particular resistance to corrosion.

Although data are already available for conventional galvanized steel, there is very little information on steel galvanized on one face, alloy type coatings (galvanized and annealed), zincrometal or coatings of zinc with 5 % aluminium.

Applicant: CRM - Liège
Budget: 287.500 ECU
Duration: 3 years

P 1159: Simplification of the surface preparation of bars for cold forming

In most cold-forming applications at present steel bars are used after scalping. This operation removes almost all the surface defects (geometrical, mechanical or chemical), but it is extremely costly and can be risky if it is not well done.

The aim of this research is to find simpler methods of surface preparation that produce parts without defects. It is necessary to have formability criteria taking into consideration both the intrinsic properties of the metal and the surface properties.

The research being done at present relates only to tests on machined test pieces, and therefore does not cover surface defects, despite their vital importance.

The upsetting test used for cold upsetting steels shows up surface defects but gives no precise idea of how harmful they are.

The aim of the proposed research is to develop from the quantitative aspect test methods for identifying acceptable surface states on different parts and thus ensuring that the surface state is suited to actual requirements.

Applicant: IRSID - St. Germain-en-Laye
Creusot Loire - Firminy
Budget: 382.500 ECU
Duration: 3 years

II.5.4. Constructional steels

In this field the research relates in particular to the fatigue behaviour of welded assemblies. As already mentioned earlier, the motor industry is an important economic sector and its efforts must be backed up by helping it to put on the market cars that meet both safety criteria and service life requirements. For this purpose, and in the light of energy considerations as well, new steel grades allowing a reduction in the weight of vehicles have been developed. The conditions for the forming and assembly of these steels are studied elsewhere. It is also necessary to determine their fatigue behaviour under their specific conditions of service.

P 1174: Predicted fatigue life and its importance in reaffirming the superiority of steel as a material for automotive components

The need for lightweight components and for cheaper manufacturing processes is felt very strongly today by the automobile industry which seizes every opportunity to use new materials that have a more favourable cost-to-performance ratio.

In the case of structural components, steelmakers have met the growing competition of other materials by introducing high-strength steels.

There is, however, a second possible line of defence regarding the uses to which steel can be put, which in fact, makes it possible to redesign a wide range of mechanical components on the basis of far lower safety factors than those required by the new materials adopted in the automotive field.

Two fundamental guideline criteria can be followed:

- the reduction of the mass of the component,
- the selection of a substitute steel having a more favourable cost-to-performance rating.

Before these criteria can be adopted, however, existing specialized methods for the characterization of materials must be further developed and improved so as to rate each type of steel scheduled for promotion on the basis of those mechanical properties which, taken as a whole, will provide a better performance in the applications for which the steel is particularly well suited.

At operative level, the objects are: (i) to obtain and make available, in classified form, data on the behaviour of specific types of steel under cyclic dynamic loading conditions; (ii) to use the data as basis for calculating the predicted fatigue life of structural components made out of such steels.

In addition, it is intended to calculate service life expectancies for a certain number of typical structural conditions.

The forecasts made will be compared with the results given by experimental bench tests and with the data reported in actual case histories.

Applicant: CSM - Roma
Budget: 262.000 ECU
Duration: 1 year

II.5.5. Fracture mechanisms

In order to understand brittle fracture phenomena in welded structures it is necessary both to undertake basic research and to carry out full scale tests. These two requirements are reflected in the proposed research projects, which plan to study the influence of precipitates at grain boundaries and ways of strengthening cohesion, and to investigate the effects of susceptibility to brittle fracture in actual structures such as gas pipelines. This application is particularly important for our economy and operating safety requirements are very important in this industrial sector.

P 1089: Influence of residual elements on the intergranular stress corrosion cracking of carbon steels

Unalloyed carbon steels are known to be susceptible to intergranular stress corrosion cracking (IGSCC) in various electrolytes, especially nitrates but also caustic solutions of carbonates, hydrogen carbonates or hydroxides. The IGSCC propensity of steels depends on the mechanical stress, the type and concentration of the environment and on the electrode potential.

In the service failure of high pressure gas pipelines carbonates are, most probably, the active crack initiating media. However, in the IGSCC of high-temperature blast furnace stoves, failure was attributed to a condensate containing a high nitrate concentration. Intergranular fracture has also been observed in stress cracking of the high-strength steels used for reinforcing bars in concrete structures, the environment here being a caustic solution of $\text{Ca}(\text{OH})_2$. Also IGSCC is a problem with boiler-steels and a range of low-alloy steels.

The overall aim of the project is to determine the effects of impurity elements in unalloyed and very low alloyed carbon steels on their susceptibility to IGSCC in different electrolytes.

This will provide a basis for specifications for residuals that are sufficient but not over-restrictive. This approach will lead to a better understanding of stress corrosion cracking and hence makes it possible to establish remedial action and to provide a prognosis of behaviour outside the limited tests proposed in this project.

Applicants: NPL - Teddington
Max Planck Institut - Düsseldorf
Budget: 483.000 ECU
Duration: 3 years

P 1090: Alleviation of intergranular failure in stress corrosion cracking of steels by rare earth metal additions

The object of the proposed research is to define the effects of residuals on intergranular stress corrosion cracking and through measurements of the segregation and the cracking properties as well as through thermomechanical calculations to define the acceptable range of rare earth additions in commercial practice to gain acceptable immunity to stress corrosion cracking in archetypal low-alloy steels.

Numerous examples of intergranular stress corrosion failures may be cited and, of the low-alloy steels that are involved, 2 1/4 % Cr-Mo and low Ni-Cr-Mo-V steels form archetypal categories. One clear route to remove

residual impurities from the grain boundaries is to use ultra-low residual steelmaking processes such as are being developed in Japan. These processes are still some way off in Europe and may involve unacceptable economic penalties as well as inferior properties in specific instances. An alternative route which has shown promise in laboratory scale melts at NPL is that of rare earth metal additions to the steel to fix the impurities in precipitates. This route shows promise in terms of both cost and effectiveness but many questions concerning its transference into commercial practice remain unanswered.

The proposed research programme consists in thermodynamic calculations to establish the reactions of rare earth metals in the archetypal 2 1/4 % Cr-Mo and low Ni-Cr-Mo-V steels to establish the products formed as a function of the rare earth metal content. These calculations will refer to the equilibrium situation and may or may not reflect the respective values for commercial practice. However, they provide a baseline scientific framework from which to carry out the experimental programme.

Applicants: BSC - London
 NPL - Teddington
Budget: 183.000 ECU
Duration: 2 years

P 1176: Prediction of ductile fracture propagation of gas pipe line through laboratory tests

Accurate prediction of the fracture behaviour of large-diameter gas pipe lines is a problem which has not yet been completely solved, despite important work carried out in this field by various Italian and foreign research establishments. In addition, the cases which have remained unresolved are precisely those of greater interest for the development of improved pipe line design and materials, i.e.: thick-walled pipes (approx. 25 mm) and high-strength steels (grade API X80).

The causes determining the reduced capacity to arrest ductile fracture shown by these materials during recent full-scale tests are still far from clear, but it is commonly held that there are two reasons for these disappointing results: on the one hand, for quenched and tempered materials the reduced plasticity revealed, for example, by their low strain hardening coefficients and on the other hand, for controlled rolled steels difficulties associated with quantifying the effects of separation.

The most recent initiative of the European Pipeline Research Group (EPRG) (round robin on embrittled Battelle test specimens) and an ECSC programme carried out by the BSC both emphasize the need for in-depth fracture mechanics studies for the purpose of developing a new laboratory test to replace the Charpy test. In fact, for obvious technical and economic reasons, it is not possible to rely exclusively on full-scale tests for studying and developing new types of materials for natural gas pipe lines; such test should be reserved for the final inspection of materials at industrial level.

The main object of the proposed research programme is to provide indications for a more accurate prediction of the ductile fracture behaviour of gas pipe line by (a) a better understanding of the strain and fracture patterns of the pipe and (b) a more effective test evaluation of the materials through laboratory tests.

Applicant: CSM - Roma

Budget: 213.500 ECU

Duration: 2 years

P 1213: Influence of the state of stress on the deformation and fracture of steels using large-scale tensile tests

The aim of much research on laboratory test pieces is to provide reliable quantitative data on the resistance of building components to failure.

Large-scale tests provide an opportunity of verifying the transferability of laboratory test results to building components, as the dimensions involved are very much nearer to the size of actual components than are the small test pieces normally used.

In the proposed research project experiments will be carried out on large test pieces, in cooperation with the experts of the VDEh committee for research on the susceptibility of steel to brittle fracture. These test pieces will have surface and side notches of various depths and lengths so as to exhibit different multiaxial states of stress, if possible up to the plane strain condition, even with fully plastic behaviour. The aim is to produce in large test pieces states of stress, even with large plastic deformations, of the kind that actually occur in building components and to obtain quantitative data on the ensuing deformation and fracture behaviour.

Applicant: Technische Hochschule - Aachen

Budget: 665.000 ECU

Duration: 3 years

P 1253: Characterization of crack arrest toughness in gas transmission pipelines in terms of the shear fracture propagation energy

The proposed research programme is based upon two principal objectives. In the first instance it is intended that the effects of plastic strain rate on shear fracture propagation comparing the performance of normalized, controlled rolled, roller quenched and tempered and quenched and tempered steels should be evaluated in order to determine the influence of microstructural characteristics on the fracture parameters. This work is directly related to the observation recently made that bainitic steels exhibit a different strain rate dependence compared with the conventional ferrite-pearlite steels, and that this difference in behaviour has been shown to have a significant influence on the performance of these steels as assessed by full scale burst tests.

The current EPRG proposal for further full-scale burst tests clearly indicates the probable use of higher-strength materials and thus supports the importance of the proposed laboratory studies.

The second objective of the proposed work is based upon the desire to determine accurate values from high strain rate conventional impact tests on materials from past and future ECSC-ERPG programmes, using the recommended test pieces and test techniques.

The final outcome of this work will be in the form of recommended fracture specification requirements necessary to guarantee pipeline safety, taking into account pipeline design (diameter, thickness and operating pressure) and the characteristics of the steels used in the pipeline manufacture.

Applicant: BSC - London

Budget: 176.500 ECU
Duration: 2 years

II.5.6 High temperature steels

A special effort is being made here so as to provide steelmakers and designers with all the data they need to improve the mechanical properties of these steel grades, since they are used for components subjected in service to extremely severe temperature conditions, often combined with high pressures. Especially when used in power stations, such components have to withstand not only high pressures and temperatures but also load variations resulting from fluctuations in user demand. Operating safety criteria have to be adhered to and the economic aspect of power station operation also has to be taken into account (maintenance, replacement of components before failure to avoid accidents).

P 1104: Steel and fabrication requirements in coal utilization technology

This research started in 1981 (see written procedure E/121/81 of 18 February 1981 - proposal P 951). For budget reasons 60 % of the amount was granted in 1980 and the remaining 40 % was to be included in the 1982 budget. It will be recalled that the main points tackled in this research, the results of which are expected in the second half of 1982, are as follows:

- material used, characterization, definition of requirements
- code of good practice for steel components
- compatibility of existing data with fabricating criteria
- fabrication possibilities and quality control (steelmakers and designers).

Applicant: BSC - London
Budget: 90.000 ECU
Duration: 1 year

P 1177: Effect of microstructure and impurities on crack propagation in creep

The durability of structural components operating at elevated temperatures is normally rated on the basis of the results given by creep strength tests performed at the duty temperature of the component.

The designer, however, can rely on the information supplied by this kind of test only when he can safely assume that: (i) the working load (and therefore the strain) is distributed evenly over the entire cross-section of the component, (ii) the component is free from pre-existing defects; (iii) no local cracks or defects are likely to develop with time in the loaded component.

The validity of this procedure has often been challenged during recent years for two reasons:

1. Ample experimental proof exists that structural components, especially thick and very thick components, are often defective prior to their installation owing to undetected internal cracks, such as can form for example in the heat-affected and fusion zones of welded joints.
2. Creep damage, together with eventual fatigue conditions, can sometimes lead to the nucleation of cracks at a very early date when replacement

of the component may be unnecessary and, in any case, uneconomical.

The purpose of the proposed research programme is to increase knowledge by (i) determining the influence of (a) residual elements (type and concentration), (b) microstructure, and (c) grain size on the nucleation, growth and propagation of cracks in low-alloyed ferritic steels subjected to creep; (ii) acquiring further and more detailed information on the selective segregation phenomena that take place on the surface of micro-cracks during creep.

Two materials will be investigated:

- 1) 1Cr-1Mo-0.25V steel for high-pressure rotors,
- 2) 2.25 Cr-1Mo steel for steam pipes.

Each steel will be investigated in two compositions characterized by different contents of P, As, Sn, Sb, Cu and S.

Applicant: CSM - Roma
Budget: 262.000 ECU
Duration: 3 years

P 1178: Microstructural properties of steel for large components for the energy industry as a function of operating variables in thermo-chemical treatment

As a result of the increasing demand for higher productivity levels in the field of hot working, manufacturers are being impelled to study means of improving operating practices in order to (a) find cheaper and more rational production methods, and (b) reduce quality fluctuations and save power by suitable standardization of the related manufacturing procedures.

The research work reported in the literature is mainly concerned with problems associated with the dimensional change and internal soundness of the component and deals only in a minor way with problems associated with the microstructural evolution of the material during the dimensional change. These latter problems, however, are of fundamental importance in relation to the effects on structural homogeneity, given (a) the highly diversified types of strain which can be produced during hot forging, and (b) the sensitivity of the material to thermomechanical working.

There is reason to believe that an effective approach to the problem of improving hot-forging practices should be based on the simultaneous consideration of both aspects, i.e.:

- 1) dimensional changes and related stress pattern;
- 2) microstructural evolution consequent on dimensional change and the thermal conditions of operation.

The object of the proposed research programme is to study the problems mentioned above.

Applicant: CSM - Roma
Budget: 322.500 ECU
Duration: 3 years

P 1179: Behaviour of steels for use at elevated temperatures in thermal electricity generating plant operating with cyclical load variations

The medium term management plan for power stations, in Italy for example, consists of using a number of high-capacity units during steady-state operation and bringing in other units at peak periods.

The design criteria normally used for steel tubing are based on creep and time yield data obtained under constant load.

The aim of the research is to define the behaviour of a high-temperature ferritic steel under the service conditions applicable to tubing in thermo-electric power stations that are designed for discontinuous operation to cope with an electricity demand that fluctuates in a daily cycle.

The steel chosen is 12 Cr Mo910 (Euronorm 43-72) which today seems the most promising material for the construction of ferritic tubing, since it appears to have the optimum properties to meet the combination of frequently conflicting requirements concerning strength, reliability, and economy.

Applicant: Dalmine - Milano
Budget: 224,500 ECU
Duration: 3 years

P 1216: Improvement of the creep rupture and toughness behaviour of high temperature turbine steels

High-temperature turbine steels are required to have a good creep rupture strength combined with adequate toughness properties. High toughness must be guaranteed both in the delivery state and after long periods in service.

Several ECSC-aided research projects have already been carried out on the improvement of the service properties of NiCrMoV steels. These have shown that the microstructure (martensite/bainite), grain size, chemical composition and in particular the content of residuals and the strength level have a great influence on toughness. The main effect of the content of residuals is to increase grain boundary segregation of phosphorous and tin, thereby reducing intergranular cohesion and causing brittle fracture. The research indicates that the service range of the NiCrMoV steels can be extended by further reducing the phosphorus content.

For forgings of 1 % CrMoV steel, there has also been a tendency recently to make increasing use of ingots with a low silicon content melted by the VCD process because any susceptibility to temper embrittlement can be further reduced in this way.

Insufficient research has as yet been conducted on the influence of a lower silicon content in VCD melts.

Under this programme more exhaustive research will be carried out on selected test pieces from the above mentioned ECSC research project; this will include:

- creep rupture tests
- ageing
- fracture toughness and instrumented notch impact tests
- microanalysis and microstructure.

Applicant: VDEh - Düsseldorf
Budget: 201.000 ECU
Duration: 3 years

P 1254: Elevated-temperature cracking of high temperature steels

A considerable amount of work has been carried out (ECSC contract) on the effects of grain size and stress state on the nucleation and growth of intergranular cavitation in ferritic high-temperature steels which leads to high temperature cracking. The results of this work have shown that the rupture life can be calculated from observed cavity nucleation rates, but there is little knowledge of the factors controlling the cavity nucleation rate. The cavity nucleation rate is of major significance in controlling the high temperature cracking of pipe, header and bolting steels such as 1 % Cr-1/2 % Mo, 2 1/4 % Cr-1 % Mo, and 21CrMoV5.7, all of which suffer intergranular cracking to some degree, particularly when coarse grain sizes are present. This type of cracking is particularly prevalent in 1%Cr-1/2%Mo, and 2.1/4%Cr-1%Mo weld HAZ's. It is proposed that the nature of the cavity nucleation sites should be defined and the factors controlling cavity nucleation rates be examined.

One of the objectives of the present work, therefore, is to establish the factors controlling cavity nucleation but the work would also be of direct application to studies of remnant life, which is a subject of considerable importance to operators of steam-generating plant, other high-temperature pressure vessels and power-generating plant.

The information obtained will be used to assess the rupture life of these materials in terms of cavity nucleation and growth as in earlier work, where it is suggested that the ability to predict cavity nucleation rates will provide all the information required to predict creep rupture lives in the regimes of stress and temperature where cracking is the operative failure mode. Such a model would also provide the necessary background for the prediction of remnant life in high-temperature components.

Applicant: BSC - London
Budget: 265.500 ECU
Duration 3 years

II.5.7 Offshore technology

The proposed work consists of a continuation of the research started in 1981. Because of budget restrictions, it was agreed that the total aid granted would be spread over 1981 and 1982.

P 1082: Service strength of welded offshore structures in seawater with particular reference to crack propagation measurements and post-weld treatment to increase fatigue strength

This work covers:

- The effects of TIG treatment of the weld
- Checks on test pieces
- Crack initiation and propagation
- Influence of corrosion

Influence of cathodic protection

Influence of a coating on corrosion fatigue

Applicants: Fraunhofer Institut für Betriebsfestigkeit - Darmstadt
Industrieanlagen Betriebsgesellschaft - Ottobrunn

Budget: 322.000 ECU

Duration: 2 years

II.5.8. Light structures

This is one of the most sensitive areas in which steel is used. Although there have been some successful technical achievements - often impressive in their audacity - steel construction is hampered in our countries by regulations geared to the use of traditional building materials, which do not take account of the specific properties of steel. It is therefore necessary to put constant pressure on the authorities concerned to remedy the situation.

P 1086: Corrosion of steel structural members inside buildings

Extensive research has already been carried out on the protection of steel structures against corrosion, even under the most extreme conditions, but there is a lack of documentation on the minimum requirements to be met by such protection for steel members situated in relatively safe areas of a building. As widely differing climatic zones can exist within the same building, a variety of protective measures are required and must be practicable. In order to help the constructional steelwork industry to overcome this disadvantage, this research project aims to determine those measures that are absolutely necessary, depending on outside influences. Suggestions for tailor-made versions of corrosion protection will also be made.

The purpose of the proposed research is:

- (a) to obtain the necessary experimental and theoretical information for the formulation of rational and simple recommendations on the protection against corrosion of steel members inside buildings;
- (b) to provide evidence to enable existing recommendations to be simplified and relaxed where corrosion problems are of minor importance or even non-existent, as is frequently the case inside buildings.

Applicant: European Convention for Constructional Steelwork - Rotterdam

Budget: 34.500 ECU

Duration: 1 year

P 1129: Computer-assisted analysis of the fire resistance of steel and combined steel/concrete structures

The purpose of this research is to devise a computer programme to analyse the overall fire resistance of a three-dimensional steel framework made up of various sections, either without protection or protected by various types of material (such as plaster, fibreglass insulating material or vermiculite-based insulating material), or used in a combined steel/concrete structure.

Previous research results will be incorporated into this design code. Research will be carried out in two stages, only the first of which is included in

this proposal and involves:

- devising the calculation method; the results obtained will be compared with those of tests on structures already built or under construction.
- adapting the code for the purposes of computer-aided design which takes the form of a non-linear programme of three-dimensional static analysis dealing with transient fields in connection with temperatures and constraints.
- During the first stage there will be tests on building components and tests to study beam-column interactions.

Applicant: Arbed - Luxembourg

Budget: 291.500 ECU

Duration: 2 years

P 1130: Statistical survey of the influence of structural fire resistance on losses due to fire in industrial buildings

On the basis of surveys on actual building fires and especially on fires that have occurred in one-storey buildings, the proposed study will establish the possible correlations between:

- the degree of fire stability and the losses due to fire;
- the initial calorific potential of the building and the losses due to fire.

The most objective way of expressing "losses due to fire" will be examined, for instance by calculating the ratio between the direct cost of the losses and the initial cost of both the building and its contents. Losses will also involve, as the case may be, the compensation paid for any insurance against the loss of exploitation.

Analyses will also be carried out as far as possible to determine the influence exerted upon losses due to fire by:

- various means of protection such as smoke paths, automatic fire extinguishing systems, partition walls;
- construction of walls and roofs with location of lighting areas;
- nature of inner structures (suspended roof structures, suspended ceilings, thermal insulation).

Particular cases amongst the various disasters examined will be selected for use as educational material to illustrate the actual fire behaviour of the structures.

Applicants: CTICM - Puteaux

TNO - Delft

Budget: 263.500 ECU

Duration: 3 years

II.5.9. Alloy and special steels

In this sector an understanding of the phenomena occurring in the making of the steel is of vital importance if the producer is to be able to provide users with a product that will meet their technical and technological requirements and their need to remain competitive. It is therefore essential

to continue research in a number of fields; this applies to the basic research proposed on quantitative metallurgy, the basic and application-oriented research on such subjects as the development of low-loss electrical sheet and the study of machinability which should help workshops to reduce production costs.

P 1091: Improvement of the magnetic characteristics and service properties of non-oriented,concast steel

The production, transport and use of electricity necessarily involve the use of magnetic circuits for operation of the relevant electrical machinery. These circuits are generally obtained from cores made up of electrical sheet, cold rolled in the form of blanks, less than one millimetre thick and described commercially in terms of loss (expressed in watts) per unit of weight when magnetized at a predetermined magnetic induction and frequency.

In the case of non-oriented silicon steel sheets, i.e. those more commonly used commercially, the situation varies according to whether the silicon contents is above or below approximately 1.1 %. With regard to motors used for domestic purposes and industrial motors with a capacity of only a few kW, there has been a tendency in recent years to replace sheet with a low silicon content with carbon steel sheet supplied in the semi-processed state, simply because it is cheaper and despite the fact that the quality is poorer from the point of view of energy dissipation. This is because users of this type of sheet tend to cut down the cost of electric motors at the expense of their efficiency.

This trend could be reversed if a guarantee of quality were also introduced for these products and if account were taken not only of the initial cost, but also of cost resulting from energy dissipation during operation of such machinery.

It is estimated that the cost of steel can be reduced by around 10 % by using continuous casting. Unfortunately, the magnetic properties of non-oriented concast silicon steels are inferior to those in ingot form in that the former have finely distributed oxide inclusions which have an adverse effect on the value of the hysteresis losses.

The proposed research programme is divided into two parts:

- post-refinement processing of silicon steel to improve the properties of non-oriented concast electrical steel.
- insulating coating for non-oriented steel with excellent characteristics from the point of view of shearing.

Applicants: Terni - Terni

CSM - Roma

Budget: 419.500 ECU

Duration; 2 1/2 years

P 1092: New qualities of non-oriented electrical sheet for the construction of magnetic circuits

The aim is to obtain new grades of non-oriented electrical sheet for magnetic circuits, and in particular the stators of high-powered rotating machines.

It is planned to study the interactions between residual impurities and manufacturing processes consisting of successive rolling and annealing

operations, using materials and conditions giving a cubic-type primary recrystallization texture. The aim will be to analyse the ways primary recrystallization textures are formed and their dependence on impurities in order to regulate manufacturing parameters so as to obtain a product of higher quality than the best non-oriented 3 % silicon sheet currently on the market.

The research will be conducted on a ferrite containing not more than 3 % of alloying elements (silicon and/or aluminium) in order to retain adequate saturation. In such material, it is sufficient to obtain a cubic-type texture, even if this is not perfect, in order to have a more favourable configuration of the elementary fields than in conventional non-oriented sheet, and this brings about an improvement in useful magnetic properties: specific losses in the longitudinal and transverse directions, losses in a rotating field and the approach to saturation.

Applicant: Creusot Loire - St. Chely d'apcher
Budget: 206.500 ECU
Duration: 2 1/2 years

P 1094: Characteristics required for the fabrication of engineering parts in micro-alloyed steels in the form of bars and sections not quenched and tempered

Increasing attention is likely to be focused on the possibilities of saving energy in the heat treatment of special steels. The addition of microalloying elements to steels whose carbon content is (approximately) between 0.35 % and 0.5 % gives them considerable strength properties with the result that, for some uses, quenching and tempering can be eliminated, and the weight of components made from these steels can be reduced through designs which take account of the increased strength.

The research project is organized as follows:

- (a) development of continuous casting of microalloy steel in bars and/or billets and subsequent rolling in a single heat, as against similar steels produced by teeming in ingot form;
- (b) thorough assessment of the mechanical characteristics obtained for bars and billets by means of controlled cooling using the rolling temperature and with varying degrees of reduction by cold drawing;
- (c) experimental evaluation of all the characteristics essential to the designer and user, both after hot forging and after chip-forming machining of mechanical components (from drawn bars), as compared with quenched and tempered steels.

Applicant: Teksid - Torino
Budget: 374.500 ECU
Duration: 2 years

P 1122: Quantitative metallography

In the research under the heading of quantitative metallography already conducted with ECSC support, the problem of measuring grain size has only been tackled as a subsidiary aspect, in particular during the comparison of measurements carried out in the different institutes taking part in the research. It was then found that although the mean diameter could be measured fairly reliable and with a reasonable degree of reproducibility, the frequency

distribution of the diameters was much less easy to determine.

Today, using computer processing of data from an image analyser, it is possible to go very much farther than a somewhat approximate estimate of the average grain size, and in particular to plot the grain size frequency distribution curve.

It would seem extremely useful to undertake a critical review of measuring methods and criteria capable of characterizing grain size distribution in steel.

This study will not ignore the complexity of the microstructure, i.e. an effort will also be made to solve the problem of measuring the size of non-polygonal and non-isotropic grains.

Applicant: CRM - Liège
Budget: 151.500 ECU
Duration: 3 years

P 1221: Statistical description of non-metallic inclusions in steels for evaluation with standard series and fully automated machines

In developing new steel grades and in quality control the degree of purity of the steels is evaluated on the basis of standard series. It is theoretically possible to use automatic image analysers but this procedure is still too costly for most quality control operations. Consequently small firms in particular will have to continue to use standard series. The standard images are at present made up from visual observation of the microstructure. The conditions of the mathematical equations describing the microstructure are only incompletely fulfilled and the images themselves are so poorly defined that, for example, they cannot be reproduced by a computer from the data given for representation purposes. It is not possible to use the standard series in order to develop a method for the quantitative description of non-metallic inclusions by means of image analysers measuring geometrical parameters that can be directly correlated with properties.

To overcome this problem, it is necessary to develop a statistical method of describing non-metallic inclusions by stereological parameters. Using this description, a computer must then draw images reproducing the measured distribution. If these images are used as standard series, a description of the microstructure will be obtained that is similar to that given by image analysers. The only difference is that the accuracy will be higher with the automatic image analyser than with the use of standard series.

Preliminary work has shown that it is possible to translate the statistical data on the arrangement and grain size of inclusions into standard images drawn by a computer. Consequently it has been established that the proposed methodology is feasible.

Applicant: MPI-Düsseldorf
Budget: 319.000 ECU
Duration: 3 years

P 1226: Influence of stresses generated by oxide layers on magnetic properties and scale adhesion of non-oriented electrical sheet

During the final annealing operation on cold-rolled non-oriented electrical

sheet, oxide layers appear on the surface of the sheet. These are essentially formed of oxidized inclusions of the alloying elements silicon and aluminium. The way in which these layers form and change during annealing, depending on the composition of the alloy and the annealing conditions, has already been studied.

This research showed that, during the high-temperature stage in the final annealing operation, the aluminium displaces the silicon outside the oxidized bond which occurs in the field of internal oxidation, to the boundary of the oxidizer/metal phases. Consequently it is assumed that the poor adhesion of the oxidizer after a short holding period at high temperature (about one minute) is due to the fact that an aluminium oxide layer forms at the boundary of the oxidizer/metal phases. This also explains why extensive changes in mechanical tension between the oxidizer and the ground mass are found.

In the proposed research project, a simulation study will be made of the usual short annealing method in the continuous furnace in order to determine any differences between the laboratory tests and full-scale results by comparative measurements.

Applicant: Stahlwerke Bochum - Bochum
Budget: 382.000 ECU
Duration: 2 1/2 years

P 1259: Relationship between crystallographic textures in fully-annealed silicon-bearing non-oriented electrotechnical steels and magnetic parameters

The importance of electrotechnical steel strip as a product possessing special properties necessary for the construction of the magnetic circuits of transformers, motors and generators is already well recognized. It is proposed that research should be undertaken on the non-oriented range of electrotechnical steels because:

- non-oriented grades now predominate as the largest market component in terms of tonnes and it is tonnes throughput which ensures the viability of a steel strip works.
- there is an increasing requirement that energy should be conserved by making electrical machines more efficient, especially the larger rotating machines where local and overall power loss can be very high.
- the European steel producers must remain at the forefront of the technology of electrotechnical steel production, particularly since that class of material is technologically strategic. Utilisation of electric power in consumer durables depends on readily available non-oriented grades of suitable magnetic and physical quality (controlled hardness for stampability, etc.)
- the trends which must be catered for are:
 - . an improved quality of machine without increase in cost or alternatively, availability of less efficient machines at very reduced cost.
 - . a reduction in the price which good core material can command or availability of better core material at existing market price levels.

The proposed research programme on non-oriented electrotechnical steels is seen as consisting of texture studies in fully-annealed silicon-bearing non-oriented electrotechnical steels and the development of

methods of measurement to correlate data derived from experimental material; mechanical properties and magnetic measurement techniques suitable for rotating machines (rotating flux and hysteresis loss etc.), the effects of crystallographic texture groups on the value of Young's Modulus.

Applicant: BSC - London
Budget: 179.000 ECU
Duration: 2 1/2 years

P 1260: Machinability of engineering steels

The objective of the research proposal is to optimise the microstructure and mechanical properties of engineering steels in order to achieve maximum machinability and to examine systematically the influence of bright drawing, reeling and grinding on the machinability of these steels.

Many engineering steels are subjected to pre-machining processes such as bright drawing or reeling in order to meet the shape and size tolerance requirements of modern machine tools. However, little systematic work has been carried out on the effects of those cold-working operations on the machining performance of the steels. In addition to the acquisition of these data, the potential for optimizing the prior microstructure will be investigated.

In this proposed research programme samples of suitable steel types will be selected from production casts to reflect the popular usage of direct-hardening and case-hardening carbon and alloy steels as well as austenitic stainless steel.

The selected steels will be heat treated either in the laboratory or in a production furnace to generate different microstructure and mechanical properties.

Each of the steels, in selected heat-treated conditions, will be subjected to various bar surface finishing operations, such as bright drawing, grinding, reeling and turning to reflect the different surface finishing conditions offered by the steel industry.

The mechanical properties of the test bars will be evaluated by hardness measurements and tensile and impact tests. A detailed metallographic examination will also be undertaken to facilitate correlation of the microstructure with the technical properties and machinability.

The cost of the heat treatment processes will be compared with the estimated reductions in the cost of machining so that the most cost-effective treatments can be identified.

Applicant : BSC - London
Budget: 172.000 ECU
Duration: 2 years

P 1268: Development of morphological algorithms for image analysis

Quantitative metallography and automatic structure analysis have become very widely used in metallurgical laboratories. However, some technical and scientific problems are still hampering the development of these methods. These problems related in particular to the understanding and automatic quantification of fairly complex metallographic structures.

To overcome these problems, one approach is to subject the images studied to iterated morphological transformation programmes having the effect of identifying the structural characteristics sought. These image processing operations obviously need new equipment.

The proposed research, based on the use of an image analyser, will tackle two of the most important problems in metallography: the characterization of grain boundaries and of inclusions.

Applicant: IRSID - Saint-Germain-en-Laye
Budget: 127.500 ECU
Duration: 3 years

II.6. PLANT AVAILABILITY

There are two proposals in this sector of the programme concerned with the problems of maintenance and equipment availability firstly of sinter plants and blast furnaces and secondly of continuous casting machines. The ultimate objective of both projects is to achieve a lowering of operating costs in these different stages of iron and steel production.

P 1228: Reduction of wear in the transport of abrasive bulk materials for burden preparation

Reduced plant availability as well as maintenance and repair work arising from abrasive wear in iron and steel plant make a significant contribution to overall manufacturing costs. Thus a better understanding of service conditions and of the factors governing the wear of the materials used in plant construction provides a potentially important means of reducing operating costs in the areas of sinter manufacture and the blast furnace.

In this research it is proposed to make a systematic evaluation of the abrasion resistance of constructional materials under the influence of selected test variables. The research will commence with a detailed examination of the conditions prevailing in practice and will be followed by the development of appropriate material evaluation procedures. The overall objective is to generate a body of test data that will enable more cost-effective solutions to abrasive wear in steelplants to be found.

Applicant: BFI - Düsseldorf
Budget: 488.500 ECU
Duration: 3 1/2 years

P 1229: Reduction in maintenance costs in continuous casting machines

A reduction in the maintenance, at present required on continuous casting machines to achieve the necessary plant availability, could lead to a significant lowering of the overall production costs. The main objective of the proposed research is the further development and testing of maintenance methods on a continuous casting plant under service conditions. The work will be undertaken in four stages covering

- (1) analysis of plant maintenance procedures and the recognition of the cause of disorders
- (2) development of models for plant reliability and disorders
- (3) application of the tested procedures and the development of models for plant maintenance and

(4) examination of the success of these procedures in relation with the condition of the plant and the cost of maintenance.

Applicant: VDEh - Düsseldorf
Budget: 948.500 ECU
Duration: 3 1/2 years

II.7. MISCELLANEOUS

P 1097: Technical steel literature

This project is a continuation of previous contracts giving ASELT financial assistance for the translation into the European Community languages of tests on iron and steel subjects published in the "difficult" languages (notably Japanese and Russian).

Applicant: ASELT - Luxembourg
Budget: 148.000 ECU
Duration: 1 year

Communication from the Commission of the European Communities to companies in the ECSC

(Article 48 of the ECSC Treaty)

In the letter to the Chairman of the Consultative Committee of the ECSC, the Commission asked the Committee to undertake the consultation laid down in Article 55 (2) (c) of the Treaty concerning the desirability of allocating the following sums from the levies laid down in Article 50 of the Treaty for financial aid aimed at facilitating the following technical research projects.

Under Article 48 of the Treaty, associations of companies in the ECSC are entitled to submit to the Commission the observations made by their members concerning the undermentioned subjects of consultation.

Any observations should be received by the Commission not later than ^{10/}March 1982.

1183	1	High reducibility of sinter with low degradability	352.800
1216	2	Factors determining the cohesive zone in grate sintering of high-grade ores	240.600
1265	3	Flames of coal water slurry	199.200
1201	4	Correlation between profile and reduction of energy consumption in modern blast furnaces with bell-less top	393.900
1215	5	Coal combustion with superheated blast in a plasma medium. Simulation at blast furnace conditions	156.600
1257	6	Model to predict the silicon content in the metal in the blast furnace	295.200
1251	7	Method of determining the burden material in a blast furnace shaft by measuring electrical conductivities	218.400
1296	8	Development of a direct strand reduction method for steel	576.000
1247	9	Development of a low-silicon and low-aluminium grade steel for continuous casting.	311.400
1218	10	Energy conservation by incorporating steelplant, continuous casting and rolling mill in a single hot line	446.700
1240	11	Improvement of continuous casting for extra-mild steel grades with a low content of desoxidizing elements	333.900
1244	12	Control of the formation of reciprocation marks and associated defects	244.200
1236	13	Reduction of reciprocation marks by high-frequency vibration of the continuous-casting mould	115.200
1229	14	Development of improved slag detection and retention in BOS vessels and the effect of certain aspects of steel quality	135.600
1238	15	Pre-heating of scrap with electric furnace waste gas from the combustion chamber	239.100
1285	16	ESR production of hollow ingots from metal powders using tubular electrodes	281.700
1080	17	Energy saving by using untired refractory materials	384.600
1242	18	Application of thin basic facings to steel ladles	99.600
1269	19	Thermodynamic research on slags and circulating materials	293.100
1292	20	Improvement of energy utilisation by heat exchangers for cooling or pre-heating rolling stock	516.600

1119 21	Continuous control-rolling without prior descaling	452.100
1120 22	Integrated computer-aided system for roll pass design	407.400
1144 23	Metallurgical optimization of rolling conditions in the continuous hot strip mill	286.800
1119 24	Changes in surface defects during the rolling of bars and sections	286.800
1146 25	New coiling procedures on the wide strip mill	324.900
1146 26	Analyses of microstructural and oxidation processes in rolling mill reheating furnaces and their incorporation in optimum process control	359.100
1147 27	Improvement in the mechanical properties of eutectoid wire rod suitable for direct drawing, made from concast billets	344.400
1194 28	Investigation of energy conservation potential in reheating and heat-treatment furnaces with the use of modern control procedures	179.700
1200 29	Development of methods of obtaining high drafts in the production of wide strip	593.700
1249 30	Studies of straightening and levelling operations for plate	93.900
1240 31	Computer-aided manufacture and robotics in rolling mills	76.800
1123 32	Rapid method for determining metallic aluminium in steels	100.500
1124 33	Internal geometrical survey of the refractory lining of torpedo ladles	114.600
1154 34	Continuous measurement of the shape of hot-rolled bars and sections	296.100
1155 35	Non-destructive monitoring of surface decarburization	172.200
1168 36	Hot ultrasonic inspection of slabs to optimize shearing	242.400
1207 37	Dynamic control of the heat regime of a cold tandem mill	396.300
1197 38	Research into the principles of high-pressure hot cutting in the production of semis	252.600
1200 39	Optimization of methods of assessing nitrogen content in steel structure	202.800
1206 40	Digital image processing and automatic image evaluation in radiation testing	322.200
1207 41	Development and industrial use of an inspection system for detecting surface defects	345.600
1208 42	Development of ultrasonic analysis of steel structure	202.200
1264 43	Quality control by automatic ultrasonic inspection of heavy plate in the production line	117.000
1202 44	Development multi-purpose automatic spraymarker system	204.000
1081 45	Survey of the present state of automation and advanced technology fusion welding in the European Community and Japan	35.000
1105 46	Metallurgy and mechanical properties of multipass submerged arc weld-metal in C/Mn and low-alloy constructional steels	187.500

1156 47	High-productivity welding of heavy plate	191.400
1177 48	Fatigue behaviour of motor vehicle parts of spot-welded sheet; influence on material selection	112.500
1157 49	Bonding of galvanized products	143.400
1177 50	Effects of cold-rolled and annealed sheet surface cleanliness: particulate and oil residues	98.100
1273 51	Improvement of the cleanness of sheet surface	424.500
1120 52	Weldability and formability of coated steel sheet	172.500
1150 53	Simplification of the surface preparation of bars for cold forming	229.500
1176 54	Promotion of steel use in motor vehicles by assessing their suitability for specified life design	157.200
1009 55	Influence of residual elements on the intergranular stress corrosion cracking of carbon steels	289.800
1000 56	Alleviation of intergranular failure in the stress corrosion cracking of steels by rare earth metal addition	109.800
1176 57	Prediction of ductile fracture propagation behaviour in gas pipelines by means of laboratory tests	128.100
1218 58	Influence of the state of stress on the deformation and fracture of steels using large-scale tensile tests	399.000
1253 59	Characterization of crack arrest toughness in gas transmission pipelines in terms of the shear fracture propagation energy	105.900
1146 60	Steel and fabrication requirements in coal utilization technologies	36.000
1177 61	Effect of microstructure and impurity content on crack propagation in creep	157.200
1178 62	Microstructural properties of steel for large components for the energy industry as a function of operating variables in thermochemical treatment	193.500
1179 63	Behaviour of steels for use at elevated temperatures in thermal electricity generating plants operated with cyclical load variations	134.700
1240 64	Improvement of the creep rupture and toughness behaviour of high temperature turbine steels	120.600
1254 65	Elevated temperature cracking of high temperature steels	159.300
1002 66	Service strength of welded offshore structures in sea water with particular reference to crack propagation measurements and post-weld treatment to increase fatigue strength	193.200

1080 67	Corrosion of steel structural members inside buildings	20.700
1129 68	Computer-assisted analysis of the fire resistance of steel and combined steel/concrete structures	174.900
1130 69	Statistical survey of fires in industrial buildings	158.100
1094 70	Improvement of the magnetic characteristics and service properties of non-oriented concast steel	251.700
1092 71	New qualities of non-oriented electrical sheet for the construction of magnetic circuits	123.900
1094 72	Characteristics required for the fabrication of engineering parts in micro-alloy steels in the form of bars and sections not quenched and tempered	224.700
1122 73	Quantitative metallography	90.900
1221 74	Statistical description of non-metallic inclusions in steels for evaluation with standard series and fully automated machines	191.400
1226 75	Influence of stresses generated by oxide layers on magnetic properties and scale adhesion of non-oriented electrical sheet	229.200
1259 76	Relationship between crystallographic textures in fully annealed silicon bearing non-oriented electrotechnical steels and magnetic parameters	107.400
1260 77	Machinability of engineering steels	103.200
1268 78	Development of morphological algorithms for image analysis	76.500
1228 79	Reduction of wear in the transport of abrasive bulk materials for burden preparation	293.100
1229 80	Reduction of maintenance costs in continuous casting machines	569.100
1097 81	Technical steel literature	148.000

Project N°	Title of the research	Research proposed			Financial aid	
		by	Duration (years)	Budget (ECU) (30.11.81)	%	Amount ECU (30.11.81)
	<u>I. ORE REDUCTION</u>					
	<u>I.1. Sinter</u>					
1103	High reducibility of sinter with low degradability	Italsider	3	588.000	60	352.800
1116	Factors determining the cohesive zone in grate sintering of high-grade ores	CRM	3	401.000	60	240.600
1265	Flames of coal water slurry	Hoogovens	3	332.000	60	199.200
	<u>I.2. Blast furnace</u>					
1101	Correlation between profile and reduction of energy consumption in modern blast furnaces with bell-less top	Italsider	2 1/2	656.500	60	393.900
1115	Coal combustion with superheated blast in a plasma medium. Simulation of blast furnace conditions	CRM	2	261.000	60	156.600
1137	Model to predict the silicon content in the metal in the blast furnace	IRSID	4	492.000	60	295.200
1231	Method of determining the burden material in a blast furnace shaft by measuring electrical conductivities	Thyssen	2	364.000	60	218.400
	<u>II. STEELMAKING</u>					
	<u>II.1. Casting and solidification</u>					
1096	Development of a direct strand reduction method for steel	Krupp	3	2.880.000	20	576.000
1117	Development of a low-silicon and low-aluminium grade steel for continuous casting.	CRM	4	519.000	60	311.400
1118	Energy conservation by incorporating steelplant, continuous casting and rolling mill in a single hot line	CRM	4	744.500	60	446.700
1140	Improvement of continuous casting for extra-mild steel grades with a low content of deoxidizing elements	IRSID	4	556.500	60	333.900

Project No	Title of the research	Research proposed			Financial aid	
		by	Duration (years)	Budget (ECU) (30.11.81)	%	Amount ECU (30.11.81)
1141	Control of the formation of reciprocation marks and associated defects	IRSID	4	407.000	60	244.200
1238	Reduction of reciprocation marks by high-frequency vibration of the continuous-casting mould	BSC	2	192.000	60	115.200
1239	<u>II.2. Steelworks: metallurgy</u> Development of improved slag detection and retention in BOS vessels and the effect of certain aspects of steel quality	BSC	2	226.000	60	135.600
1138	<u>II.3. Steelworks: technology</u> Pre-heating of scrap with electric furnace waste gas from the combustion chamber	IRSID	3	398.500	60	239.100
1165	<u>II.4. Special processes</u> ESR production of hollow ingots from metal powders using tubular electrodes	CSM	3	469.500	60	281.700
1080	<u>II.5. Refractories</u> Energy saving by using unfired refractory materials	Hoesch	3	641.000	60	384.600
1242	Application of thin basic facings to steel ladles	BSC	2	166.000	60	99.600
1189	<u>II.6. Theoretical metallurgy</u> Thermodynamic research on slags and recirculating materials	VDEh	3 1/2	488.500	60	293.100
1192	<u>II.7. Energy in steel industry</u> Improvement of energy utilisation by heat exchangers for cooling or pre-heating rolling stock	VDEh	3 1/2	861.000	60	516.600

Project No	Title of the research	Research proposed			Financial aid	
		by	Duration (years)	Budget (ECU) (30.11.81)	%	Amount ECU (30.11.81)
	<u>III. MECHANICAL WORKING</u>					
1119	Continuous control-rolling without prior descaling	CRM	4	753.500	60	452.100
1126	Integrated computer-aided system for roll pass design	Arbed	4	679.000	60	407.400
1144	Metallurgical optimization of rolling conditions in the continuous hot strip mill	IRSID Usinor	3	478.000	60	286.800
1145	Changes in surface defects during the rolling of bars and sections	IRSID	3	478.000	60	286.800
1146	New coiling procedures on the wide strip mill	IRSID Solmer	3	541.500	60	324.900
1166	Analyses of microstructural and oxidation processes in rolling mill reheating furnaces and their incorporation in optimum process control	CSM Italsider	3	598.500	60	359.100
1167	Improvement in the mechanical properties of eutectoid wire rod suitable for direct drawing, made from concast billets	CSM	2 1/2	574.000	60	344.400
1191	Investigation of energy conservation potential in reheating and heat-treatment furnaces with the use of modern control procedures	Univ. Wuppertal	3 1/2	299.500	60	179.700
1200	Development of methods of obtaining high drafts in the production of wide strip	BFI	3 1/2	989.500	60	593.700
1245	Studies of straightening and levelling operations for plate	BSC	2	156.500	60	93.900
1246	Computer-aided manufacture and robotics in rolling mills	BSC	2	128.000	60	76.800
	<u>IV. MEASUREMENTS AND ANALYSIS</u>					
1123	Rapid method for determining metallic aluminium in steels	CRM	3	167.500	60	100.500
1124	Internal geometrical survey of the refractory lining of torpedo ladles	Arbed	2	191.000	60	114.600

Project No	Title of the research	Research proposed		Financial aid		
		by	Duration (years)	Budget (ECU) (30.11.81)	%	Amount ECU (30.11.81)
1150	Continuous measurement of the shape of hot-rolled bars and sections	IRSID	3	493.500	60	296.100
1155	Non-destructive monitoring of surface decarburization	IRSID	3	287.000	60	172.200
1168	Hot ultrasonic inspection of slabs to optimize shearing	CSM	3	404.000	60	242.400
1169	Dynamic control of the heat regime of a cold tandem mill	CSM } Italsider }	3	660.500	60	396.300
1197	Research into the principles of high-pressure hot cutting in the production of semis	VDEh	2	421.000	60	252.600
1202	Optimization of methods of assessing nitrogen content in steel structure	VDEh	3	338.000	60	202.800
1206	Digital image processing and automatic image evaluation in radiation testing	BFI	3	537.000	60	322.200
1207	Development and industrial use of an inspection system for detecting surface defects	BFI	3	576.000	60	345.600
1208	Development of ultrasonic analysis of steel structure	Izfp	2 1/2	337.000	60	202.200
1261	Quality control by automatic ultrasonic inspection of heavy plate in the production line	Izfp	1 1/2	195.000	60	117.000
1262	Development multi-purpose automatic spraymarker system	Hoogovens	3	340.000	60	204.000
<u>V. SERVICE PROPERTIES AND PERFORMANCE</u>						
<u>V.1. Weldability</u>						
1081	Survey of the present state of automation and advanced technology fusion welding in the European Community and Japan	W.I.	1/2	35.000	100	35.000
1105	Metallurgy and mechanical properties of multipass submerged arc weld-metal in C/Mn and low-alloy constructional steels	T.N.O.	3	312.500	60	187.500

Project No	Title of the research	Research proposed			Financial aid	
		by	Duration (years)	Budget (ECU) (30.11.81)	%	Amount ECU (30.11.81)
1156	High-productivity welding of heavy plate	C.L. IRSID }	3 }	319.000	60	191.400
1171	Fatigue behaviour of motor vehicle parts of spot-welded sheet; influence on material selection	CSM	2	187.500	60	112.500
1157	<u>V.2. Corrosion and surface protection</u> Bonding of galvanized products	IRSID	4	239.000	60	143.400
1247	Effects of cold-rolled and annealed sheet surface cleanliness: particulate and oil residues	BSC	2	163.500	60	98.100
1273	Improvement of the cleanness of sheet surface	Hoesch	3	707.500	60	424.500
1120	<u>V.3. Cold forming</u> Weldability and formability of coated steel sheet	CRM	3	287.500	60	172.500
1159	Simplification of the surface preparation of bars for cold forming	IRSID C.L. }	3 }	382.500	60	229.500
1174	<u>V.4. Constructional steels</u> Promotion of steel use in motor vehicles by assessing their suitability for specified life design	CSM	1	262.000	60	157.200
1089	<u>V.5. Fracture mechanisms</u> Influence of residual elements on the intergranular stress corrosion cracking of carbon steels	NPL MPI }	3 }	174.000 309.000	60 60	104.400 185.400
1090	Alleviation of intergranular failure in the stress corrosion cracking of steels by rare earth metal addition	BSC NPL }	2 }	183.000	60	109.800
1176	Prediction of ductile fracture propagation behaviour in gas pipelines by means of laboratory tests	CSM	2	213.500	60	128.100

Project No	Title of the research	Research proposed			Financial aid	
		by	Duration (years)	Budget (ECU) (30.11.81)	%	Amount ECU (30.11.81)
1213	Influence of the state of stress on the deformation and fracture of steels using large-scale tensile tests	RWTH Aachen	3	665.000	60	399.000
1253	Characterization of crack arrest toughness in gas transmission pipelines in terms of the shear fracture propagation energy	BSC	2	176.500	60	105.900
1104	<u>V.6. High temperature steels</u> Steel and fabrication requirements in coal utilization technologies	BSC	1	90.000	40	36.000
1177	Effect of microstructure and impurity content on crack propagation in creep	CSM	3	262.000	60	157.200
1178	Microstructural properties of steel for large components for the energy industry as a function of operating variables in thermochemical treatment	CSM	3	322.500	60	193.500
1179	Behaviour of steels for use at elevated temperatures in thermal electricity generating plants operated with cyclical load variations	Dalmine	3	224.500	60	134.700
1216	Improvement of the creep rupture and toughness behaviour of high temperature turbine steels	VDEh	3	201.000	60	120.600
1254	Elevated temperature cracking of high temperature steels	BSC	3	265.500	60	159.300
1082	<u>V.7. Offshore technology</u> Service strength of welded offshore structures in sea water with particular reference to crack propagation measurements and post-weld treatment to increase fatigue strength	LBF IABG	2 } }	322.000	60	193.200

Project No	Title of the research	Research proposed			Financial aid	
		by	Duration (years)	Budget (ECU) (30.11.81)	%	Amount ECU (30.11.81)
	<u>V.8. Light structures</u>					
1086	Corrosion of steel structural members inside buildings	CECM	1	34.500	60	20.700
1129	Computer-assisted analysis of the fire resistance of steel and combined steel/concrete structures	ARBED	2	291.500	60	174.900
1130	Statistical survey of fires in industrial buildings	CTICM TNO	3	199.000 64.500	60 60	119.400 38.700
	<u>V.9. Alloy and special steels</u>					
1091	Improvement of the magnetic characteristics and service properties of non-oriented cast steel	Terni CSM	2 1/2	419.500	60	251.700
1092	New qualities of non-oriented electrical sheet for the construction of magnetic circuits	C.L.	2 1/2	206.500	60	123.900
1094	Characteristics required for the fabrication of engineering parts in micro-alloy steels in the form of bars and sections not quenched and tempered	Teksid	2	374.500	60	224.700
1122	Quantitative metallography	CRM	3	151.500	60	90.900
1221	Statistical description of non-metallic inclusions in steels for evaluation with standard series and fully automated machines	SMPi	3	319.000	60	191.400
1226	Influence of stresses generated by oxide layers on magnetic properties and scale adhesion of non-oriented electrical sheet	Stahlw.Bochum	2 1/2	382.000	60	229.200
1259	Relationship between crystallographic textures in fully annealed silicon bearing non-oriented electrotechnical steels and magnetic parameters	BSC	2 1/2	179.000	60	107.400
1260	Machinability of engineering steels	BSC	2	172.000	60	103.200
1268	Development of morphological algorithms for image analysis	IRSID	3	127.500	60	76.500

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		by	Duration (years)	Budget (ECU) (30.11.81)	%	Amount ECU (30.11.81)
1228	<u>VI. PLANT AVAILABILITY</u> Reduction of wear in the transport of abrasive bulk materials for burden preparation	BFI	3 1/2	488.500	60	293.100
1229	Reduction of maintenance costs in continuous casting machines	VDEh	3 1/2	948.500	60	569.100
1097	<u>VII. MISCELLANEOUS</u> Technical steel literature	Aselt	1	148.000	100	148.000
	Sub - total			33.078.000		18.750.000
	Ancillary costs and dissemination of information					250.000
	Total					19.000.000