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Expert Group Meeting on the Development of Engineering Design Capabilities in Developing Countries

Vienna, 11 - 15 May 1970

# ORGANIZATION AND STRUCTURE OF SCIENTIFIC ENGINEERING CENTRES IN THE DEVELOPING COUNTRIES AND THE ROLE OF TECHNICAL LABORATORIES AND EXPERIMENTAL SHOPS [1]

by

V.S. Belov
Deputy director of scientific work of the
USSR Experimental Scientific Research Institute
of Metal-Cutting Machine-Tools
Union of Soviet Socialist Republior

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## SUMMARY

# ORGANIZATION AND STRUCTURE OF SCIENTIFIC ENGINEERING CENTRES IN THE DEVELOPING COUNTRIES AND THE ROLE OF TECHNICAL LABORATORIES AND EXPERIMENTAL SHOPS 1/

by

V.S. Belov
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In the developing countries, industrialisation is of decisive importance to the economic development process. This is true above all of the development of the metal-working industry, and in particular of the establishment of national industries for the production of machine tools and other tools, general-purpose machinery, and woodworking and other equipment. At the same time, the production of spare parts for the repair and maintenance of the machinery and equipment employed in the various branches of the national economy must be organized. The machinery manufacturing and metal-working branches thus established call for the organization of centralized production of individual units and the development of specialization in the production of general-purpose tools and tool-holders, which in turn makes necessary the production of metals and castings and the organization of co-operation between the individual branches.

If the developing countries do not make use of the latest achievements in science and technology which are available to the developed countries, they will be unable to accelerate their industrialization, and hence the industrialization gap between the developed and the developing countries will grow. The transmission of technology to the developing countries is therefore a matter of prime importance at the present stage. The developing countries should be enabled to make active use of the technology received: in other words they should be able to adapt it to local conditions or develop it to meet their present and future needs.

The solution of the problem of the transmission of technology to the developing countries lies not so much in the analysis of the reasons for the lack of technological information or of the means of acquiring it as in the finding of ways of establishing a scientific and technological infrastructure which will enable the developing countries to mobilize their resources and develop the ability to establish their own production, to work out and introduce production methods based on the latest achievements of science and technology, and to carry out the necessary scientific research.

The United Nations' efforts to promote industrial progress in the developing countries should be directed towards the creation in those countries of an infrastructure for the assimilation of technological achievements.

In the developing countries, institutes for applied scientific research and various types of laboratories and design offices for the individual industrial branches are a necessity. A first organizational and directive step towards the establishment of such an infrastructure for the more rational harnessing of forces and resources for the economic development of the developing countries could be the creation in those countries of scientific and technological centres which would take the lead in action for the well-planned development of particular branches of the national mechanical engineering industry in accordance with the present technological level and with a view to accelerating the pace of industrialization. Subsequently, such scientific and technological centres could be divided into specialized institutes, laboratories and design offices for particular industrial branches. All this could be the long-term programme.

The short-term programme should consist of the creation of scientific and technological centres to enable the developing countries very rapidly to adapt the technology transmitted to them so as to take account of the conditions and requirements in a particular country or group of countries. The combination of these long-term and short-term programmes will permit the developing countries to solve for themselves the problems regarding the establishment of industry and achieve genuine independence.

The recommendations prepared, which take into consideration the specific features of each developing country, its level of industrial development, and its natural and economic conditions, provide for a comprehensive set of measures relating to organizational and technological assistance designed to enable developing countries to acquire more quickly the technological and economic skills needed to allow their own technical cadres to accelerate industrial progress by their efforts. The scientific and technological centres will be schools for the training of national cadres of engineers and workers capable of effectively directing technological progress in their particular developing country.

The countries of Asia, Africa and Latin America, which have followed the road of independent development are striving for the organization and expansion of national industry. They establish enterprises both with their own efforts and with the assistance of other countries.

The material and technical base in the state-owned sector of these countries cannot be successfully developed without training of national skilled workers of corresponding specialities for the creation of their own national mechanical engineering and machine tool industries as well as others, which are key branches for the development of the national economics.

The countries of Asia (Afganistan, Burma, India, Iraq, Iran, Yemen, Cambodia, the Lebanon, Pakistan, the Philippine), under some differentiation, increase capital investments for the development of mechanical engineering, machine tool industry ( India), metal-working, oil-extracting industries and metallurgy as well as for the production of agricultural machinery, spare parts and electric power equipment. In these countries measures are taken for the creation of repair shops to keep working equipment in good conditions as well as for the development of domestic branches of national production. Such measures show the striving of these countries to obtain economic independence.

The countries of Africa (Algeria, Ivory Coast, Ghana, Guinea, the Cameroons, Congo, Mali, Morocco, the United Arab Republic, the Sudan) outline the development of machine tool industry (U.A.R.), tube-rolling production, railway and motor transport, as well as the production of cars, tractors, various agricultural machinery, consumer goods (bicycles, radio-sets and plastics).

They design the development of metallurgic production, manufacture of spare parts for industrial equipment, textile and mining machinery as well as the development of houding construction ( house-building plants) and other branches which are of vital significance for the formation of national independence.

Thus, these countries create the foundation of modern economics, which requires further development and improvement. Profound contradictions between abundance of natural resources and extreme backwardness of productive forces exist in to-day's Africa.

African countries mine 90% of diamonds, realized by the capitalist market, 81% of cobalt, 62% of platinum, 70% of gold, 50% of magnesium and chromium, 36% of manganese, 32% of copper. Africa produces 66% of cocoa, 66% of sisal, 95% of peanuts, 25% of coffee-beans and cotton. There are rich reserves of coal, oil and iron-ore. At the same time Africa gives only 2% of industrial output, produced by the capitalist world.

The countries of Latin America (Argentine, Bolivia, Brazil, Venezuela, Colombia, Mexico, Peru, Uruguay, Chile, Ecuador) design the development of ferrous metal and machine tool industries, electric power and heavy engineering industries, lifting, transport and road-building machinery, non-ferrous metal industry, motor-car and tractor industries and other branches of engineering production. In spite of the fact that the countries of Latin America go far ahead of Asian and African countries in their industrial development, nevertheless, the process of industrialization in these countries proceeds rather slowly. This process requires the rapid development of national mechanical engineering, metal-working and other branches, which assist in delivering from the influence of capitalist monopolies and provide these countries with equality of rights in the international economic relations.

In the course of economic development the problem of industrialization in the developing countries is the basic one. The United Nations Organization considers that the most important thing for these countries is the development of metal-working industry, in particular, the establishment of national branches of machine-building and tool production, the manufacture of general purpose machinery, woodworking and other equipment, necessary for the economics of these countries. The participation in the external market is also of great importance for the developing countries.

Alongside this, the developing countries of Asia, Africa, Latin America are to solve the problem of spare parts production for repairing and keeping in good condition machines and equipment, employed in various branches of national economics.

Branches of machine tool and metalworking industries to be created will require the organization of the centralized production of separate units in specialized shops and plants. They will also demand for the development of specialization in the production of universal tools and fixing pieces (bolts, nuts, screws and other parts) that, in its turn, will cause the necessity to produce metal, castings, forgings as well as to organize the cooperation of separate branches and exchange of information on economic and technical problems.

Without use of modern scientific and technical achievements, obtained by the developed countries, the developing countries cannot carry out the speeded up industrialization and it means that a gap in industrialization between the developed and developing countries will be increasing.

Therefore at present the problem of transferring technology to the developing countries is of great importance. The developing countries must have a possibility to make an active use of the received technology, i.e. to change it in accordance with the local conditions or to develop it meeting the needs of the country both at present time and in future.

The settlement of the problem of transfering technology to the developing countries consists not only in the analysis of reasons for the lack of information on technology or means to purchase it, but also in the analysis of possibilities to create a scientific and technological infrastructure, which would allow the developing countries to mobilize their resources and develop the production of their own output. This infrastructure would also allow to work out and introduce methods of production, based on modern scientific and technical achievements as well as to carry out necessary scientific research work.

Efforts of the United Nations Organization, concerning the industrial development in the developing countries, should be aimed at the creation of the infrastructure for introducing technological achievements in these countries.

The developing countries should have research institutes for applied sciences, various laboratories and design offices on various branches of industry.

The establishment of scientific engineering centres in the developing countries could be an organizing and directing principle in creating such infrastructure with a view of the most rational concentration of forces and means for the development of the economics in these countries.

The scientific engineering centres should be initiators in purposeful formation of various branches of national mechanical engineering production, which corresponds to the present standard of technical progress and speeds up the industrialization in these countries.

Subsequently, such scientific engineering centres could be devided into special institutes of various branches of industry, laboratories and design offices. This may be a long-term program.

A short-term program within the next few years should include the establishment of the scientific engineering centres, mentioned above, and the training of technical specialists on a national wide scale.

Such centres will allow the developing countries to adapt the received technology with regard for the conditions and requirements of a country or a group of countries, practically within the next few years.

The combination of long-term and short-term programs will allow the developing countries to solve by themselves the problems of industrial construction and to obtain the genuine independence.

Recommendations prepared with regard for specific peculiarities of each developing country, its standard of industrial development as well as its formed natural and economic conditions envisage a complex of measures which could render an essential organizing and technical assistance to the developing countries in rapid acquiring of technical and economic habits of speeding up the progress of industrialization by the efforts of their own national specialists. Scientific engineering centres are a school of training national engineers and skilled workers, capable of directing properly the

the technical progress in the developing countries.

According to the standard of the development of mechanical engineering and metal-working industry the developing countries may be divided into 3 groups.

The first group covers those countries that have machine-building entreprises including rather large and modern ones, for instance, separate countries of Latin America (Argentine, Brazil, Mexico) and of Asia (India).

The second group covers such countries, where modern mechanical engineering is at the initial stage of development as for instance in Africa (the United Arab Republic, Syria).

The third group covers countries where mechanical engineering, as it is, does not exist, at the best there are shops for repairing imported machines, for instance, in Asia (Yemen) and in Africa (the Sudan).

Specific features of each country, its natural and economic conditions and its standard of industrial development must be taken into account in recommendations on the development of mechanical engineering and metal-working industry in the developing countries.

When determining the structure of organizations, called to give a technical direction to the development of mechanical engineering, and the main problems which these organizations should solve it is necessary to establish one and the same general approach to each group of countries, taking into account in these recommendations the different standard of industrial development.

## Recommendations for the First and Second Groups of Countries

One of the important factors, providing the development of mechanical engineering and metal-working industry, the training and growth of national high-qualified mechanical engineers in the first two groups is to create for this all the necessary conditions and find the most rational form of using these specialists.

Due to the small number of engineers and other technical workers of corresponding specialities in the developing countries it is advisable to concentrate the most qualified of them as well as of those who graduate from higher and secondary technical schools in the united scientific engineering centres of various branches of industry. Each of these centres should be a head organization in technical development of a corresponding branch of mechanical engineering and metal- working industry.

## Scientific Engineering Centre's Tasks

Judging from the standard of the economic development of the country the scientific engineering centre of the given branch of industry should play the leading role in determining a technical policy for the development of the given branch of mechanical engineering. It should also project long-term plans of the development of the given branch, coordinated with plans of industrialization of the country, and work out proposals on the specialization of enterprises.

The scientific engineering centre should be an organization on mastering the technique of the given branch as well as on rendering assistance in the proper exploitation of new machines, both imported and produced by national enterprises. The training of national specialists, familiar with new techniques of foreign and national production must be one of the tasks of the scientific engineering centre.

The scientific engineering centre should carry on the correspending research work, make up the designing and technical documentation for new and modernized machines to be mastered at the enterprises of the country. The staff of the scientific engineering centre should take an active part in the mastering of new technique. One of the important tasks of the scientific engineering centre is the working out of state standards on workpieces and their elements. This must be based on the use of the standards recommended by International Standards Organizations, and standards of industrially developed countries, which the development of mechanical engineering of the given country follows. The scientific engineering centre should methodically direct a complex of measures on repairing the corresponding stock of working machines in the country.

The scientific engineering centre submits to the corresponding ministry or state planning organization and is in constant business-like contact with enterprises and organisations of the corresponding branch of industry.

The activity of the scientific engineering centre is financed at the expense of the state budget and partially at the expense of works, fulfilled according to economic agreements with the industry.

Taking into consideration the lack of experience and insufficient training of national engineers and working personnel, it is more advisable during the first period to aim the activity of the scientific engineering centre at the settlement of the most urgent problems which correspond to the given stage of the industrial development of the country, bringing forward more complicated problems in the course of further development of the branch, qualitative growth and improvement of specialists' skill.

To make the work of the scientific engineering centre more efficient it should have at its disposal an experimental base with the necessary complete set of basic and auxiliary technological equipment to produce models of designed machines and mechanisms.

The scientific and engineering centre should have a demonstration hall with models of new machines both imported and produced in the country to make thorough study and test of these machines possible.

The scientific engineering centre should have at its disposal a technical library, research laboratories, photographing and copying equipment etc.

## Model structure of the scientific engineering centre for machine tool production

Due to comprehensive nomenclature of machines and equipment which are necessary for the needs of the national economics of the developing countries, it is advisable, when establishing a scientific engineering centre, to take into consideration the service of similar branches and the activity of such centre within the limits of the given specialization, for instance, the production of metal-cutting, woodworking and forging machinery, metallurgic, transport and electric power equipment; the production of motor and tractor equipment, the manufacture of textile, shoe, and poligraphic machinery etc.

For the developing countries of Asia (India) and Latin America the following model structure of a scientific engineering centre may be recommended:

The machine tool design office should consist of 8 groups, including 50 to 60 persons.

1) Design engineers of lathes, turret-screw, multi-tool, turning machines, automatic and semiautomatic - 10 persons.
2) Design engineers of milling, planing and slotting machines- 10 persons;
3) Design engineers of grinding and finishing machines - 5 persons;
4) Design engineers of gear working machines - 5 persons;
5) Design engineers of drilling and boring machines - 5 persons;
6) Engineers dealing with the types of machines, unification and specialization of all groups of machine-tools - 5 to 7 persons;
7) Engineers dealing with the calculations of machines - 5 persons;
8) Copyists of all groups of machines - 10 persons.

The duties of each group may be characterized as follows.

The design office works out the technical documentation and drawings of machines, being imported or introduced into the country, makes an examination of design, takes part in establishing types of machine tools and introducing new models, produced in the country, and studies the experience on the exploitation of machine tools in industry. This office works out drawings for special machines on the basis of available designs.

The design office should have a machine tool laboratory where it may be possible to carry on research and test of machines and their mechanisms as well as to improve the designs of machines and their elements.

## Model structure and equipment of machine testing laboratory

### STRUCTURE

| | |
|---|---|
| 1. Chief | - 1 |
| 2. Leading engineer | - 1 |

| | |
|---|---|
| 3. Research engineer | - 2 |
| 4. Engineer | - 1 |
| 5. Technician | - 3 |
| 6. Machine operator | - 1 |
| 7. Mechanician | - 1 |
| 8. Fitter | - 2 |
| | total: 12 persons |

## EQUIPMENT

| | | |
|---|---|---|
| 1. Vibro-acoustic apparatus, completed | Brüel-KJAER | (Denmark) |
| 2. Small displacement measuring devices | Hottinger | ( FRG ) |
| 3. Kinematic accuracy measuring devices | Klingelnberg | (FRG ) |
| 4. Geometric accuracy and surface rigidity measuring devices | Taylor-Hobson | ( FRG ) |
| 5. VDF engine lathe | | ( FRG ) |
| 6. Bench-drilling machine, dia 10mm | | |
| 7. Cathode-ray oscillograph | Marconi | |
| 8. Solartron AD-557, Cathode-ray oscillograph | | (England) |
| 9. Solartron CD-643 Cathode-ray oscillograph | | (England) |
| 10. Voltage stabilizer | Solartron | (England) |
| 11. УИП -1 Universal power supply | | ( USSR ) |
| 12. TY-5 Strain gauge amplifier | | ( USSR ) |
| 13. 6-channel paper recording oscillograph with set of shunts and additional resistors, frequency up to 100Hz. | | ( Japan ) |

14. Unigor-3M portable universal measuring device (Austria)

15. П - shaped compression dynamometers for 250, 500, 100 kg loads.

16. Ring-type traction dynamometers for 250, 500, 100kg loads.

17. 2500 and 5000 kg calibrating dynamometer.

18. Dial scales up to 5kg.

19. Post scales up to 50kg.

20. Technical balance up to 1kg.

21. Inertia-type dynamometer (with an indicator) for measuring cutting forces.

22. Seconds counter.

23. Prophilometer (surface finish tester)

24. Poldi hardness tester.

25. Hydraulic or screw press for calibrating dynamometers.

26. x6 and x16 magnifiers

27. 5,10 and 20kw Prony brakes.

28. Band brake.

29. 15°C and 250°C laboratory thermometers

30. Indicators with stands, 0.01mm graduations.

31. Frame level with 0.02mm graduation.

32. Special angle gauge for cutting tools.

33. Reference plate.

34. Centre gauge.

35. Block gauges.

36. Thread gauges.

37. Feelers.

38. Set of angle gauges.

39. Set of templet rules

40. Vernier-height gauge, with 0.02mm graduation.

41. 350mm calliper, with 0.05mm graduation.

42. 150mm calliper with 0.02mm graduation.

43. Micrometer for diameters up to 100mm.

44. Universal milling machine

45. Universal lathe.

A group of engineers dealing with types, unification and specialization of machines works out together with plants and the design office the types of machines to be put into production during a year or longer period of time. They also determine models which are to be taken off the production because of their obsolescence or for some other reasons as well as those to be modified.

This group elaborates recommendations on the development of machine tool production and the establishment of more rational specialization.

A group of engineers which is engaged in calculating machines develops instructions on calculations of widely used parts of machines, makes more complicated calculations of machine parts. A group of copyists copies the drawings, made by design engineers of all groups of machines. The scientific engineering centre should have a group on standardization and normalization, consisting at least of 5 persons.

This group studies and makes up materials on normals, standards and various instructions concerning normalization, in particular, normals on making machine tool drawings (dimensions of drawings, rules for making drawings etc.), normals on basic technical standards ( gauge diameters, threads, tapers, gear modules, spline joints etc.). This group also prepares proposals on organization of centralized production of individual normals for general application in the production of machines. This group works out new normals and normalized units and renders assistance to machine-building plants in carrying out normalization.

In view of complex development of machine tool production and organization of more improved technology in production of machine tools it is advisable to establish a technical department, consisting of 45-50 persons approximately.

This department should generalize the latest experience on technology of machine-tool production, work out technological processes, and take part in designing various fixtures, tooling and machines.

The technical department should have the following laboratories:

1. technological laboratory;
2. measuring
3. material mechanical test
4. protection coat
5. chemical
6. metallographic
7. heat-treatment

Works on investigation of technological processes in machining special materials, new designs of cutting tools, special set-up as well as works on specifying optimal cutting conditions should be concentrated in the technological laboratory.

In addition, this laboratory can work out technological processes, using new machining methods ( plastic deformation, electrophysical and electrochemical methods, generating, vibration machining).

Various types of cutting coolants are tested depending on technological operations ( turning, planing, milling, tapping etc.) and materials to be machined.

The measuring laboratory is intended for inspection of the most important parts of machines (spindles, gears, index gear pairs etc.) after they have been produced, as well as for the organization of inspection service in experimental shops. It also works out measuring tooling for in-process control of workpieces. The material test laboratory is designed for testing various materials with the purpose of proper selecting sections of parts used in machines. This especially important in producing new parts from other materials instead of those being worn out. The protection coat laboratory works out technological processes on protecting parts from corrosion depending on different operating conditions. Metallographic and chemical laboratories are intended for investigating material structure of the parts of imported machines, which failed to operate because of breakage, with the purpose of changing these materials for that available in the country. In addition, these laboratories should select materials for the production of new machines as well as substitute scarce materials for plastics in machine-tool industry. They also can analyse and determine fields of application of various oils and fluids.

The heat-treatment laboratory is designed for strengthening bearing surfaces of parts with the purpose of increasing their service life. It works out new methods of strengthening materials by means of heat treatment, depending on chemical structure of material and working conditions.

The model structure and equipment of the technical department laboratories.

## TECHNOLOGICAL LABORATORY

### STRUCTURE

| | |
|---|---|
| 1. Chief | - 1 |
| 2. Senior research engineer | - 1 |
| 3. Research production engineer | - 1 |
| 4. Senior technician | - 1 |
| 5. Machine operators and fitters | - 3 |
| | total: 7 persons |

### EQUIPMENT

| | | |
|---|---|---|
| 1. VDF engine lathe | ( FRG ) | - 1pc |
| 2. Superuniversal milling machine | (Japan ) | - 1pc |
| 3. R.Blohm Universal grinding machine | ( FRG ) | - 1pc |
| 4. Bench-drilling machine, dia.10mm | | - 1pc |
| 5. Double-ended grinder | | - 1pc |
| 6. П-shaped compression dynamometers for 50, 100, 200, 500, 1000, 2500, 5000, 10 000, 20 000kg loads, type ДМ | ( USSR ) | - 9pcs |
| 7. Ring-type traction dynamometers for 100, 200, 500, 2500, 1000kg loads, type ДП | ( USSR ) | - 5pcs |
| 8. 500 and 5000kg calibrating dynamometers, type ДС | ( USSR ) | - |
| 9. Technical balance with weights up to 1kg | | - 1pc |
| 10. ДС-1 speed counter | ( USSR ) | - 1pc |
| 11. ДС-1 speed pick-up | ( USSR ) | - 1pc |

| | | | |
|---|---|---|---|
| 12. | seconds counter | (Switzerland) | - 4pcs |
| 13. | x 4, 7, 10, 20 magnifiers | | - 4pcs. |
| 14. | 150° and 250°C copper-constantan thermocouples | | - 4pcs |
| 15. | K-50 Power meter, completed | ( USSR ) | - 1set |
| 16. | Unigor - 3M portable universal tester, completed | | - 3pcs |
| 17. | Laboratory autotransformer, 10amp. | | - 3pcs |
| 18. | Wire-strain gauges, bases: 20mm | | - 200pcs |
| | 10mm | | - 100pcs |
| | 5mm | | - 100pcs |
| 19. | H-377 recording wattmeter | ( USSR ) | - 1pc |
| 20. | Cutting force measuring instrument | | - 1pc |
| 21. | Vibrometer, type УР - 101 | ( USSR ) | - 1pc |
| 22. | Test indicator with 0.002mm graduation. | | - 1pc |
| 23. | Test dial indicators with 0.01, 0.002, 0.001mm graduations | | - 3pcs |
| 24. | Measuring support for dial indicators with 0.01mm graduation | | - 1pc |
| 25. | Measuring support for dial indicators with 0.001mm graduation | | - 1pc |
| 26. | Ш- type frame level with 0.02mm graduation. | ( USSR ) | - 1pc |
| 27. | П- type external and interior angle protractor. | | - 1pc |
| 28. | "0" accuracy grade surface plate | | - 1pc |
| 29. | Workpiece run-out measuring instrument, type ПБ- 500 | ( USSR ) | - 1pc |
| 30. | Calliper with 0.05mm graduation and 0 to 160mm measuring limits. | | - 5pcs. |

31. Micrometers for measuring smooth surfaces with 0.01mm graduation and 0 to 25, 25 to 50, 50 to 75, 75 to 100mm measuring limits - 8pcs
32. High accuracy inside callipers with 1+2 $\mu$ graduation. - 2pcs
33. Metallic measuring rulers, 0 to 1000mm - 3pcs
34. Bench vices - 3pcs
35. Set of fitter's tools - 3sets
36. Electric drill - 1pc

## MEASURING LABORATORY

### Structure

| | |
|---|---|
| 1. Chief | - 1 |
| 2. Senior engineer | - 1 |
| 3. Engineer | - 1 |
| 4. Inspectors | - 3 |
| | total: 6 persons |

### Equipment

#### I. Shape and Roughness Testers

| | | |
|---|---|---|
| 1. Interferometer microscope | C.E. Johansons | (Sweden ) |
| 2. Talysurf-4 Profilograph-profilometer | Rank Taylor Hobson | (England) |
| 3. Surtonic Shop-profilometer | | (England) |
| 4. Talylin-5 Straightness tester | Rank Taylor Hobson. | (England) |
| 5. Dual Microscope | C. Zeiss | ( GDR ) |

| | | |
|---|---|---|
| 6. Talyrond-51 Roundness tester | Rank Taylor Hobson | (England) |
| 7. Talyvel Electronic level | | (England) |
| 8. Bubble levels | C.Zeiss | ( GDR ) |

II. Gear testers

| | | |
|---|---|---|
| 1. Pitch tester | C.Zeiss | ( GDR ) |
| 2. Involute meter | C.Zeiss | ( GDR ) |
| 3. Set of laid-on gauges | MAAG | (Switzerland) |

III. Planeness and plane-parallelism Testers

| | | |
|---|---|---|
| 1. Set of flat glass plates | C.Zeiss | ( GDR ) |
| 2. Straight edge | C.Zeiss | ( GDR ) |
| 3. Surface plates | Microflat | ( USA ) |
| 4. Reference and lay-out prisms | C.Zeiss | ( GDR ) |

IY. Thread gauges

| | | |
|---|---|---|
| 1. Screw pitch gauge | Coventry gauge | (England) |
| 2. Set of thread micrometers | C.Zeiss | ( GDR ) |
| 3. Set of inserts for metric, inch and trapezoidal threads | C.Zeiss | ( GDR ) |
| 4. Sets of wire and roller gauges | C.Zeiss | ( GDR ) |
| 5. Thread gauges | C.Zeiss | ( GDR ) |

## V. Instruments and accessories for testing measuring devices

| | | |
|---|---|---|
| 1. Micrometer tester | C.Zeiss | ( GDR ) |
| 2. Dial-indicator tester | C.Zeiss | ( GDR ) |
| 3. Levels Tester | Rank Hilger Watts | (England) |

## VI. Miscellaneous devices and instruments

| | | |
|---|---|---|
| 1. Universal microscope | C.Zeiss | ( GDR ) |
| 2. Tool Microscope | Opton<br>- " - | ( FRG )<br>- " - " - |
| 3. Vertical optical indicator | - " - | - " - " - |
| 4. Universal horisontal comparator with accessories | C.Zeiss | ( GDR ) |
| 5. Measuring machine | C.Zeiss | ( GDR ) |
| 6. Projector | SIP | (Switzerland) |
| 7. Optical indexing head | F.Leitz | ( FRG ) |
| 8. Autocollimator | Rank Hilger Watts | (England) |
| 9. Theodolite | C.Zeiss | ( GDR ) |
| 10. Optical quadrant | Rank Hilger Watts | (England) |
| 11. Microtelescope | Rank Taylor Hobson | (England) |
| 12. Telescope with collimator | C.Zeiss | ( GDR ) |
| 13. Set of slip gauges | C.Zeiss | ( GDR ) |
| 14. Accessories for slip gauges | Johansson | ( Sweden) |
| 15. Set of optical spring-type measuring heads | Johansson | ( Sweden) |
| 16. Set of spring-type heads | C.Zeiss | ( GDR ) |
| 17. Set of test indicators | TESA<br>Cary<br>C.Zeiss | (Switzerland)<br>- " - " -<br>( GDR ) |

| | | |
|---|---|---|
| 18. Set of dial indicators | C.Zeiss | ( GDR ) |
| 19. Set of test indicators | C.Zeiss | ( GDR ) |
| 20. Set of indicator accessories | C.Zeiss | ( GDR ) |
| 21. Set of supports | C.Zeiss | ( GDR ) |
| 22. Set of stands | C.Zeiss | ( GDR ) |
| 23. Set of radius gauges | C.Zeiss | ( GDR ) |
| 24. Magnifiers of various magnification | C.Zeiss | ( GDR ) |
| 25. Set of callipers | C.Zeiss<br>TESA | ( GDR )<br>(Switzerland) |
| 26. Depth gauge | C.Zeiss | ( GDR ) |
| 27. Height gauge | C.Zeiss | ( GDR ) |
| 28. Set of micrometers | C.Zeiss<br>TESA | ( GDR )<br>(Switzerland) |
| 29. Micrometer height gauge | Coventry gauge<br>Mitutoyo Mfg Co. | (England)<br>( Japan ) |
| 30. Set of inside micrometer gauges | C.Zeiss<br>TESA | ( GDR )<br>(Switzerland) |
| 31. Set of inside dial gauges | C.Zeiss | ( GDR ) |
| 32. Set of optical inside gauges | Technica | (Switzerland) |
| 33. Electronic variable inductors | TESA | (Switzerland) |

**Material Mechanical Test Laboratory**

| | |
|---|---|
| 1. Chief | - 1 |
| 2. Senior engineer | - 1 |
| 3. Senior technician | - 2 |
| 4. Technician | - 2 |
| 5. Mechanician | - 1 |
| | total: 7 persons |

**Equipment**

| | | | |
|---|---|---|---|
| 1. | Horizontal metallographic tool microscope | Opton | ( FRG ) |
| 2. | Vertical metallographic tool microscope | Opton | ( FRG ) |
| 3. | Material Microhardness Tester | | |
| 4. | Universal metallographic microscope | C.Zeiss | ( GDR ) |
| 5. | Surface quality tester | Opton | ( FRG ) |
| 6. | Stereoscopic microscope | C.Zeiss | ( GDR ) |
| 7. | Vertical optimeter | Opton | ( FRG ) |
| 8. | Material wear testing machine | HUB | ( GDR ) |
| 9. | KT-2 Lubricant tester | | |
| 10. | Universal material wear testing machine with 30t Load | Shopper | ( GDR ) |
| 11. | Universal material tensile testing machine with 5t load | Shopper | ( GDR ) |
| 12. | M■ - M material wear tester under reciprocating motion conditions | | ( USSR ) |
| 13. | Engine lathe | | |
| 14. | Bench drilling machine | | |
| 15. | Bench vice | | |
| 16. | Set of fitter's tools | | |

**Protection Coat Laboratory**

**Structure**

1. Chief - 1
2. Engineer - 1
3. Senior technician - 2
4. Laboratory assistant - 2

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total: 6 persons

## Equipment

1. M-3 Pendulum-type coat hardness tester ( USSR )
2. Elasticity scale for enamel and ground coats.
3. Y-1 coat impact strength tester ( USSR )
4. B3-4 Funnels for testing viscosity of enamel and ground coats ( USSR )
5. B3-1 Funnels for testing putty viscosity ( USSR )
6. Dyeing chamber (laboratory type)
7. KPY-1 Dye-sprayer ( USSR )
8. Oil-water-separator
9. Thermostats
10. T-2 Hydrostat - 1pc ( USSR )
11. BH4 Balance with a set of weights - 1pc ( USSR )
12. T-1 Analytic balance with a set of weights. - 1pc ( USSR )
13. Electric stoves with covered spiral - 5pcs
14. Draught hoods - 2pcs
15. Chemical heatproof porcelain and glassware, including measuringglassware
16. Rubber gloves
17. Pincers.

## Chemical Research Laboratory

### Structure

1. Chief of Laboratory - 1
2. Senior engineer - 1
3. Engineer - 2

4. Senior technician - 2

5. Laboratory assistant - 2

total: 8 persons

## Equipment

1. ТОУ-1 Gas analyser ( USSR )
2. +1000 +1200°C Muffle furnaces
3. D-1 distiller ( USSR )
4. ФЭК-М photocolorimeter ( USSR )
5. Drying chamber, up to +150°C
6. Г-1 analytic balance with a set of weights up to 1kg ( USSR )
7. Г-1 analytic damped balance with a set of weights up to 200g ( USSR )
8. Electric stoves with covered spiral, including water bath, sand bath
9. Domestic refrigerator
10. Oil viscosimeter ( USSR )
11. Thermostats
12. АПУ-1 acid content potentiometer ( USSR )
13. Г-2 thermomoisture chamber (Hydrostat) ( USSR )
14. ИТП -1 galvanometer ( USSR )
15. МГ -ДАЗ non-magnetic coat thickness gauge ( USSR )
16. КТП -2М non-magnetic coat thickness gauge ( USSR )
17. ЭТУ-2 thickness gauge
18. Set of specific-weight areometers (hydrometers)

19. Stereoscopic microscope C.Zeiss
20. СЛ -11 styloscope ( USSR )
21. СЛ -12 styloscope ( USSR )
22. ИСП-30 spectrograph ( USSR )
23. Draught hoods
24. Titration table
25. Laboratory tables
26. Set of mercury thermometers
    up to +30° - 10pcs
    up to +50° - 10pcs
    up to +100° - 10pcs
    up to +150° - 10pcs
27. Retort stands - 50pcs
28. Chemical heatproof glassware, including measuring glassware
29. Chemical porcelain ware
30. Pincers
31. Rubber gloves
32. Set of x4, x7, x10, x20 magnifiers

## Metallographic Laboratory
### Structure

1. Chief - 1
2. Senior engineer - 1
3. Technician - 2
4. Laboratory assistant - 1

---

total: 5 persons

## Equipment

| | | |
|---|---|---|
| 1. Metallographic microscope | C.Zeiss | ( GDR ) |
| 2. Microhardness tester | Richert | (Vienna) |
| 3. WRM hardness tester | | (Vienna ) |
| 4. Dilatometer | Shewenar | (Switzer-land ) |
| 5. Stereoscopic microscope | C.Zeiss | ( GDR ) |
| 6. Portable hardness tester for quideways, type ET II.31.101 | | (Austria) |
| 7. Hole hardness tester, type 83.11, 83.12, 83.13 | | (Austria) |
| 8. Hardness tester for external ge-aring involute, type 84.31.101 | | (Austria) |
| 9. Hardness tester for internal ge-aring involute, type 84.31.101 | | (Austria) |
| 10. Device for electrolytic polishing | C.Zeiss | ( GDR ) |
| 11. Grinding machine for preparing metallographie specimens | | |
| 12. Polishing machine for preparing metallographic specimens | | |
| 13. Press for pouring metallographic specimens | | |
| 14. Magnetic flaw detector | | |
| 15. Microstructure photographing device | C.Zeiss | ( GDR ) |
| 16. Hardness tester | Wicers | (England) |
| 17. Draught hood | | |

## Heat-treatment Laboratory

| | |
|---|---|
| 1. Chief | - 1 |
| 2. Engineer | - 1 |
| 3. Technician | - 2 |
| 4. Laboratory assistant | - 2 |
| | total: 6 persons |

## Equipment

| | | | | |
|---|---|---|---|---|
| 1. | Chamber electric stove | | - 1pc | |
| 2. | Muffle furnaces | | - 5pcs | |
| 3. | Pit electric furnace with protective atmosphere and a generator | | - 1pc | |
| 4. | Salt bath | | - 1pc | |
| 5. | Furnace for chemical and heat treatment | "Brimik" | - 1pc | (England) |
| 6. | Potentiometers for temperature control | | - 10pcs | |
| 7. | Drying chamber | | - 2pcs | |
| 8. | Arbours for pouring metallographic specimens | | - if required | |
| 9. | Balance with a set of weights up to 1kg | | - 1pc | |
| 10. | Bench vice | | - 1pc | |
| 11. | Set of fitter's tools | | - 2sets | |

The scientific and engineering centre for machine-tool industry should include a technical information department with a staff of translators, technical archives, blueprinting and photographing laboratories and a technical library, 15 persons in number. This department is responsible for filing technical documentation, publishing and distributing the elaborated papers as well as for maintaining close contact with certain organizations and compiling bibliography on problems of interest. It should also get published papers, make translations from foreign languages, blue prints and photographs, file documents in the technical library ensuring the normal functioning therein.

It is necessary to have ten skilled fitters for experimental works performed in the laboratories.

The scientific and engineering centre must have an experimental shop with an area of about 3000 sq.m. indispensable for successfully mastering newly developed machine-tool designs, making stands for testing machines, certain simple instruments, special tools and tooling used for machining parts and units failed to operate.

This shop incorporates assembly section, tool making and sharpening section, repair and electromechanical section, machine-tool painting, packing and quality checking sections.

Besides, it is advisable to arrange in a separate room the production of castings and forgings, a section for welding and heat-treating parts and tools with a special department for making wooden models.

The electrical and hydraulic equipment for machine tools to be completed with, can be supplied at first by way of cooperation.

It is also advisable to establish special services for these fields of engineering if wider experience is gained.

The experimental shop should have 65 or 70 machine-tools of various technological groups which require 150 skilled workers for their operation, taking into account auxiliary services.

This equipment is as follows:

| | pcs |
|---|---|
| Engine lathe, workpiece dia. 250mm | 1 |
| Engine lathe, workpiece dia. 320mm | 2 |
| Engine lathe, workpiece dia. 400mm | 4 |
| Engine lathe, workpiece dia. 630mm | 1 |
| Engine lathe, workpiece dia. 800 to 1000mm | 1 |
| Single-upright vertical lathe, workpiece dia. 1250mm | 1 |
| Universal machine | 1 |

Drilling machines.

| | |
|---|---|
| Bench-type drilling machine, drilled dia. 12mm | 1 |
| Upright-drilling machine, drilled dia. 18mm | 1 |
| Upright-drilling machine, drilled dia. 25mm | 2 |
| Upright-drilling machine, drilled dia. 36mm | 2 |
| Upright-drilling machine, drilled dia. 50mm | 1 |
| Upright-drilling machine, drilled dia. 75mm | 1 |
| Radial-drilling machines, drilled dia. 25mm | 1 |
| Radial-drilling machines, drilled dia. 35mm | 1 |
| Radial-drilling machine, drilled dia. 50mm | 1 |
| Radial-drilling machine, drilled dia. 75mm | 1. |

Boring machines

| | |
|---|---|
| Boring machine, spindle dia. 65mm | 1 |
| Boring machine, spindle dia. 85mm | 1 |

| | |
|---|---|
| Boring machine, spindle dia. 85mm | 1 |
| Boring machine, spindle dia. 110mm | 1 |
| Boring machine, spindle dia. 125mm | 1 |
| Boring machine, spindle dia. 160mm | 1 |

Jig-boring machines

| | |
|---|---|
| Jig-boring machine, table 630mm x 1100mm | 1 |
| Jig-boring machine, table 630mm x 900mm | 1 |

Grinding Machines

| | |
|---|---|
| Universal plain grinding machine, swing 100mm | 1 |
| Universal plain grinding machine, swing 200 to 280mm | 2 |
| Universal plain grinding machine, swing 400 to 560mm | 1 |
| Universal internal-grinding machine, hole dia 50mm | 1 |
| Universal internal-grinding machine, hole dia. 100mm | 1 |
| Universal internal-grinding machine, hole 200 to 400mm | 1 |
| Surface grinding machine, table 200mm x 630mm | 2 |
| Surface grinding machine, table 320mm x 800mm or 320mm x x 1000mm | 1 |
| Surface grinding machine, indexing table dia. 400 to 800mm | 1 |
| Tool grinding machine, | |
| wheel dia. 200mm | 1 |
| wheel dia. 300mm to 600mm | 1 |
| Universal thread grinding machine, | |
| swing 125mm | 1 |
| swing 200mm to 320mm | 1 |
| Universal tool grinding machine, | |
| workpiece dia. 250 | 1 |
| workpiece dia. 250mm to 400mm | 2 |

## Gear-Cutting Machines

| | |
|---|---|
| **Universal** gear-milling machine, | |
| milling dia. 125mm, module 1,5mm | 1 |
| milling dia. 200mm, module 4mm | 1 |
| milling dia. 320mm, module 6mm | 1 |
| milling dia. 500mm, module 8mm | 1 |
| milling dia. 800mm, module 10mm | 1 |
| Gear shaping machine | |
| gear dia. 200mm, module 4mm | 1 |
| gear dia. 500mm, module 5mm | 1 |
| gear dia. 800mm, module 12mm | 2 |
| Gear shaving machine, | |
| gear dia. 125mm, module 5mm | 1 |
| gear dia. 320mm, module 6mm | 1 |
| gear dia. 500mm, module 8mm | 1 |
| gear dia. 800mm, module 10mm | 1 |
| Spur gear grinding machine, | |
| workpiece dia. 125mm x 1,5mm | |
| workpiece dia. 320mm x 4 | 1 |
| workpiece dia. 500mm x 6 | |
| workpiece dia. 800mm x 8 | |

## Milling Machines

| | |
|---|---|
| Horizontal milling machine, | |
| table 250mm x 1000mm | 1 |
| table 400mm x 1600mm | 1 |
| Superuniversal milling machine, | |
| table 200mm x 630mm | 1 |
| table 320mm x 1250mm | 1 |
| table 200mm x 800mm | 1 |
| table 400mm x 1600mm | 1 |

| | |
|---|---|
| Single-upright plano-milling machine, | |
| table: 800mm x 3000mm | 1 |
| 1000mm x 4000mm | 1 |
| Double-upright plano-milling machine, | |
| table: 630mm x 2000mm | 1 |

Planing Machines

| | |
|---|---|
| Single-upright planing machine, | |
| table: 900mm x 3000mm | 1 |
| 1120mm x 4000mm | 1 |
| Shaping machine | |
| ram stroke: 500mm | 1 |
| ram stroke 700mm | 1 |
| ram stroke: 900mm | 1 |

Slotting Machines

| | |
|---|---|
| Slotting machine, | |
| slotting tool stroke 200mm to 320mm | 1 |
| slotting tool stroke 500mm | 1 |

Cutting-Off Machines

| | |
|---|---|
| Hack sawing machine, | |
| workpiece dia. 250mm | 1 |
| Cutting-off milling machine, | |
| saw dia. 240mm to 710mm | 2. |

A laboratory for testing electric machines should be provided for the experimental shop. The main function of the laboratory is to test electrical apparatuses and motors used both for machine-tool production and instead of the imported electrical equipment.

Model Structure of Laboratory for Testing Electrical Equipment

| | |
|---|---|
| 1. Chief | - 1 |
| 2. Senior Engineer | - 1 |
| 3. Engineer | - 1 |
| 4. Technician | - 2 |
| 5. Electrotechnician | - 1 |
| | total: 6 persons |

Equipment

| | | | |
|---|---|---|---|
| 1. AD-527 cathode-ray oscillograph | Solartron | | (England) |
| 2. CD-642 double oscillograph | Solartron | | (England) |
| 3. Cathode-ray oscillograph | Duscopf | | ( GDR ) |
| 4. Unigor-3M universal portable meter, completed | | | |
| 5. Laboratory autotransformer, 10A | | | |
| 6. Laboratory autotransformer, 2A | | | |
| 7. Ohmmeter or Wheatstone Bridge | | 2pcs | |
| 8. Capacity meter | METRA | 2pcs | |
| 9. RFT low-frequency generator | | 2pcs | |
| 10. Radio-frequency oscillator | Solartron | 1pc | |
| 11. Mirror galvanometer | TESLA | 1pc | |
| 12. Board-mounted d.c. voltmeter, 0 to 50V | | 10pcs | |
| 13. Board-mounted a.c. voltmeter, 0 to 50V | | 10pcs | |

| | | | | |
|---|---|---|---|---|
| 14. | Board-mounted d.c. ammeter, 0 to 150A | | 10pcs | |
| 15. | Board-mounted a.c. ammeter, 0 to 25 A | | 10pcs | |
| 16. | Tachometer with a stop watch | Jaget | 2pcs | (Switzerland) |
| 17. | Automatic 8-channel paper recorder, up to 100Hz, completed | | 1pc | ( Japan ) |
| 18. | D.c. ammeter | METRA | 2pcs | |
| 19. | Voltmeter, up to 250V | METRA | 5pcs | |
| 20. | Valve voltmeter | MARCONI | 1pc | |
| 21. | M-101 Megohm-meter | | 1pc | |
| 22. | Resistance box | METRA | 5pcs | |
| 23. | Winder | | 1pc | |
| 24. | Bench vice | | 3pcs | |
| 25. | Bench-drilling machine, dia.10mm | | 1pc | |
| 26. | Soldering iron | | 10pcs | |
| 27. | Tweezers | | 10pcs | |
| 28. | Scalpels | | 10pcs | |
| 29. | Insulating screw drivers | | | |
| 30. | Insulating cutting nippers | | | |
| 31. | Rubber gloves tested for breakdown | | | |
| 32. | Electric drill | | | |
| 33. | Set of fitter's tools | | | |

Such structure of the scientific and engineering centre for machine-tool production can be recommended for the developing countries of Asia, Africa and Latin America, where the national machine-tool industry is planned to be created.

At first stage the scientific and engineering centre should number some 250 technical and production workers except those of calculating, distributing and planning groups.

The following structure of the governing body for the scientific and engineering centre can be recommended.

1. Manager
2. Chief engineer
3. Chief technologist
4. Chief designer - the head of the design office.
5. Chiefs of laboratories and groups.
6. Chiefs of experimental shops and auxiliary services.

Chiefs of departments, groups, laboratories, sections and shops are subordinate to the chief engineer as far as technological questions are concerned. He directs and coordinates their activity.

The recommended structure of the scientific and engineering centre can be used by other branches of mechanical engineering and metal-working industry with certain corrections due to specific features.

## Model Structure of the Scientific and Engineering Centre for Branches of Metal-working Industry

For the scientific and engineering centre of metal-working industry the following subdivisions and problems they should solve are recommended.

1. Nomenclature of equipment to be made in the country and specialization of enterprises of the branch - 5 persons.
2. Standardization and normalization - 5 persons.
3. Investigation of imported machines, the designing of new machines and modernization of working equipment and mechanisms, carrying out experimental and research work as well as making translation from foreign languages - 60-70 persons.

4. Technology of machine production.

Specialists in cutting tools, metallurgical science, metrology, plastics and varnish-painting materials should be involved in this case.

5. Use and repair of working machines and equipment - 15-20 persons.

6. Technical information on standards and manuals worked out by the scientific and engineering centre as well as on research technological and designing works - 10 persons.

Thus the total number of specialists empoyed at the scientific and engineering centre will be as much as 140-150 persons. Taking into account the number of the personnel of both the governing board and auxiliary services the staff of the scientific and engineering centre will total 250 to 300 persons.

The number of workers of its experimental production base will be as much as 200 to 250 persons; the metal-working equipment amounts to 65-70 units. The industrial area of the base is about 3000 sq.m. Primarily the base may be set up at one of the enterprises available.

The above mentioned number of specialists of the scientific and engineering centre and its production base should be regarded as a proximate one. Corrections are possible depending on the volume of the scientific research work planned. According to the specific conditions of the country this number of specialists may be more or less.

When a scientific and engineering centre is to be set up in a certain country it is desirable to cooperate with an appropriate research institute of any economically developed country. The institute should help to work out a specific plan for setting up and organization of a scientific and engineering centre. Such assistance can be rendered through the UNIDO.

The equipment of the experimental production base may be the same as that of machine-tool production with slight changes in certain sections.

For the developing countries of Asia which are more backward as compared with Latin American countries it is advisable to set up scientific and engineering centres for the development of the most important branches of the national economy, for example:

1. Scientific and engineering centre for production of agricultural machines and spare parts.
2. Scientific and engineering centre for developing oil-processing equipment.
3. Scientific and engineering centre for developing textile, shoe-making, printing and publishing equipment.
4. Scientific and engineering centre for developing electric power equipment.
5. Scientific and engineering centre for developing wood-working equipment.
6. Scientific and engineering centre of developing equipment for industrial and housing construction.

The development of mining, oil-extracting, machine-building and metal-working branches of industry ( tube-rolling, carriage building, agricultural machines, radio-sets, bicycles, shoe-making equipment, canning industry equipment, chemical equipment) is a characteristic feature of the developing countries of Africa.

The development of the above mentioned branches puts forward an idea of the expedient establishment of scientific and engineering centres, for example:

1. Scientific and engineering centre for developing heavy-engineering industry (tube-rolling machines, carriages etc.).

2. Scientific and engineering centre for developing agricultural machine production.
3. Scientific and engineering centre for developing domestic industry.
4. Scientific and engineering centre for developing chemical and shoe-making industries.
5. Scientific and engineering centre for developing mining industry etc.

With regard to the outlined development of machine-building and metal-working industries in the countries of Latin America it is advisable to establish scientific and engineering centres on the following branches:

1. Scientific and engineering centre for the production of electric power equipment and apparatuses.
2. Scientific and engineering centre for the production of lifting transport equipment.
3. Scientific and engineering centre for the production of road--building equipment.
4. Scientific and engineering centre for developing automobile and tractor industry.
5. Scientific and engineering centre for the production of textile equipment.
6. Scientific and engineering centre for the production of food industry equipment.
7. Scientific and engineering centre for the production of light industry equipment.
8. Scientific and engineering centre for the production of pulp and paper industry equipment.
9. Scientific and engineering centre for the production of metal-working tools.

10. **Scientific and engineering centre for the production of press and forging equipment.**

Depending on specific features of the development of various branches in a country similar centres may be organized for other branches of industry.

There is no doubt that scientific and engineering centres will face difficulties in qualitative and quantitative selecting of staff and equipment. The proposed recommendations should be regarded according to specific conditions and economic problems which may occur during different periods of time.

## Recommendations for Countries of Group 3

This group includes developing countries where machine-building and metal-working industries do not exist while imported machines and equipment available are kept due to repairs carried out by suppliers.

The third group of countries has no national engineers and workers of their own familiar with designing, technology, production and operation of machines.

The setting up of training centres with machine repair shops may be recommended for this group of countries.

## Tasks of Training Centres and Machine Repair Shops

The main task of the centr[illegible] to provide the training of national specialists in mastering the rules of service and repair technique for imported machines. In these centres it is advisable to envisage separate [illegible]ivisions, which should study the nomenclature of imported machines and work out repair techniques.

For the training of national skilled workers it is advisable to employ specialists of the country responsible for the machines to be imported. The mechanical engineering in the countries of this group should have a united centre with subdivisions on its most important branches.

It is advisable for the training centre to have a machine repair shop with a complete set of equipment capable of manufacturing spare parts and individual units used for repairing machines and equipment by its own efforts.

For the complex solution of problems on repairing machines and equipment it is advisable to set up casting, forging and welding sections at the machine repair shops.

The training centre should necessarily be engaged in setting up a production base for manufacturing metal-working tools and fixing devices (bolts, nuts, screws etc.) and effecting the cooperation of separate branches as well as the exchange of information on problems of economics and techniques and creating a metallurgical base in the country.

As far as the developing countries of group 3 are concerned the problem of the most rational use of repair shops or plants, wood-working enterprises and other mechanical shops available should be considered at the first stage. The centralization of repair shops or plants could be the most important condition indispensable for metal-working industry. Such measures will assist in acquiring experience, teaching and training of skilled workers and designers, capable of creating their own machines. It is advisable to follow the practice of licence purchasing for producing machine tools abroad as well as to invite firms for rendering assistance in creating national engineering industry.

## Model Structure of a Training Centre

The following model structure of a training centre with a machine repair shop may be recommended.

A group of consultants for teaching the rules of servicing the imported machines and equipment depending on their application - up to 10 persons.

A methodical group providing visual aids for training - up to 5 persons.

A group providing the production of spare parts and units and working out maintenance technology - up to 5 persons.

A group of designers and technologists preparing drawings for machine-tool spare parts and units - 5 persons.

A group for perspectively developing separate branches of industry important for the country - 5 + 5 persons.

The number of specialists of the training centre will be as much as 50-60 persons and with the number of the personnel of both the governing board and auxiliary services included it will be 80-90 persons.

The production base of the machine repair shop with its subdivisions will have an area 2 000sq.m., its equipment numbering 50 or 70 units and the staff - 100 or 120 persons.

More detailed structure may be worked out and recommended for this or that country, taking into account the real state of techniques in separate branches.

A group of consultants is headed by a specialist from a developing country or by a specialist from an economically developed country. The task of this group is to acquaint national specialists with the designs of machine-tools, operating instructions (maintenance, starting, speed control, filling-in, repair) and other specific features of the machine or assembly.

The methodical group is headed by an institute competent in the design and performance of machine-tools. The group works out recommendations, prepares visual aids and curriculum for training consultants, directs the teaching and imparts practical skill to the national specialists for effectively mastering techniques. The group providing the production of spare parts and units and working out maintenance techniques is headed by a specialist familiar with operating instructions and designs of machine-tools. This group makes proposals on repairing most rapidly worn out units or parts, works out repair technology, carries out preventive maintenance (permanent and thorough) and is responsible for performing repair and keeping machines in good condition .

The group of designers and technologists is headed by an engineer competent in machine designs and production technology. This group works out the designs of rapidly worn-out units or parts and technological procedure of manufacturing spare parts and units.The group for perspective development of national branches is headed by a specialist of the country. This group studies economic features, plans the production of machines, sets up new enterprises, builds up capacities, finds the cheapest ways and forms of cooperation and exchanges information within its own country and with others.

Model structure of the training centre and machine repair shop comprises the services mentioned above. This centre is headed by a manager and a deputy manager, the latter being a chief engineer. In addition, it is advisable to have chiefs of the planning department, workshops and other auxiliary services who are subordinate to the manager of the centre or his deputy.

The nomenclature of technological equipment for the machine repair shop may be the same as for the experimental shops at the scientific and engineering centre of machinetool building.

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