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The Seminar on the Establishment and Development
of the Automotive Industry in Developing Countries

Karlovy Vary, CSSR, ~~14 Oct - 1 Nov 1968~~
24 Feb - 14 March 1969

PLANNING OF FACILITIES FOR THE MANUFACTURE OF AUTOMOBILES AND TRUCKS

With Special Reference to Developing Countries[1/]

by

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and
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Prague, Czechoslovak Socialist Republic

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PLANNING OF FACILITIES FOR THE MANUFACTURE OF AUTOMOBILES AND TRUCKS WITH SPECIAL REFERENCE TO DEVELOPING COUNTRIES[1/]

by

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SUMMARY

1. Prior to the establishment of an automotive industry in a developing country, a systematic review of all factors influencing its development is necessary. The pre-investment studies to be carried out are:

(a) Prerequisite studies on market research, availability of raw materials, degree of industrialization in the country, and governmental policies

(b) Technical and economical feasibility studies,

(c) Studies on the influence of the introduction of the automotive industry on the national economy etc.

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1/ The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO.

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2. In the pre-investment phase, economic and political decisions must be made.

3. Investigations must be undertaken and criteria formulated in order to select the type of vehicle to be produced and to define the optimal production capacity.

4. The demand for labour, raw materials, automotive components, energy, machines etc. must be determined.

5. Indices for the assessment of investment costs are given.

6. All previous decisions, considerations and calculations will influence the layout of the automotive plant.

7. The erection of an automotive plant in a developing country should be entrusted to experienced automotive manufacturers.

8. The automotive industry should be established with the participation or support of the Government.

9. Planning of the distribution and service network should begin at an early stage.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

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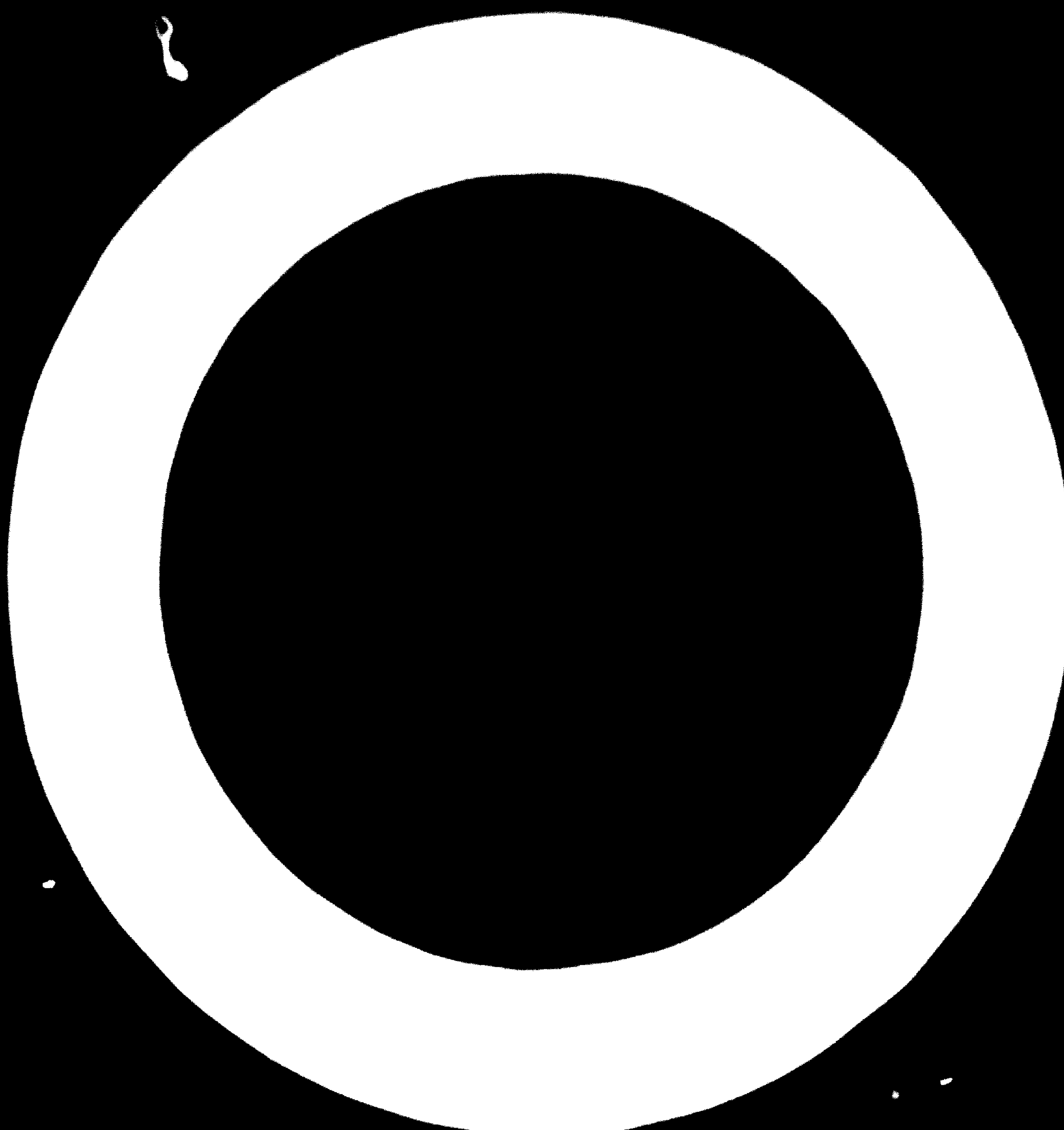


I. POLITICAL, ECONOMIC AND TECHNICAL PREREQUISITES OF AUTOMOTIVE PRODUCTION - BASIC CRITERIA AND RESUME OF ALL PROBLEMS

1. The production of automobiles and lorries is a challenging task from the point of view of organization, technology and economics, since it is a typical representative of mass production. Conditions vary widely in the developing countries with respect to level of development, natural resources, number of inhabitants, area and national income. Not all of the developing countries are ready to begin building automotive industries. This development is limited to a number of the larger and relatively richer countries which possess a certain level of production, labour and standard of living. Because of these reasons, it was necessary to apply a methodical approach to this work, showing the programme of considerations and steps which must be undertaken before and during the construction of an automotive production plant. The figures and examples in the individual chapters are case studies made available to the authors. Their character must be considered as purely explanatory and illustrative, and not as a consolidation of criteria and knowledge on this subject.

Political and economic criteria

2. The increase in national income and the rising standard of living within a country is accompanied at a certain level by a rise in automobile demand and sales. However, this does not always imply the necessity of introducing automotive production into the country. The creation of a country's automotive industry has certain prerequisites and requires a further development of other industries and services, such as the steel, chemical, and rubber industries, electrical supply, road construction, and engineering, technical and consulting services. At first, the developing countries rely on imported cars, but later they may develop a plant for the assembly of automobiles produced under licence. Only in the final stage, when suitable conditions have been created in the other industrial branches, will it be possible to construct an autonomous production plant of the type described below.

3. The prerequisites for the development of an automotive industry are:

(a) Minimum size of the country, providing a sufficient market of customers;

(b) Inhabitants' purchasing power;

(c) Government policy supporting the development of the automotive industry;

(d) Raw material base including energy;

(e) Existence of mechanical engineering and other industries able to co-operate and to supply components.

The appraisal of these political and economic criteria is an initial factor in deciding to establish an automotive industry.

4. Before making this decision, it is necessary to study the experiences of countries with a developed automotive industry and to search for analogies between the problems of a certain country and the home country. The growth of average demand is indicated by the number of inhabitants for each motorcar. These data and examples of determining the capacity are included in chapter III.

5. Automotive industries should be established only in countries that have reached at least an average level of industrialization and standard of living. Such countries are usually able to solve the problem of their own industrialization, employment, specialization etc.

6. The decision to create an automotive industry in a developing country should be accompanied by securing fiscal, commercial and political measures of a supportive, restrictive or even a prohibitive character. The main tool used by the government in a given country is the restriction of automobile imports or a complete prohibition of importing a certain automobile. The local government can thereby force the foreign automotive manufacturer to begin production in that country, providing the market is sufficiently attractive.

7. If a foreign manufacturer is reluctant to introduce production in a developing country, it is most often for economic reasons. He faces higher production costs than at home if the manufacturing cannot be carried out on custom-built machines in large quantities. The experiences of some of the larger automotive manufacturing plants show that with a corresponding production in a developing country may increase the production costs as much as 50 per cent.

8. When the foreign manufacturer begins production in a developing country, his first step is to set up an assembly plant with an import of 100 per cent of the components.

9. The foreign manufacturer very often reserves the right to return those vehicles produced in the assembly plant, and later on in the automotive production plant, to the existing sales network of his own country. He also insists on checking the quality of production so that the reputation of automobiles with his trademark will not be impaired.

10. For supplying the technology needed (technical know-how, production documentation, engineering etc.), the foreign manufacturer demands either a flat sum as remuneration, or a certain percentage of the value of each produced item, or a combination of the two systems. In establishing the automotive industry in a socialistic country in collaboration with a foreign manufacturer, general contracts are often signed for a lump-sum price if engineering know-how, technical assistance and special machine equipment are included.

11. More advantageous conditions are present when the produced automobiles are destined for the market of the developing country. If these cars are to be exported, the manufacturer quite frequently demands further supplementary fees for his part in supplying the technology.

12. Under these circumstances, it is not surprising that the foreign manufacturer does not express a special willingness to finance gradual production in the developing country. It is more agreeable to him when the financing is ensured by the manufacturer himself in the country in question. Should he be forced by competition, however, to change his standpoint, then it usually makes no difference to him whether he is offered the financing in the form of credit or in the form of capital participation in the newly organized automotive industry.

13. From the point of view of the developing country, there is usually an effort to require the direct financing of the engineering know-how and components from the foreign manufacturer, at least as an intermediary, as in case of the credit transaction. The investor in the developing country must consider carefully whether a credit transaction or the capital participation of the foreign manufacturer is more advantageous for him.

14. Another prerequisite for the developing country, even before deciding to begin assembly or gradual production of automobiles or lorries, is a technical and economic feasibility study. The conclusions of this study indicate whether or not the technical and economic conditions of the country are advantageous

for industrialization of this type. The economic portion of this study renders data regarding the expected factory and the national-economy profitableness of establishing the automotive industry. The calculation of this profitableness is decisive in considering the expediency of the investment, and guides in evaluating the results expected by the manufacturer. In the national-economy profitableness, the influence of distorting factors is eliminated. Such factors are various tax and customs benefits, unreal rate of exchange of the local currency and so on. On the other hand, phenomena accompanying investments of this type are also considered. Such phenomena are higher consumption of fuels and lubricants bringing tax income into the treasury, and favourable factors influencing the employment of the co-operating industrial plants (e.g. taxes and insurance). The study should be conducted by an independent consultant who would recommend the most suitable vehicle for the market in question and suggest a corresponding trade mark. The next question is whether the manufacturer of the recommended trade mark will be willing to collaborate.

15. During the consideration of the above process, the authors paid particular attention to experiences obtained from the building of the Czechoslovak automotive industry. Before the Second World War, this industry was quite scattered in Czechoslovakia and was characterized by a predominance of manual work. The development of the present mechanized large-scale production industry with an output of about 400 cars per day, offered many problems similar to those in a developing country with a good level of industrialization and a good purchasing power of the population. The only difference is that the production documentation is of Czechoslovak origin, so the costs for submitting technology were minimal. Experiences of the developing countries and accessible knowledge from world-renowned automotive manufacturing plants were taken into consideration.

16. The recommendations in this paper concentrate on the production of passenger cars since this is the focal point of the automotive industry. Production of trucks is considered a supplementary production and will be described in chapter VII.

Technical and economic prerequisites

17. After considering political and economic factors, it is usually necessary to carry out studies on the selection of the type of vehicle and the optimum production capacity.

18. One criterion for selection of the vehicle type is the determination of the engine capacity best suited to the specific country. Other car parameters are a useful guide in this determination. These are described in detail in chapter II.

19. The criteria for determining the optimum production capacity of an automotive plant are:

(a) Marketing possibilities at home and abroad (sales at home from the point of view of the main trend of motor development, sales abroad from the point of view of a ratio of costs per product, and present and future export prices);

(b) Availability of raw materials, parts and groups within the framework of the national economy, or import possibilities;

(c) Rational production organization;

(d) Influence of technology on productivity, capacity and investments in technological equipment, and their relation to each other;

(e) Consumption of energy, fuel and water, and the evaluation of coverage with respect to a chosen branch of construction;

(f) Transportation possibilities;

(g) Exploitation of labour from certain regions;

(h) Production distribution into several plants, and the development of a supplementary capacity for the newly designed plant.

20. Some of the above points are limiting criteria for the determination of the plant capacity. It is not the task of this study to evaluate in detail all the mentioned influences decisive for determining the optimum capacity limits; however, consideration of the basic criteria aiding this determination is included in chapters III, IV, and V.

Advantages and disadvantages of a plant with a complete production cycle and of a final assembly plant co-operating with specialized plants

21. After determining the planned car requirement and the optimum production capacity, it is necessary to study various technical and economic problems of the plant construction. The development of the automotive industry will proceed from a plant assembling a licensed automobile with a gradually increasing content of locally produced components towards a plant having a complete production cycle. This concentrated manner of production is not typical for the developing countries. Such plants are not generally found even in the more developed countries. Economic, technical and organizational problems lead instead to the establishment of specialized plants. To point out the basic problems of developing one or another type of production (final assembly plant or plant with a complete production cycle), all the problems involved in the automobile plant construction are listed in the following specifications of the two basic types of plants. The main characteristics, and the advantages and disadvantages of each are given in such a way that the entire link may be studied.

22. A plant with a complete production cycle (concentrated production) usually includes the following shops:

(a) Grey iron and malleable iron foundries, steel and light alloy foundries, forging and hot pressing shops;

(b) Metalworking shops for the production of all kinds of boxes, rotary and gear wheel parts and so on;

(c) Cold pressing shops, including a large car body pressing shop, pressing shops for medium and small stampings, workshops for volume forming, welding shops, hardening shops, surface shops for treatment and upholstery production;

(d) Shops for the assembly of sub-groups, car bodies and the car itself.

23. The advantages of the complete production cycle plant are:

(a) Basic semi-products made to measure in the plant's own specialized workshops, ensuring high quality;

(b) Minimum transportation distances between the production areas;

(c) Maximum use of metal-scrap materials coming from the mechanical shops and pressing shops to the foundries;

(d) Accurate on-the-spot planning so that the plant is not as influenced by the supplier possibilities and variations in market prices (particularly important in developing countries where timely and good quality co-operation is difficult to obtain).

24. The disadvantages of plants of this type are that they require:

(a) Higher qualifications for the personnel in various professions;

(b) Higher level of production control and quality checking;

(c) A rather high production capacity for a great variety of parts.

25. A final assembly plant usually includes a car body welding shop, car body assembly shop, paint shop and final assembly shop. It must be sufficiently equipped with storage areas. It co-operates with several specialized production units geographically dispersed which supply the central assembly plant with parts.

26. The advantages of such a final assembly plant are:

(a) More effective assembling with no significant difficulties (particularly in the case of smaller capacities and less developed production);

(b) Considerable specialization and a simpler production start;

(c) Mosaic-pattern layout, i.e. locating individual specialized workshops in various areas with the required production base and qualified employees, which encourages the further industrialization of various areas of the country and the utilization of existing similar plants for the production of components;

(d) Easier production control even though the requirements for supplying the plant with components increase.

27. The disadvantages of this system are:

(a) High requirements in the co-ordination of external supplies;

(b) Larger storage areas, the sizes of which are determined by the supply cycle;

(c) Higher transportation costs especially in the case of various bulky or delicate parts.

28. The most common plant is a compromise between these extreme cases. The actual production conditions, their complexity, the possibility of co-operation, labour and other factors must always be seriously considered when determining the plant type.

29. The assembly plant allows the developing countries a fast introduction of automotive production quite challenging and complex with respect to investments. Production starts by purchasing the licence from an automotive manufacturer with long traditions and experience, and adopting his methods of organization and production, which enables an economical and gradual developing of and investing in the automotive production in that country. Contacts with the basic plant offering the licence gradually decreases and the actual production of components increases according to the technical and economic possibilities of the developing country.

Work organization and plant operation

30. Working hours: The working hours are determined by the country's laws and customs and vary from 42 to 48 hours per week.

31. Number of shifts: This number is determined by the composition of the workshops, possibilities of labour recruitment and by equipment costs. With respect to frequent changes in production provoked by customers' requirements, it is desirable to aim at a rapid equipment amortization. This coefficient (number of shifts) should be in the range of 1.8 to 1.95. In workshops with expensive machines and equipment, a three-shift operation should be considered.

32. Workplace fund: The workplace fund is an annual fund in the case of two-shift operation, minus the vacation of the whole plant (usually set at two weeks).

33. The exploitable annual fund of machines and equipment: This is equal to the nominal annual fund minus a number determined by the coefficient of losses per repairs (minimal repairs and a share of the general repairs). Detailed descriptions of these problems are given in chapter IV.

Requirements for materials and components

34. The requirements of an automobile with respect to the consumption of various types of materials and products of diverse industries are rather high. The production economy is particularly influenced by the metallurgical products and by those products obtained through co-operative association with other plants.

35. The motor-car production requires a considerable volume of:

(a) Rolled metallurgical stock (bars, sheets) purchased from metallurgical works;

(b) Forgings and castings;

(c) Various materials from other industrial branches (fuels, lubricants, chemicals, joining materials, plastics, paints, textiles etc.);

(d) Finished parts obtained by co-operation from other plants (electrical equipment, carburettors, various filters, coolers, bearings, wheels, tires etc.)

For a detailed description of these problems see chapter IV.

Labour requirements, training and technical assistance

36. In spite of mechanization, automation and a high degree of settled features, automotive production still places high demands on labour, especially in the stage of final assembly and in the auxiliary departments. Even though there are considerable requirements regarding the volume of unskilled labour, production still needs many qualified workers for organization and control, adjustment and maintenance of complex production equipment, and so on. Thus the development of production in automotive plants must be carried out in collaboration with a well-established automobile manufacturer who offers:

(a) A licence for a technically perfect product backed-up by many years of experience;

(b) Production documentation with verified and practice-proved production technology;

(c) Production documentation with the basic materials needed for realization of production;

(d) Training and education of selected categories of employees.

For a detailed description of these problems see chapter V.

Energy supply needs

37. The consumption of various forms of energy in an automotive plant is high. The types of energy are as follows: steam, electrical power, industrial water, compressed air and town gas. Other industrial gases, e.g. acetylene and oxygen, are consumed only in smaller volumes. The consumption of energy depends on the type and capacity of production, type of plant, production technology, degree of production mechanization and automation, climate conditions, working environment, culture and hygiene.

38. The establishment of an automotive plant must be preceded by a proposal of the production technology which helps to determine orientation indices for the consumption of the different types of energy. In the first phases of plant construction, there are usually very few concrete basic data on hand. Therefore, it is necessary to start with the ascertained and well-proved indices of other plants which are rendered more precise in the course of further work. The indices usually refer to a production unit: one manufactured car to one employee and one square metre of floor space. For a detailed description of these problems see chapter IV.

General layout of a plant with a complete production cycle and an assembly plant with main production flows

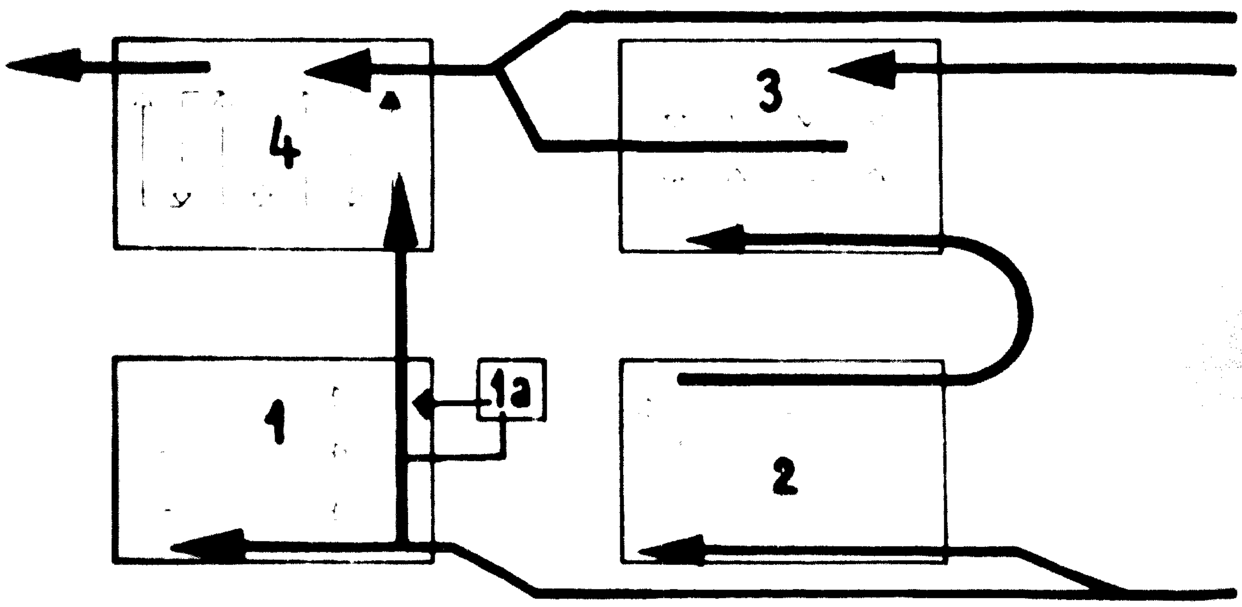
39. The drawings introduced in figure 1 as examples of general layouts and main production flows refer in all cases to medium or large plants co-operating with suppliers to the normal extent and producing cars of common construction with engines of low or medium capacity.

40. The width of the pre-production area is determined by the pressing shop, whereas the width of the finishing zone is determined by the car body shop. The cross-wise production lines, especially the drying ovens and paint booths with a length of about 170 to 190 metres, determine the width of the building (about 200 metres). This ensures the installation of the equipment in a straight line. The width of the mechanical shop is equal to the width of the car-body shop.

41. Raw materials are fed into the buildings in both zones from the longitudinal sides turned away from the main road of the plant. The material flows through the pre-production sections width-wise at a right angle to the main axis of the plant and continues in a similar manner through the last stages of production, i.e. through the mechanical shop and car body shop. By introducing outside sidings and inside connexions between both main zones, the loop of material and product movement is completed. In such a manner, the shortest route from the pre-production stage to the finishing shops is achieved.

Figure 1

Plant with complete production cycle



Key: 1 Large and small pressing shop
1a Electroplating shop
2 Foundries and forging shop
3 Production of mechanical parts and assembly of undercarriage groups
4 Welding shop and car-body assembly shop, paint shop and final assembly shop

42. The mechanical shop is fed from both sides (one side semi-products from metallurgical shops, the other side bar material). This determines the longitudinal location of the assembly-groups assembly shop in the central bays of the building. The length of the production lines exceeds 60 metres. Dividing the mechanical shop into two parallel production lines, placed at a right angle to the group assembly area, proves to be very advantageous.

43. The transportation of all material and supplied parts is carried out along the sides of the buildings, turned away from the plant's main axis. The metallurgical buildings, which have the largest consumption of material, are located

nearest the railway station. Thus, sheets for the pressing shop, metallurgical, charging and moulding materials, as well as metal for the metallurgical works follow the shortest possible route feeding into the respective shops.

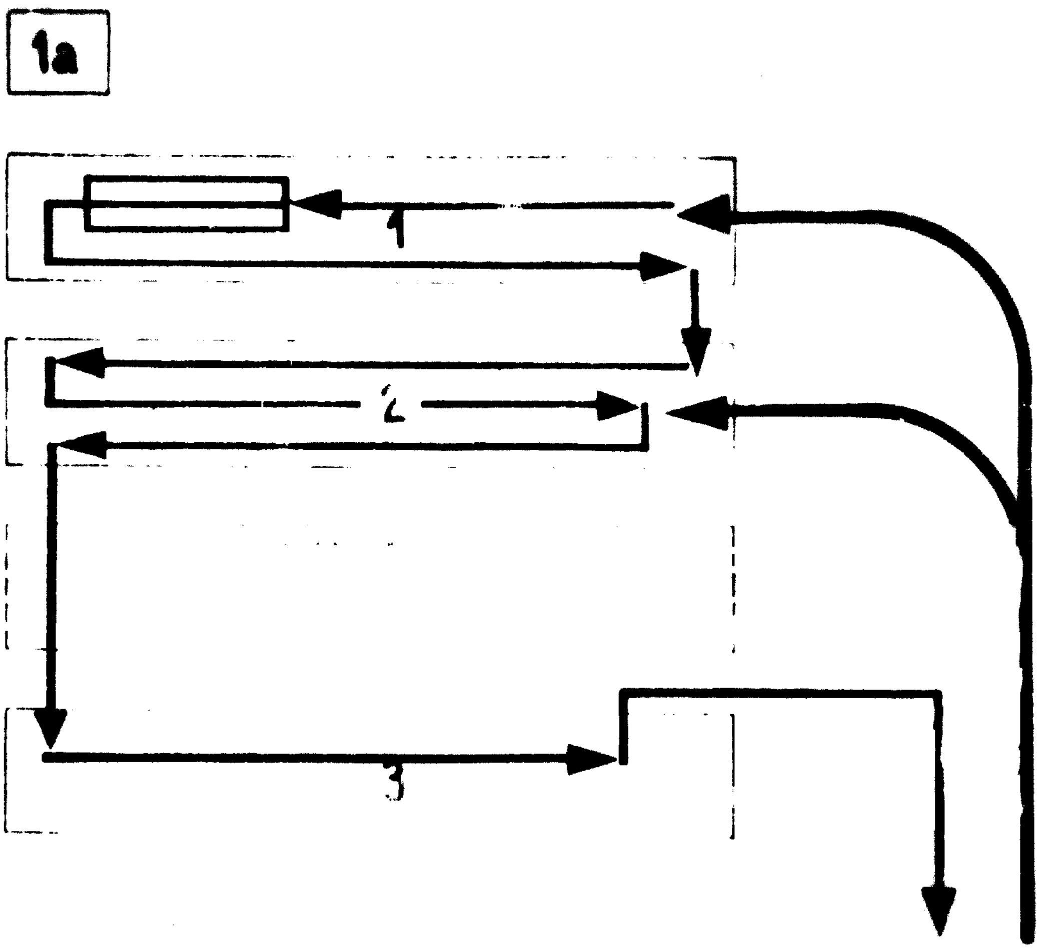
44. All materials coming from outside the plant, including supplied parts, are delivered to the mechanical and car-body shop buildings by means of a siding at the side turned away from the main road.

45. With buildings grouped in blocks, an important consideration is to safeguard the possibility of future extension of all the shops to keep up with the expansion of production. Fixed limiting points in the mechanical shop building are the transfer lines, engine test rooms and gear-box test rooms, and in the car-body shop building, the welding and paint shops. This single-purpose built-in equipment and machinery cannot be relocated in the same way that other machines and equipment in the other workshops can. Thus, the general layout has to go along with these fixed points whenever expansion is considered. However, expansion of the plant by adding new areas is the last step in production gradation. With respect to the single-purpose lines, machinery and assembly workplaces, the plant must be designed in such a manner as to meet production gradation without any major supplementary investments purely by speeding up the production time, reducing the operation time by employing various fixtures and handling equipment, and by exploiting the reserves in machines or shifts. In case of a considerable rise in production, a reasonable way may be found in proper specialization and co-operation in the production of selected parts with various factories.

46. It is possible to implement other general layouts of medium and large plants. In any case, these proposals must be subjected to the technological flow of production by eliminating the return routes and crossings. The organized material supply flow and the components and supplied parts flow are the decisive factors of the proposal.

Figure 2

Assembly plant



Key: 1 Pressing shop and car-body shop
1a Electroplating shop
2 Paint shop and car-body accessories shop
3 Final assembly shop and shipping department

47. The larger or smaller assembly plants have a considerable number of deliveries of material and components. The latter are usually more problematic with respect to their volume, since they arrive already processed and their shapes (engine, clutch, axis) consequently require larger car-loading areas and more care in transit. In this case, technological production flows must be strictly observed, even though the flows are simplified and eliminate relationships between the production of semi-products and the mechanical shop.

One can reduce this to the basic relationship:

final assembly ⟵ pressing shop

final assembly ⟵ undercarriage groups and supplied parts

Facilities outside the plant

48. Since an automotive plant requires high amounts of energy and water, public sources and facilities must be available for the manufacturers. Research concerning public sources and networks must be undertaken simultaneously with the elaboration of the balance of consumptions, since the extension or possible reconstruction of the sources and networks is a rather costly and extensive matter which sometimes may even lead to the rejection of the selected site.

Housing centre and services for employees

49. The automotive plant site must be selected with respect to the chosen plant type and its projected development. It must have sufficient reserves in area and a connexion to the public energy and transportation network. In no case may one neglect the housing, recreation and transportation of the employees. Great attention must be paid to the protection of the environment since a plant with a complete production cycle including the metallurgical base makes heavy demands on transportation and causes concentrated industrial exhausts. The disposal of the latter is very important. The plant also requires a large number of employees. The site selection, therefore, must be preceded by a thorough population structure and sociological survey which will uncover labour resources, their number, location and qualifications.

50. On the basis of production demands and population structure surveys, conclusions can be drawn regarding housing and possible public transportation of employees. The construction of a housing centre which includes public, health and cultural facilities poses complex problems. As a rule, it is regulated by tradition and by the standard of living in the respective country. The construction of housing centres may be concentrated in the vicinity of the plant or may be dispersed to the neighbouring villages up to a maximum commuting distance of 30 to 45 minutes by public transport means. All these points must be discussed with the authorized regional offices.

Transportation problems

51. Transportation is an important factor when considering the automotive plant location. A large volume of material requires a good public network of roads, railroads and possibly waterways. Similarly, transportation of finished automobiles causes a considerable volume of traffic. A passenger car with a dead weight of one ton requires, including scrap and auxiliary materials, about two tons of various production materials. This means that with an annual production of 25,000 passenger cars (25,000 x 2), 50,000 tons has to be supplied and 25,000 tons plus non-exploitable waste has to be shipped. However, the supplied materials are of various kinds, ranging from bar materials, electrical materials, and supplied components to complete groups, coming from different places in various volumes and packings. This necessitates a concrete analysis according to types before the type of transportation is determined. The shipping of the finished passenger cars is problematic owing to size and irregular shipping schedules. The shipping is subject to seasonal variations as a result of fluctuations in demand. Thus, adequate free space must be considered for the storage of finished products. Test runs of the manufactured cars are a burden for the roads and are a negative factor from the point of view of exhaust gases and noise. These problems must be considered in detail and discussed with competent transportation officials and regional offices.

II. AUTOMOBILE CONSTRUCTION AND PRODUCTION

Selection of swept volume

52. The development of automobiles in European countries shows a transition from low swept volumes to the 1500 cm^3 and 2200 cm^3 classes. For countries wishing to develop their automobile industry, the following standardized row of passenger cars and their engine parameters shows the advantages:

Volume (cm^3)	Bore/stroke	No. of cylinders	Output (hp)
1000	Ø 68/68	4	45
1500	Ø 82/68	4	65
2200	Ø 82/68	6	100

A four-stroke, four-cylinder, in-line engine of the 1500 cm^3 class in comparison with the higher volume class calls for a relatively lower technological labour input.

Engine location

53. The probable development tendencies in the passenger car construction expected in the coming years were specified according to the basic character of the car, i.e. the construction and location of the engine, gear box, driving axle, brake mechanism, body design and the extent of accessories. With respect to the world passenger car production volume, the engines are categorized as follows:

(a) In 82 per cent of the total world production, cars maintain the classic engine location - at the front with a transmission shaft to the rear driving axle;

(b) Only in 15 per cent of the world production do the cars have the engine at rear and a rear driving axle;

(c) About 3 per cent of the world production deals with engines located at the front with a front driving axle.

54. This distribution has remained basically the same and it may be presumed that no remarkable shift will occur in the near future. The advantages of the "(a)" construction lie particularly in the production and economic field, since the engine located at the front makes it possible to produce a wide scope of car modifications without changing the standard chassis structure; e.g. delivery

car, sports car, and ambulance bodies may be assembled. In this way, the possible applications of produced vehicles in a given class are extended. In addition, good riding characteristics of cars require a centre of gravity located in front of the centre, i.e. nearer to the front axle. This can be achieved only by placing the engine at the front. Thus, this conception appears as most advantageous in the outlook for the future.

Gear box location

55. According to a survey of the majority of produced cars, the gear box is located by the engine, although some manufacturers locate the gear box near the rear axle. From the point of view of production, the creation of an assembly group "engine-gear box-axle" appears most advantageous. The requirements of a broad scope of modifications in car bodies would mean transferring the drive to the front axle.

Driving axle location

56. Locating the driving axle at the rear in cars with the engine in the front prevails in 82 per cent of the world production. However, in order to eliminate the transmission shaft tunnel between the engine and the rear axle, some manufacturers introduce circulation shafts.

Engine design

57. The classic four-stroke, in-line petrol water-cooled engine, perfected to a level of high quality and high working reliability, shows no sign of being replaced in the near future by engines of any other conception. Air-cooled engines account for less than 5 per cent of the world production. Rotary piston engines still require certain design and technological development to lessen sealing, high speed, and temperature problems. Turbine engines still require the development of exchangers with acceptable thermic and economic effectiveness. It is very risky for a passenger car manufacturer to carry out experiments on his customers; therefore, he seeks to improve engine details rather than attempt revolutionary changes. There are tendencies to increase the valve diameter, to produce rigid construction cast crankshafts, and to improve the quality of materials of the parts.

Gear box design

58. There is a world tendency towards the application of automatic hydromechanic gear boxes that are an advantageous combination of the present mechanical gear boxes and well-tried types of hydrodynamic torque converters. Proof of these tendencies are the introduced designs of hydromechanic gear boxes of the Ultramatic, Dynaflow, Fordomatic, Powerglide, Voith-Divabus, Hydromedia and especially of the Borg-Warner 35 type introduced in cars of the 1500 to 2500 cm^3 class, as well as the gear boxes of the Hydromatic - General Motors Corp. and the Mercedes Benz automobile. The constructional and technological complexity of these gear boxes with their epicyclic gears, multiple disc clutches and hydramatic converters is higher than in the case of the present mechanical types. Both turbine wheels and the converter stator are made of precision steel forgings. The gear box is heavier than the four-speed mechanical type. In introducing the hydromechanical gear box, European manufacturers will also be seeking a desirable automation of the speed control of the passenger cars in the 1500 and 2200 cm^3 volume classes.

Axle design

59. The application of the two main types of axle construction, i.e. rigid and oscillating, in European countries in the last few years is shown in the following table:

	Federal Republic of Germany	United Kingdom	France	Italy
		(percentages)		
Rigid axles	42	87	62	69
Oscillating axles	42	5	25	19
Other axles	16	8	13	12

The rigid axles prevail corresponding to the quality of roads in the listed states. With additional improvements in roads of other countries, similar tendencies are to be expected in axle design. According to the volume categories, the shares of the basic types of axles are as follows:

	Volume (cm^3)			
	1000	1200	1500	Larger
		(percentages)		
Rigid axles	50	75	90	70
Oscillating axles	25	25	10	23
Other axles	25	-	-	7

Brakes design

60. An outstanding transition from the present drum brake design to disc brakes is apparent. The disc brakes are more effective, their cooling is better and their size is more advantageous. It is evident that the future cars will be equipped exclusively with disc brakes, the technological complexity of which will not be higher than in the case of drum brakes.

Car accessories

61. Trends in passenger car production indicate that the buyers' demand for first-rate car accessories will increase. It is correct to assume that future cars will be better equipped with air conditioning devices and other equipment to increase the passengers' comfort. The demand for other automatic devices will also increase. All of this will lead towards a higher constructional complexity of the car, especially in applying various servo-mechanisms. Parallel to this growing complexity, the requirements regarding troublefree operation of the car, a minimum of maintenance work, minimum upkeep costs etc. will increase as well.

Car body

62. The production requirements of a standard undercarriage with the engine in the front include a bearing platform, or some other solution not requiring a self-supporting body. The trends in car body design tend towards a panel design, i.e. welded frame with screwed-on panels enabling easy change-over of the panels in case of deformation as a result of accidents etc., a rapid and ready change-over of the body shape and a saving in the investment of costly car-body welding equipment. The panels will probably be pressed from plastic-clad metal sheets so that the majority of painting work may be avoided. The architectural design of the bodies will probably be subject to constant changes. The traditional textile and plastic materials will be used for upholstery.

Tires

63. There is a trend towards tires with steel belts and a low section and larger contact surface with the road. Also important is increased springing and a higher load carrying capacity. The minimum wheel diameter probably will not drop below ten inches.

Tendencies in car design

64. The foregoing paragraphs reveal the basic construction conception of passenger cars. It is possible to estimate that in the next ten to fifteen years:

(a) Basic or revolutionary changes in the design of the car engine and other units cannot be expected but a gradual improvement of the well-tested principles is to be anticipated.

(b) The manufacturers will concentrate primarily on improving the driving properties of the vehicles, on raising the reliability of a troublefree operation level, on decreasing the maintenance requirements, on increasing travel comfort and passenger safety, and on reducing the driving control requirements. This will lead towards a more complex constructional and technological car production labour input.

(c) There will be a tendency to change the body design technology in such a way that it would be possible to reduce the production costs and to meet easily the shape change requirements (new models at a minimum cost).

Influence of construction on the basic technology and the development of mechanization and automation

65. In the present automotive industry, basic attention is concentrated on seeking ways to reduce the body labour input which is considered to be higher than the entire undercarriage labour input. In implementing the panel body design using coloured plastic-clad metal sheets, the share of surface treatment (painting) and welding should be considerably reduced. Screwing on individual panels to the body frame would partially replace welding. Most effective for other parts of the car would be progressive welding methods, e.g. in CO_2.

66. Trends indicate that labour input in the production of parts for the engine, gear box, final drive etc. will be higher in the future than it is now. The demands for production automation will grow. The conception of machines and machinery equipment, e.g. transfer lines composed of standardized machinery, checking and handling units, will not change basically in the next fifteen to twenty years.

67. The share of assembly work will probably increase in comparison with the present situation owing to the changed body design requiring a larger volume of assembly operations, more complex car accessories, increase in the number of servo-mechanisms and so on. This will lead to necessary automation and mechanization of the assembly work.

68. In comparison with the present practice, it may be presumed that, owing to the improvements in car accessories, the volume of external co-operation in the

production of car accessories and equipment will increase. The same applies to the production of some assemblies and sub-assemblies of the undercarriage units.

69. All automobile manufacturers must strive towards maximum effectiveness of the materials employed, as well as towards reduction of the costs of parts that are governed mainly by the cost of the material. This attitude should be maintained even if this leads to new constructional and technological techniques. It was discovered in automotive production that for each ton of finished cars there is at least one ton of waste. This necessitates the orientation of investments towards basic production processes, such as precision casting and forging production, cold pressing, use of sintered metals and plastics. This should bring about a decrease in waste and lead to the substitution of mechanical shops by basic production processes. Basic production automation, which at the present time is still in its infancy, would increase as well. In the future, the mechanical shops of the plant will carry out only the precision finishing of the parts. One effective aspect leading towards the reduction of material costs in car production must be the recovery of used materials. Castings made of aluminium alloys and all plastic materials which enable new forming may be considered as recovery materials with a small reduction in the quality and re use value. It is also necessary to make use of the waste material from the liquidation of old and crashed cars. In the future, a new seat design will be necessary so that seats are airy, hygienic, light and comfortable, particularly in warm seasons.

70. The technology of the future car must be adjusted in such a manner that the requirements for the manufacture of parts would be reduced by the proper selection of semi-product types and there would be minimum material allowances. It will also be necessary to reduce considerably the costs of equipment, such as car-body presses, multiple spot welders and so on.

III. DETERMINING OPTIMUM CAPACITY OF A PLANT

71. After the basic deliberations in the previous chapter, it seems to be necessary to discuss in more detail the production capacity and to consider the economic compatability of the capacity. The latter will be discussed with respect to rational production organization, production equipment, labour productivity, investments and resources, raw materials, materials, transportation, labour, energy and services. All requirements originating from this capacity will be discussed in chapter VI.

Establishing the demand for automobiles and determining the production capacity

72. When determining the demand for automobiles, it is necessary to consider the following basic factors and influences:

(a) Existing vehicle fleet;

(b) Growing number of passenger car owners;

(c) Substitution of used cars;

(d) Increase in average family income enabling the purchase of a passenger car;

(e) Extent and influence of public transport services;

(f) Shift in population;

(g) Import and export.

A country which decides to manufacture passenger cars must concentrate on the production of a car which will suit the demands of the majority of the people in a financial position to buy a car. Types of cars in lesser demand should be imported.

73. The number of existing cars must be determined on the basis of statistical data regarding registered cars in the country. It is advantageous to chart the data in the following manner:

Passenger cars:

Age up to 5 years

Age 5 - 10 years

Age 10 - 15 years

Age over 15 years

Inhabitants and owners of cars

	Number of inhabitants	Owners of cars	percentage
having an average annual income of:			
up to A monetary unit			
A - B " "			
C - D " "			
over D " "			

This data will enable determination of the existing vehicle fleet, classification according to car age and owner's income, and will enable recognizing trends in increase of demand. It should not be a difficult task to obtain data regarding the age of the cars and their number. More complex is the problem of dividing this number according to the annual incomes of the owners. It is probable that data of this type will not be available. The letters A, A-B, C-D and D stand for typical income categories of the car owners in the country.

74. The growing number of passenger car owners may be derived from proper statistical surveys. Table 1 is a guide for predicting the consumption in a developing country when proper indices based on experience do not exist.

75. The substitution of used cars depends on the useful life of the cars which in turn depends on the:

(a) Type and construction of the vehicle;

(b) Number of kilometres travelled per year;

(c) Level of services;

(d) Quality of the roads;

(e) Weather conditions.

Substitution of used cars is also influenced by the economic situation of the country, by the incomes of the inhabitants (consumer units), and by the introduction of new models. The used cars are an important factor affecting the demand for new cars. The manufacturers usually take such cars as partial payment for new cars which speeds up sales of new cars. The used cars are then repaired and sold to less wealthy customers in the industrial centres or perhaps to customers in poorer, less developed regions of the country. In the first phases of development, this method aids dynamic expansion of demand for passenger cars and a gradual decrease of the average age of the car. The estimate of the average annual substitution is based on the average life of a car, usually between six and ten years. During this period the vehicle usually changes owners two or three times, while the number of kilometres travelled by the first owner is usually the highest at an average rate of 10,000 - 25,000 kilometres per year. The older the car, the lower the number of kilometres travelled by subsequent owners.

Table 1

Inhabitants per passenger car in various countries, 1954-1964

Country	Inhabitants (in millions) (1961)	Inhabitants per passenger car			
		1954	1957	1961	1964
(a) Germany (Federal Republic)	54.0	36	21	10	7
United Kingdom	52.7	16	12	9	6
France	42.8	16	11	7	6
Italy	50.5	64	39	20	11
(b) Belgium	8.5	20	17	11	8
Denmark	4.5	23	17	10	7
Netherlands	9.6	49	29	19	11
Austria	7.1	76	31	15	10
Czechoslovakia	14.4	-	-	-	34
(c) Portugal	8.9	97	82	56	-
Greece	8.4	477	225	-	-
Spain	30.4	247	192	104	49
Turkey	27.8	820	743	546	-
Yugoslavia	18.5	1,534	743	238	136
Poland	29.7	741	364	220	148

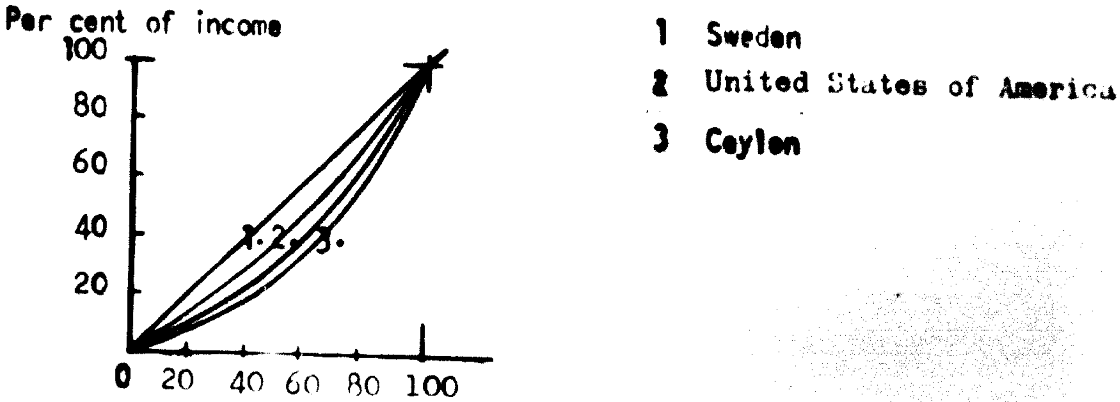
Notes: (a) Countries with a developed industrial base, a local automotive industry and a large population with good purchasing possibilities;

(b) States with a developed industrial base, a less complex production of passenger cars (not including licence assembly plants) and a smaller population with good purchasing power;

(c) States with minimal or average developed industrial base, non-existent or minimal automotive industry, and a population with minimal or medium purchasing power.

76. The average family income (consumer units) is based on statistical data and depends on the increase of national income and its division among the typical income classes of the population. This matter is subject to national economy considerations of a very complex nature: the future development of the country, increases of the inhabitants' incomes according to individual categories, distribution of the inhabitants' incomes, and separate expenditures and price policy of the country. It is a recognized fact that developing countries have a far lower standard of living than the developed European countries, the United States of America and Canada. One must also note how the national income in the developing countries is distributed. In the majority of these countries a major group of the population consists of those families who can afford only the bare necessities from their income. These families have, for the most part, no dental care, practically no meat, no newspapers, cinema etc. At the very best, they might afford the minimum of medical care, relatively varied food and modest recreation. A more limited number of families can enjoy average comfort, i.e. adequate meals, occasional vacations, entertainment, smoking, books, education for their children etc. The number of families that may afford a second-hand car or a new car is thus limited. The incomes are divided up unevenly as may be seen on Lorenz's Diagram below:

Income Inequalities



Per cent of people (1965)

On the horizontal axis of this diagram, population percentage is plotted from the poorest to the richest levels, whereas on the vertical axis, the percentages from the total income volume are plotted. From the diagram one can conclude that the income distribution is more even in Sweden than in the United States (it approaches more the diagonal) whereas Ceylon, a representative of the developing countries, shows a far greater inequality. This fact must be taken into consideration when carrying out comparison studies of the number of automobiles per capita in various countries

77. The extent and influence of public transport services is another factor which affects the passenger car growth. One must note that the development of private transportation calls not only for investments in the automotive industry itself but also in other industrial branches (necessary machinery and equipment may have to be imported), roads and services. These investments generally are several times higher than the investments in the automotive industry. Thus, available, inexpensive public transportation, combined with private transportation, will be most economical and hygienic in a developing country.

78. The shift in population towards the city appears hand in hand with the progressive industrialization of the country owing to the concentration of industry in the cities and suburban areas of large cities. This phenomenon increases the purchasing power of population classes and the necessity of private car ownership. The extent of this shift must be carefully considered with all its effects on car consumption. The example of a rapid increase in population of the suburban industrial regions may be seen on the following chart from the United States:

Increase in population, 1940-1950	In the city (percentage)	In its vicinity (percentage)
New York	4.7	22.6
San Francisco	21.8	104.3
12 large cities	3.6	34.8

79. This phenomenon naturally evokes an increased demand for passenger cars, especially as a result of increased distances between the home and plant. At the same time it is necessary to study the presumed classification of car ownership according to the annual income of the population as in the example from United States dating back to 1952:

Income per consumer unit[a]	Consumer unit	Cars	Cars per 100 consumer units
(US dollars per year)	(percentage)		
Under 2,000	27.9	12.4	37
2,000 - 3,000	17.9	14.7	68
3,000 - 5,000	32.5	39.5	101
5,000 - 7,500	14.4	20.6	119
Over 7,500	7.3	12.8	146
Total	100.0	100.0	83

a/ The consumer unit is a group of persons having a certain relationship and a common income. However, parents and a married son are two units, although they are one family. Thus, a consumer unit is less than a family, but this number will be higher than the number of families.

80. The influence of import and export must be projected into the number of demands in such a manner that real numbers regarding domestic production can be deduced. A developing country will generally choose to produce a certain type of car for the widest consumer range of the population. Other car types will usually continue to be imported so that the total demand for cars must be decreased by these numbers in order to obtain the proper production capacity. In the first phase of establishing the automotive industry, licence production will be considered. Often the manufacturer submitting the licence insists that the cars produced in the given country according to his licence are not to be exported. This was described in the introductory chapter.

81. The total result of the partial surveys, analyses and considerations mentioned leads to the determination of the demand for motor cars. The following example shows a simplified calculation:

No. of inhabitants in millions	a	5	5	5	10	10	10
Projected no. of inhabitants per car	b	100	50	20	100	50	20
Average useful life of car in years	c	10	10	10	10	10	10
Annual car demand[a]	d	5000	10000	25000	10000	20000	50000

a/ Calculated according to the formula: $d = \frac{a}{b \times c}$

The number of inhabitants per car as well as the average useful life of a car must be determined on the basis of a complex consideration of all the factors discussed in the paragraphs above. It can be noted from the above table that in the case of small and average sized countries there is a comparatively little annual demand for cars, even in the case of a desirable but not easily obtainable low projected number of inhabitants per car. Thus, in these developing countries, assembly plants for a licensed motor car production will probably be the first phase.

Effect of production capacity on progressive production organization

82. The introduction of a most rational and effective production organization in an automotive plant presumes a production capacity where it is possible to specialize operations, introduce special single-purpose machines, automate production lines, mechanize processes, and thereby eliminate alternations in the production of parts on machines and on lines, and eliminate repeated adjusting and incident time losses. Such requirements correspond to a typical mass production with an uninterrupted production flow, i.e. flow production. Batch production is less effective since the machine investment exploitation does not usually exceed 50 per cent. In flow production the equipment exploitation reaches 80 per cent. This means that the flow production techniques enable not only a highly effective production but an increase in the effectiveness of the investments as well. The evaluation of the capacity optimum of an automotive plant cannot be carried out for the plant as a whole but for separate technological sections only, since the conditions for introducing a continuous production flow will differ in the individual sections. When determining the optimum, it is necessary to divide the entire production according to the main technological groups of machines and equipment. One must start with the relationship for the series production, expressed by the following formula:

$$k_s = \frac{t_k}{r} = \frac{t_k \cdot N}{T}$$

where t_k = time of the operation carried out on the part in minutes,

N = number of products produced in a period of T minutes.

This coefficient k_s for a continuous production flow equals 0.8 - 1.0 in case of theoretically balanced operations. If $k_s = 1$, the number of products produced in one minute, N', is then determined by the following ratio:

$$N' = \frac{1 \cdot 1}{t_k} = \frac{1}{t_k}$$

where t_k will equal the average operation time in minutes.

The smallest economic number of products (N min.) produced in a continuous production flow is then determined by the relationship:

$$N_{min.} = \frac{1}{t_k} \cdot F_v 46 \cdot 60$$

with theoretically balanced operations with regard to time.

$F_v 46$ = annual exploitable time fund of a machine or equipment in effective hours.

According to this consideration it is possible to calculate the minimum annual capacity of the separate sections according to average operational times.

Table 2

Minimum annual capacity of various sections

Production section	Annual exploitable time fund of a machine in hours [F_v 46][a]	Operation time t_k in min. for longest operation	Minimum economic capacity N min.
Automatic machine shop	4,500	0.82	330,000
Extrusion	4,500	0.15	1,800,000
Gear cutting	4,500	0.95	284,000
Gear box and rear axle	4,500	0.95	284,000
Engine and clutch	4,500	1.33	203,000
Undercarriage assembly	4,500	2.00	135,000
Small pressing shop	4,500	0.05	5,400,000
Car-body pressing shop	4,220	0.20	1,270,000
Electroplating shop	4,400	1.83	144,000
Small welding shop	4,500	0.71	380,000
Car-body welding shop	4,400	2.21	119,000
Multiple point welding	4,400	0.50	527,000
Car-body paint shop	4,400	4.00	66,000
Final assembly	4,500	2.00	135,000

a/ The values are calculated for annual exploitable time funds with a 46 hour working week. If the working week length differs, the results must be adjusted.

83. Table 2 shows the apparent basic difference in the minimum capacities of the individual types of workshops. The minimum capacity for the production of undercarriage groups is in the range of about 200,000 to 300,000 cars per year. In car-body production, the decisive section is the car-body pressing shop where the highest minimum may be reached, 1,270,000 cars per year, and the car-body welding shop where, by exploiting effective multiple-point welding machines, the minimum is about 500,000 cars per year. The other car-body production sections are not as decisive since they involve the same repeated operations in parallel lines. According to the analysis, the minimum capacity in undercarriage groups production is approximately 200,000 to 300,000 cars per year, and the minimum capacity in car-body production is about 600,000 cars per year if, on each line of the body pressing shop, two different kinds of stamping products are alternatively produced. In recently established plants, where the car-body pressing shop is

equipped with modern presses having run-out tables reducing the time for resetting the line for the other part, a minimum capacity of the same range as the undercarriage groups, i.e. 500,000 cars per year, may be expected.

84. The stated theoretical considerations show the minimum capacities for the most effective production. These high numbers cannot usually be reached in the developing countries. It is therefore necessary to calculate with a less effective production and with deliveries of the more sophisticated components (e.g. undercarriage groups and stampings).

Effect of production capacity on production technique and its relationship to labour productivity and investments in technical equipment

Relation between labour productivity and the equipment of a main shift production worker

85. The characteristics of the projected production techniques are as follows:

(a) Concentration of an increasing number of technological operations in one machine (aggregate);

(b) Creation of a functionally bound set of machines (transfer-lines);

(c) Automation of auxiliary operations (feeding, handling and transportation equipment);

(d) Partial automation of technological process control of a larger number of production sections by means of control desks and automatic programming equipment;

(e) Further progressive techniques.

Without mentioning other aspects, this progressive production technique leads towards:

(a) Multiple increase in the machine performance;

(b) Increase in the price of the machines owing to the growing constructional complexity;

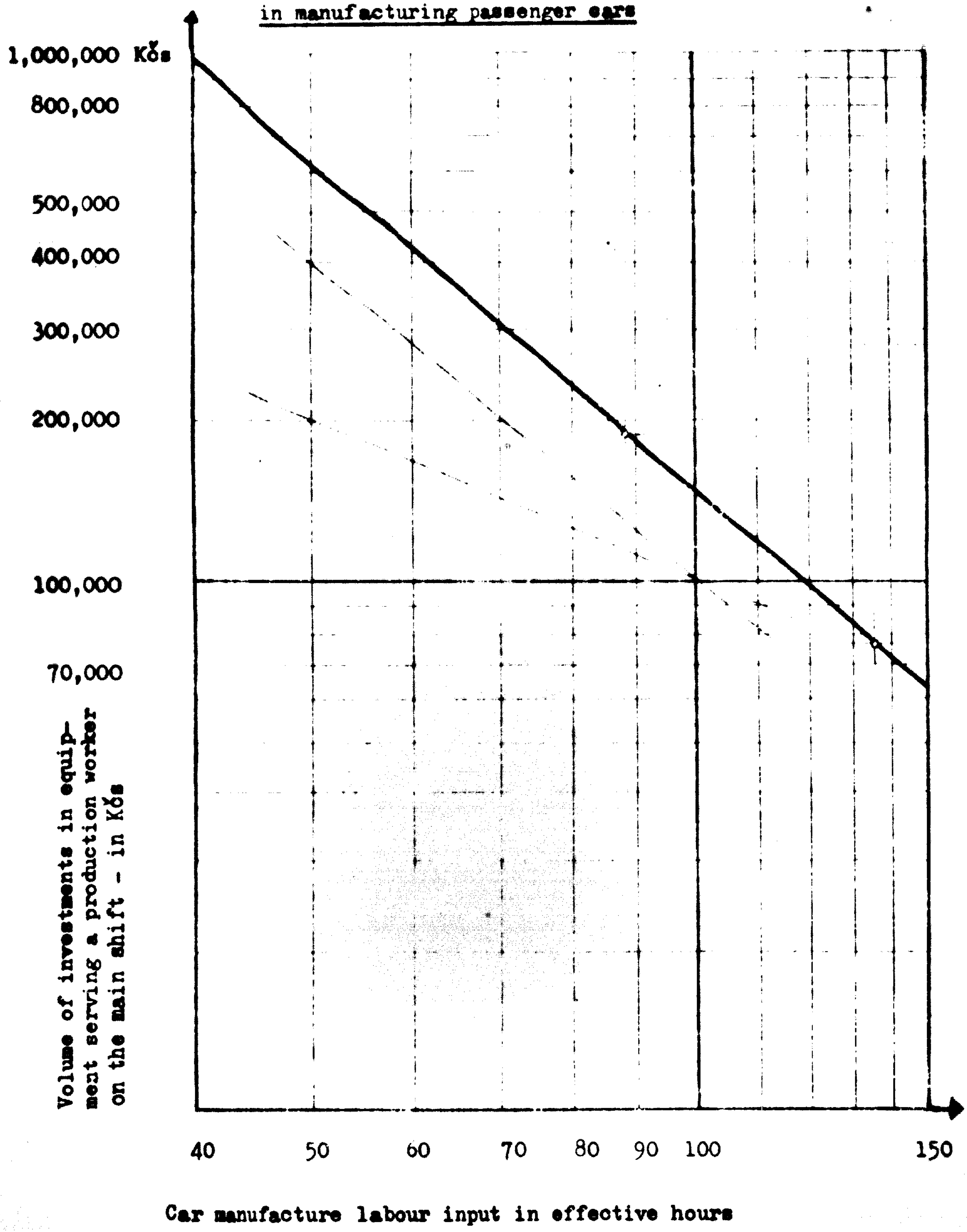
(c) Decrease in the number of attending production workers.

86. The resulting economic effect of these three factors is that the capital investment in technical equipment for one production worker does not grow proportionately with the equipment's productivity, but grows much faster. The present standard production technique is in a linear relation with the prices of the technical equipment per production worker and his productivity. A quadratic relation can be expected in the future.

87. This consideration was confirmed by studies carried out for a specific case - an automotive plant in Czechoslovakia. The dependence of equipment and productivity in passenger car production (excepting forgings and castings) may be noted in figure 3.

Figure 3

Dependence of equipment and productivity in manufacturing passenger cars



88. In further discussion of a production worker's equipment, the mentioned relation is considered to be quadratic. The following chart indicates labour input, productivity and costs of the equipment of the production worker in car production:

Labour input (hours)	135	90	80	70	60	50	40
Labour input index (per cent)	100	67	60	52	45	37	30
Productivity index (per cent)	100	150	169	193	225	270	337
Equipment (mil. Koruna)	76.2	188	240	315	420	610	980
Equipment index	100	247	314	414	550	800	1290

89. The stated values of labour input and equipment were chosen as a basis for further considerations of the influence of change in the projected production capacity and projected labour input on total investments, and in the technical production equipment of the passenger car manufacturing plant.

Influence of change in the labour input on total investments in technical equipment, in the case of constant capacity

90. If constant capacity is to be maintained, further reduction of the labour input by new investments in the production techniques does not appear to be economical since the savings in wages of the production workers are reduced by the growing depreciations and general repair costs. This fact is even more apparent if we consider the technological investments necessary for further reduction of the labour input:

Car labour input (hours)	135	90	80	70	60	50	40
Total investments in the technical equipment (mil. Koruna)	362	503	575	660	755	915	1180
Technological investments to reduce 1 effective hour (mil. Koruna)	3.1	7.2	8.5	9.5	16	26.5	

91. The progressive growth of investments needed for further reduction of the labour input is logical and in line with the increasing prices of more advanced equipment.

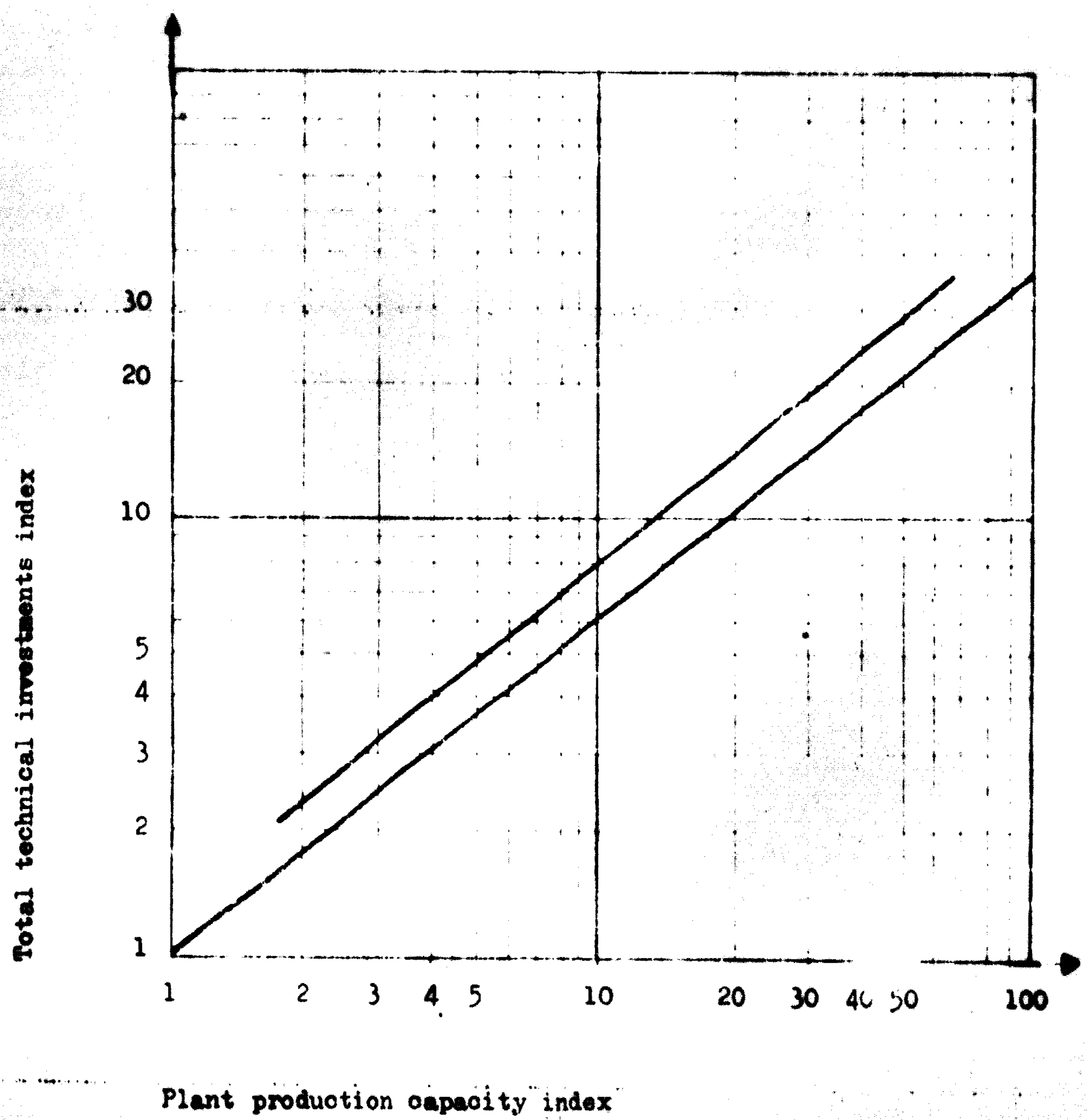
Influence of change in labour input and production capacity on the total investments in technical equipment

92. Given a certain, unchangeable labour input per unit, an analysis of the capital investment in technical equipment for different capacities shows that the investment does not vary in proportion to capacity, but in a digressive, non-linear manner. On the basis of experiences gained while designing mechanical

Figure 4

Production capacity and investments in technical equipment with a constant labour input:

$$\frac{J_2}{J_1} = \left(\frac{K_2}{K_1}\right)^{0.67}$$



engineering plants, the authors have reached the conclusion that the ratio of investment changes according to the relation:

$$\frac{I_2}{I_1} = \left(\frac{K_2}{K_1}\right)^n$$

where I_1, I_2 are the investments, K_1, K_2 the production capacities, and <u>n</u> the exponent, reaching values of 0.67 to 0.75 according to the type of production assortment.

93. For further considerations on the relation of investments and capacities in passenger car production, an exponent of $n = 0.67$ is selected, in order that the indices of investments increase in relation to capacity show the following values:

Capacity	1.0	2.0	3.0	4.0	5.0
Investments	1.0	1.4	2.1	2.5	3.0

94. By calculating the total capital investments in technical equipment with respect to changes in labour input per unit and production capacity of the projected plant, we obtain, according to the above mentioned deductions, the following chart indicating the relation between labour input, production capacity and capital investment in technical equipment:

Labour input	Investments in millions of koruna with a production capacity of						
	120,000	200,000	300,000	400,000	500,000	700,000	1,000,000
89 eff. hours	503	705	905	1,160	1,360	1,660	2,220
80 " "	575	805	[illegible]	[illegible]	[illegible]	1,950	2,520
70 " "	660	925	1,190	1,520	1,780	2,240	2,900
60 " "	755	1,060	1,360	1,740	2,040	2,570	3,320
50 " "	915	1,280	1,650	2,100	2,470	3,100	4,000
40 " "	1,180	1,650	2,120	2,720	3,180	4,000	5,200

95. Figure 5 represents axonometrically the interrelationship of the indices "labour input-capacity-investments". If to the "labour input-capacity-investments" indices are added the calculated periods in which additional investments pay off, expressing the effectiveness of gradation in capacity and reduction of labour input per unit, the following table indicating the economic effectiveness of investments is obtained:

Labour input	Production capacity						
	120.000	200.000	300.000	400.000	500.000	700.000	1.000.000
89 eff. hours	Comparison basis						
80 " "	8.2	7.1	6.2	5.9	5.6	5.4	5.2
70 " "	8.7	7.6	6.6	6.3	5.8	5.6	5.2
60 " "	9.0	8.1	6.9	6.6	6.2	5.8	5.3
50 " "	11.2	9.7	8.5	8.0	7.6	6.9	6.3
40 " "	12.8	12.7	10.9	10.6	9.9	8.9	8.3

The periods in which additional investments in technical equipment pay off were calculated in the same capacity scope (vertically).

96. If we consider that the periods indicated in this table in which additional investments pay off were calculated on the basis of provable savings in production workers' wages, it may be seen that the product labour input decrease is economical only in reasonable co-ordination with the production capacity increase.

Conclusions regarding the influence of progressive production techniques on the work productivity growth

97. Manufacturing passenger cars with an unchanged constructional and technological complexity, the production worker productivity may be raised economically and reasonably only in the case of the following labour input and production capacity relations:

Original labour input (in hours)	Reduced labour input (in hours)	Reduced labour input (%)	Necessity of raising productivity (%)	With a minimum annual car capacity (in pieces)
135	70	48	193	400,000
135	60	55	225	700,000
135	50	63	270	1,000,000

98. These capacities considered economically as a minimum from the point of view of the period in which additional investments pay off will not change considerably, even when dividing the plant for technological specialization, e.g. a separate plant for undercarriage groups production (predominantly machinery), a separate body manufacturing and final assembly plant (predominantly forming, welding, surface treatment and assembly work).

Figure 5

Interrelationship of the indices "labour input-capacity-investments"

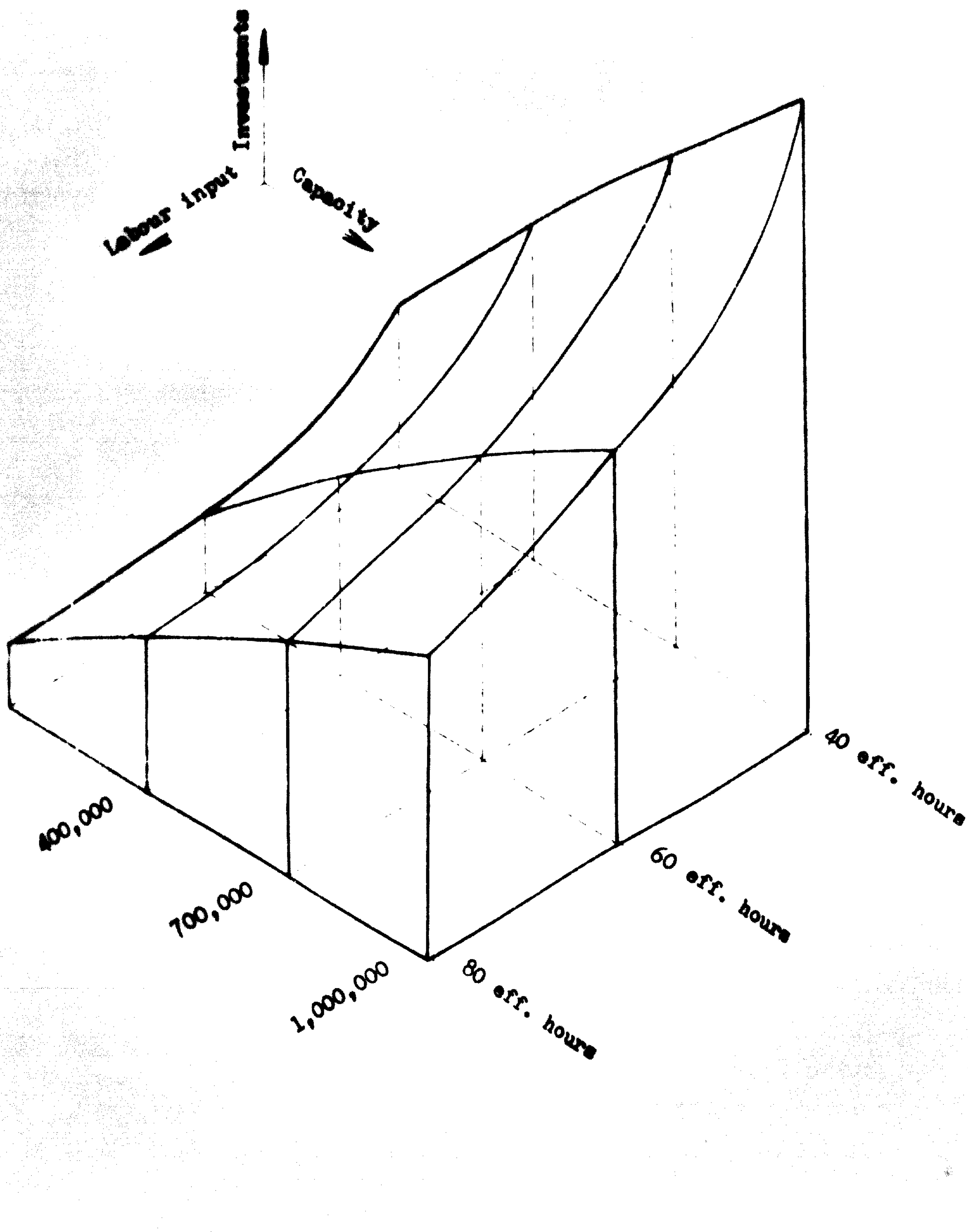
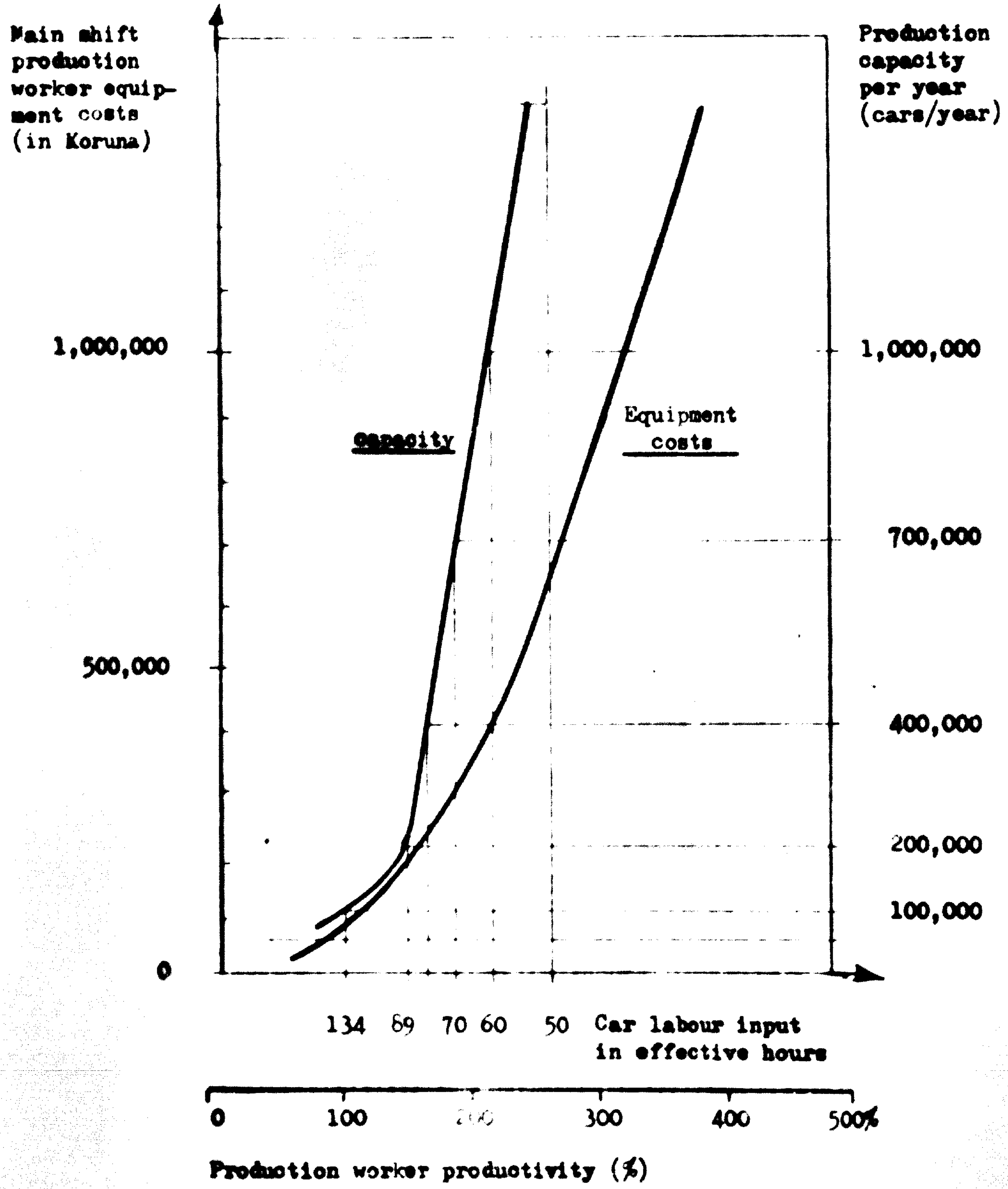


Figure 6

Economic minimum capacities of automotive production with various labour inputs, with respect to a reasonable period of investments pay off



Effect of production capacity on the industrial base and its organization

99. The selection of the production capacity must also be considered from the point of view of establishing industries which are the basis of automotive production. It is possible to depend for a certain period on the supply of all parts and components from the foreign manufacturer who gives the licence, but it is not advisable to rely on this indefinitely. Establishing an automotive industry, it is necessary to consider in a responsible manner the potential of the existing industrial base, and the feasibility of its expansion and completion to such an extent that it would satisfy in the best manner the needs of the motor car production for the determined capacity.

100. One of the decisive factors is the metallurgical industry of the country (accurate grey and malleable iron castings, aluminium castings and accurate forgings). It would not be economical to obtain these semi-products permanently from the co-operating foreign manufacturer because of the large volume of consumption. Of no less importance is the development of the car accessories industry which has a production technology quite different from the motor car production itself. Besides the mechanical engineering products, the motor car production requires quite a number of products of non-mechanical engineering branches, such as rubber, glass, textile, plastics and fuels.

101. It is a fact that countries with a certain level of their basic industries can cope more easily than other countries with the introduction of the automotive industry. They are quickly able to become independent from the co-operating foreign manufacturer, whereas countries which want to establish their own basic and ancillary industry at a later period have to rely on foreign firms until the necessary industrial base can be built in their own country.

102. Requirements regarding material, forgings, castings, as well as mechanical engineering and other co-operation, labour, and investments, arising when establishing an automotive plant are considerable. The consumptions with respect to the selected capacity of production are discussed in detail in chapter IV.

Comparison of plant types

103. From the above considerations, it is evident that the developing countries start with assembly plants. However, their goal should be a gradual development of the whole base and a gradual transition towards a plant with a complete

production cycle. Each of these plant types has its own specific problems which must be considered in the establishment of the plant. The main problems of both types of plants or a combination of the two are evident from the analysis of advantages and disadvantages in chapter I, and from the following considerations.

104. <u>A complex automotive plant with a complete production cycle</u> includes all the basic workshops. Even this type of automotive plant is dependent to a large degree on co-operation from the factories in other branches. The motor car production creates conditions for employing a large number of workers from all categories, as well as engineers and technical employees in other plants, especially in the car accessories plants.

105. At the time of a widely developed work distribution and specialization, it is advisable from the technical and economic points of view to separate the production of car accessories from actual motor car production, even in the case of plants with a complete production cycle. The development of metallurgical shops from the production of semi-products in an automotive plant with a complete production cycle ensures deliveries of castings and forgings in essential volumes on time and with the required precision. This is very important for automated mass production.

106. Further factors to be taken into account when deciding about the production of semi-products are the availability of raw materials base, transportation, flexibility in carrying out construction changes, independence of semi-products and so on. The suppliers are often interested in delivering heavier shipments, since they are usually paid according to weight.

107. The complexity of a plant should be determined by the evaluation of all decisive technical, organizational and economic factors in the respective country. It appears that the majority of medium and large automotive plants in the world have complete production cycle, although it involves production distribution among several plants and co-operation with the final mechanical assembly plant. This conception was implemented successfully by newly developed plants in smaller countries, e.g. by the SKODA plant in Czechoslovakia.

108. In comparison to the plants with a complete production cycle, the <u>assembly plants</u> have to establish even wider co-operative relations. Their organizational structure is simpler because they do not have their own metallurgical base for the production of semi-products, i.e. forging shops and foundries. The machinery shops are considerably smaller since the decisive components (complete engines,

gear boxes, clutches etc.) are manufactured and supplied by other specialized factories. The processing shops are also limited to workshops of some of the surface treatment operations. Large pressings are obtained from co-operating factories.

109. This conception of plant structure will enable the developing countries to rapidly introduce car production which is quite sophisticated from the investments point of view. In the beginning, production and organizational experiences of plants having many years of tradition are used, leading towards gradual establishment of and investment in the motor car production in the country, accompanied by gradual reduction of the co-operation with the foreign manufacturer. The establishment of specialized plants dispersed over the country enables gradual exploitation of local resources, especially labour, materials, transportation and so on.

110. A typical representative of such a plant is the Ford Company of Antwerpen. Assembly plants with their great demands for components supply are also established in countries with a developed automotive industry. In such cases, the advantages of the existing industry of the country are especially exploited by using the existing plants for production and delivery of components and assemblies (e.g. engines, clutches, gear boxes, front and rear axles).

111. A combination of both types of plants represents a certain transitional phase from typical assembly plants to plants with complete production cycles.

112. The automotive manufacturers in the developing countries must also attempt to become independent as soon as possible from the foreign manufacturer. This goal is met solely by gradual building up of co-operative shops to supply the final assembly plant with parts and components, or by developing certain departments in the framework of the existing assembly plant. Thus, the automotive plant in developing countries must be viewed as dynamic and changeable. The plant's composition will change with progressive development and the capability of the technical personnel to master in their own factory or in new plants in the country the production of parts and components which, at the beginning, were supplied by the co-operating foreign manufacturer.

113. The form and composition of the plants cannot be identical for all countries, since they are influenced by many factors, the most decisive of which is the ability to produce in the country, either within the framework of a final plant or by building up co-operating plants.

114. Evaluating the two types of automotive plants or a combination of the two, the following conclusions may be useful for developing countries:

(a) In order to introduce such a technically intricate process as automotive production, one must choose in the first phase an assembly plant system with considerable co-operation with the mechanical engineering industry for the supply of parts and components, as well as co-operation with other industrial branches.

(b) According to the degree of the country's own industrial base, it is necessary to exploit to the maximum the possibilities of gradual transition from depending on the foreign licensing manufacturer to establishing plants for the production of parts (within the framework of the plant itself, gradually approaching a plant with a complete production cycle), or to establish plants in the country to produce parts for the final assembly plant.

(c) Even a final plant with a complete production cycle must depend on the supply of products from co-operating manufacturers working in other branches, such as rubber, glass, textile and plastic products, in addition to accessories which, even in the more developed countries are obtained through co-operation.

(d) From the point of view of labour recruitment, it is advantageous to establish specialized ideally located plants rather than great factories with complete production cycles.

(e) The degree of co-operation with plants within the country must be determined from case to case, taking into consideration all technical and economic factors.

IV. LABOUR, RAW MATERIAL, RESOURCE AND INVESTMENT REQUIREMENTS

115. In this chapter the requirements for labour, materials, co-operation, energy and investment will be determined. Given the proper background, this can be accomplished with sufficient precision. These factors may influence the decisions regarding construction, economy and location, and may even lead to complete or partial abandonment of the plans to establish plants. At the same time, investment, operational and transportation problems must also be discussed and solved.

Labour

116. In order to calculate labour and the capacity of machines and equipment, it is necessary to determine the mode of operation specified by the number of shifts, the length of the working day and the available hours per year of workers, machines and workplaces (called "time fund"). The definitions of these expressions were included in chapter I. In calculating these data, we arrive at the necessary requirements regarding labour and machines from which we can derive areas for the main and auxiliary production, social welfare installations, and the necessary investment costs. Table 3 gives data for different modes of operation.

117. The calculation of the labour requirements for manufacturing 10 per cent of spare parts and 400,000 cars (1,000 cm^3, four-seat, four-door, four-cylinder water-cooled engine of 40 hp, rear mounted, self-supporting body and ordinary accessories), requiring a labour input of 75 hours, is as follows:

$$400{,}000 \times 1.1 \times 75 = 32{,}900{,}000 \text{ effective hours per year}$$

In the case of 2,000 effective hours per year per production worker, about 16,300 production workers will be needed. This number is a starting point which enables deriving other employee categories by means of average, as shown in the following example:

Basic production: production workers	16,500
Auxiliary production: production workers	2,500
Total production workers	19,000
Other auxiliary workers	9,500
Total workers	28,500
Engineers and technical employees	4,200
Clerks	1,700
Auxiliary and attending personnel	600
Total employees	35,000

118. Mass production of automobiles requires in spite of its mechanization and automation a large volume of labour. In the case of 400,000 cars per year, the resulting total labour requirement is 35,000 employees, which necessitates locating this production near a city of about 100,000 inhabitants As the range of inhabitants of medium cities is between 10,000 to 30,000, it will be very difficult to situate such a large plant without a wide-scale housing scheme. Building such a plant near a city of, for example, 10,000 inhabitants, will call for enormous investments in housing construction. From the point of view of labour recruitment, it would be more advantageous to build up specialized, well-allocated co-operating plants instead of gigantic plants with a complete production cycle.

119. When carrying out such calculations it is necessary to consider the employees' skill, the quantity of machines and equipment in the plant, degree of mechanization of administrative work, extent of the research and development departments, and so on. It is understandable that plants with a smaller capacity will have a relatively larger staff of engineers. The distribution of personnel in the different shops is shown in tables 5, 6, and 7.

Raw materials, materials and components

120. The automotive production economy is primarily influenced by the industrial base, especially by the metallurgical industry. This is confirmed by the fact that there is a considerable consumption of metallurgical

Table 3

Operating mode survey

Working hours per week	48	46	44	42
Days in year	365	365	365	365
Sundays, holidays, free Saturdays	58	58	58+26 Sat. = 84	58
Working days per year	307	307	281	307
Working hours per year – Monday – Friday	255x8 hours = 2040	255x8 hours = 2040	255x8 hours = 2040	255x7 hours = 1785
Saturdays	52x8 hours = 416	52x6 hours = 312	26x8 hours = 208	52x7 hours = 364
Annual time fund per employee	2456	2352	2248	2149
Non-exploited days: vacation	37	18	17	18
absence	–	19	15	16
total	37	37	32	34
Exploited days	270	270	249	273
Time fund loss (approx.)	12%	12%	11.5%	10.5%
Annual exploitable time fund per employee	2160	2070	1990	1910

Table 4

Time funds' survey

Working hours per week		48				46				44				42			
		No. of shifts			Continuous operation	No. of shifts			Continuous operation	No. of shifts			Continuous operation	No. of shifts			Continuous operation
		1	2	3		1	2	3		1	2	3		1	2	3	
Work day in hours		8	8+8	3x8	24	8	8+8	3x8	24	8	8+8	3x8	24	7	7+7	3x7	24
Annual time fund in hours		2456	4912	7368	8760	2352	4704	7056	8760	2248	4496	6744	8760	2149	4238	6447	8760
Exploitable annual time fund for machines and equipment, with respect to different percentages of time losses for repairs	Per cent of losses for repairs																
	2	2410	-	-	-	2300	-	-	-	2200	-	-	-	2100	-	-	-
	3	2390	-	-	-	2280	-	-	-	2180	-	-	-	2060	-	-	-
	4	2360	4710	-	-	2260	4520	-	-	2160	4320	-	-	2060	4120	-	-
	5	-	4660	7000	-	-	4470	6700	-	-	4270	6410	-	-	4080	6120	-
	6	-	4620	6930	-	-	4420	6630	-	-	4230	6340	-	-	4040	6050	-
	7	-	-	6850	-	-	-	6560	-	-	-	6270	-	-	-	5980	-
	8	-	-	6780	-	-	-	6490	-	-	-	6200	-	-	-	5920	-
	9	-	-	6710	-	-	-	6420	-	-	-	6140	-	-	-	5860	-
	10	-	4420	6630	-	-	4230	6350	-	-	4050	6070	-	-	3870	5790	-
	11	-	-	-	7800	-	-	-	7800	-	-	-	7800	-	-	-	7800
	12	-	4320	6480	-	-	-	6210	-	-	-	5940	-	-	-	5660	-
The reduction of the exploitable annual time fund in case of an all-factory vacation	1 week	-	-	-	-	40	90	140	-	40	90	130	-	40	80	130	-
	2 weeks	-	-	-	-	90	180	270	-	90	180	270	-	80	170	250	-

Table 5

Personnel in assembly plant[a]

Shops	Shop employees			Office employees			Auxiliary personnel	Total
	production	auxiliary	sub-total	technicians	clerks	sub-total		
Welding and paint shops of small parts	320	145	465	25	10	35	10	510
Car-body welding shop	980	260	1,240	60	20	80	30	1,350
Car-body paint shop	325	50	375	25	10	35	10	420
Final assembly shop and shipping	1,160	205	1,365	35	10	45	25	1,435
Transportation utilities storage	-	400	400	30	30	60	10	470

Total employees of main production	4,185
Total employees of auxiliary production	650
Direction, technical and engineering staff	765
Total employees	5,600

a/ Supplied with 100 per cent of components with a total capacity of 165,000 cars per year.

Table C

Personnel in mechanical assembly plant[a]

Shops	Shop employees			Office employees			Auxiliary personnel	Total
	production	auxiliary	sub-total	technicians	clerks	sub-total		
Foundry	135	95	230	40	10	50	5	285
Forging shop	90	60	150	35	10	45	5	200
Pressure foundry of Al parts	120	60	180	35	10	45	5	230
Metallurgy-total	345	215	560	110	30	140	15	715
Mechanical shop	1,100	480	1,580	120	30	150	25	1,755
Pressing shop	180	120	300	25	10	35	10	345
Pressing, welding and paint shops of small parts	565	260	825	65	20	85	20	930
Electroplating shop	180	100	280	20	5	25	5	310
Car-body welding shop	980	260	1,240	60	20	80	30	1,350
Car-body paint shop	330	50	380	25	10	35	10	425
Final assembly shop and shipping	1,160	205	1,365	35	10	45	25	1,435
Transportation utilities, storage	-	500	500	40	35	75	15	590

Total employees of main production	7,655
Total employees of auxiliary production	1,835
Direction, technical and engineering staff	1,410
Total employees	11,100

a/ Supplied with 50 per cent of components with a total capacity of 165,000 cars per year.

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Table 7

Personnel in plant with complete production cycle[a]

Shops	Shop employees: production	Shop employees: auxiliary	Shop employees: sub-total	Office employees: technicians	Office employees: clerks	Office employees: sub-total	Auxiliary personnel	Total
Foundry	270	190	460	80	20	100	5	565
Forging shop	185	120	305	75	15	90	5	400
Pressure foundry of Al parts	230	120	350	70	15	85	5	440
Metallurgy-total	685	430	1,115	225	50	275	15	1 405
Mechanical shop	2,055	960	3,015	220	55	275	45	3,335
Pressing shop	370	225	595	45	15	60	10	665
Pressing, welding and paint shop of small parts	820	385	1,205	95	30	125	20	1,350
Electroplating shop	210	110	320	25	5	30	5	355
Car-body welding shop	980	260	1,240	60	20	80	30	1,350
Car-body paint shop	325	50	375	25	10	35	10	420
Final assembly shop, shipping	1,200	205	1,405	35	10	45	25	1,475
Upholstery section	300	75	375	10	10	20	5	400
Transportation utilities, storage	-	190	190	20	15	35	5	230

Total employees of main production	10,990
Total employees of auxiliary production (tools etc.)	3,215
Direction, technical and engineering staff	2,300
Total employees	16,500

a/ Metallurgical base included with a total capacity of 165,000 cars per year.

materials, namely:

(a) Rolled metallurgical material including first-rate sheet metal for deep drawing for the production of car bodies and other stampings, which are purchased from metallurgical works.

(b) Castings and forgings usually produced by the motor-car factories with complete production cycle in their specialized shops - grey iron and malleable iron foundries and aluminium pressure casting foundries.

121. Automotive production inevitably requires various types of materials from other branches, e.g. from the chemical, textile and consumer industries, as well as deliveries of materials and products from co-operating plants and local corporations.

122. The consumption of basic and overhead materials is always high. This is shown in the following example for the production of the passenger car (with total dead weight about 750 kilograms) mentioned above:

Type of material	Consumption per unit (kg)
Metallurgical material:	
Thin sheets	400
Other metallurgical profiled material	655
Non-ferrous and light metals	32
Plastics	12
Paints	23
Textiles	2
Various other materials	38
Total basic material	1,162

123. By deriving material exploitation from the relationship

$$\frac{\text{weight of finished products}}{\text{weight of basic materials}} \times 100$$

we receive a value of 70 to 75 per cent for motor-car production.

124. The following items are also required for the given example: dynamo, starter, controller, distributor, coil, battery, lamps and other electric accessories, carburettor, fuel pump, thermostat, air filter, oil filter, fuel filter, radiator, heating and ventilation, steering wheel, products made of plastics, shock absorbers, anti-friction bearings, glass, seats, rims, tires, inner tubes, etc., having a total weight of [illegible] kilograms.

125. From this data it is possible to calculate orientation procedures regarding the individual types of materials serving as a basic document for the calculation of the transport turnover. It is necessary to point out that modern car bodies require 0,7 - 0,8 mm thick high-quality sheet metal for deep drawing. The accessories supplied by the co-operating plants should also be first-rate, constructed from fine quality production materials, perhaps imported as is often the case in developing countries in the first phase of development. There are high requirements regarding the quality of rims, tires and inner tubes (at least five units per produced car) owing to their shorter useful life compared to the useful life of the car itself. Because of bulkiness, these parts are difficult to transport.

<u>Energy</u>

126. The consumption of energy depends on the technical equipment, production workshop layouts, degree of mechanization and production capacity, as well as the level of work hygienics and the climate conditions of the site. The indices listed below serve as an orientation example based on the data of a plant for the production of 1,000 cm^3 cars having a standard construction. The plant in question has a complete production cycle with a metallurgical base, heating plant and paint shop, which are the most important consumers of steam, water and electrical power. The data may not be applied without due considerations, calculations and check-ups of the specific situation and given factors. Data for certain types and sizes of plants are published from time to time in various foreign technical magazines. For example, the French magazine <u>Usines d'aujourd'hui</u> published complex data regarding the Renault (Flins), Renault (Cléon), Simca (Poissy), Peugeot (Sochaux-Montbéliard), Citroën (Rennes) plants, the German magazine <u>Zentralblatt für Industriebau</u> dealt with plants in the Federal Republic of Germany, and the Czechoslovak magazine <u>Architektura CSSR</u> discussed the Skoda plant (Mladá Boleslav).

127. Here is a survey of indices of basic types of energy in a plant with a complete production capacity for manufacturing 1,000 cm^3 cars:

Type of energy	Unit	Cars per year [illegible]	[illegible]	[illegible]
Heat (steam or hot water)				
Heat for technical equipment	(tons of steam)	1.2	1.1	0.8
Heat for heating and ventilation (incl. paint booths)	(tons of steam)	2.8	2.5	1.8
Electrical power	(kWh)	1,300	1,200	1,000
Industrial water (without drinking water) Requirements for fresh (additional) water from sources/total consumption of fresh and recirculation water per car.	(m^3)	25/80	20/70	18/60
Compressed air 7kg/cm^2	(Nm^3)	1300-1500	1200-1400	800-1000
City gas 3,360 kcal/Nm^3	(Nm^3)	180	160	110

128. The consumption of thermal energy for room heating, and for the heating of air for ventilation purposes (mainly for paint booths ventilation), depends on the outside air temperature. The average requirements are valid for a region with a calculated outside air winter temperature of minus 12 to minus 15 degrees Centigrade. In regions with a warmer climate the consumption will be considerably lower.

129. The technique of determining and evaluating energy indices was applied in determining the output and consumption indices of electric power in mechanical engineering plants. On this basis, various data per production unit may be calculated. The processing of this data was preceded by considerable research work and analysis. Preparation work for the establishment of an industrial plant is a very complex process. Its course and success depends on whether or not all the basic technical and energy data of the plant were correctly determined in the documentation stage. In the first phases, the composition of the plant is usually not yet sufficiently known. This applies also to the technical equipment. It is necessary, therefore, especially in dealing with energy, to start with estimates and comparisons with other plants.

In table 8 the definitions of the basic indices are given, while table 9 indicates the values of output and consumption indices for [illegible] with respect to the plant area and number of employees. Table 9 was compiled on the basis of evaluating indices of many Czechoslovak plants according to the situation in the years [illegible].

130. Table 9 classifies various plants in four groups and includes in detail the shares of installed capacities (Pi) and electrical energy consumptions (A) of individual groups of consumers in the plant. These four groups are:

Group A: Plants with metallurgical departments, forging and pressing shops; large volume of heat treatment, great size and weight of products requiring machine tools with high installed capacities (e.g. manufacturers machine tools, lorries, diesel locomotives etc.)

Group B: Same as group A, but with smaller size of the products calling for machine tools with normal installed capacity (e.g. manufacturers of motorcars, motorcycles, textile machines, plants for series production of consumer goods, refrigerators, washing machines, etc.)

Group C: Plants without metallurgical departments, forging and pressing shops; small amount of heat treatment, production characterized by a large number of machine tools with low installed capacity; high requirements regarding surface treatment (especially electroplating), and a large share of assembly work (e.g. plants of the electrical and precision industry, manufacturers of computers and instruments, medium and large scale producers of small consumer goods)

Group D: Plants with the same characteristics as indicated in group C, but with requirements with respect to machining, mainly plants of the telecommunication equipment and radio industry (e.g. manufacturers of radios, telephone equipment etc.).

131. Using the indices mentioned in table 9, it is necessary to consider the main influencing factors:

(a) Regulations concerning electrical energy consumption;

(b) Changes carried out in production type and extent;

(c) Technology and production control techniques and levels;

(d) Degree of precision reached in deducing these indices.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Installed capacity of consumers in the plant (or group of consumers)	kW	
[illegible]	Average input of the plant	kW	
	[illegible] factor	[illegible]	
A	Electric energy consumption	kWh	El. energy consumed in the plant per year
[illegible]	Average utilization period	hours	[illegible]
S	Floor space of the plant a/	m^2	
Z	Number of employees in the plant b/	[illegible]	
[illegible]	Installed specific capacity	[illegible]	[illegible]
[illegible]	Specific input per employee	[illegible]	[illegible]
[illegible]	Specific consumption per employee per year	[illegible]	[illegible]
pi	Share of characteristic consumer groups of the total installed capacity of plant	%	pi = [illegible] of the group / [illegible] of the plant 100
a	Share of characteristic consumer groups of the total annual electrical power requirements of the plant	%	a = A of the group / A of the plant 100

---

a/ Sum of the area of all the floors in all the buildings belonging to the plant including peripheral walls and inside partitions.

b/ Total number of the plant's employees (production, auxiliary, technical and administration) participating in the plant's production.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]			
			[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	pi	%	[illegible]	[illegible]	[illegible]	[illegible]
	e	%	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	pi	%	[illegible]	[illegible]	[illegible]	[illegible]
	e	%	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	pi	%	[illegible]	[illegible]	[illegible]	[illegible]
	e	%	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	pi	%	[illegible]	[illegible]	[illegible]	[illegible]
	e	%	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	pi	%	[illegible]	[illegible]	[illegible]	[illegible]
	e	%	[illegible]	[illegible]	[illegible]	[illegible]
Forging, pressing shops	pi	%	[illegible]	-	-	-
	e	%	[illegible]	-	-	-
Drives	pi	%	[illegible]	[illegible]	[illegible]	[illegible]
	e	%	[illegible]	[illegible]	[illegible]	[illegible]
Other	pi	%	1	5.5	5.4	[illegible]
	e	%	[illegible]	[illegible]	[illegible]	[illegible]
Total plant	pi	%	100	100	100	100
	e	%	100	100	100	100

a/ See paragraph 130 for description of these groups.

[illegible]

[illegible] Production specialization, output level and technological level are [illegible] through the [illegible] of [illegible] and [illegible] of the [illegible]

[illegible]

[illegible]

113 [illegible]

114 [illegible]

115 The production area [illegible]

116 The auxiliary area contains rooms in the buildings and in the [illegible] for inspection, [illegible] stores, departments for distribution of drawings and [illegible] stores, [illegible] stores, cutting and lubricating emulsion preparation shops, and [illegible] shops. The auxiliary area does not include stairways, elevators, or shafts.

137. The main production operation area is the sum of production and auxiliary areas. A detailed evaluation of all the influences increasing or reducing the area index with respect to technical changes and capacities would be very difficult to offer at this time.

138. In evaluating the future area index of a workpiece, deductions are made on the basis of the present and projected situation or by comparison with similar plants. Workpiece area size indices are charted according to the main production sections for [illegible] and [illegible], and include the following data (on the basis of data obtained from a similar domestic or foreign plant):

(a) Operating area in m²;
(b) Production area in m²;
(c) Main shift production workers;
(d) Operating area in m² per main shift production worker;
(e) Production area in m² per main shift production worker.

139. [illegible] for the production of [illegible] for different [illegible] capacity of [illegible] tons per year:

[illegible]	Production of [illegible]	Production of [illegible]
Total operation area	[illegible]	[illegible]
Shops	[illegible]	[illegible]
Storage facility equipment	[illegible]	[illegible]
Administration area	[illegible]	[illegible]
Social area	[illegible]	[illegible]
Other	[illegible]	[illegible]
Total area	[illegible]	[illegible]

Figure 7

Dependence of area index on capacity

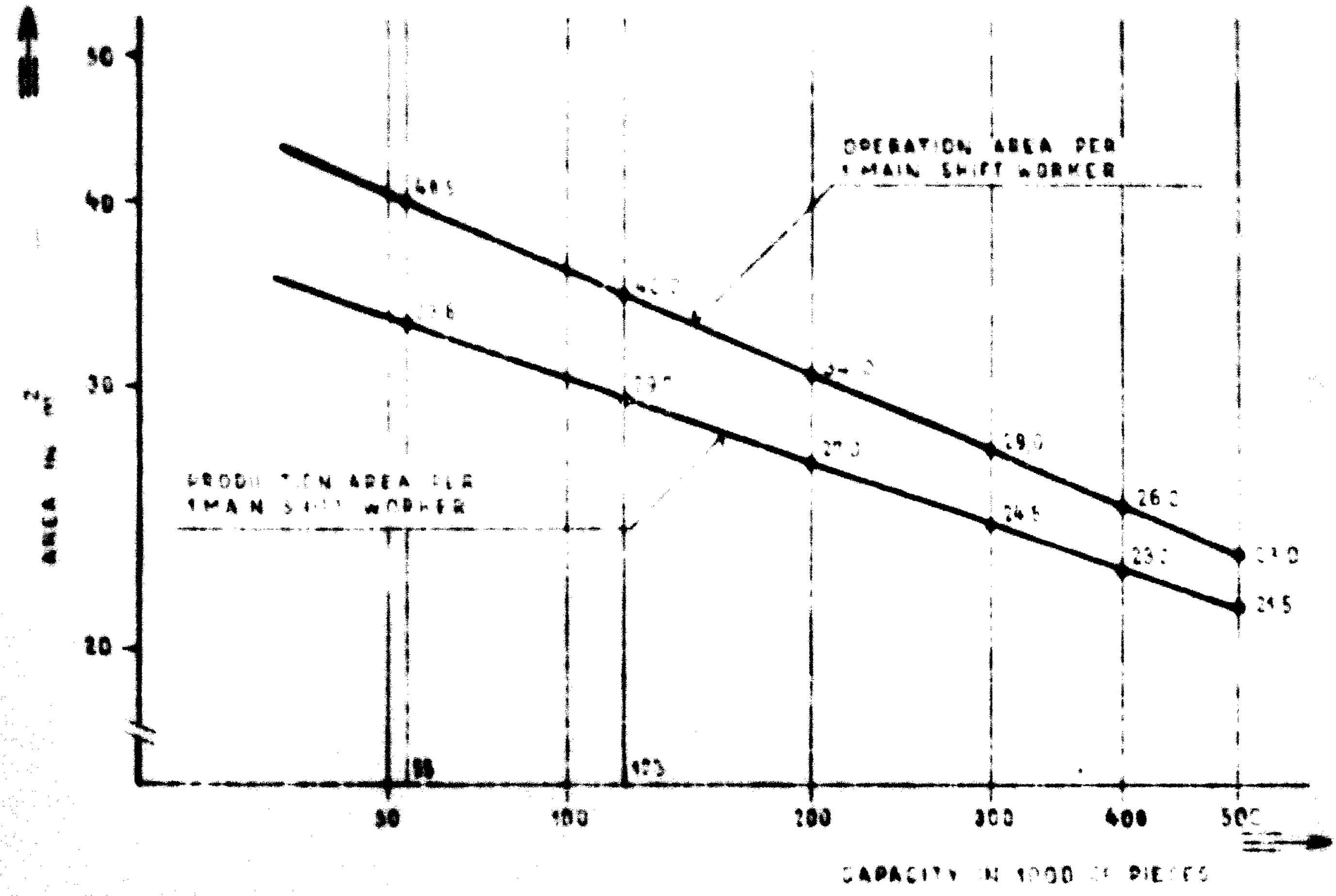
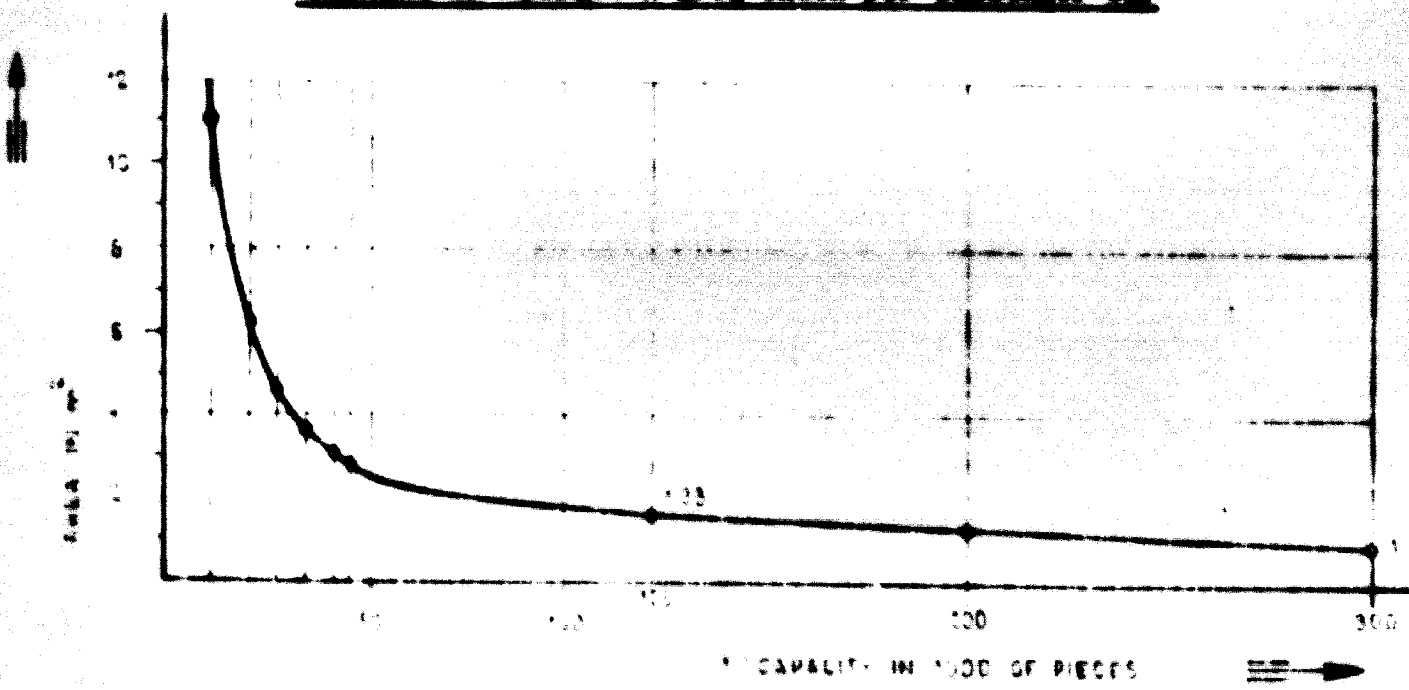


Figure 8

Decrease of operation area index per passenger car



141. From these basic considerations regarding areas and their mutual relationships, it is possible to assess approximately the area required for the automotive plant of the selected type. For the determination of the size of the entire site, a coverage coefficient of about 0.35 should be considered.

Investments

142. The capital investments for the automotive plant depend on the type of the plant, its size, machines and equipment, and the price level of deliveries in the country. In the study phase, the investments are derived from indices. The investments generally include:

(a) Total investment costs per m^2 of floor space;

(b) Costs of machines and equipment per m^2 of floor space;

(c) Construction costs per m^2 of floor space.

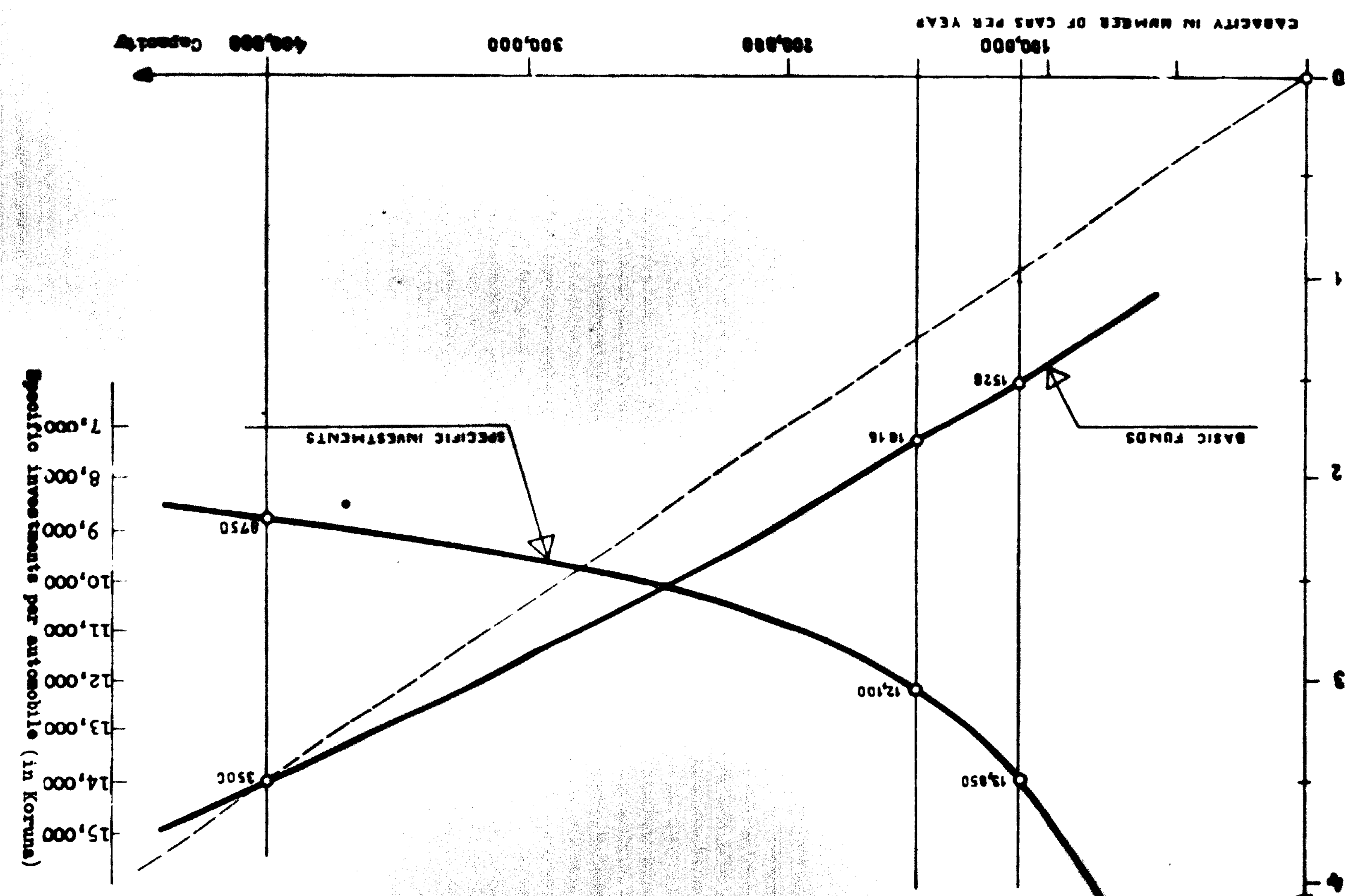
143. Another way of deducing investment costs is to employ investment cost indices per production worker or per employee or possibly per manufactured car. The calculations are rather simple. However, it is very important to make these calculations carefully on the basis of available data or, if possible, on the basis of examples from other similar plants.

144. As an example, the indices were calculated for the production of the 1,000 cm^3 motor-car in Czechoslovakia. The investment costs from which the indices were derived were taken on one hand from real investment costs of a recently established automotive plant having a complete production cycle supplied with modern technical equipment, and from the verified relationship between capacities and investments as described in chapter IV on the other hand. The dependence of the accruing investments on the production capacity is shown on the following table and in figure 4.

145. From the following table, it is evident that the investment growth coefficient for a plant having a capacity of 400,000 cars per year is very good. The capacity grows 1.18 times faster than the investments. It is also evident that the investments' structure corresponds with the required trend (68 per cent of investments are made in technology and energy supply equipment).

Figure 9

Dependence of basic fund and of specific investments on production capacity



146. The amount of "basic funds" per main shift production worker is almost constant. This may be explained by the degree of mechanization and automation of the technological process, achieved even in a plant with a capacity of 110,000 cars. The higher the capacity, the lower the specific investments. This is in line with previous indices.

	Base of reference	Variant I		Variant II	
Capacity	110,000	150,000	Factor [illegible]	[illegible]	Factor 3.64
Technological and energy supplying equipment (mil. of Koruna)	772	[illegible]	[illegible]	[illegible]	3.08
Construction (mil. of Koruna)	362	452	-	1,120	-
Total (mil. of Koruna)	1,134	1,422	1.25	3,500	3.08
Total basic fund (mil. of Koruna)	1,528	1,816	1.19	3,500	2.29
Specific investment (in Koruna)	13,850	12,100	0.90	8,750	0.83
Investment yield	1.25	1.40		1.70	

V. PREREQUISITES FOR AUTOMOTIVE PRODUCTION

Technical assistance from experienced foreign manufacturers

147. Experiences show that the introduction of automotive production in developing countries must be entrusted to some experienced automotive plant with a high technical level of production and long years of experience in automobile construction and production. Such a plant may cope successfully with such a task in collaboration with a complex layout designing organization specializing in automotive production.

148. The experienced manufacturer offers the following technical assitance to the new plant:

(a) A licence for a technically perfect and tested product;

(b) Production documentation (construction drawings, production sequences, and standards for licensed products);

(c) Project documentation;

(d) Education and training of workers.

Licence and necessary production documentation

149. By receiving a licence and the necessary production documentation, the new plant saves the costs of prototypes' development, tests, checking series and clearing up mistakes which always are present in the beginning. The new plant accepts not only a technically perfect and tested product, but also benefits from production experiences gained through long years of development. Thus, a rapid introduction of production is made easier in the new plant.

Project documentation

150. The project documentation created by a layout designing organization in co-operation with the plant submitting the technical assistance enables a rational development and the realization of a progressive production technique with economic effectiveness.

151. The project documentation usually includes:

(a) An investment study of the new plant, which clarifies the purpose of the construction and the selection of the most effective alternative for determining the optimum technology and capacity. It also helps to determine the location of the plant. Through this study, the customer gets acquainted with the main technical parameters of the designed plant and can have at once an informative survey of the investment costs. All the data of the study are corrected and improved on the basis of consultations with the customer (i.e. with the representatives of the new plant) in the next stage of the project documentation.

(b) A project offer which includes the general layout of the plant and a complex technical, economic and architectural opinion as to the construction of the new plant. It states the main principles of conception and is an agreement with the investment study. It includes specifications of machines and equipment and material for ordering them. The project offer also contains specifications of technical assistance from the foreign plant.

(c) A detailed layout-project including details on technology, construction and energy.

Education and training of workers

152. In spite of mechanization and automation, modern mass production of automobiles requires a large volume of labour which must cope with work on complex production machines and equipment. It is necessary to become acquainted with this equipment and to ensure a faultless operation and perfect maintenance. Thus, it is of utmost importance to train selected workers, technicians and engineers. Their training and gaining of production experience should raise the standard of their professional qualification.

153. The number of employees in a complete production cycle automotive plant, co-operating with car accessories' suppliers and other branches (chemistry, plastics, textiles, rubber, glass, etc.) is as follows:

Categories of labour:	Production capacity in items/year		
	120,000	165,000	400,000
Workers	10,500	13,000	2[illegible],100
Engineers, technical employees	1,700	2,500	4,200
Clerks and other employees	800	1,000	2,700
Total number of employees	13,000	16,500	35,000

154. Technical assistance to the personnel should ensure the proper development of production and a faultless quality of the products. The qualifications of the locally recruited employees will determine the kind of technical assistance. The experienced manufacturer will gradually send leading technical employees, specialists, foremen, fitters and instructors to the new plant. The permanent participation of these employees in sufficient number must be ensured throughout the construction period and from beginning of production up to the time when full capacity is reached. The following employees and categories are generally involved:

Consultants to the director
Chief of production
Chief of production planning and control
Technologists
Product designers
Material standards' technician
Performance standards' technician
Tooling technician
Tool designers
Mechanics
Auxiliary departments' technicians
Chiefs of workshops
Foremen
Instructor, specialists
Master workers
Technical inspection workers
Chief metallurgist
Heat treatment technician
Planning and dispatching technician
Economist

155. It is presumed that personnel assistance for the start of automotive production will be about 4 to 5 per cent of the presumed total number of employees in the new plant. The length of employment will vary according to the problems of the specific branch and function. The group of specialists mentioned will be supplemented by a medical doctor and necessary auxiliary personnel. Personal assistance in introducing plant organization and control is the work of qualified consultants and instructors of the following branches:

(a) Technical specialists for organization and control
(b) Auxiliary services organization and control
(c) Chief of the department of technical services
(d) Instructor for the service installations
(e) Sales (including spare parts manager)
(f) Chief economist

156. The training programme is offered to employees in the following categories and is sponsored by the original manufacturer:

(a) Organisation employees
(b) Managing and administration staff
(c) Employees who will be responsible for investments
(d) Chiefs of workshops and technical personnel
(e) Foremen
(f) Master workers and instructors

The number of the above mentioned employees depends on the experience of the personnel, but it is usually about 3,5 per cent of the total number of employees.

157. Extensive studies of workers' qualifications in a certain important automotive plant showed that the ratio of fully qualified (trained) workers to unqualified workers (instructed for certain work only) was in the range of 0.790 to 0.712 in the past years. With progressing automation, the training in European automotive plants is aimed at raising the employees' qualifications. Considerable attention is being paid to mastering production on automated machines and equipment and the maintenance of these machines.

158. Training follows two lines:

(a) Normal training which lasts about four years for workers who master two basic professions, e.g. locksmith and milling machine operator, turner and milling machine operator, turner and grinder, moulder and pattern maker, electrician and electro mechanic.

(b) Special training which is available for high school graduates who want to add to their professional training experiences in mathematics, natural sciences, electrotechnics, technology and foreign languages.

159. These methods of training should serve as good models for automotive plant employees in developing countries. Attention should be drawn to the necessity of continuous training of employees not only in main production but also in the tool shop, i.e. to workers engaged in tool production, and tool designers and designers of gauges and fixtures. This will lead to an increase in the main production labour productivity. Especially important is the continuous training of employees who maintain the technically complex production equipment, since the capability of the plant to meet the production and quality demands depends on the level of production equipment maintenance.

160. Installation and assembly of machinery and equipment are most effective assistances given to the new plant by the supplier of machines and equipment. This assistance consists mainly in control and inspection of assembly work. The customer provides auxiliary and trained employees and the necessary assembly equipment, carried out on the basis of a contract. The following staff should be supplied:

(a) Assembly co-ordinator - chief technician-engineer

(b) Consultant in the field of stock organization with special reference to assembly problems.

(c) Technical inspector

(d) Technician for installation and assembly of machinery

(e) Interpreter

(f) Assembly foremen

161. During installation and assembly of machinery and equipment, the new plant can gain valuable experience in the functions of the machines and equipment. This applies especially to the plant's employees who have the possibility of getting well acquainted with the machines' and equipments' functions during installation, testing and operation.

Material base of important semi-products

162. The automotive production economy is influenced by the industrial base, particularly by the metallurgical branch. This is confirmed by the large consumption of metallurgical materials, for example:

(a) Rolled stock including high-quality sheet metal for deep drawing for car bodies and other pressings. This material is usually bought from metallurgical works;

(b) Castings;

(c) Forgings, which like castings, are usually produced by automotive plants with a complete production cycle in their specialized grey and malleable cast iron and in aluminium die cast foundries.

In addition, the automotive production requires various types of materials from other branches, e.g. chemical, textile and consumer goods industries, as well as deliveries of materials and products from foreign co-operating firms and local enterprises.

163. A car (for example, a 1,000 cm^3 volume passenger car, four-seat, 40 hp engine, four-cylinder rear mounted, self-supporting body without frame, total net weight 745 kilograms) would require:

Material	Consumption (kg/car)
Ferrous metals	655
Non-ferrous metals	34
Paints and thinners	27
Small (standardized) parts	36
Other	13
Total basic materials	765
Finished components and parts supplied in co-operation	293

For passenger car production, exploitation of materials is in the range of 73 to 75 per cent.

164. The following table shows the materials supplied to a passenger car manufacturing plant:

Basic material	Capacity of cars and spare parts	
	120,000	150,000
	(metric tons/year)	
Metallurgical materials	66,285	(break-down unknown)
Raw materials	18,120	
Non-metal materials	2,870	
Material provided by means of co-operation	28,250	
Total basic materials	115,526	170,000
Auxiliary materials	33,945	60,000
Chemicals and inflammable products	2,480	-
Coal[a]	180,000	220,000
Total other materials	216,425	280,000
Grand total	331,950	450,000

a/ If another heating medium is employed, the data will differ.

165. Castings and forgings form a large part of materials required for automotive production. For example, in the above mentioned passenger car, they make up 24 per cent of the weight and in a twelve ton lorry, they make up almost 60 per cent. Thus, an economically effective automotive production requires the establishment of foundries and forges equipped so that they will ensure the high quality of these semi-products. When developing the material base of the automotive industry, great attention must be paid to the metallurgical shops.

166. Required foundry and forging capacities for passenger cars (four cylinders, 1,000 cm^3, 40 hp) are as follows:

Metallurgical shops	Capacity of cars and spare parts	
	120,000	150,000
	(metric tons/year)	
Grey-iron foundry	6,500	9,000
Malleable iron foundry	6,700	9,000
Aluminium die cast foundry	4,700	6,000
Drop forge	7,100	9,500

167. The requirements for castings and forgings for a passenger car with a weight of 755 kilograms and an engine with a swept volume of 1000 cm^3 are:

Steel castings (kg/car)	Grey-iron castings (kg/car)	Malleable iron castings (kg/car)	Aluminium alloy die castings (kg/car)	Number of forgings	Weight of forgings (kg/car)
2	41	44	27	68	0.2-4.5

168. The requirements for castings and forgings for lorries are:

Loading capacity (metric tons)	Weight of castings (kg/lorry)			Weight of forgings (kg/lorry)
	Grey iron	Malleable iron	Steel	
2.5	300	205	a/	260 - 300 b/
4	550	450	a/	420 - 500 b/
7	1,200	765	a/	900
12	730	4	1,820	2,190

a/ In series production of lorries, cast steel is seldom used except for lorries of the heaviest tonnage.

b/ The lower figures do not include the weight of crankshafts and camshafts which can be made of cast iron.

Other industries and co-operating plants

169. Going hand in hand with the development of a country's automotive industry is the development of other plants or services (not including the mechanical engineering branches) which manufacture and supply the automotive plants with materials, semi-products or metallurgical products e.g. thin sheet-metal, rubber, glass, textiles, plastics and fuel. These semi-products or products manufactured in specialized plants require technology different from those used in the automotive industry itself. Therefore, these products will be provided by means of co-operation at any time, even in countries having a well-developed automotive industry.

170. The following table gives a clear picture of the material requirements from plants other than the mechanical engineering branches for the passenger car example:

Material	Weight (kg/car)
Rolled material	483
Steel tubes	15
Hoop steel	51
Drawing sheets	18
Non-ferrous metals	35
Other products	88
Metallurgical industry-total	690
Tires and tubes	41
Various sealing materials	2
Rubber industry-total	43
Paints and thinners	27
Plastics leather with textile base	9.1
Semi-products	16.9
Chemical industry-total	53.0
Glass industry	3 m^2/car

171. The production of automotive accessories differs in production technology from the actual production of automobiles. These plants involve special electrotechnical and technological problems, techniques calling for precision instruments and the use of special testing equipment.

172. The accessories include the following typical items: dynamos, starters, governors, distributors, coils, batteries, lamps and other electrical accessories, as well as carburettors, fuel pumps, thermo-regulators, air filters, oil filters, fuel filters, radiators, heating and ventilation equipment, shock-absorbers, and car brakes.

173 The labour input of the components forming a complete set of accessories for the given 1,000 cm^3 car is equal to about 56 effective hours and the total weight is 223 kilograms. They are manufactured at seven separate specialized plants.

174. The same plants manufacture accessories for lorries. For example, a five ton lorry requires about 68 effective hours for complete accessories. The car accessories are supplied permanently from specialized plants to the automotive plant on a co-operation basis.

Gradual development of production

175. Gradual production development is always divided into several stages regardless of the type of plant, be it a plant with a complete production cycle or an assembly plant. The stages must be determined by the layout planning group of the founding plant or by a separate layout planning organization engaged in designing plants. The design will be based on the results obtained from a systematic research study, on consultations with the founding plant, and with the aid of the production equipment suppliers and the customer. The stages must be so designed that it is possible to uphold the quality of the product and enables the supplier to offer the customer appropriate guarantees.

176. Experience indicates that it is possible to divide the process of equipping automotive plants into four phases. The period before the first phase is devoted to a detailed survey of technological, constructional and energy sources at the location of the proposed production plant. After finishing the research work, a project offer must be prepared. Detailed specifications of research and design will be discussed with the customer. Production will be introduced gradually depending on the complexity and labour input of the components, on the progressing skill of the employees, and on the development of the industrial base of the country. In this paper it is possible to indicate some of the principles governing the

determination of the phases of production. Depending on the design, not all phases need to be carried out in every case.

177. In the first phase, the final assembly begins with finished parts and components supplied by the founding plant which also offers technical assistance. The supplied components packed in suitable overseas cases are already prime coated, and machined and functionally important surfaces are protected by special means. In this first phase, the finished parts and components may account for as much as 90 to 95 per cent of the automobile. To complete assembly, the new manufacturer may supply some parts or products which he can get from his own market, e.g. tires, tubes, car accessories, such as accumulators, plugs, headlights, starters, or items which he is already able to produce himself, e.g. installation and small connecting materials, oil fills, lubricants, paints etc. It is presumed that the first phase will already utilize certain finished areas of the new plant. In order to assure timely completion of a new assembly building, it would be advantageous to begin construction directly after selecting and securing the location and after agreeing on the general layout plan.

178. In the second phase, it is possible to introduce gradually the manufacturing of simple parts and components which do not require highly skilled production workers. The produced parts build up a sufficient volume of work-in-progress and serves as a head start before the products' assembly in the third phase. In the course of the second phase, equipment necessary for the introduction of production of additional components planned for the third phase should be delivered and installed.

179. In the third phase, the share of parts and components delivered by the supplying plants continues to decrease. The manufacturer acquires from local sources additional finished products, production and auxiliary materials of good quality, and forgings and castings. The production of more complex components is introduced. Machines and equipment for the last phase are delivered, completing the deliveries of machines for the projected plant capacity. The assembling of machines should be carried out as fast as possible according to a predetermined time schedule and with respect to the presumed production in the fourth phase.

180. In order to ensure the production capacity in the fourth phase, the managing plant delivers components which have not been introduced during the third phase. Production of the remaining parts and components is gradually introduced in the fourth phase so that the dependence on deliveries from the managing plant are at a minimum or correspond to agreements made by the managing plant and the customer. Presuming that projected outputs have been met, conditions will be set for full production with a projected number of shifts and capacities. Upon reaching the final production state, deliveries of components from the founding plant terminate or are limited to those which for longer periods will be provided by means of co-operation.

181. Requirements for ensuring production in a new automotive plant may be listed in chronological order, starting with the basic commercial dealings and ending with production:

(a) Compilation and submission of an investment study for the new plant;

(b) Negotiations with respect to the study and the conception of the plant;

(c) Negotiations regarding the volume and supplying of designing work and specifications of materials and documents required for the project and survey work;

(d) Elaboration of the project offer;

(e) Acceptance of the project offer and procuring all the basic materials for it;

(f) Development of the project offer including the general plant layout;

(g) Elaboration of a binding offer with respect to the delivery of machines, equipment and technical assistance according to the specifications of the project;

(h) Approval of the project and reaching an agreement;

(i) Contracting for partial delivery of machines and equipment for the first and second phase;

(j) Making the specifications more precise, and contracting for delivery of machines and equipment for the third and fourth phases;

(k) Elaboration of the technological, constructional and energy part of the detailed layout project;

(l) Construction work including supply of energy;

(m) Training of employees at the main (founding) plant;

(n) Delivery of machines and equipment from the foreign supplier and from the country's own sources for all four phases;

(o) Assembly and installation of machines and equipment for the four phases;

(p) Delivery of tools for the four phases.

182. Owing to the development of a metallurgical base, the new plant progresses from a pure assembly plant to a plant with a complete production cycle. According to the development of the industrial base a course towards further specialization may be adopted. This generally involves the manufacture of complete components in shops or in existing plants which change over to the necessary production.

Car maintenance, distribution and service network

183. The company must build up a service network which covers the area where its cars will be used. The company arranges this through its own installations or with the assistance of other companies or proprietors who can ensure the observance of the company's standards of first-rate services. A service network usually has the following three classes:

(a) Large company branches (repair shops, service, car sales etc.);

(b) Concessionaire sales shops (same as above, but not belonging to the company);

(c) Dealers (small sales shops with a minimum of service or no service at all).

184. Servicing the car is a very important activity of automotive companies. They must render first-rate and full-extent services since the customers tend to judge the company itself by the quality of these services. Thus, it is necessary even in the preparation phase to consider proposals for future distribution and service network and the necessary maintenance shops.

185. The extent of the services depends on:

(a) Type and construction of the vehicle;

(b) Number of vehicles in the specific region;

(c) Level of services;

(d) Type and quality of the road network;

(e) Weather conditions.

186. All these factors must be considered when developing the service network proposal. Usually they are preceded by a systematic statistical analysis, on the basis of which plant standards for calculating the extent of the repairs and services are derived. The main data which must be reviewed and determined according to the types of vehicles are:

(a) Number of cars manufactured by the company and used in a specific region or repair shop zone, generally dependent on the number of sold cars per year;

(b) Life of the automobile varying on the car construction, quality of materials, car and road maintenance, weather conditions etc.;

(c) Average number of repairs (coefficient of frequency) for a given time, depending on the number of kilometres travelled per year, the average age of the vehicle, and road conditions;

(d) Time for one average repair, depending on the shop layout, the repairs' organization and control, repair shop tools and equipment, the effectiveness of the repair techniques, the specialization of work and employees' teamwork;

(e) Area standards per car;

(f) Costs per repair.

Most of the companies use various company aids for determining these data, such as charts, standardized layouts and equipment.

187. The French Regie Renault (RR) Company determines the extent of repair work and services in the following manner:

Car life	5 years
Number of repair work hours per car per 5 years	120 hours
Average time per repair	10 hours/car
Extent of predominant repair work	5 to 6 hours/car

Example:

Number of cars sold per year		150
150 x 120 = 18,000 hours	=	3,600 hours/year

188. Repairs occur more frequently at the end of the cars' life; however, an average can be considered since the new cars sold every year have a balancing effect on the average age of all cars in use.

189. A worker's time fund: 46 hours/week x 50 weeks = 2,300 hours/year. Thirty per cent is lost time owing to handling materials, clean-up, maintenance, overhead activity etc.

2,300 x 0.7 = 1,600 hours,

Number of workers $\frac{18,000 \text{ hours}}{1,600 \text{ hours}}$ = 11 workers

Add thirty per cent for engineers, technical and administration employees, = 4 employees

Space determination for 11 workplaces:

15 m^2 per car (15 m^2 per passenger car, 30 m^2 per lorry) = 165 m^2

Add:

100% for handling space
100% for aisles, walk-ways
30% for auxiliary shops
50% for acceptance areas

= 280%, i.e. 2.8 x the basic area;
total area = (15 m^2 + 2.8 x 15 m^2) x 11 workers

190. The German Volkswagen (VW) Company determines the extent of services in the following manner:

Number of Volkswagens in area
"Frequency factor" (percentage of cars in area to be serviced daily)
Average repair time per car

The percentage of cars to be serviced daily and the average repair time per car vary with local conditions and might be influenced by:

(a) Frequency factor, with respect to average annual mileage per car, average age of car, and road conditions;

(b) Average repair time per car, with respect to shop layout, shop management and organization, tools and equipment, mechanics' efficiency, and job specialization and team work.

191. Extensive investigations in various countries have shown that:

(a) Two to three per cent (frequency factor two to three) of the Volkswagens in the dealer's area come in daily for maintenance and repair;

(b) The average repair time per car is between two and half and four hours.

Taking these figures as a basis, the following simple formula:

$$\frac{\text{VWs in area} \times \text{average repair time per car} \times \text{frequency factor}}{\text{working house of shop per day} \times 100}$$

gives a sufficiently accurate idea of the number of working places required for maintenance service and mechanical and body repair. (The working places needed for paint preparatory work are not included.)

192. The expected increase of the number of Volkswagens in a given area should be included in these determinations. For example:

VWs in area according to official registration figures	228
Increase expected in the next two years (e.g. 8 VWs per month)	192
Average repair time per car (figure ascertained in the particular area)	3.8 hours
Number of cars serviced per day (frequency factor's figure ascertained in the particular area)	3%
Working house of shop per day	8 hours
Number of working places required: $\frac{420 \times 3.8 \times 3.0}{8 \times 100}$ =	6 working places

193. There are generally no applicable rules from which the space for rooms and offices connected to the working places can be determined. This is influenced by local conditions and must be planned to suit individual requirements.

194. It has been proved by experience and practice that a medium-sized workshop offers the best conditions for an efficient and economical operation.

Workshops of the size ranging from 15 to 25 working places are still easy to supervise and provide a solid basis for efficient control of all factors that make the operation profitable.

195. Available information shows that the maximum size of efficient and profitable service operations is approximately 40 working places. Such a large workshop is hindered by a number of aspects:

(a) Increased non-productive time owing to vehicle movement and longer distances to parts for mechanics;

(b) Number of key personnel required;

(c) Shop supervision;

(d) Increased overhead expenses.

196. A repair shop consisting of six working places represents the smallest size of economical construction for automotive repair and maintenance operations.

197. As a guide for estimating the required area, 2,000 square feet (approximately 200 m^2) can be considered per service working place. This constant includes all rooms of a service operation as well as a sufficiently large service court and a filling station, assuming that building restriction lines are ten feet (three metres) from the foundary. However, the constant does not include space in reserve for expansion. Hence, options for adjoining areas should be acquired at an early stage in case the need for expansion should become urgent at a later date.

198. It should also be noted that it is not advisable to deviate from the ideal shape of the building site. Variations from the ideal shape call for a special layout of buildings and increases the space requirements. Building restriction lines and other limitations may substantially reduce the usable area of a lot.

199. The size of sites required by distributors planning to concentrate service, new-car wholesale and retail business, and central parts depot in one location can only be determined individually with respect to the business volume concerned.

200. Customer satisfaction is not only dependent on the quality of the work performed, but also to a large extent on the interest taken in the customer's personal welfare and the distance from home or office to the service shop. For this reason it is of vital importance in large towns to aim at decentralization the service facilities.

VI. PRINCIPLES OF PLANT DESIGN

Layout planning

201. The results of all previous considerations, calculations and comparisons form a layout plan of a plant that will ensure the most effective production flow within the plant as a whole and within the individual buildings, shops or machine groups. The layout plan is basic for any type of organization or production activity and helps to determine and demonstrate:

(a) Correct location of all needed machines and equipment;
(b) Correct interrelation of all activities;
(c) Effective mode of production;
(d) Shortest possible route of materials and products.

202. Each layout plan examines the five following production factors:

P - Product to be manufactured (motor-car);

Q - Quantity to be produced (production volume and assortment);

R - Routing and its operations;

S - Services and activities supporting production, obtained by means of co-operation;

T - Time during which all the action must take place.

203. The methodical sequence of investment preparation, layout planning and installation follows basically the patterns seen in figure 10 and the phases seen in table 10.

Figure 10

Sequence leading towards production

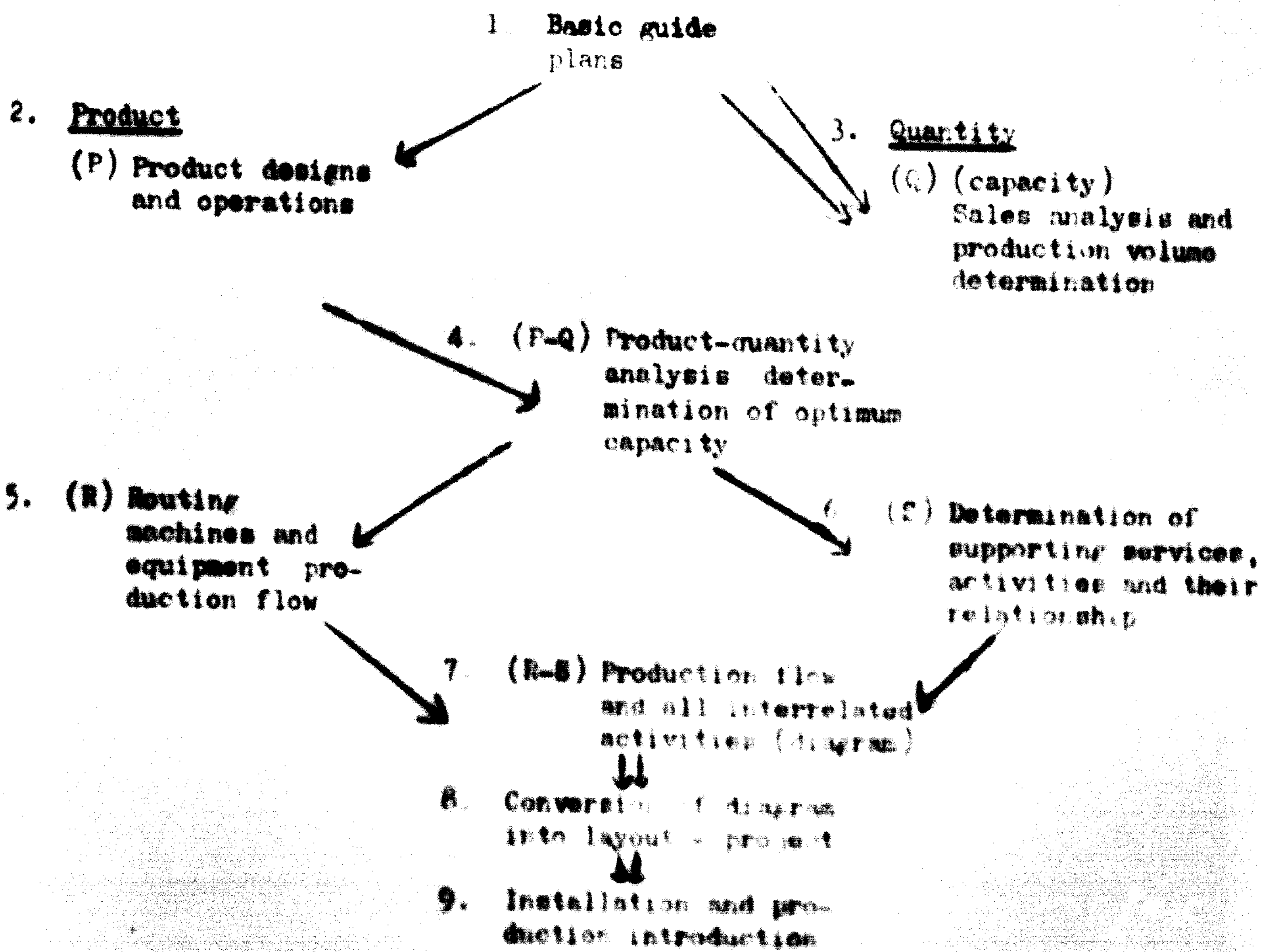


Table 10

Phases of production

Phase	Description of activity	Corresponds with figure 10	For description, see chapter
I. Preparatory	Product, assortment, quantity determination and their analysis	1, 2, 3, 4	I, II, III, VIII, IX,
	Production location		I, IV,
II. Layout planning	General layout of plant	4, 5, 6, 7, 8	I, II, IV, VI,
	General layout of each building (shop)	4, 5, 6, 7, 8	I, II, IV, VI,
III. Layout	Detailed layout plan of each shop	4, 5, 6, 7, 8	I, II, IV VI,
IV. Installation	Installation and introduction of production	9	V

204. The investment and layout plan preparation sequence in figure 10 makes the entire production activity easier. The individual phases have a certain sequence but for a better effectiveness they should overlap.

205. The preparatory phase is decisive as it specifies the basic data determining the automotive production profitableness. Maximum attention must be paid to this phase by the management in the developing countries and by the government authorities. This phase must be based on serious research and analyses which serve as a basis for considerations described in the previous chapters. It is advisable to ask foreign specialist-consultants and layout planning companies for co-operation in this phase.

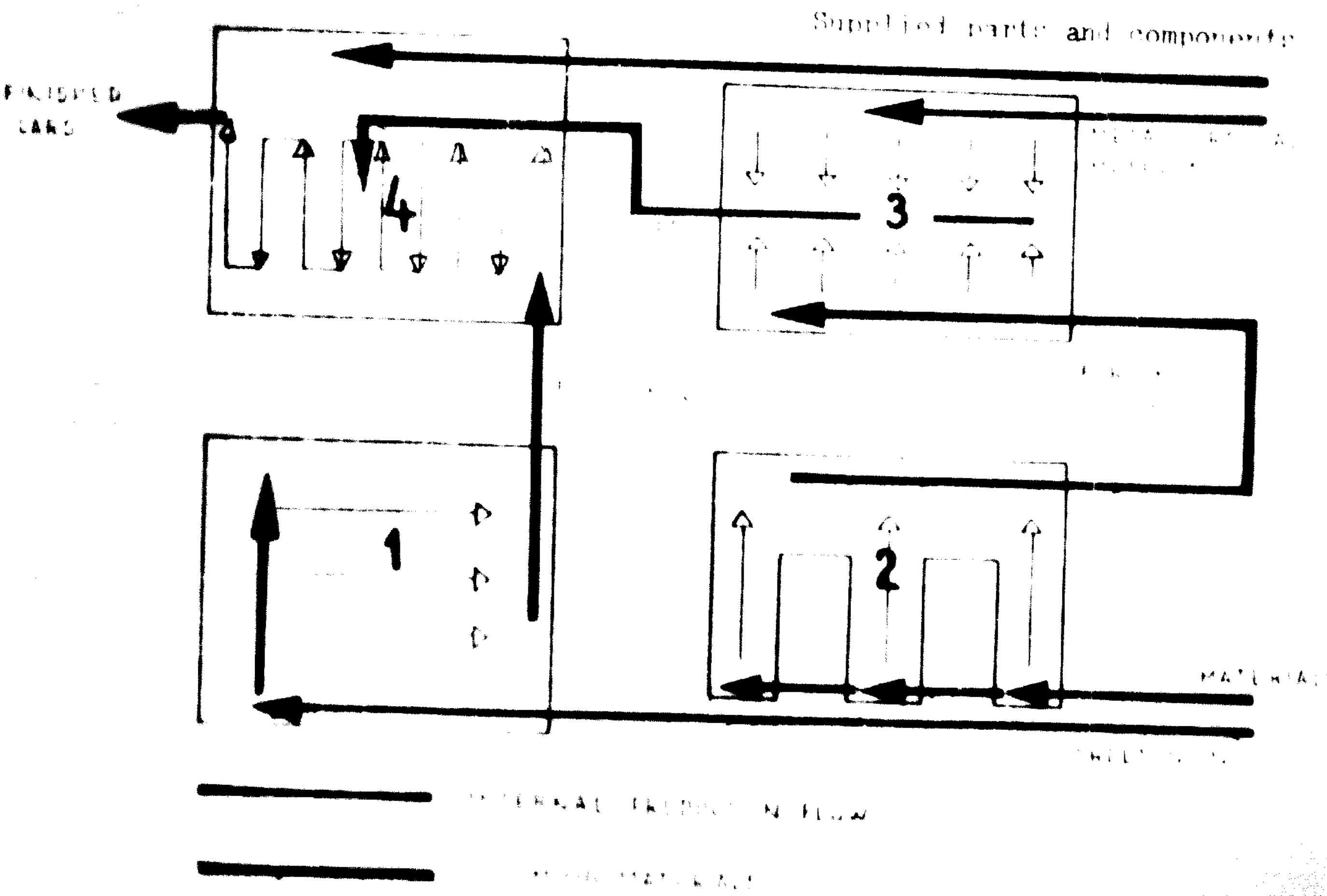
206. The layout planning phases are described in this paper only rough outline since this stage is dealt with in detail in a number of special papers published throughout the world.

Layouts and flow-sheets of typical plants

207. For purposes of clarity, the general layout schemes include only the main production buildings and basic production flows. The other auxiliary and social administration buildings and energy resource were not included. These are generally located in the vicinity of the areas or departments which they serve.

Figure 11

Plant with complete production cycle



1 **Pressing shop**

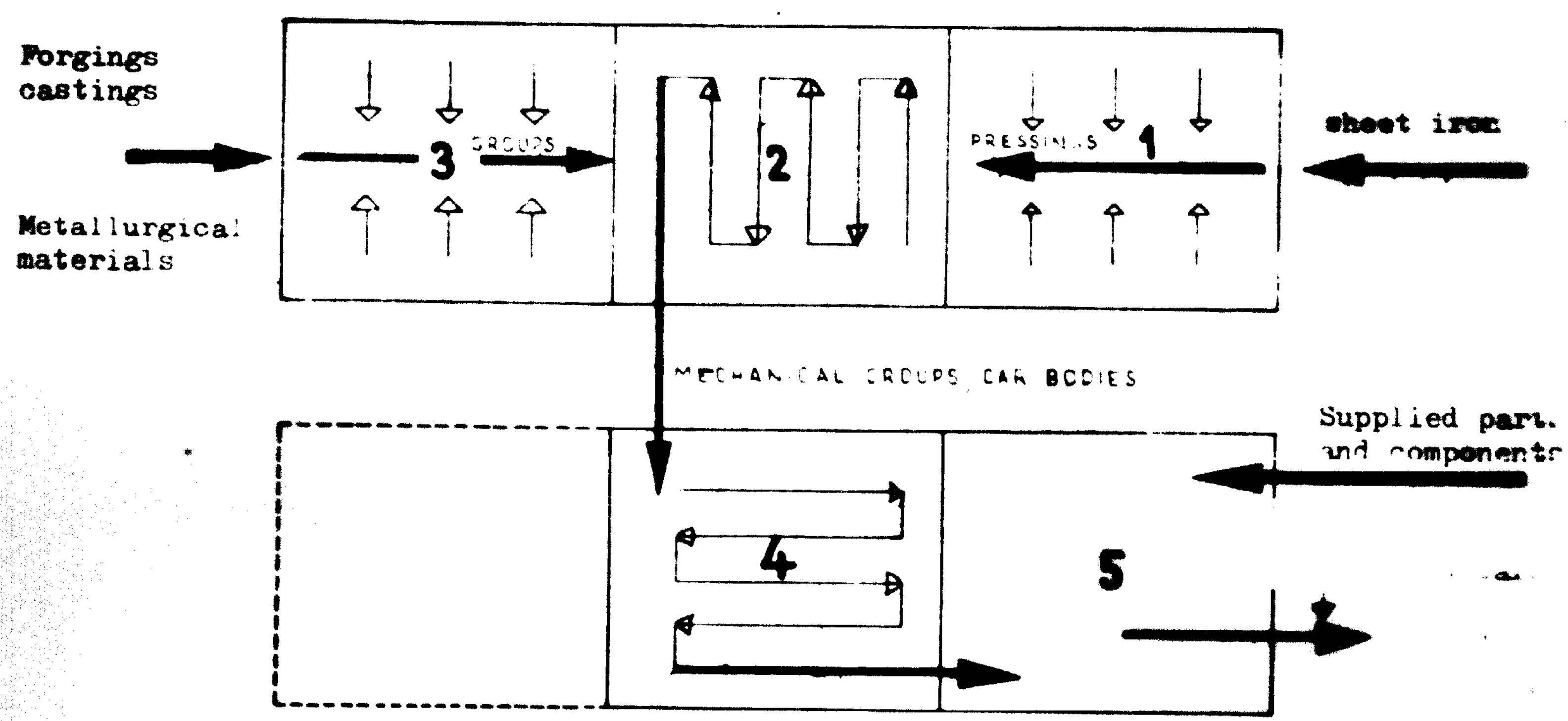
2 **Foundry, forging shop**

3 **Mechanical groups manufacture**

4 **Welding, paint and assembly shop**

Figure 12

Mechanical assembly plant



1 Pressing shop

2 Welding shop
Electroplating shop

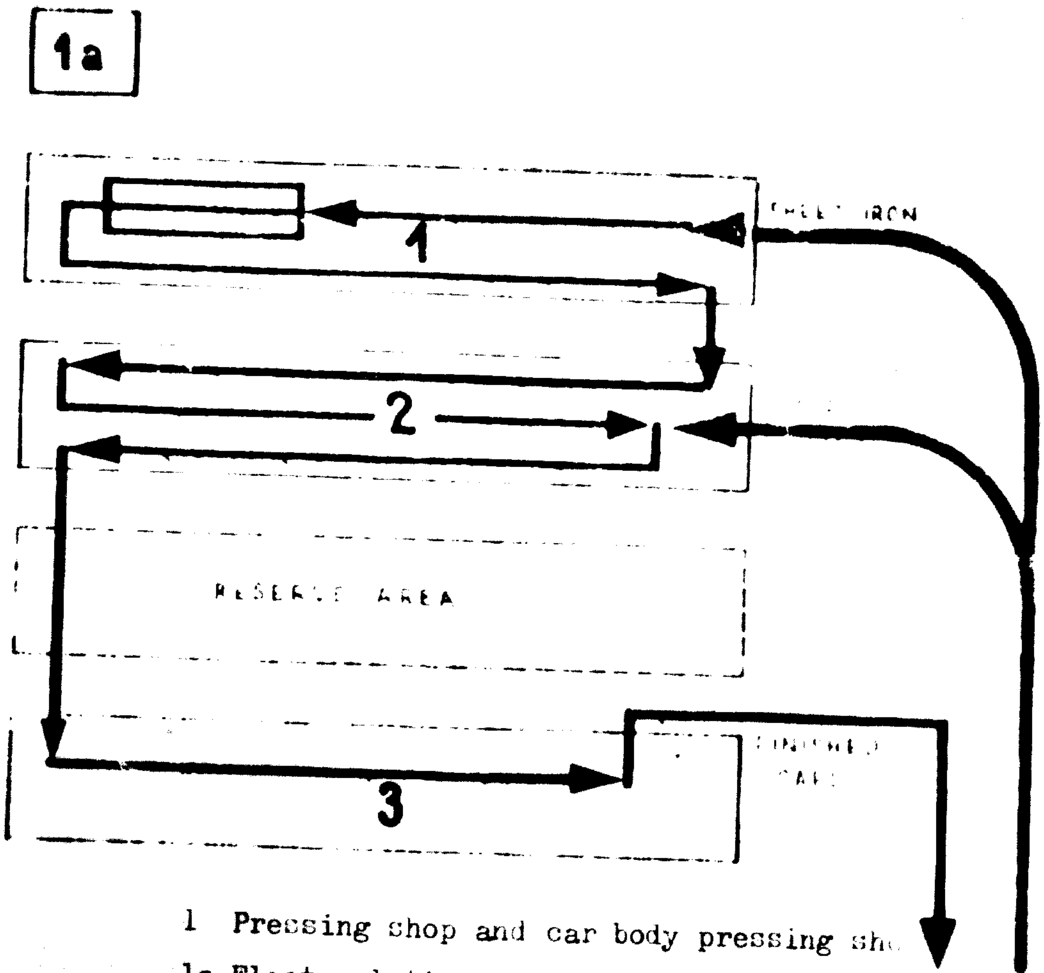
3 Mechanical groups manufacture

4 Paint shop and final
assembly shop

5 Storage, shipping

Figure 13

Assembly plant with pressing shop



1 Pressing shop and car body pressing sh…

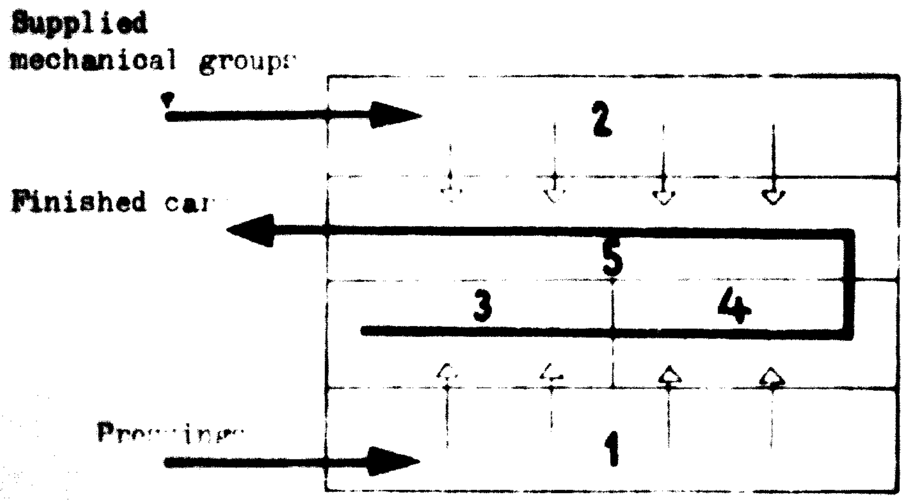
1a Electroplating shop

2 Paint shop and outfitting car bodies

3 Final assembly and shipping

Figure 14

Small assembly plant



1, 2	Storing and preparation of pressings, components, groups and outfits
3	Welding shop and car body assembly shop
4	Paint shop
5	Final assembly

208. Figure 11 shows a typical plant with a complete production cycle, including the metallurgical base. Figure 12 shows a mechanical assembly plant similar to that of Figure 11, but excluding the metallurgical base. The forgings and castings are obtained by means of co-operation. Figure 13 shows an assembly plant with its own production of pressings, but where all the mechanical groups are obtained by means of co-operararation. These three figures apply to medium and large plants having a minimum capacity of [illegible] cars per day.

209. Figure 14 shows a small assembly plant with a capacity of five to ten cars per day. All the parts not only the standard parts, but also mechanical groups and pressings, are obtained by means of co-operation. The production process starts with welding the car bodies by means of hand spot-welding equipment. The machines and equipment in such an assembly plant are not so complex as in the other plants.

210. These examples of the general layouts show the basic relationships between the individual production phases. Except for the basic evaluation of the two main types of plants (the plant with a complete production cycle and the assembly plant) discussed above, it is difficult to evaluate the advantages and disadvantages of individual general layouts, since each manufacturer starts with specific economic, organizational, production and population conditions which lead him towards a certain solution. Thus, each proposal of a new production must be considered in detail and evaluated according to this or another paper so that the results are most effective.

VII. SUPPLEMENTARY PRODUCTION OF TRUCKS IN AUTOMOBILE PLANTS

Labour input in producing trucks

211. Many European automotive plants manufacturing passenger cars include the production of trucks, but in a considerably lower volume than in the passenger car production. The labour input is indicated as follows:

Load capacity (tons)	Effective hours per truck including foundry and forging shop	Average annual truck production
2.5	170	20,000
3 - 4	350 - 400	14,000
5 - 7	500 - 850	10,000
12	1400	3,000

Advantages and disadvantages in combining passenger car and truck production

212. An important component determining the decision regarding the production combination is the production base of the metallurgical shops, i.e. the foundry and forging shop. The metallurgical shops should be designed to produce semi-products also for the truck plant. Some forging aggregates for manufacturing heavier forgings and the necessary equipment for heat treatment must be supplemented. The layout planner for the grey cast iron foundry must consider the increased production, especially with respect to larger castings required by the truck manufacturer. Cast steel castings could be possibly supplied from co-operating factories. The volume of truck production will be considerably smaller than the volume of passenger car production.

213. As a result of this, the technical level of the production equipment in the grey cast iron foundry for truck castings will be lower than in the castings' production lines for the passenger cars. The production of the undercarriage and cab of the truck, as well as the truck assembly should be separate from the corresponding passenger car production.

214. Supplementary truck production in the passenger car plant has certain advantages in exploiting the workshops which will serve both trucks and passanger cars. These shops are, after installing certain aggregates, the

metallurgical shops (forging shop and foundry), the pressing shop, automatic machines' shop, gear cutting shop, paint shop etc., as well as some of the auxiliary production shops, e.g. tool shop, machines' repair shop and maintenance. A typical shop which is able to serve the production of both types of vehicles is the car body pressings' shop where the passenger car body panels may be manufactured along with the truck cabin parts. The welding of the cab is technically not so complex as the welding of the passenger car bodies. In the production of the undercarriage, i.e. engines, gear boxes, rear tube (axle) link etc., larger parts are involved e.g., the cylinder block will be produced by equipment which is a combination of universal and single-purpose machines with equipment for transport between operations. Transfer machines will not be employed. The same applies for the gear boxes and other items. Gear box and shaft gears have larger dimensions (a module of five to seven according to the tonnage) and in some cases have ground tooth sides. This naturally imposes higher requirements on the gear cutting shop and hardening shop, and installation of equipment in these shops must be made accordingly. The assembly of aggregates including the engines should be organized separately for each group. The same should be the case for the final assembly of the truck itself.

215. The truck frame production requires a specific shop with a different technology. At the present, modern frame structures are manufactured by a complex technology of cold forming and by the utilization of modern welding and material handling methods.

Conclusions

216. Truck production as a supplement to passenger car production has certain advantages. A part of the initial investments may also be employed for truck production, particularly in the metallurgical shops (even though it will be necessary to supplement some of the needed production equipment), in the car body pressing shop, gear cutting shop, hardening shop, paint shop, and in some auxiliary shops such as the tool shop, machines' repair shop, and maintenance.

217. The production of the undercarriage for trucks does not cause more problems than its production for passenger cars. However, owing to the larger size of the parts, it is more difficult to produce. There will also be

higher requirements for labour since the volume of production does not allow for a high degree of automation. Universal equipment combined with special purpose equipment is utilized. This requires workers with more skill and a higher labour input.

218. On the other hand, the quality of the cabin and truck bodies need not be as high as in the case of the passenger car bodies, and this production may be classified as simpler. Progressing specialization may create in a developing country conditions for building up a specialized plant for manufacturing trucks. When making this decision it is necessary to take into account several factors: the state of the industrial base, the situation of regional distribution of labour, and the trend of increasing production.

219. Truck production may also be organized at the beginning in an assembly plant supplied with components and parts from the founding plant. In any case, it is necessary to count on the co-operation of specilized plants for car accessories and supplies of material, semi-products and products of other non-mechanical engineering branches, such as the metallurginocal, rubber, glass, textile and chemical industries.

VIII. ECONOMIC ASPECTS OF ESTABLISHING AN AUTOMOTIVE INDUSTRY

Technical and economic interrelations in the national economy

220. The building up of the automotive industry is always a grave intervention in the economy of the country even in the case of gradual transition from the assembly of imported components to production of less complex parts. The economic scarcity is a basic fact of life and only a finite amount of human and non-human sources is on hand to produce a limited amount of each and every piece of goods. With this in mind, the gravity of the decision to build up the automotive industry becomes quite apparent.

221. An important question must be raised: Should not the limited sources be exploited in another way, e.g. for improving agricultural techniques, for establishing an industry closely connected with the local raw material resources, or should they not be explcited to a wider extent for social overhead, from which infrastructural projects might be financed serving further economic development? The decision must be made solely on the basis of a sufficient volume of reliable data, summarized in basic indices. In such case, the sequence of planning would be as follows:

(a) A technical prerequisites study;

(b) A technical feasibility study and analysis

(c) An economic feasibility study and analysis;

(d) Analysis of economic interrelations in the national economy arising from automotive production.

Technical prerequisites study

222. The technical prerequisites study gives reliable data showing what technical prerequisites will be required in developing the automotive industry. This study includes a discussion of the volume and quantity of raw materials, materials, components, machines and technological equipment, spare parts, consumption of energy, waste disposal, transport, labour foreign specialists, and so on. These prerequisites are divided into the individual phases of gradual introduction of production. According to this division, the estimate shows capital investments of the total project divided into costs stated in local and foreign currency and relevant costs and yields. This study does not usually include the evaluation of site alternatives, since a site selection study might prove

too costly if the results of the technical prerequisites study prove to be negative. For the same reason, the estimate of costs should not be founded on drawings, projects and specifications, but rather on the basis of rough calculations derived from already realized constructions, tables, and charts. It is advisable to entrust this activity to a competent consultant.

Technical feasibility study

223. The technical feasibility study employs balancing methods. It compares the prerequisites for introducing the automotive production obtained from the technical prerequisites study with available resources and specific conditions in the country. An important part of this study is the site selection which has an influence on the composition of the costs. It is usually necessary to consider several alternate sites, carry out a technical and economic analysis at each, and project the results into the technical feasibility study. Another very important function of this study is the determination of the schedule of the gradual introduction of automobile production with respect to the presumed plant capacity and its possible growth during the period of acquiring knowledge in different production techniques. In this case, there is quite often a variance in the capacity from the technical and economic point of view and the sales possibilities on the local market. These possibilities are usually limited. One solution lies in the possibility of sales in a specific region. However the most advantageous solution would be to reach a regional co-operation at the very beginning of the project with respect to production and sales distribution in the region. If this is not possible, then it is necessary to reach an agreement with the foreign manufacturer of automobiles so that the manufacturer can incorporate the produced vehicles into his sales network. The greater the participation and interest of the foreign manufacturer in the automotive industry, the more realistic this agreement would be.

Economic feasibility study

224. In the economic feasibility study, all the facts found in the previous technical study will be projected, and the profitableness indices, the financial structure of the investment, and the cash flow will be indicated. The numerical conclusions would be offered in the text of this study. An important part of the economic study is the project analysis, not only from the point of view of

the company, but especially from the point of view of the national economy. The table below is a part of such a study. On this chart the most important data of the project can be summarized, e.g. indices reflecting the financial structure of the plant, the profitability, and so on.

[illegible]

II. ATTITUDE OF GOVERNMENTS TOWARDS ESTABLISHMENT OF AUTOMOTIVE INDUSTRY

Participation of the government in establishing an automotive industry

229. The previous chapters dealt in detail with the prerequisites and inputs in comparison to the expected outputs for the national economy of the country where the automotive industry is to be established. However, one more question remains unanswered: should the industry be built in the public or private sector. If one observes the practices of experienced plants of this type in developing countries, it is clear that the majority of these projects were realised with the participation or active support of the local government within the private sector. In the introductory chapter, it was mentioned that economic and fiscal reasons more or less force the foreign automobile manufacturer to start with gradual establishment of this industry in the developing country. Besides requiring capital investments and a certain level of industrialisation in the specific country, the production of passenger cars and trucks makes exceptional demands on technical assistance, work management and organization, which cannot be imagined without the closest co-operation of the competent manufacturer. The governments in developing countries realise the difficulties of establishing flexible and operative economic units which act not only as investors, but also as successful organisers of the importation of parts and material, and of product sales on the local market or through exportation. Thus, they limit themselves to the creation of favourable conditions for a gradual production of vehicles in the country. However, it is up to the government of the developing country to ensure that these conditions are not a detriment to the majority of the population. The government must at all times be aware of the national economic interests and the limited resources available, and must assume corresponding policies towards the newly established automotive industry. The local government may offer physical support and/or administrative support.

Physical support of the government

230. Physical support involves the participation of the government in financing from public means the infrastructural objectives which may mean a considerable savings in the total capital cost of gradually establishing an automotive industry. At the same time, the development of the infrastructure must be understood to be quite flexible and changeable in certain cases.

The term "development of the infrastructure" usually means the ensuring of an adequate surrounding for the prospective manufacturing plant. Sometimes the objectives of infrastructure penetrate into the plant layout, e.g. the plant power station is financed by the government with the provision that a larger or smaller volume of the total capacity in megawatts (MW) will serve as a source of energy for consumers of the specific region. Quite often public means finance the plant sidings, access roads, river or seaports, which facilitate the supply of raw materials, materials and parts, as well as the delivery or exportation of manufactured automobile. In the framework of the infrastructure, a gas line and a sewage system may be built leading to the plant, and usually a part of a housing centre for the plant's employees along with schools, nurseries, health centres and supermarkets are constructed.

227. Another form of physical support is direct aid which may include land granted without charge for the construction or the payment of a part of the construction costs. Or the government may decide to finance a part of the investment costs of the automotive plant. Direct support may be possible when the government first suggests the establishment of the automotive industry in the public sector, and then decides on the basis of technical and economic feasibility studies that it would be more advantageous and less expensive to subsidize a private venture rather than run the risk of such a construction in the public sector. The support can be given either in one sum or in instalments over a certain period of time with the provision that the amounts gradually decrease. It is clear that such support is not to be permanent. It should only assist in overcoming the "infant diseases" of the initial phase of automotive production and sales.

Administrative support of the government

228. The administrative support includes various government decrees safeguarding the prospects of the new industry during the pre-investment phase, as well as establishing optimum conditions for construction and operation. Direct measures of this type include the following:

(a) Duty exemptions on machine and techonological equipment and components in accordance with the time schedule of the gradual introduction of production;

(b) Customs protection against foreign competition;

(c) Encouragement by tax benefits after beginning the automotive plant operation;

(d) Guaranteeing lacking financial sources;

(e) Granting financial guarantees to local and foreign creditors;

(f) Assistance in safeguarding an effective and attractive sales network and in offering advantageous credit for car sales with minimum instalments;

(g) Assistance in ensuring sales, e.g. by taking a certain number of passenger cars and trucks for public services and the army, in creating a more extensive market on the basis of agreements with other governments;

(h) Granting other guarantees, assurances and additional services.

A brief explanation of these measures aiding the development and operation of the automotive industry follows.

229. Machines and techonological equipment necessary for establishing the automotive industry should be exempt from duties. This should not cause any great problem for the financial authorities of the specific country. They should consider this measure with respect to future benefits, i.e., automobiles will be taxed upon sale and thereby ensure a larger income for the national budget. Nevertheless, this taxation tool should be used at the same time as an incentive for the future investor. The tax exemption should be applied only in such a case where the imported machines and technological equipment will be installed and introduced into operation in agreed-upon stages.

230. The same principle of customs policy should be applied in the case of imported components, the volume of which is very important, especially during the first years after establishing the industry. The customs on components are in the long run more burdensome than customs applied to the imported machines and technological equipment. Even in such a case, the customs exemption should be granted only when the volume of imported components decreases according to the schedule of introducing production in the country.

231. Measures of customs exemption alone are usually not sufficient. The automotive industry requires a thoughtful tariff protection against foreign competition, at least in the phases of initial development.

232. It is well known that during this period the production costs of locally manufactured automobiles are usually higher than the C.I.F. (cost insurance freight) prices of vehicles imported from the traditional manufacturers, owing to the fact that the local production never will be as high as the production with the traditional manufacturers. At the beginning of production, the output is usually lower than expected and money must be paid for foreign specialists and royalties for patented know-how. The work productivity of local labour is lower, costs of maintenance are higher, the percentage of waste is also more considerable, and so on. Hand in hand with the introduction of production, a service network must be established with stores of spare parts serving the future owners of locally manufactured automobiles. This creates an additional organizational and financial super-structure which must be satisfactorily handled in order that the automotive industry can fulfill its goal.

233. On the other hand, it is necessary to emphasize that these protecting customs should not be valid for an unlimited length of time since the consumer cannot be forced permanently to pay higher prices for vehicles manufactured in his own country. The period of customs protection should correspond with attaining a commensurable profitability, assuming this is reached in a reasonable length of time. Should this not be the case, then the government authorities should have access to relevant reports and data so that an analysis of costs and yields could be carried out, the reasons for unfavourable profitability eliminated, and measures aimed at improving this situation could be prosposed. If a responsible feasibility study was worked out in the pre-investment period, there should not be the discovery of some inherent cost disadvantage after the industry is put into operation.

234. Customs protection is usually combined with import control regulations concentrating especially on vehicles of the same or similar technical parameters as of those manufactured in the country. Generally vehicles of differing parameters continue to be imported into the country. However, sometimes it is recommended that, although the automobiles are manufactured in the country, a limited number of foreign vehicles of similar parameters should be imported in order to achieve a climate of regulated competition having a favourable impact on the domestic protected automotive industry which

otherwise could acquire monopolistic tendencies.

235. Another administrative-economical incentive improving the climate for introducing automotive production is the tax exemption. This tax exemption includes generally complete or partial exemption from income, business, and property taxes for a period of from five to fifteen years. It is clear that a whole range of alternatives exists, with respect to time, extent, decreasing trends in exemption and so on. In the case of a newly introduced production, a tax exemption is at the same time a discrimination of the existing industry in the country with the same or similar production programme. This is not the case when a new industrial branch is to be established in the country. Nevertheless, the automotive industry requires in the further stages of development the establishment of new specialized and co-operating plants or the adjustment of production programmes of the existing plants in such a way that gradual production of automobile accessories would be ensured. If this happens, the tax exemptions will generally be applied also to these production units. In spite of this, tax exemptions must be applied reasonably to the benefit of the country's industrialization.

236. Sometimes the new automotive industry shows losses, particularly in the first years after its commissioning. In such a case, tax measures should exist so that past losses could be subtracted from the present or future profits if these profits are not subject to tax exemptions or advantages.

237. Of great importance is the rate of corporation tax. This tax should not be higher than 20 to 30 per cent of the acquired profit, otherwise it would seriously discourage the investor in the automotive industry who might naturally be afraid of the favourable profitableness turning into a loss after the period of tax exemption and advantage passes.

238. On the periphery of taxation there are taxes on exported goods. With respect to the automotive industry, it is not possible to consider realistically that a considerable quantity of manufactured vehicles would be exported in the first period after starting production. Nevertheless, such a case should be considered with respect to tax exemption and advantages of exported automobiles. The price of a specific category of automobiles is determined by the current world price and possible export taxes automatically become a part of the operation costs.

239. Automobile exportation should be supported by special export premiums. If, in the country where the automotive industry is located, there are foreign exchange limitations, premiums received by this industry might be used for importing equipment, components, materials, etc., or may be exchanged for local currency with a bonus equal to the difference between the official and real rate of exchange. In any case, the following principle is valid: An industry of as great an importance as automobile production requires access to adaptations of the tax system which previously served predominantly fiscal interests.

240. If the automotive industry is built up in the private sector, then quite frequently active participation of the government is necessary especially in safeguarding financial sources. Obtaining long-term foreign credits comes into question, usually through industrial development banks which either exist in the country or will be established in order to support the industrialization. An industrial bank of such a type offers credits from five to fifteen years usually with a lower rate of interest than in commercial banks. It may mobilize local financial resources by selling stocks on the free market, issuing guarantees on the granted local and foreign credits and similar measures. State financial development organizations may be established which have similar aims or both systems may exist at the same time. These would be in place of banks.

241. Another problem remains and that is the granting of short-term credits, necessary for the financing of the working capital. It is necessary to span the time needed for delivering the vehicles to the dealers, and it is quite often necessary to finance automobile stores at the dealers. There are many possibilities for ensuring financing of this sort, and reports are on hand stating how similar problems were solved, e.g. in Turkey, and in Mexico, where the dynamic force behind such financing is the National Financiera S.A. and specialized credit agencies in Brasil. A possible method for financing sales is the discounting of bills or bonds covering effective sales of automobiles with payments due after a longer period of time.

242. An effective aid in planning and ensuring sales may be the taking over of certain quota of passenger cars and trucks for the use of the public

sector. A measure of this sort is not only an important publicity factor, but at the same time a guarantee of sales of a specific part of the produced volume. It is also important to develop a demand to be met by purchases on the local market by offering credits to the population for buying passenger cars. Such an activity will be generally undertaken by existing local financial institutions which offer such credits usually for a period of two years. Sometimes they demand payment in advance and offer a credit for the rest or, even more advantageous for sales, they do not demand any payment in advance.

Conclusion

243. It is necessary to emphasize once again that establishing an automotive industry in a developing country is an important step on the way to industrial development. It may bring benefits into the country, but it may also evoke difficulties or be a permanent burden if it has not been well considered from all the aspects of national economy. It must be stressed that the term "consideration" not just a mere deliberation, but a systematic analysis of all questions in the pre-investment phase before the establishment of this industry.

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