B. P. ORLOV

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achievements, problems, solutions

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CONTENTS

FOREWORD

This book deals with the past, present and near future of the economy of Siberia. In outlining the prospects for the development of the productive forces of this enormous region the author tries to discuss the main trends in the development of the Siberian economy and its role in the creation of the economy of communist society in the USSR. The author also aims to establish the most rational methods of exploiting the natural resources of the region.

It may seem to some that the author is partisan to his subject, and that he talks of Siberia from the point of view of a "local patriot", exaggerating its potential and immoderately showering it with compliments. This is far from true. It would be in order here to refer to G. M. Krzhizhanovsky, Chairman of USSR Gosplan (State Planning Committee) who, at a meeting of the

Gosplan presidium in 1930, spoke of the mineral wealth of Siberia and of the need to utilise this wealth, saying that this was of importance not merely to the USSR, but to the whole world.

Having lived in Siberia for a long time and having roamed pretty much all over it, the author is deeply convinced of its great potential possibilities and of the abilities of the Soviet people to turn Siberia in the near future into an industrial giant of world significance.

Whenever people talk of Siberia's natural resources they often apply such epithets as "colossal", "unique" and so on. This is fully justified. We will recall that hundreds of years ago eminent members of Russian society were greatly interested in the future of this region. M. V. Lomonosov, the founder of Russian science, prophesied that Russia would derive her power from Siberia. "What a rich land this Siberia is, what a vast land!" wrote the great Russian revolutionary democrat A. N. Radishchev when in Siberian exile a little under two hundred years ago. "It will take centuries, but when it is populated it will play a great part in the annals of the world."

And Pierre Rondiere, a French writer who was in Siberia about fifteen years ago, noted: "Siberia is already pressing on the destiny of the world with the weight of the steel and coal it produces. And in 30-40 years' time, by the beginning of the 21st century, enormous efforts could bring it to the head of the list of world producers. Siberia, fabulous and unbounded, already exists, and he who knows nothing of her cannot know the future of our planet."

There have been plenty of prophecies like these, but our task now, knowing the Siberia of today, transformed by the efforts of Soviet people into the country's major industrial base, is to try and picture what Siberia will become in the near future. She will certainly play an ever-increasing role in the economic development of the Soviet Union. Here one would like to point out two vital facts: the growing significance of Siberia in the deepening economic cooperation between socialist countries, and the great interest shown in her natural resources on the part of Japan. The member-countries of the Council for Mutual Economic Assistance have evolved and are implementing a long-term comprehensive program of socialist economic integration which should lead to the solution of the most important economic and social problems faced by the CMEA countries. One such problem is to meet the growing demand of the socialist countries for fuel and raw materials, and Siberia, with its unique natural resources, should make a major contribution to achieving this aim.

Before moving on to analyse the ways in which the Siberian economy may be developed, we must bear in mind that from the very first days of the Russian settlement of the vast territory which stretches from the Urals range to the Pacific coast, it was seen by the Russians as a single region known as Siberia. But in presenting the factual material of this book, however, we shall have to keep to the modern, economic divisions. The eastern part of the Russian Federation consists of three large economico-geographical regions: Western and Eastern Siberia and the areas of the Soviet Far East which lie next to Eastern Siberia. In accordance with modern zoning Yakutia is included in the Far Eastern area. It is essential to bear this demarcation in mind when talking of the share of these regions in national capital investment and production, and when dealing with such problems as regional economic development, and so forth.

Much is known about Siberia. Many books and scientific works have been written on the area's history and economy and on its natural resources, and the press has widely covered the achievements of Soviet people there. This has made the author's task easier, but at the same time has complicated it, for it would not be good to repeat what is already common knowledge. We hope this book may offer some useful information.

1. FROM THE BEGINNINGS TO THE PRESENT DAY

In the last century the outstanding Russian writer A. P. Chekhov traversed the whole of Siberia on his way to Sakhalin Island. In 1890 he published his notes *From Siberia*, in which he gave a vivid impression of contemporary Siberia. Here is some of what he wrote: "All across Siberia from Tyumen to Tomsk there are no hamlets or farmsteads but only large villages which lie at a distance of 20, 25 or even 40 versts one from another. You meet no estates along the way, for there are no landowners here; you will see no factories, or mills or inns.... The only objects which remind one of man as you travel the road are the telegraph wires humming in the wind, and the verst-posts."

In those days a journey from Moscow to Vladivostok by horse-drawn transport could take a year. Now the train does the same trip in a week, and a supersonic plane can cover the distance (7,500 kilometres) in a matter of several hours.

Siberia is a veritable storehouse in which nature, with unequalled generosity, has gathered together valuable minerals, which contain nearly all the elements of the

Mendeleyev Table. Many natural substances are to be found here in unique quantities. These include fuels (oil, natural gas, coal, lignite and turf), diamonds, mica, timber, the ores of many non-ferrous and rare metals, animals and marine plant life. The majority of the mineral deposits were discovered, studied and begun to be exploited only after the Great October Socialist Revolution, and the natural resources of Siberia which long before that had amazed contemporaries by their abundance, variety and high quality had only been exploited to a very insignificant extent.

To gain a clearer idea of the vast changes which the socialist system has brought to this area, let us make a voyage into history. We shall begin from the time when the natural resources of Siberia began to be drawn into the economic cycle relatively extensively. This came about as one of the results of Russia's entering the age of capitalism due to the collapse of serfdom in 1861. So our voyage will take in about a century of Siberian economic history.

THE PRINCIPAL STAGES OF ECONOMIC DEVELOPMENT

Vestiges of serfdom had relatively little effect upon the development of agriculture in Siberia, as there was almost no feudal landlord property ownership and there was much free land. For this reason capitalist relations were quickly established in the peasant economy, and there was an evolution of bourgeois agriculture which, as Lenin pointed out, was reminiscent of the establishment of capitalism in the agrarian system of the USA.

The outstanding feature of the settlement of Siberia was the intensive colonisation of her lands by peasants who had left the overpopulated European gubernias (provinces). This process had begun long before Siberia gained reliable transport links with the Urals, but it accelerated briskly at the turn of the 20th century thanks to the construction of the Great Siberian Railway, whose western section from Chelyabinsk to Irkutsk was opened in 1897. At that time many hundreds of thousands of peasant families settled in the lands surrounding the Trans-Siberian Railway. Some had been driven to Siberia by land-hunger and the hope of escaping the land-owner's bondage, while other, prosperous peasants, strove for the gains of enterprise and freedom of action in these little-populated lands, which were attractive not only for their vast spaces, but for the money that could be made from furs, and trade in grain, fish and textiles.

Western-style farms mushroomed in the fertile lands of the Altai, Irtysh area and along the Yenisei and Amur rivers. The virgin soil gave good grain harvests and enabled farmers to store up for bad years, and the roomy water-meadows with a rich variety of fodder grasses provided grazing for the developing cattle breeding which in turn produced meat, milk, and butter which was known for its wonderful flavour and soon found its way onto the home and export markets. There were over three times more cattle to each inhabitant of the Siberian region than in the central gubernias of Russia, and the peasants of Siberia lived in greater material plenty than did their brothers in Central Russia.

Surpluses on the farms and the relatively low cost of production led to a rapid rise of marketability in agriculture, and the rich rivers provided the shopkeepers with valuable fish, including such delicacies as white salmon, sterlet, various kinds of balyk and sturgeon caviar.

Bankrupt peasants and paupers from the towns provided the bourgeois entrepreneurs with ready supplies of hired labour, and the accelerated development of the commodity economy and of relations of capitalist exploitation meant that the process of class stratification took place more rapidly in the Siberian countryside than in the country as a whole. There was a more significant and economically more powerful bourgeois stratum among the peasantry here than in most other parts of Russia. Various authorities set the figure for kulaks among the total peasant households in Siberia at between 19 and 24 per cent, whereas the figure for Russia as a whole was only 15 per cent. Due to the availability of free lands Siberian farms were relatively large, many of them owning more than 10 horses. In four Siberian gubernias 24 per cent of peasant farms came into this category. The short periods of field work, shortage of labour and the size of the sown acreage led to Siberian farms being mechanised to a relatively higher level.

The pace of development in Siberia's agricultural production considerably exceeded that of Russia overall, and in a short period of time a large market-oriented agricultural output was achieved. The fastest development was in the grain and butter trades, and in 1913 Siberia contributed 5.3 per cent of Russia's overall grain yield, including 8 per cent of the wheat harvest.

In the mid-80s of the 19th century a factory butter industry was established. A Siberian "butter-rush" soon broke out, and the output of butter increased greatly. The development of the butter industry led to the increase of commodity-money relations in the peasant economy and to the transformation of its technical basis.

Siberian butter, with its famous flavour, was in great demand on the export market, and exports of butter rose 4.2 times between 1900 and 1912. On the eve of the First World War butter accounted for two-thirds of the value of agricultural products going from Siberia to the

Russian home market and abroad, and the development of the butter industry further led to an increase in the population of productive cattle.

Agriculture played a much greater role in the material production of Siberia than it did in the country as a whole. In 1912 agriculture accounted for 78 per cent of total production, whereas 22 per cent went to industry. In Russia the proportion of industrial production was twice as high on average.

Siberia considerably lagged behind the European part of Russia in industrial development, and it had few large enterprises on the eve of the October Revolution. These in the main were mines and pits for the extraction of coal, gold and silver, and the extraction industry accounted for about a third of the total industrial output of Siberia, which was Russia's main producer of gold.

Siberia's processing industries produced mainly food products (flour and grain products, distilling, beer and brewing of honey-based beverages, etc.). The majority of enterprises were semi-cottage-industry factories and workshops. Siberia mainly fulfilled her demand for manufactured goods by bringing them in from the European gubernias of Russia, herself only producing 2 per cent of the country's industrial output.

Much of the area's natural wealth lay untapped. Russian capitalists showed little interest, engaging in trade where the profits were highest. The comprehensive and planned exploitation of Siberian natural resources in practice only began after the victory of the socialist revolution in Russia. The revolution heralded a new stage in the economic growth of Siberia.

While in Siberian exile Lenin had been interested in the wealth of this vast country, and it was not surprising that from the first days of the socialist revolution he showed an interest in the events in Siberia and in practical measures towards the exploitation of her resources.

During the civil war Lenin saw a direct connection between the consolidation of Soviet power and the liberation of the Siberian territories from the whiteguards. In an interview with Arthur Ransome, correspondent of *The Daily News*, the leader of the revolution said that "if a bourgeois government, supported by outside help, should establish itself in power in Siberia, and Eastern Russia become lost to the Soviet, then in Western Russia the Soviet Power would become weakened to such an extent that it could hardly hold out for long...."[1]

Foreseeing the great role which the natural wealth of Siberia could play the Soviet government gave priority to plans for its exploitation. In April 1918 Lenin proposed the drawing up of a comprehensive plan for the linking of the iron ores of the Urals with the coal of the Kuznetsk basin. He pointed out the importance of studying the potential of Siberia for producing hydroelectricity. "The development of these natural resources by methods of modern technology," he wrote in *The Immediate Tasks of the Soviet Government*, "will provide the basis for the unprecedented progress of the productive forces."[2]

The GOELRO plan,[3] adopted in 1920, spoke of the special significance of Siberian resources for the restoration of the war-ravaged economy and for its subsequent industrial development. "The extremely rich deposits of

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[1] V. I. Lenin, *Collected Works*, Vol. 42, p. 67.

[2] *Ibid.*, Vol. 27, p. 257.

[3] The GOELRO plan, Soviet Russia's first long-term industrial development plan, was designed to cover a 10-15 year period. The principal idea of the plan was to rebuild the economy structurally and technically on the basis of all-out electrification.

coal in the Kuznetsk region, the fortunate combination of coal and iron very near to one another," runs the text of the GOELRO plan, "make it justifiable to describe the Kuznetsk basin as an area of iron and coal industry with extensive development prospects." An increase in the production of coal, mainly coking coals, and the construction of metallurgical and light engineering factories and thermoelectric power stations were envisaged in this area. One task of the plan was the laying of a railway that would connect the Kuznetsk basin with Kazakhstan and the South Urals (the future South Siberian Railway).

The GOELRO plan regarded Siberia as the country's major agricultural base: "When economic life has been restored, Siberia and the steppe regions will once again show themselves, maybe with even greater power, to be a mighty reserve for the supply of grain, meat, fats and hides to European Russia, and as a source of currency-earning goods for export." These trends in the development of Siberia's productive forces were subsequently realised.

With the ending of the civil war much time and money had to be spent on re-establishing the economy, and in 1926 the Soviet Union achieved a gross national income equal to that of Russia in 1913. This signalled the success of the tasks of the re-establishment period. It now became necessary to define the long-term prospects of the development of the Siberian productive forces. In 1927 the first version of the General Plan for the Development of the Economy of the Siberian Region, covering a 15-year period, was approved. This version saw the fundamental trends of Siberian economic growth from the point of view of agricultural interests, since agriculture dominated the region's economy. In 1927 agriculture accounted for about three-quarters, and industry for slightly more than a quarter of the total output of both sectors together. In 1928 the share of the USSR's total output between agriculture and industry was 49 and 51 per cent respectively.

In the evolution of the first version of the General Plan it was assumed that as before agriculture would be the determining factor in the structure of the Siberian economy. For this reason it was planned to increase the national income per head of rural population 2 times over 15 years, and per head of urban population by about 80 per cent.

This trend in the development of the Siberian economy, however, limited the scale to which her natural resources were used in order to create a powerful industry in the USSR. Meanwhile the Communist Party had decided upon the socialist industrialisation of the country.

The second version, evolved in 1929-30, was based upon the idea of giving preference to the development of industry.

Let us look at the situation in Siberia as she began her transformation into the country's leading industrial zone. At that time Siberia still greatly lagged behind the old industrial regions of the USSR in the level of industrial development and the pattern of her economy. Siberia's proportional contribution to national industrial output had not increased in comparison with that of 1913, and a much smaller place in the composition of her economy was taken up by heavy industry than in the Soviet Union as a whole. Small production predominated in Siberia's industry. Of all the industrial goods on the Siberian market, more than 60 per cent were brought in from other regions, a mere 10 per cent were produced by large Siberian enterprises and about 30 per cent were produced by her small enterprises. There was practically no machine-building industry in Siberia.

In short, the industrialisation of Siberia began from a fairly weak base. So a major modern industry had to be built here practically from scratch, with almost exclusive concentration of capital construction in the early stages upon the creation of heavy industry. This was in response to the great need to accelerate the industrialisation of the country and to the possibility of organising large-scale production of fuel and industrial raw materials in Siberia.

In order to achieve rapid growth in Siberia's productive forces it was essential to make a correct choice of priority objectives which would determine the rate of development of her economy as a whole, the sequence in forming its various sectors and Siberia's contribution to the solution of the whole country's tasks. These priorities were defined by the Communist Party which on May 15, 1930 ordered the creation of the country's second main coal and metallurgical base in the East of the USSR, which would draw its material from the immensely rich reserves of coal in Western Siberia and the iron ore deposits of the Urals.

This decision is an obvious example of the broad approach taken in drawing up of a long-term program of economic development based on the profoundly motivated choice of the decisive trends of Siberian industrialisation. The creation in the East of the second coal and metallurgical base was a catalyst for economic growth in Siberia which gave a powerful stimulus to the developing coal industry and led to the appearance of a wide range of new industries. Other benefits were development in agriculture and transport and rapid growth in Siberia's towns, brought about by an inflow of large masses of people from other regions. This had inestimable significance for the strengthening of the USSR's defence capability, and Siberia's enormous contribution to the victory by the Soviet Armed Forces over Hitler Germany showed the far-sightedness of the Communist Party's measures taken in the initial period of industrialisation in the Soviet East.

Fulfilling Lenin's behests, during the first five-year plan (1929-32) the Soviet people set about building the Urals-Kuznetsk Combine, one of the largest industrial complexes of prewar times. Of the capital investment in Siberian industry realised in the first five-year plan, 35.6 per cent was spent on building the Siberian part of the Urals-Kuznetsk Combine, as well as 43.9 per cent of capital investment in Western Siberia. The basic idea behind the creation of the combine was to link the Kuznetsk coking coal with the Urals iron ore, and on this basis to organise major industrial centres in the Urals and in Siberia. The program for building the USSR's second coal and metallurgical base (the first was situated in the Donets basin and in the Dnieper region), was all-embracing and multi-purpose. The Urals-Kuznetsk Combine was seen as a combination of the sectors of industry which composed one of the main bases of the socialist industrialisation of the Urals, Siberia and the other eastern regions of the USSR.

In the period of the socialist construction of the USSR the Urals-Kuznetsk Combine was the first inter-regional industrial complex based upon the mutual exploitation of the resources of an extensive area of a number of regions: the Urals and Bashkiria, Western Siberia and North-East Kazakhstan. Here was a new territorial form of production organisation making it possible to promote industrial forms of economies, concentrated upon extensive inter-regional cooperation, in the new areas. The Siberian part of the Urals-Kuznetsk Combine was based on iron and steel and coal-mining. Apart from those the main activities of the combine were in non-ferrous metallurgy, power, chemicals, heavy and electrical engineering.

The setting up of the UKC was outstanding for the incomparably rapid rates of capital construction which are possible in a socialist state. The first blast furnace in the Kuznetsk Iron and Steel Mills was blown in, three years after building work was commenced, in April 1932. Soon after that open-hearth furnaces began to produce steel and a second blast furnace was blown in, and at the end of 1932 the builders finished a rail and structural steel mill (giving the world's second largest output at that time), so completing the metallurgical cycle.

The initial plan for the output of the Kuznetsk Iron and Steel Mills was 360,000 tons of pig iron a year. In the fourth version of the plan the annual output was raised to 1,200,000 tons, but this target was subsequently revised, and in 1940 the mills produced 1,536,000 tons of pig iron. This mill was intended to be the country's biggest iron and steel enterprise. Its orientation was determined mainly by the needs of the country's eastern regions for transport construction as the vital precondition for the speedy transfer of productive forces to the eastern part of the USSR. One of the main tasks of the mills from their beginning up to the present day has been the production of rails and other rolled metal for use in transport.

A major centre for the production of coking and power coal was created at the same time as the West Siberian iron and steel industry was set up. In the first five-year period 24 mines were sunk in the Kuznetsk basin instead of the planned 12. The main task facing the Kuznetsk basin was to step up the extraction of high quality fuels and raw materials for the iron and steel and chemical industries of Siberia and the Urals.

The Kuznetsk basin had a vital advantage over a number of other coalfields in its favourable geological and mining conditions which permitted wide-scale production and the more effective use of modern mining methods and equipment. Another significant factor was that the Kuznetsk basin's coalfields were not handicapped by numerous small mines as was the case in the Donets basin, the country's oldest coal-mining region. For this reason an increase in coal production was achieved more cheaply in the Kuznetsk basin than in most other coalfields.

Rapid development was achieved in a number of other branches of the extraction industry in Siberia (gold, tin, rare metals, mica, etc.) in the prewar five-year plans, producing reserves of raw materials for the whole country.

The creation of the Kuznetsk Iron and Steel Mill and the opening of the Kuznetsk coalfield paved the way for Siberia's industrial progress of the 1930s. In these years the industry of Siberia developed faster than that of the country as a whole. Whereas during the first two five-year plan periods the gross output of the USSR's heavy industry rose 5.4 times, that of Siberia increased 9.2 times. This discrepancy in pace continued in the prewar years, though it was less.

There were some substantially different features about the industrialisation of Siberia in comparison with the industrialisation of a number of other regions in the USSR. These were brought about by the specific natural and climatic conditions of Siberia, the relatively low level of production development, transport and public services in the past. For at the outset of industrialisation in the USSR, in the 1930s, Siberia was in practice a pioneer zone, and its large-scale machine industry was only just being created.

The industrial development of Siberia in the 1930s was marked by the following main features. Firstly, limited resources and the sparse population of the territory had made it impossible in the prewar decade to form a relatively versatile economic complex which a number of long-settled areas of the European part of the USSR possessed by the beginning of the war. In state expenditure on Siberian industrial development priority was given to sectors of an ancillary nature, those which supplied industry with fuel and raw materials: coal mining, ferrous and non-ferrous metallurgy and the coal chemicals and timber industries. A considerably high proportion of their output was assigned for consumption in other parts of the country, mainly in the European regions.

Secondly, due to the underdevelopment of its own production base, Siberia had before the war been receiving all essential machinery, equipment, and rolling stock from the European regions of the USSR. These regions also sent large quantities of consumer goods to Siberia, goods which she could not produce in the needed quantities (textiles, footwear, clothing, sugar, confectionary, etc.).

Thirdly, industry and other sectors of the economy were in the main located in a narrow zone which lay on either side of the Trans-Siberian Railway and its few spur lines. This zone thus stretched from the Urals to the Pacific. Only rare industrial centres specialising either in producing valuable or unique commodities which could not be obtained in other areas in the needed quantities were located a long way from the railway (the goldfields of Kolyma and Aldan and the metals of Norilsk).

Thanks to its accelerated industrial development Siberia's share of the country's industrial output had by 1940 risen several times in comparison with prerevolutionary times. A number of major industrial centres were set up, mainly in the administrative centres of Siberia. The Kuznetsk basin became Siberia's most developed industrial region. In the North work was begun on the construction of the Norilsk mining and metallurgical combine, the first giant enterprise in the Siberian Arctic, and gold-mining operations were extended in Kolyma. The first mechanical-engineering and metalworking plants made their appearance in Omsk, Novosibirsk, Kracnoyarsk, Ulan Ude, Barnaul, Vladivostok, Khabarovsk and other towns. The concentration on mechanical engineering was linked to this zone's urgent need for machines and equipment. Capital investment priority was first given to enterprises producing machines and equipment for the extraction industry (coal and gold mining) and agriculture. Repair and service facilities for these industries were also enlarged. As a result there was a certain growth in the number of mechanical-engineering enterprises, and work was begun on setting up transport mechanical engineering, shipbuilding and repair, and some other kinds of enterprises.

The decision of the 18th Congress of the Communist Party in 1939 to set up a number of ancillary mechanical-engineering industries in the eastern regions of the USSR was of enormous economic importance. In particular, Siberia was to gain such a sophisticated branch of machine-building as turbine engineering, and also sections of the aviation and shipbuilding industries.

The setting-up of machine-building enterprises in the East of the country required higher initial expenditure than on similar projects in the old industrial regions, but the Communist Party was guided in its decisions by more far-sighted considerations than that of the speed with which capital investment would be repaid. The establishment of machine-building in the East was in the country's long-term economic interests, which, for example, played a decisive role in the creation of Komsomolsk-on-Amur as one of the Far East's machine-building centres.

Limitations in time did not permit the formation of large machine-building complexes based on the extensive cooperation of mutually-linked enterprises which could do more to satisfy local demand for various machines and equipment.

Timber resources began to be exploited on a wide scale, with Siberia specialising in round timber and elementary wood products: saw timber, pit-props, sleepers, etc. The woodworking industry underwent considerable development, but Siberia had no pulp and paper industry, and wood chemistry was relatively poorly represented. The fundamental mechanical and chemical processing of timber was concentrated in the old timber regions of the North-West and Centre, and also in the Urals.

In the prewar period Western Siberia led in industrial development, producing almost half of Siberia's industrial output in 1940. The Far East in turn slightly outstripped Eastern Siberia in production figures.

A special kind of reproduction took place in the Siberian economy during the Great Patriotic War, as it did in the country as a whole. Its resource base was drastically reduced as a result of losses of material and people, the temporary occupation by the Hitlerites of a number of Soviet territories and the very high increase in military consumption.

At the beginning of the Great Patriotic War Siberia's productive plant was considerably augmented by the enterprises which were evacuated here. In 1941 the equipment of 244 enterprises was brought to Western Siberia from the European regions of the USSR, and 78, mainly machine-building plants, were brought to Eastern Siberia. In addition new enterprises were built and existing ones extended, with the result that Siberia's productive base was substantially strengthened, primarily in machine-building. The aviation, tractor-building, harvester-building industries made their appearance, and plants producing ball-bearings, motorcycles, new types of lathes, instruments and tools went into operation.

The main task facing Siberian industry in the war years was to achieve a rapid increase in armaments production, and Siberia made a vital contribution to the development of machine-building for defence purposes. For example, over the war years (1941-45) she gave the USSR more than 59,000 fighter planes. The decisive factor in determining the overall pace of Siberian industrial growth was provided by machine-building and its temporary defence output. In 1945 machine-building and metalworking contributed 55.4 per cent to the overall output of Siberian and Far Eastern industry. A number of major machine-building and metalworking centres grew up in Siberia, the largest of them being Novosibirsk, and the second largest in terms of capacity was Omsk.

The introduction of new plant and the intensification of manufacturing processes gave rise to a sharp increase in the output of ferrous metals, and the aluminium and nickel industries also appeared in Siberia.

The end of the war brought a dramatic change in industrial development. Postwar reconstruction in the eastern part of the Russian Federation had a great effect upon industry in Western Siberia. Its close connection with wartime production meant, as it also did in the case of the Volga area and the Urals, a long period of transition to peacetime output. This transition required profound changes in intersector and territorial links, in production technology and the organisation of manpower. Much time and effort had to be expended on the adaptation of enterprises evacuated here in wartime, to the special nature of reproduction in Siberia and to the pattern of demand, and so on.

Not only did this require the radical reconstruction of technology, but also a substantial supplementation of the basic production assets with those kinds of machinery and equipment which were not brought in from the European parts of the country during the evacuation of industrial enterprises.

Economic resources had to be redistributed between the eastern and western zones of the country so as to re-establish industry in the European areas which had suffered from the war. In the period 1946-50 Siberia's share of capital investments by the state and cooperatives (not including collective farms) decreased in comparison with the war years, though there was a sharp increase in the productive apparatus of its industry, and the assets of a number of other sectors also increased. One must bear in mind that enterprises which were evacuated to Siberia during the war were, as a rule, set up in hastily adapted buildings which had formerly served other purposes, and that plant was set in operation according to simplified technological schemes. For this reason great expense was required for the completion of these enterprises after the war. New industrial buildings were erected, permanent railway sidings, power and communication lines (water mains, reservoirs, etc.) replaced temporary ones; permanent garages, warehouses, and roads were built. This naturally relatively reduced the expenditure upon developing and modernising the active elements of the basic assets, in other words technological equipment (machines, instruments and means of transport) which limited the growth of labour productivity. It follows that there was no great level of construction of large industrial projects in Siberia in the first postwar decade.

For these reasons Siberia's rate of increase of industrial production in that decade was considerably lower than the average for the USSR. In the period 1946-50, though the gross output of Soviet industry increased by 89 per cent, that of Siberia and the Far East only registered a 27 per cent increase. In the following five-year period, however, this discrepancy in industrial growth rates was greatly reduced.

The Directives of the 19th Congress of the Communist Party on the fifth five-year plan for 1951-55 envisaged the construction of the Novosibirsk hydroelectric station, and proposed to increase the capacity of the Kuzbas thermal power stations and to exploit the hydroelectric resources of the Angara river in order to provide a source of cheap power, which, together with local raw materials, would enable the development of the aluminium, chemical, ore-mining and other industries in Eastern Siberia.

In other words, the 1950s saw the beginning of work on the Angara-Yenisei project. This had been developed before the war under the leadership of Academician I. G. Alexandrov and professors N. N. Kolosovsky and V. M. Malyshev. This project envisaged the creation of large territorial-production complexes founded upon the natural resources of Eastern Siberia. The Angara-Yenisei project formed the basis of the adoption of the second long-term investment program, which signified a further shift of the country's productive forces to the East. Under this program Krasnoyarsk Territory and Irkutsk Region underwent intensive industrialisation, and the trans-Baikal area's economy was also developed.

In the mid-1950s Siberia's agriculture was greatly stimulated by the cultivation of vast areas of virgin land. The area under spring wheat doubled in a few years.

The time had come to step up efforts to exploit Siberia's natural wealth. New branches of industry appeared as Siberia's economic complex branched out and its links with the country's economy became stronger.

Siberia's share of national capital investment increased, as did the scale of construction work. Most efforts were aimed at developing the most promising sectors of the economy—power, chemicals, paper and pulp—and also at discovering natural resources. The taming of the energy potential of the great Siberian rivers got under way.

In the 1950s one of the main areas of large-scale capital construction was that of power. At the end of 1956 the Irkutsk hydroelectric station, the first "electricity factory" to be built on the Angara, was opened. This was followed in March 1959 by the Novosibirsk station, which was a little less powerful than the Irkutsk station. But both these stations, which were considered large by contemporary standards, were dwarfed by the giant which was growing rapidly on the banks of the Angara near the old Russian settlement of Bratsk.

In June 1959 the Bratsk section of the Angara's channel was blocked in a record time of 19 hours, and in November 1961 the first hydroturbine, the largest in the world with a capacity of 225,000 kw, was set in motion. Three other such turbines were put into operation, and the Bratsk hydroelectric station began to produce more and more electricity for the East Siberian power grid.

This power giant had still not been completed when the builders moved over to the banks of the Yenisei to begin work on a yet more powerful station—the

Krasnoyarsk station, which would supply 6,000,000 kilowatts.

At the same time a major thermal power station was being built at Nazarovo. It would be fed by rich deposits of cheap coal.

The creation of the Siberian Unified Power System was a significant event. At the end of 1963 long-distance transmission lines were set up between Nazarovo and Kuzbas, and between Bratsk and Taishet. Siberian thermal and hydroelectric power stations over a massive area from Lake Baikal to Irtysh were linked into one power grid which had its control centre in Kemerovo. This grid is unequalled in world history. The control system is provided by automatic and telemechanic systems which smoothly distribute power among consumers lying within three time zones. This system achieves great savings due to the full use of the power stations' capacities, and increases the reliability of the power supply.

Cheap power made it possible to develop power-consuming industries, and Siberia became the national centre for aluminium smelting, which could be done at a far smaller cost than that in the Urals and in the old aluminium centres. The first aluminium plant in Eastern Siberia was set up in Shelekhovo, not far from Irkutsk, and even more powerful plants were built in Krasnoyarsk and Bratsk.

The development of the aluminium industry in Siberia was dependent not only upon the building of unique hydroelectric stations, but also upon providing major supplies of raw materials. The Krasnoyarsk aluminium complex was set up comprising the Kiya-Shaltyr nepheline deposit, the Achinsk alumina combine and the Krasnoyarsk metallurgical plant. This was a very costly project, and no wonder, for the Krasnoyarsk complex is one of the largest enterprises of its kind. The creation of this complex was one of the most outstanding events in the industrial development of Siberia.

The foundations of the Siberian large-scale chemical industry were laid in the 1950s. For many years the Soviet chemical industry had been almost exclusively producing traditional non-organic chemical products (soda, acids, mineral fertilisers, varnishes, paints, etc.). This was not providing a basis for the radical chemisation of the economy and was not permitting the chemical industries to play a large part in the formation of the national consumption fund. But in the late 1950s the USSR set about making a radical transformation of the chemical industry, giving priority to organic synthesis, which would draw its materials from highly economical sources such as oil and natural gas. The development of the petrochemical industries is one of the main features of the scientific and technological revolution, and Siberia made its contribution in the creation of large chemical plants and various manufacturing complexes. Siberia was becoming a major producer of synthetic resins, plastics, synthetic rubber and artificial and synthetic fibres. The production of mineral fertilisers was stepped up, and the chemical industry led the other Siberian sectors in pace of development.

Chemicals based on organic synthesis is a big consumer of heat, water and materials, and Siberia, with its cheap fuel and electric power, big rivers and reserves of minerals meets this requirement better than the European parts of the country. For this reason the industry developed rapidly in Siberia and its role in the national production of chemicals was enhanced.

Even before the war the eastern regions of the Russian Federation specialised in the timber industry. In 1940 Siberia and the Far East contributed 23 per cent of the USSR's workable timber production, and this had risen to 26 per cent by 1960. This timber, however, was either processed to produce semi-finished goods (saw-timber, sleepers, pit-props, etc.) or was directly transported in the form of round timber to the distant European regions, Kazakhstan and Central Asia. This was obviously unprofitable to the economy, for transport expenses were 2 or 3 times higher than the production costs of timber.

Thus in the 1950s considerable resources were assigned to set up timber-processing enterprises in the East. The construction of a pulp and paper combine was started in Krasnoyarsk, and a cord pulp plant was set up near Lake Baikal. Work was begun on setting up large timber-industry complexes which would produce many kinds of semi-finished and finished products, using not only regular materials, but also waste from lumbering and woodworking. The first such complexes were the Maklakovo-Yenisei and the Bratsk complexes (the building of the latter began in 1959). By 1960 East Siberia's pulp and paper, plywood, cardboard, panel products industries and wood chemistry were in operation, though on a small scale. In subsequent years there was a significant expansion in timber processing due to the introduction of new plant into the pulp and paper industry.

The discovery of diamonds in Yakutia after the war had been predicted by Soviet geologists. As early as 1949 geologist G. Kh. Fainstein had found diamond crystals in the middle reaches of the Vilyui river, and in 1954 geologist L. A. Popugayeva discovered the Soviet Union's first kimberlite pipe, which was given the name "Zarnitsa" ("Summer Lightning"). Though this pipe did not yield diamonds in commercial quantities its discovery had confirmed the predictions of the scientists (Prof. V. S. Sobolev and others) and was instrumental in speeding further searches for this mineral. During the following years kimberlite pipes were discovered in the basins of a number of West Yakutian rivers, including the pipes known as "Mir", "Udachnaya" and "Aikhal". Diamonds were first mined in Yakutia in 1957. Diamond, the hardest of all natural and artificial substances, is employed in all sorts of technical fields, and has a high foreign exchange value. It is irreplaceable as the most efficient abrasive for working steel. Cut diamonds have exquisite beauty and give a wonderful play of colours, even in ordinary daylight.

We have already seen that in the first postwar five-year plan Siberia's mechanical-engineering and metalworking industries underwent radical realignment. Plants switched over from wartime to peacetime production, and this required considerable time and extra expenditure.

This switching over affected the postwar development of mechanical engineering in Siberia more than in the European regions. Many kinds of goods had to be produced for the first time. There was, moreover, a lack of planning and design organisations and a shortage of qualified manpower. Demand for the latter was rising, and there was a great shortage of workers for the various jobs in the mechanical-engineering industry, due to the small number of mechanical-engineering enterprises here before the war. Another factor was that some of the personnel who arrived with their enterprises at the beginning of the war returned to the European regions, and part of the plant was also re-evacuated.

For this reason Siberian mechanical engineering increased its output in the first postwar five-year plan (1946-50) at a slower rate than that in the European regions, and this had its effect upon the overall pace of industrial development in Siberia.

Mechanical engineering was remodelled on new patterns in those years, and in the years which followed. Mass production of tractors, generation equipment, metal-cutting lathes and tools, radio apparatus and electrical goods got under way. Three groups of sectors played a decisive role in the development of Siberian mechanical engineering: heavy mechanical engineering, the production of generating and electrical equipment, and tractor and agricultural machine-building. Three-quarters of Siberia's mechanical-engineering output in 1965 comprised drilling, mining, metallurgical, generating, electrical, tractor and agricultural equipment.

In the 1960s the pace of Siberian industrial development came more and more to be determined by the sectors which had been brought to the fore by the scientific and technological revolution, and which had evolved as major industries in the postwar period (generating, oil refining, organic synthesis chemistry, aluminium and rare metal refining, pulp and paper and the new mechanical-engineering sectors). On the other hand, the traditional sectors which had been established before the war (coal, forestry and woodworking) were relatively slow in increasing their output since the area of demand for them had relatively narrowed.

Gross industrial output in Western Siberia in the period 1961-70 grew 2.2 times, while the output of the chemical and petrochemical industries increased 3.7 times, and that of mechanical engineering and metalworking 3.2 times. Eastern Siberia increased her gross output in the same period 2.5 times, with the output of power increasing almost 4 times, that of ferrous metallurgy 3.2 times and of mechanical engineering and metalworking 3.6 times.

Since the early 1960s most capital construction has been concentrated in the West Siberian Plain. The opening up of the country's biggest oil and natural gas-fields has led to the inauguration of a new long-term investment program, the third to be realised in the East of the RSFSR. The scale of this program far exceeded that of the work in creating the Urals-Kuznetsk Combine before the war, and of that in the Angara-Yenisei region in the following years.

* * *

Since the formation of the USSR in 1922, Siberia and the Far East have made a great leap in the development of their productive forces. Major industrial centres have been established in this area, and this is where the country's largest power stations, mines, plants and factories are located. New cities have sprung up, and the old ones have increased in size many times. The Siberian expanses have been criss-crossed by air services, new railways, pipelines and high-voltage transmission lines. This vast territory, formerly a God-forsaken outlying district of tsarist Russia, has undergone a transformation on a scale which impresses not only Soviet people, but visitors from abroad as well. Hugo Portisch, a highly-informed journalist (he was chief editor of a leading Vienna newspaper for many years), visited cities and construction projects in Siberia. "The Soviet people have set about the development of Siberia in earnest," he wrote in his book *Siberia As I Saw It.* "They want to populate the taiga and tundra, and to exploit the natural reserves of this region which have only just been discovered. The new map of Siberia and the Soviet Far East published by the US National Geographic Society on the basis of data issued by the Soviet press has hardly any white spots.

"It is no longer possible to colonise such an enormous land using the methods by which the virgin lands of North America were colonised in the 18th and 19th centuries, with frontier cordons and waggon-trains. Anyone who in the second half of the 20th century intends to conquer and develop this continent must have at his disposal the latest achievements of science and technology and be able to put them into practice. This is exactly what the Soviet Union is doing."

Over the years of socialist construction Siberia, which until the October Revolution was an "internal colony" of Russian capitalism, has been turned into a major producer of many kinds of goods and is now making a vital contribution to creating balances of national material resources.

The economic growth of Siberia is an indication of the success of the Communist Party's plan for the rapid development of the Soviet eastern zone.

THE ESTABLISHMENT OF SIBERIAN SCIENCE

Science has today become one of the basic factors of economic growth, and its importance is especially felt in areas which are undergoing an accelerated development of their productive forces, as in Siberia. It is not by accident that a centre of theoretical science, which does research in applied science, was created here. The results of this research are used in the economy to raise the productivity of social labour and improve the well-being of the people.

In order to get a clearer picture of how Siberia became an area of major scientific activity, and to understand the role accumulated knowledge can play in the future, we shall try briefly to trace the path Siberia has followed in this field. As we are interested in the development of Siberia's productive forces, we will not deal with all the branches of science, but only with those which are either directly concerned with production, or which evolve ideas which are materialised in the form of new technological means of production or which make it possible to introduce new raw material or power resources into the economic cycle. We are consequently talking about economics and also about those branches of pure and applied science whose findings serve as a foundation for the development of industry.

Science as a special field of activity appeared in Siberia considerably later than, say, heavy industry, and before the October Revolution had only taken its first steps in studying the area's natural resources and its potential economic growth.

The first years after the revolution, the civil war and the economic dislocation which followed were not favourable to scientific research, and the scientific literature of this period is meagre. It must be noted, however, that the knowledge which had been gathered up till then enabled scientists to make bold predictions on the future of Siberia which were reflected in the GOELRO plan. The authors of this plan anticipated the powerful industrial upsurge of the Kuznetsk basin, the extensive exploitation of the East Siberian hydroelectric potential and the harnessing of the other resources of the Angara area on a wide scale.

The stormy years of the civil war passed away, and the country could set about the peaceful construction of the economy. The final stage of the rehabilitation period of the Soviet economy was marked by lively discussions on future developments and by attempts to determine the main trends of economic growth in the long term. Various ways of industrialising the country, modernising agriculture and rebuilding transport, etc., were suggested in books and in articles published in journals devoted to economics, technology and politics. The work of Siberian scientists, engineers and planners in researching into these problems resulted in the publication of a number of general works on the future of the Siberian economy. The idea contained in the GOELRO plan of the necessity of comprehensively developing the natural resources of the eastern zone of the USSR was given a concrete expression and discussed in detail in these publications. The ultimate aim was to create a major industrial centre in Siberia, to develop the transport system and bring about a substantial increase in agricultural output.

In 1925 the first Siberian Regional Scientific Congress was held in Novosibirsk. The development prospects of various sectors of the Siberian economy were discussed, and the congress formulated the vital economic, scientific and technological problems of the future. Decisive significance was ascribed to Siberia's potential for the production of power and to its unique reserves of fuel and water energy. Scientists and engineers came to the conclusion that Siberia's role in the economy of the country would chiefly be determined by these resources.

Experts tried to anticipate the development of Siberia's productive forces over a relatively long period of time, and their efforts resulted in "Basic Directions of the General Plan for the Economic Development of Siberia for 1926/27-1940/41" published in Novosibirsk in 1927. By this time the rehabilitation of the Siberian economy had been concluded, the USSR had set out on the road to industrialisation, and studies of the role which Siberia was to play were of great practical significance.

In the drawing up of the General Plan for the Economic Development of Siberia, wide use was made of the balance method of statistical calculation. This was a great achievement for regional planning. Balance calculations were drawn up, taking into account the consumption of Siberia's output in various parts of the USSR. The plan envisaged the comprehensive development of Siberia's economy by means of the combined, or all-round exploitation of its natural resources. It was intended to employ Siberia's raw material potential both for the supply of semi-finished goods to other regions of the USSR and for the wide-scale development of local industry. "Siberia cannot, and does not have the right," declared the compilers of the General Plan, "to refuse either to exploit the opportunities for creating its own industry, or to cooperate with the western regions of the USSR in the sense of supplying the latter with raw materials for their industry. The future industrial nature of Siberia will be formed on the basis of a harmonious combination of the region's specific interests and those of the USSR as a whole." The entire progress of subsequent economic development confirmed the correctness of this principle of the General Plan.

The first five-year plan (1929-32) brought intensive industrialisation to the country's eastern regions, and the scope of research in Siberia and the Far East widened considerably at the beginning of the 1930s. The plans which emerged were founded upon many scientific findings. Scientists naturally paid most attention to the technological and economic foundations of the organisation of modern metallurgical, power, chemical and mechanical-engineering industries in Siberia. The Urals-Kuznetsk Combine was under construction, and there was a need to provide a fuel and power supply system for this in good time.

At that time it was possible to provide industry with fuel and electricity in the shortest possible time by the speedy development of coking and power coal production in the Kuznetsk basin. But even then the idea was suggested, though only realised several decades later, of harnessing the power of the Ob and the Yenisei. Coal mining was expanded in the Cheremkhovo basin of Eastern Siberia. A number of scientists spoke of the expediency of mining coal in the Kansk-Achinsk basin and other deposits in Eastern Siberia, and this idea was subsequently materialised.

The country urgently needed metals, and scientists directed a great amount of attention to the development and distribution of ferrous metallurgical industries. In particular suggestions were made on the siting of a new metallurgical plant in Western Siberia, and on the establishment of the aluminium industry. There were also wide discussions in the 1930s on the development prospects of the Siberian chemical industry.

The development of Siberian economic studies in the 1920s and 1930s was mainly characterised by the distinctly applied inclination of most research, and scientists were tackling the most urgent problems. They were spurred on by practical conditions which demanded an immediate answer to everyday problems.

Another factor here is that Siberia had few scientists who specialised in academic research and methodology. The East had no academically-inclined scientific establishments, and university work on theoretical problems was relatively weak.

There are two distinct periods in Siberia's postwar scientific development. They differ in the range of problems dealt with and the depth in which they were explored. The end of the 1950s can be said to be the dividing line between these two periods.

The first period was marked by the predominance of applied research and by a relatively narrow field of interest. Siberia had few specialised research centres, and those which existed were scattered across the vast territory.

Even so, Siberian scientists in this situation achieved a number of important scientific results, and made well-founded recommendations of practical benefit to the economy, in mining, for example. The Siberian school of economic geography was taking shape.

In Irkutsk in 1947 one of the first regional conferences on the development and distribution of Siberia's productive forces was held. Similar conferences were held in Krasnoyarsk, Chita, Ulan Ude, Yakutsk and Kyzyl. The 1958 conference on the development and distribution of East Siberian productive forces also held in Irkutsk was a major event in the region's scientific life. This extremely broad forum of scientists and workers of central and local planning organisations, ministries and design institutes delineated the main trends in which Eastern Siberia would develop her productive forces over an extended period. The ten or more volumes of materials produced by the conference have not to this day lost their importance to scientists and practicians. They determined the direction of further research, and served as a basis for planning decisions and new construction projects.

The founding of the Siberian Branch of the USSR Academy of Sciences was an important milestone in the history of Siberian science. Until then the Academy had four subdivisions in Western and Eastern Siberia and in the Far East, uniting a relatively small number of scientific establishments. The overall field of Siberian science was fairly small, and it lacked advanced schools of physics, mathematics, chemistry, biology and economics. The foundation of the Siberian Branch of the USSR Academy of Sciences marked a great step forward in science in the Soviet East. Siberia became a major scientific centre, and was soon to occupy the forefront of world scientific progress in many fields, from mathematics and physics to economy and archaeology.

The Siberian Branch was intended to develop the main areas of science upon which radical change in the techniques and technology of production, and scientific progress itself most depended, to achieve a rapid growth of new trends in natural and social research, and to combine theoretical and applied research.

The structure of the Siberian Branch, which was formed as a complex of research establishments of varying profile was determined by the specific problems which science had to solve. The Novosibirsk scientific centre is most fully representative of this complex, with its 23 institutes specialising in mathematics, mechanics, physics, chemistry, biology, geology, mining, botany, soil sciences, economics, sociology, history, philology, philosophy and other natural, technical and social sciences sited in Akademgorodok not far from the city. The combination of all areas of science in this little science town built specially in the forest meant that close contacts were quickly established between workers in various areas of research. The harmonious development and mutual enrichment of different branches of science in one centre generated a climate beneficial to scientific research.

Apart from Novosibirsk, scientific centres were set up in Irkutsk, Krasnoyarsk, Vladivostok and Yakutsk. Regional research centres were established in a number of Siberian and Far Eastern towns such as Ulan Ude, Chita, Khabarovsk, Magadan, Yuzhno-Sakhalinsk and Petropavlovsk-Kamchatsky.

These days new important ideas arise at the point of contact between different sciences; mathematics and physics, physics and chemistry, mathematics and biology, and so on. This mutually-linked development of science disciplines is also essential if basic prospects of the development of Siberia's productive forces are to be established. This principle of the all-round study of the natural resources of the Russian Federation's eastern zone and the drawing up of a broad program for exploiting them to maximum effectiveness underlay the work being done in the Siberian Branch.

One must note that academic science has not become introspective, but has had a beneficial effect upon the range and scale of problems under research in other scientific establishments such as the departments and laboratories of the Siberian higher educational establishments and planning organisations. Siberian science has consolidated its forces and gained "attacking potential", owing to the setting up in Siberia of large scientific groups under the leadership of major scientists in the main fields of modern science and of energetic organisers, and owing to the comprehensive nature of research and collaboration between institutes, laboratories and departments in various areas of science.

Research teams from Moscow, Leningrad and other towns in the European part of the country, and whole groups of graduates came to Siberia. This, combined with the fact that Siberian universities and institutes raised their output of specialists for work in research establishments, gave rise to a rapid increase in the numbers of research personnel.

Without fear of exaggeration one can say that the founding of the Siberian Branch of the USSR Academy of Sciences opened a new era in the development of science in Western and Eastern Siberia and in the Far East.

The flourishing of economics was encouraged in the first place by the creation of favourable organisational forms. Departments were set up under the auspices of the Siberian Branch, the largest of which being the Novosibirsk Institute of Economics and Industrial Organisation.

The second and probably the main factor was that economics as a science was placed into a climate favourable for the development of its ideas, since it could lean on the contiguous or related fields of knowledge intensively cultivated in the Novosibirsk science centre and other subdivisions of the Siberian Branch of the USSR Academy of Sciences. Mathematics introduced new research methods into economics, making it possible to penetrate deeply into the essence of economic processes and to explore interrelationships which had been inaccessible to the users of former, so-called traditional, methods. The mathematisation of science, with the intensive use of precise measuring apparatus to study the laws of natural and social development and their expression in the form of mathematical models is the main trend of our age. The framework of the Siberian Branch created favourable conditions for this. A Mathematical Institute, uniting major specialists, and a Computer Centre were set up in the Novosibirsk scientific centre. Economists and mathematicians in the Far Eastern subdivision of the Siberian Branch and in its other departments have formed a creative union.

Economists have also been working in close collaboration with geologists and chemists. The natural scientists have supplied economists with rich material for calculations and have stimulated the search for methods of determining the most effective ways of exploiting Siberia's natural resources.

The essence of the Siberian Branch's work is reflected in its motto: "Science should not be introspective, but should actively help industry and people." In order to speed up the implementation of scientific ideas in industry, a workable organisational form of bringing the interests of academic science and production together had to be found. A link between the two fields of activity was provided by the formation of "innovatory" firms. Scientists and engineers work together in these to apply scientific discoveries to experimental technological systems, designs, and work methods of direct interest to industrial enterprises, planning and design organisations. An example of this is the State Institute for Research into Automated Planning and Management Systems set up in Akademgorodok on the initiative of scientists of the Siberian Branch. The task of this institute is to employ the economico-mathematical models and methods of realising them suggested by academic establishments in order to calculate optimal plans for economic sectors and enterprises, and to introduce automated production management systems.

Another characteristic feature of the organisation of science in the Siberian Branch is that it strives to fuse together the scientific maturity, research experience and broad outlook of the older generation with the thirst for knowledge and boundless energy of the young. This alloy of what is best in the old and the young gives "second wind" to the veterans and a mighty stimulus to the young crop of scientists. It is an extra resource, acting as a catalyst in speeding up the process of cognition.

But there was a need to rear young researchers and train skilled personnel for the "innovatory" organisations, for industry and other fields, and soon after the formation of the Siberian Branch the Novosibirsk State University was founded in Akademgorodok. The first students graduated in 1963, but some of them subsequently returned as lecturers.

To get back to economics, a new stage in its development in Siberia and the Far East, which began around the beginning of the 1960s, was brought about by the formation of the Siberian economico-mathematical trend which soon won undisputed authority, raised the scientific level of research and speeded up the application of its findings to the economy.

A major branch of the Soviet school of economics and mathematics occupying an important place in the whole country grew up in the Siberian Branch under the guiding influence of the ideas of Academicians L. V. Kantorovich, V. S. Nemchinov and Professor V. V. Novozhilov. This school regards the economy as a complicated "large" system whose internal connections can be expressed as a complex of mutually-linked economico-mathematical models. A team of researchers in the Siberian Branch under Academician A. G. Aganbegyan is developing this system of models designed not only for research, but also for territorial-production planning.

Research conducted in Siberia and the Far East into the methodology of optimal planning has led to important theoretical conclusions on the law of development in a socialist economy. Research into macro- and microeconomic models has made it possible to evolve various types of economico-mathematical models in which the economy appears as a total of links which join its various sectors both "vertically" and "horizontally" and is expressed in a quantitative form. The intersector dynamic model of the economy contains a mathematical reproduction of the mechanism of interrelations between the basic proportions: between social product and the national income, social product and capital investment, production of producers' goods and output of consumer goods. This model is used for calculating the long-term rate of economic development and the prospective structure of the economy.

One of the main problems which concerns scientists is the development of Siberia's productive forces. It is obvious that in making long-range calculations they cannot be restricted by the bounds of a decade. For what is created now will serve the nation for many years to come. The long-term forecast for the development of Siberia's productive forces should answer the question as to how the present economic structure and the planned construction projects would fit into the future economy, and of the role Siberia is to play in the economy of the Soviet Union and of the whole world on the threshold of the new century. A conference on the development and distribution of Siberia's productive forces held in Novosibirsk in 1969 analysed the actual state of the Siberian economy and its long-term development trends, making it possible to work out an extensive long-term program for the economic growth of this wide area of the USSR, and for the planned strategy of the Soviet people who live in it.

"Bookish" knowledge and calculations made in an office or computer centre are not sufficient to enable scientists to make well-founded proposals for ways of developing productive forces. Much must be learned on the spot. A scientist must see how an industrial project is built and talk to experienced people in order to gain information which cannot be gleaned from articles, scientific reports, speeches at meetings, and so on.

For this reason Siberian economists have continued the honoured tradition of field research. The Institute of

Industrial Economics and Organisation has been sponsoring research expeditions since 1967. What is the immediate aim of these sometimes long voyages, costly both in time and resources?

In military terms, the purpose of these expeditions is to conduct a kind of reconnaissance of the territory, to gather intelligence about it and to determine the economic and social problems which need to be solved. Research expeditions have been made to the oil and gas fields of the West Siberian Plain, Krasnoyarsk Territory and the Tuva ASSR, Baikal and trans-Baikal areas, the North-East of the USSR and the southern zone of the Far East. An interesting problem arose during the Angara expedition which visited the places which were to be flooded as a result of the building of massive hydroelectric power stations. Experience showed that much timber is lost in the area of man-made reservoirs, for there is insufficient time to fell and transport it. Large tracts of forestland can be lost in this way, and much time and resources are needed to set up permanent timber farms and to build roads, and the greater part of this expenditure is lost as enterprises, houses and roads disappear under water. The alternative would seem to be to set up not permanent but temporary timber felling and transport bases sited on the river. The equipment for felling the timber is borne on a caravan of vessels which moves down the river as each area of forest is dealt with. Timber in more distant sectors is brought down to the river before being floated down to where it can be loaded onto other forms of transport or else directly to woodworking factories sited further downriver.

This method could produce great savings of time and resources in comparison with those practised at present, and could cut down the loss of timber in flooded areas to a minimum.

Besides economists, geographers have also achieved results which are extremely valuable for the scientific foundation of economic development plans. The Institute of Siberian and Far Eastern Geography has organised comprehensive studies of the population and economy of the taiga areas which are becoming increasingly important in the economy of this part of the USSR. Medico-geographical research by Irkutsk and Khabarovsk scientists has made possible a number of suggestions in the course of working out plans for distributing productive forces in the new industrial regions.

Thus Siberia has emerged in the forefront of science in the middle years of this century. Her economic growth has been supplemented by a growth in reserves of knowledge, which we will continue to describe later when we come to talk of the future development of Siberia's productive forces.

2. THE SPRINGBOARD OF ECONOMIC GROWTH

As we have seen Siberia in the several decades under socialism has become a modern industrial region, an area where large investment programs are being implemented.

In 1975 Siberia contributed about 12 per cent of the country's industrial output, and this has to be seen in the light of the fact that Siberia's output in 1975 exceeded that of the whole country's industrial output in 1940. This is one of the important results of the creation of a powerful industrial base in Siberia.

But the achievements must be set against the potential for economic growth which the area has now, and will have in the future.

Natural resources, its productive apparatus and potential in science—these are the powerfully-active factors in the long-term economic growth of Siberia. They can be seen as a springboard for speeding up this growth. The combination of these factors gives one reason to be optimistic for the role of Siberia in the development of the country's productive forces. Let us now look at the facts which support this point of view.

WHY SHOULD SIBERIA'S GROWTH RATE BE HIGHER THAN THAT OF THE COUNTRY AS A WHOLE?

The need for the rapid development of Siberia's productive forces is dictated by the constantly-increasing demand of the national economy for the output of Siberia's industry and agriculture, and that development is made possible by the richness and variety of Siberia's raw materials and the efficiency with which they can be mined and processed.

In determining the rational extent to which the natural resources of the Russian Federation's eastern zone will be exploited we must take into account the degree to which they will answer the scale and pattern of demand for them in the future. Let us examine some important trends which have recently emerged in this field.

In the era of the scientific and technological revolution the demand for machinery, equipment and other means of production is growing much faster than demand for raw materials. This is leading to structural changes in the economy. The sectors of industry concerned with the supply of primary materials and semi-finished products (fuel, metals, timber and saw-timber, non-metallic ores, etc.) are diminishing in importance, while the share of the sectors engaged in the processing of materials and in the production of finished goods is increasing fairly intensively. This can clearly be seen from differences in the dynamics of production — whereas in 1973 the value of the output of the processing industries had increased 1.9 times in comparison with 1965, that of the extraction industries had only grown 1.5 times.

Although the production of producers' goods is increasing comparatively slowly, the absolute demand for them will still grow very greatly in the future. Figures produced by the USSR Geological Fund show that over the 20 years since the war (1945-65) the world had mined more mineral resources than in all the history of the extraction industries.

By the end of this decade Soviet mining will increase its output by 2 or 3 times as compared with the mid-1960s. It should be noted that the volume of raw materials was used in Soviet industry in the same proportions over the 30 or so years from the beginning of industrialisation (1928-60), but the level of their consumption was many times lower than the contemporary scale of raw material consumption.

Of vital importance for the Siberian economy is not only the absolute increase in demand for producers' goods, but also a radical change in the pattern of that demand. There has been a relative decrease in the expenditure of less economical materials on social production, and a successive increase in the consumption of more efficient materials (gas, oil, petrochemical products, electricity, aluminium, cheap kinds of rolled iron and steel, light-weight structural units, pulp and paper products, etc.). Consequently the traditional industries supplying primary materials have been gradually giving way to new sectors which are providing a raw material basis for scientific and technological progress.

In connection with this we must mention the exploitation of the oil and gas reserves of the West Siberian Plain, whose discovery can rightly be considered the most important of our age. The increase in the production of oil and gas — these highly-efficient sources of fuel and raw material, serving as a basis for the formation of an economical fuel and power potential and of the intensive development of organic synthesis chemistry — will greatly depend upon Siberia.

Another factor determining the scale and pace of industrial development is Siberia's vast advantage over the European regions in being able effectively to distribute power-consuming industries, which represent one of the main trends in the modern industrial revolution. Examples of sectors with a high proportional (that is, per unit of output) consumption of electric power are ferrous metallurgy and some non-ferrous metallurgical industries (the smelting of aluminium, titanium, magnesium and ferro-alloys) and the production of quite a number of chemical products (man-made fibres, synthetic rubber, plastics, liquid chlorine, etc.). The chemical and petrochemical industries also require much heat. Large amounts of heat are also essential to the oil refining, pulp and paper and cement industries, and to iron and steel. The latter is outstanding for its high absolute consumption of fuel: a major iron and steel combine consumes up to 12,000,000 tons of fuel every year, that is, 4 times more than a modern aluminium plant. Many power-consuming industries also have high demand for water. The high cost of fuel and power and a shortage of water in the European regions of the USSR limit the level of development of the power-consuming sectors of industry, which will in future be increasingly sited in the eastern regions.

Thus the formation of material balances of many kinds of products and increases in the efficiency of the Soviet economy will depend in the long term upon the rate of Siberia's economic growth to a greater extent than at present.

Exactly which of Siberia's natural resources will make a vital contribution to the creation of the material and technical basis of communism in the USSR and to raising the well-being of the Soviet people? Which of her resources will take her into the world market?

It should be noted that Siberia plays an important role in the formation of the Soviet Union's long-term fuel pattern (not forgetting exports). Per capita volume of fuel extraction is one of the main indicators of the level of development of any country's productive forces, for in the final analysis it is the per capita consumption of fuel which determines the level of power supply per worker.

The world's fuel production is growing very rapidly. Figures produced by Academician A. P. Vinogradov show that about 70 per cent of all oil extracted from the earth was produced in the past 20 years, and about 40 per cent of the world's coal. The production of fuel and energy resources in the industrially-developed countries more or less doubles every 10 years. Take the USSR as an example, where between 1950 and 1970 the extraction of fuel (in reference units) increased almost 4 times. In the USSR today more than 95 per cent of the total fuel reserves (in terms of reference fuel) is composed of coal, oil making up only 3 per cent and gas a mere 1 per cent. That is more or less the structure of the world's reserves of combustible fuels. Bearing this in mind, and also remembering the particular value of gas and oil as materials for chemical refining, they are likely to be used as fuel to a relatively limited degree. This will do much to stimulate increases in coal mining.

About three-quarters of all fuel and energy produced in the USSR are consumed by the European regions, including Transcaucasia and the Urals, while about 80 per cent of the country's known natural energy resources, including the greater part of the most economical resources, lie in the eastern regions, mostly in Siberia and the Far East. The increasing deficit of fuel and energy in the European part of the USSR can only be covered by supplies from the Asian regions, mainly from Siberia, and at a great profit. The Siberian Energetics

Institute has forecast that by the year 2000 the USSR's production of fuel and energy will have at least doubled in comparison with 1980, and Western Siberia's contribution will have gone up to 40-45 per cent, against about 15 per cent at the beginning of the 1970s.

The resources of natural gas which can most efficiently be supplied to the European regions are the unique deposits of Tyumen. The Urengoi gasfield alone is one of the largest in the world with more than 5,000,000 million cubic metres. The second most economical and plentiful source of fuel for the European regions after Tyumen gas is mazut, or black oil, produced from West Siberian oil.

There has been a marked increase in the flow of Siberian fuels to the European zone of the USSR, and, consequently, the Siberian energy reserves are proving a powerful stimulus for the further development of industry in that zone.

It can be said without exaggeration that Siberia is playing the decisive role in the rational build-up of the European regions' fuel and energy reserves in the present decade. Siberia's contribution to the country's total fuel and energy supply will increase substantially due to the establishment of the USSR's largest oil- and gas-extracting region in the West Siberian Plain, to the intensive exploitation of the deposits of cheap brown coal in the Kansk-Achinsk basin, and to the continued development of coking-coal mining in the Kuznetsk basin.

Siberia possesses a great wealth not only of cheap fuel but also of water in its rivers. Suffice it to say that the costs of producing power in the hydroelectric stations of Western Siberia are twice as low as those in the best hydroelectric stations on the Volga, and the planned technical and economic figures for the production of power in the thermal power stations of the Kansk-Achinsk coalfield are very nearly the same as the cost of running the Volga hydroelectric stations.

Siberia is exerting a positive influence on the rates of development of the Soviet economy, and the efficiency of the national industries, not only through her fuel and power resources. Her future role will become even more versatile and weighty. This region will give the country many new kinds of industrial goods and will make a substantial contribution to the development of the socialist state's potential in science and technology.

In the first place, Siberia, with her natural wealth, is capable of multiplying and diversifying the Soviet Union's supply of raw materials. Due to her large deposits of minerals and the cheapness of exploiting them, Siberia will increase her contribution to the national production of traditional raw materials such as ferrous metals, copper, zinc, lead and timber. Siberia, however, will begin to produce the more economical kinds of raw materials on an ever-increasing scale—aluminium, plastics, synthetic rubber, man-made fibres, cellulose, high-grade steel, alloys and rolled metal for the manufacture of large-bore pipes, and so on.

The rapid increase in the demand of the eastern zone for metals and the availability of cheap fuel and large reserves of iron ore are making it essential to speed up the development of ferrous metallurgy in Siberia. A start has been made in the opening of the West Siberian Metallurgical Plant, now one of the largest in the USSR.

Ferrous metallurgy is not outstanding for a particularly high fuel consumption per unit of output (rolled metal), but large plants use a great deal of fuel due to the scale of production. Twenty per cent of the fuel and energy consumed by Soviet industry goes to iron and steel, and as fuel is cheapest in Siberia, this is another factor supporting the speedy development of ferrous metallurgy in the area.

But Siberia's role in the production of non-ferrous metals, and especially of aluminium, will grow even more markedly. For the economical smelting of aluminium Siberia has no rivals among the country's regions. There are already four aluminium plants here, and the further construction of large hydroelectric power stations in Siberia will make it possible to build more such enterprises there. At the moment Siberia is producing a substantial proportion of the whole country's non-ferrous metals. In the next decade this sector will be developed in Siberia at a considerably greater pace than the average throughout the USSR. The recent discoveries of copper and nickel deposits in Siberia should most probably make the USSR one of the world's chief producers.

Organic synthesis chemistry has of late been playing an ever-increasing role in the production of structural units.

The basic reserves of hydrocarbons (i.e., oil and gas) used in the production of synthetic materials are concentrated in Siberia, which has the additional advantage of being able to provide petrochemical and synthetics factories with cheap heat, electricity and water. So Siberia is a priority area for the construction of organic chemicals plants manufacturing polyethelene, polypropylene, polystyrol, synthetic rubber and fibres (lavsan, nitrol, kapron, etc.).

The creation of the USSR's largest oil and gas chemicals centre in Siberia will considerably enhance the area's role in the economy.

There will be a slower increase in timber consumption than in the past, owing to the replacement of timber by other building materials and to the more complete processing of materials.

Siberia possesses resources some of which are still not valued at their full potential, but which in future will be in great and growing demand. Chief among these are water and tourism.

We are still not accustomed to consume water economically, and for a long time our reserves have seemed inexhaustible. Alas! Practice is beginning to convince us clearly that they are indeed limited. UN statistics reveal that only one person in ten has access to good water that does not require radical purification. Take, for example, the experience of the USA, where in a number of areas there is a real water famine. In an American newspaper in 1972 it was announced that about one half of all Americans drink water that definitely does not meet accepted standards.

There is a water shortage in a number of other countries, and this has led to water becoming a commodity of foreign trade. Canada now sells water to the USA, and Norway sells to the Netherlands. There is a plan to throw an enormous dam across Hudson Bay to build up stocks of fresh water. The transportation of this water to the eastern states of the USA will require a thousand-kilometre pipeline.

A number of areas of the USSR also suffer a shortage of water for industrial and domestic needs and some agricultural lands are also affected. The progressive growth of water consumption in the economy, and the rising standard of living have given rise to a new problem for our country: that of supplying water economically and in sufficient quantities to enterprises and homes. In this respect Siberia has an undeniably decisive advantage over the rest of the USSR with her deep rivers and numerous lakes concentrating half the country's fresh-water resources.

Lake Baikal, unique in the quantity and quality of its water, holds almost one-fifth of the world's surface fresh water. It has five times more water than all the large and average-sized lakes in Europe and Asia. Its exceptional purity and unique chemical composition makes it ideal as a source of water for Siberian towns and for industrial enterprises which have a particular need for high-quality water.

Research and planning organisations have developed the main trends of a general scheme for the comprehensive exploitation of the Baikal basin's natural resources. A national park is to be established here, which means that Lake Baikal and its surrounding area will be designated as a special zone, governed by strict rules of nature conservation and exploitation. The lake's outflow will continue to drive the turbines of hydroelectric stations, and its exceptionally pure water will be piped to homes and some industries in Siberian towns. Apart from protecting Lake Baikal and exploiting its natural wealth, the national park could also become a national health resort, and major centre for Soviet and foreign tourists. This national park in time could attract many hundreds of thousands of people in need of rest and treatment or who would like to spend their holiday in rest homes or hiking. It is estimated that up to a million people a year could stay in tourist centres. A trip along Lake Baikal and its shores is a wonderful experience. Its beauty, its unique fauna, virgin taiga forests, excellent hunting and fishing make Lake Baikal a tremendous tourist attraction.

The scenery of many other parts of Siberia also holds great promise for the development of tourism there, and Gorny Altai and Tuva could become world-popular tourist centres. Another area of great tourist potential is the Kamchatka Peninsula, with its many volcanoes, some of them active, the unique Valley of Geisers and the picturesque river valleys. Kamchatka also offers thermal springs famous for their curative properties.

The great Siberian rivers provide another great possible tourist attraction. Tourists already make trips along the Ob and the Lena, and there is the unforgettable two-week cruise on the Yenisei (Krasnoyarsk-Dikson-Krasnoyarsk) during which the boat crosses the famous Kazachinsky Rapids by means of special machinery. In its middle reaches the Yenisei is bejeweled by picturesque islands, and the impenetrable taiga presses down to its very shores. The grass is waist-high, and the mighty trees tall, and straight as arrows. You might look up at a lofty cedar and espy some big cedar cones full of nuts, but they are not to be had, for the crown is high up and the trunk is bare of branches. Squirrels chase each other up and down, paying no heed to the unexpected visitors.

Next you come to the enterprises of the Maklakovo-Yenisei timber complex, some under construction and others already in operation, which stretch for many kilometres along the river. You see rafts washed against the banks, cranes lifting logs out of the water, and factory chimneys rising high over the mill buildings. South of Maklakovo the beautiful Angara joins the Yenisei, and then another great Siberian river, the Podkamennaya Tunguska, at whose mouth a timber combine is planned to be built.

Then the Yenisei takes in the waters of the Nizhnyaya Tunguska, and not far away lies the town of Turukhansk, where the tsars sent revolutionaries into exile. One of its houses has been turned into a museum displaying photographs of exiles, inscriptions telling of their life and work in the Turukhansk area, and an exhibition showing furniture and household utensils of the period. And to one's mind come the words of the historian V. Andriyevich, spoken so bitterly a hundred years ago: "Everyone sees Siberia as a cold land, unfit for human habitation and is only valued by the state as a place of exile."

Then you reach Igarka, where the banks are lined for kilometres by the quays and warehouses of its enormous timber combine. Ocean-going timber transporters stand loaded and ready to sail to Western Europe. The town, which tops the steep bank, was once entirely made of wood, and used to burn down fairly regularly. But now many houses are made of brick and concrete.

Dudinka, nearing the end of the river trip, is Norilsk's gateway to the Yenisei. Its port is filled with ships which have brought many a load to supply the mining and metallurgical combine. Shunt engines scurry up and down the dock sidings. This is a modern town with relatively few wooden houses. From here an electric train travels to Norilsk, one of the Soviet Union's largest non-ferrous metallurgical centres, set up several decades ago in the remote Taimyr North. Neither the long polar night, nor the 40° C frosts, nor the furious blizzards which sometimes hit the town could stop the building of the combine, and now tens of thousands of people work here.

There is a beautiful square in the centre of Norilsk, and a long avenue of modern houses leads away from it. The houses are built in squares enclosing their courtyards to keep the blizzards out.

The Norilsk mining and metallurgical combine once had a unique mine where you had to go up, not down, to reach its coal faces, which were at the top of a mountain. But the Norilsk mines were closed a few years ago when coal was replaced by natural gas, which was piped here from beyond the Yenisei (the pipeline had to be laid along the bottom of one of Siberia's greatest rivers). Not far from Norilsk stands the Khantaika hydroelectric power station, the most northerly in the USSR.

Our boat continues its journey to reach Ust-Port settlement at the beginning of the Yenisei gulf. At its fish cannery there is a lift which will take you down into a refrigerator which has no working parts, for the permafrost does the job perfectly well...

While in Krasnoyarsk one must visit the famous Stolbi rocks of unusual shapes, some of which have been given names, like "Great Eagle", "Lesser Eagle", and then there is "Grandad", which even the not-so-adventurous can climb easily. From here you can see the Yenisei, dotted with toy-like ships, and the taiga beyond.

At the Arshan spa in the foothills of the Eastern Sayan mountains you can take a famous Narsan mineral water bath. Here, where the mountain river Kyngyrga thunders past the houses, the stones have been polished to a shine by the water. There are waterfalls nearby, and the river plunges down into a narrow gorge to become a gurgling spray in which the sun's rays play with all the colours of the rainbow. As you go further up into the mountains you come across more waterfalls, and if you have the energy and the time you can climb to the top of a two-kilometre peak.

Kamchatka is an unusual part of the world. The Yelizovo airport seems like any other, but as soon as you leave it you find yourself in an enormous trench, formed by two-metre deep snow-drifts on either side of the road. Local people once showed me a photo of a man standing and holding the top of a telegraph pole which only came up to his waist. No, it was not Hercules, but an ordinary man whom the Kamchatka snow-drifts had lifted higher than a telegraph pole. The city of Petropavlovsk-

Kamchatsky stretches in a twenty-kilometre horseshoe round the Avachinskaya Gulf. There is a good view of the volcanoes on the horizon from here.

Not far from the city runs a little river Paratunka, which offers bathing all the year round. Subterranean thermal springs keep it warm, and even in mid-winter you can have a nice warming dip in its 40-degree-water.

Siberians and Far Easterners do have something to show, something with which to amaze people — things of the past, and the breathtaking achievements of the modern day. Siberia and the Far East have vast "reserves" for mass tourism. Few people come here yet, as most are accustomed to the beaten tracks of other parts of the USSR. The East must attract visitors, and develop tourism in a big way.

The term "tourist industry" has become accepted now, and it really is an industry which has a developed network of services to the traveller, and international tourism has become a most profitable commodity on the world market.

Let us think how tourism would fit in as a sector of the Siberian economy. Returning once more to Lake Baikal — when the National Park is set up here, the flow of tourists from the rest of the Soviet Union will increase many times.

If one assumes the optimistic forecast of the number of tourists who will visit Lake Baikal to be correct, one comes to the conclusion that the tourist industry will become one of the leading sectors in the area's economy.

Developing tourism means building and modernising airports, roads, hotels, restaurants, shops, cinemas, urban facilities, restoring things of historical and cultural interest, forest, river and lake conservancy, increasing agricultural production and developing local arts and crafts. But tourism brings not only economic benefits.

Through tourism Soviet people can get to know their country better and learn what is going on in its vast expanses, and foreign visitors can have a look at our achievements in the East of the country.

The reader may wonder whether the future role of Siberia in the national economy will be confined to supplying primary and intermediary goods to industry—oil and gas, plastics and man-made fibres, ferrous and non-ferrous metals, timber and paper, electricity, etc., and also to touristic "exports". In answer to this natural question, it must be said that, beyond all doubt, Siberia will also produce its share of the national output of finished goods (machinery, instruments, vehicles, rolling stock) and also of consumer goods.

Admittedly we are not talking here of all kinds of goods, but of those whose manufacture in Siberia is justified by being more efficient than in other parts of the USSR.

Let us turn briefly to the Far East. The economy of this region is closely linked with the Pacific Ocean, and this link will probably become stronger in the future. The USSR is the world's third largest catcher of fish after Peru and Japan. The Soviet Far Eastern fishing fleet accounts for a third of the country's total catch.

Ocean fishing is the main trend in the development of the Far East's fishing industry, and in future the fishing fleet will move further afield and the variety of products will be extended.

As Academician S. G. Strumilin, eminent Soviet economist, figuratively put it, the economy of the future will first and foremost be the economy of the World Ocean. It not only threatens Man with its taiphoons and tsunamis, but it is generous too, and in the future it will give him more products than he now gets. We can count on extracting gold and tin from the sea, and on exploiting underwater deposits of titanium and zirconium ores. This will require dredges and floating concentration factories. The USSR already has a floating ore mine in the Arctic Ocean. The lighter *Gornyak*, equipped with mining and concentrating machinery as well as living accommodation, produces kassiterite from the rich deposits of tin ore at the bottom of the Vankina Gulf in the Yakut Autonomous Socialist Republic. The bottom of the Chukotsk Sea and the seabed near the mouths of the gold-rich Kolyma and Lena rivers hold great promise of gold.

The Far East will obviously become the USSR's main area for marine chemistry, and it also has great potential in farming red algae and other sea plants.

Another developed industry in the Far East, apart from fishing, is ferrous metallurgy, which will continue to develop its output on the basis of existing ores, and of new deposits, mainly in the Primorye and Amur areas and Yakutia. Another important factor is that in future along with the mining and concentration of ores the production of rolled metal will be developed. This sector will then take on a multi-purpose nature, and accompanying mining chemistry enterprises will develop, thus increasing its efficiency.

The Far East will continue to specialise in supplying timber to other parts of the USSR, but the decisive factor will be the development of timber processing (the manufacture of pulp and paper, cardboard, etc.). A start was made on this in the building of the Komsomolsk timber complex.

The Far East's geographical situation as the Pacific region of the USSR will have a beneficial influence on its economic development. Far Eastern produce will take on an increasing significance in the USSR's foreign trade links, a number of sectors of the Far Eastern economy sending a large proportion of their output to Japan and to other countries of the Pacific and Indian oceans. There are great prospects for the export of oil, petroleum products, liquid gas, iron ore and pellets, marble and other non-metals, and the output of the timber, pulp and paper and marine industries. The Far East's engineering plants will probably be oriented towards exporting part of their output to the developing countries of South-East Asia.

The growing demand for iron ore and pellets, pig iron, and rolled metal on the Pacific market has created favourable conditions for the setting up of mining and concentration plants in the Soviet Far East. This could be followed by the development of exports of pig iron and rolled metal.

Export-oriented specialisation makes it possible to achieve a more universal and rational approach to exploiting the ocean's resources, and particularly those products which form a part of the traditional diet of people in many countries (sea cabbage, mussles, oysters, lamprey, cuttlefish, octopi, shrimps, whale flesh, etc.). Another way the Far East could extend its economic links is to develop production on the basis of international cooperation.

Yakutia is the largest area in the Soviet Far East. This republic is rich in many resources, and socialism has turned this previously backward land into one of the East's major industrial centres. It will undergo great economic growth in the future, and one of the main tasks is to set up a major gas industry here. Yakutia has a potential gas reserve of 13,000,000 million cubic metres, and that gas could allow the North-East of the USSR to radically improve its balance of fuel and power, which is a vital condition for increasing the efficiency of its non-ferrous metallurgy.

It is likely that large deposits of oil will be discovered in the republic, and this would give a mighty stimulus to Yakutia's industrial development. For oil is a resource which leads to the formation of an economic complex, and turns new areas into leading industrial centres, as was the case with Azerbaijan.

The south of Yakutia has great economic potential. The exploitation of the coking coals and iron ore of the Aldan-Chulmansk region will soon be in full swing, and this could be the foundation of a new iron and steel centre, and yet more materials for export. The Guidelines for the Development of the National Economy of the USSR for 1976-1980, adopted at the 25th Congress of the CPSU, envisage the setting up of the South-Yakutian territorial-production complex which will comprise an open-pit coalfield, concentration factory and a big thermal power station. This complex will be linked to the Trans-Siberian Railway by the Bam-Tynda-Berkakit Railway Line (its Tynda-Berkakit section will be completed during the Tenth Five-Year Plan).

Yakutia's economic development will proceed with the cooperation of adjacent areas (Magadan Region and Transbaikalia). The transporting of Vilyui's natural gas to Magadan, thus making it possible to electrify the gold-extraction industry, is an attractive idea.

We would like to conclude this section of the book with the extraordinarily profound words of Academician M. A. Lavrentyev, in which he ties up the future of the Siberian economy not only with its natural resources, but also with the moral outlook of its new society, for whom respect for nature will be a norm of behaviour. In answer to a journalist's question, whether the growth of industry would destroy the primordial balance of nature (and this fear is not uncommon), the Academician replied: "Our descendents will not lose the feeling of the Siberian expanses, the stern beauty and the uniqueness of this land. Siberia will be ... synonymous with prosperity and industrial might, a region of harmony between nature and civilisation."

THE UNION OF SCIENCE AND INDUSTRY AS THE ACCELERATOR OF ECONOMIC GROWTH

We will try to show clearly the possible role of science in the economic growth of Siberia, and see what the scientific trends which have "settled in" in the region can offer to industry and agriculture. But first let us take a broader, more general look at the essence of the problem, so gaining a clearer picture of the range and substance of the tasks which Siberia faces or will soon have to face in scientific development and the application of its achievements. The scale of Siberia's future industrial development should be supported by a scientific and technological basis of equal standing. In other words, Siberian economic development is only a viable proposition if a developed system of research exists. And its possibilities must be realised.

In recent times knowledge has become a valuable resource and has been playing an increasing role in the development of industry and the raising of living standards. The application of science to economic activity gives a powerful stimulus to economic growth and social progress. In "supplying" knowledge to mankind, science has become itself a powerful direct productive force, as Karl Marx foresaw one hundred years ago. The pace of the accumulation of knowledge has been growing at an incredible rate. Experts have calculated that over the 1950s and 1960s, in other words, in twenty years, the sum-total of the world's scientific and technological knowledge doubled for the first time in human history. However the pace of accumulation of knowledge in the future is expected to be even higher, and today's sum total will double in the course of the next 10 years.

The unprecedented multiplication of this vital resource, and the accelerated growth of technology are founded upon the drawing of more and more people into science and ancillary scientific services, into planning and designing. The sum of these can be called the research potential, and this concept refers not only to the country as a whole, but also to its individual regions. In particular, it can be said that the Siberia of today has a powerful scientific potential at its disposal. Numbers of people employed in science and expenditure on it are growing much faster than in the other fields of activity.

The scientific and technological personnel essential to the development of research and the application of its results in the economy, education, health, etc., are mainly trained by higher education. The accelerated development of higher education and research, and the rapid realisation of its findings have become urgently important for Siberia, as it is essential to step up industrial growth and the economic development of a vast territory, which for the first time in history has become a centre of large-scale research.

In the last chapter we devoted our attention to the history of science in Siberia. Let us now take a look at its present state, and examine the possible role of Siberia's scientific potential in the future development of its productive forces. We shall start with the work of the establishments of the Novosibirsk Scientific Centre which represents the spearhead of academic science, and has been most successful in its union with industry.

The main trend in modern science is the intensifying cooperation between different disciplines in studying the complex phenomena of nature and society. The earth's crust is one field which requires a comprehensive study with the participation of various branches of science. Not only geologists study it, but also geophysicists, geochemists and mathematicians. Researchers are interested in the structure and composition of the earth's crust, and in the history of its development. They explore the conditions in which minerals were formed, and modern geological phenomena which reflect the continuing process of the formation of the earth's crust. They not only use the classical geological methods of geochemistry, geophysics and seismology, but also mathematical models of geological processes.

Even before the Second World War the eminent Soviet geologist Academician I. M. Gubkin foretold the presence of oil in Western Siberia. Many experts regarded this bold prophecy with scepticism, but enthusiastic scientists continued to explore this region, and the doubters were finally proved wrong. Much credit in this must be given to the outstanding geologist, M. K. Korovin, posthumously awarded the Lenin Prize, to Y. G. Ervye, head of the Tyumen Geological Authority, who also won the Lenin Prize, and to the research teams of the Siberian Institute of Geological, Geophysical and Mineral Studies and the West Siberian Institute of Petroleum Geology of the USSR Academy of Sciences. One of the main figures in this was Academician A. A. Trofimuk of the Siberian Branch of the USSR Academy of Sciences, who was one of the most energetic and persistent champions of the search for Siberia's oil. He led a comprehensive program of studies which aimed to estimate the potential quantities of oil and gas in the West Siberian Plain, the eastern part of the Siberian platform and the areas of the Far East adjacent to it. The methods evolved by the Siberian geologists made it possible, with the use of a minimal number of bore-holes, to evaluate the volume of oil and gas in the wild and remote regions of the West Siberian Plain, the Vilyui depression and the Upper Yana depression.

The Siberian Branch has made the first attempt to systematise world knowledge on the formation of the concentrations of mineral deposits which were thrust up from the bowels of the earth. This has made it possible to suggest to geologists where they should look for iron ore, complex ores and rare metals. Research in geochemistry led to the introduction of new methods of prospecting for deposits of gold ores. All this led to the discovery of deposits of diamonds, rare metals and extensive exploration for potassium salts and phosphorites.

Let us look at the practical results of the research conducted in Siberia's oldest academic establishment—the Institute of Mining. Much of the institute's work is of an applied nature, and one of its most important achievements has been the creation of a series of pneumatic mining machines for boring blast holes and digging tunnels, and a vibration-free pick hammer. The institute is playing a truly pioneer role in mining technology, and semi-automatic boring equipment designed by it made it possible for the first time to sink very deep wells through extremely hard rock. Not one foreign firm could offer anything of the kind. The institute's drills are used not only in the USSR, they were also used in the building of the Aswan Dam. The institute has produced an original pneumatic borer, which has been nicknamed the Mechanical Mole. This machine, which looks like a small rocket, has made it possible to lay communication cables and pipes cheaper, faster, and without the need to dig trenches. It threads its way under streets, roads and buildings, leaving a tunnel of between 13 and 30 centimetres diameter in which cables and pipes can be laid. The borer can be used by prospector-geologists, land-reclaimers, divers and miners. More than 30 countries have bought this "underground rocket", and, in the words of a Copenhagen newspaper, it has "brought about a revolution in Danish road-building".

The Institute of Mining has also evolved a number of methods for the working of thick coal seams and large ore bodies. The highly-productive technique for the mining of ore worked out by the institute's researchers, for example, should bring about a drastic reduction in labour costs. This method was used in 1971 at a mine on the Tashtagol iron ore deposit in Gornaya Shoria. The number of men per shift was reduced from forty to four, and the yield per man rose to 158 tons of ore.

Researchers consider that the mining technique evolved by the institute could offer prospects for the development of Siberian iron and steel industry which were unimaginable before. It makes it possible to extract ore from great depths, but using about the same amount of labour as open-cast mining requires. This means that the reserves of ore which are now unprofitable to bring up from deep levels will become economically workable. The yield of Siberian ore could increase 8 times by comparison with that of today, and this will make it possible to create many a new iron and steel centre, and it can be said that the development of that sector is being held up at the moment by a shortage of raw materials.

Research into theoretical and applied mathematics is being conducted over a wide range and in great depth by the Siberian Branch, and especially in the Novosibirsk Scientific Centre. This is now the country's second mathematical school after Moscow, and it leads in various individual fields.

What are the physicists doing for the economy? The researchers at the Siberian Branch's Institute of Nuclear Physics have evolved a method for the acceleration of elementary particles by clashing beams. This original method has led to the making of some profound theoretical conclusions, but the scientists have gone further, and their newly-discovered principles for the creation of accelerators for theoretical research have been used in the designing of industrial accelerators which are now in production. Experts say that these machines provide the cheapest and most convenient source of radiation which is widely employed in various sectors of the Soviet economy.

The findings of research into the physics and mechanics of continuum medium conducted by the Siberian Branch's Institute of Hydrodynamics have been used to evolve an original technique for producing bimetals by explosion welding, in which any two metals can be welded together by explosion. The new areas of technology have a great need for these "hybrid" materials, and it was not possible to obtain a firm weld between different metals using traditional methods. In particular this technique has been used for strengthening railway points, bringing great savings. The explosion welding method was also used to make the turbine blades for the Krasnoyarsk hydroelectric station.

The same institute has been studying the action of high pressures on water, producing the theory of so-called impulse streams. On the basis of this researchers and designers have created a series of high-power hammers, giving a force of 200 tons per metre used for pressing complex shaped items from various materials. A new technique for making dome-shaped bottoms for various high-pressure chemical reactors has been evolved and introduced into industry. The institute's researchers also propose to examine new ways of boring oil wells.

The Siberian Branch's Institute of Thermophysics, which specialises in low-temperature energetics, has created the world's first model of power-turbine run on freon vapour, and they have also developed a powerful absorption refrigeration plant, which first went into production in 1967.

Siberian chemists are doing research which is closely linked to the needs of the economy. The Institute of Inorganic Chemistry of the Siberian Branch has been successful in evolving a theory of metal-extraction processes. The methods developed by the institute make it possible to selectively extract required substances of high purity, and the automation techniques of this process are extremely simple. Mining and metallurgical enterprises are making extensive use of these methods, including a process for obtaining the world's purest gold (99.9999 per cent pure).

The Novosibirsk Institute of Organic Chemistry studies aromatic compounds (dyes and high-molecular substances) and natural compounds. They have been highly successful in synthesising organic substances, suggesting the use of a group of synthesised primary products in order to produce new materials possessing unique qualities. Organic ethers have been used to produce isolating materials which are capable of withstanding temperatures of up to 250°-300° C. Many other practical problems have also been solved.

Scientists at the Institute of Mineral Processing Chemistry of the USSR Academy of Sciences have suggested a technique of producing alumina from nepheline ores by sintering at high temperatures, and made a great contribution to silicate chemistry.

The developing of the theory of catalysts has inestimable value for modern chemical technology and the control of biological processes. About 70 per cent of all industrial chemical reactions are conducted with the aid of catalysts. Europe's first Institute of Catalysis has been set up under the Siberian Branch of the USSR Academy of Sciences.

In addition to developing the theory of catalysts, the institute is developing new catalysts and technology to produce them. They have already given industry a number of new catalysts; for instance those used in the manufacture of a number of synthetic rubber monomers. Probably the most remarkable achievement of the scientists of this institute has been the use of mathematics and computers to calculate optimal catalyst processes, and the equipment they require. This has great practical significance. Formerly the move from laboratory experiments to the industrial realisation of new techniques and equipment called for much expense in time and materials in constructing experimental equipment in order to try out the new ideas. It was found that this intermediate stage could be replaced by mathematical models which simulate the behaviour of the equipment in the industrial process. This saves much time on the mastering of the new methods and avoids large-scale expenditure in adapting them to practice.

Biological research is also conducted in the Novosibirsk Scientific Centre, and the work here is especially outstanding for the close contacts between biologists, chemists, physicists and mathematicians. Scientists have evolved a number of new medicines and the technology to manufacture them. The geneticists at the Novosibirsk Scientific Centre have been able to influence the hereditary mechanism, producing new species of coloured minks, with an increase in fertility of 15-20 per cent. The effect of chemicals upon the nuclei of cells has made it possible to produce highly productive triploid hybrids of sugar beet. This gave 10-20 per cent higher sugar content than in the sorts of beet used at present. The development of new hybrids can make seed-growing simpler and cheaper. Ordinary sorts of hybrid maize will only give a maximum harvest through one or two generations, whereas the tetraploid hybrids produced by the Novosibirsk geneticists give high yields over 5-6 generations, thus drastically lowering expenditure on seed-growing.

High-yield and early-ripening sorts of spring wheat have been produced, which is of especial importance to Siberia, one of the country's main spring wheat producers. Cereals are often hit by snow and autumn rains, which lowers the wheat harvest drastically. The "Siberian-67" strain evolved by the Institute of Cytology and Genetics gives a yield three times as great as that produced by traditional Siberian strains. Geneticists have also produced an early-ripening high-yield sort of tomatoes which are disease-resistant, and early-ripening sorts of potatoes.

Though this is not a complete list of the scientific developments at Novosibirsk, it does give a sufficiently clear idea of that town's academic establishments and their fields of research. A major scientific centre is soon to be set up in Irkutsk, where the Siberian Branch already has about ten research institutes in operation, specialising in geology, physics, chemistry, geography, biology, and energetics. The framework of the scientific centre has made it possible to develop extensively those areas which fall between the main branches, and which call for cooperation between the intermediary fields of knowledge. Scientists in Irkutsk, under Corresponding-Member of the USSR Academy of Sciences, L. V. Tauson, have been doing successful research into the geochemistry of the ore-forming processes. They are aiming to produce geochemical methods for finding the so-called blind ore bodies and ore fields, i.e., those which do not appear on the surface. At present trace elements like germanium are extracted in very small quantities, though they are of great value to the new branches of industry, to semi-conducter technology in particular. Geochemistry will help to make it possible to drastically increase the yield of these elements, and this in turn promises a real technological revolution in industry.

The Institute of Earth's Crust Studies has done much in researching possible earthquake danger spots, in the theoretical aspects of hydrogeology and geological engineering, and is now being of great assistance to the designers and builders of the Baikal-Amur Railway.

The scientists of Irkutsk under Academician L. A. Melentyev were the first in the Soviet Union to apply the method of mathematical models to large power networks. This will make it possible to calculate the optimal variants of developing the Siberian Integrated Power Grid. For example, research showed that out of the two planned hydroelectric power stations (Sayan on the Yenisei and Ust-Ilimsk on the Angara), it would be more viable to build the second one first, and this was, in fact, done. Irkutsk scientists have also evolved a long-term forecast of the development of Siberian power.

Research conducted by experts of the Siberian Institute of Plant Physiology and Biochemistry have proved that it would be possible to grow tomatoes under synthetic sheeting in the south of Eastern Siberia. This is a very urgent problem, for the proportion of vitamin foods in the Siberians' diet is still fairly small.

The Limnological Institute, which lies not far from Irkutsk, has won extensive fame through its research into the physical and chemical processes which take place in

Lake Baikal and into its fauna. The institute's research workers are studying this unique body of water in great detail. On the basis of many years' observations, experiments, analysis and calculations, rational ways of exploiting Lake Baikal's natural resources have been evolved, with the accent on the preservation of the water's purity and of the lake's normal biological cycle.

A great role in the forming of Irkutsk as the major scientific centre of the East has been played by the research workers of the city's higher educational establishments, mainly of Irkutsk State University and also the specialised research institutes.

The country's leading centre of forest studies is the Institute of Forestry and Timber under the Siberian Branch, in Krasnoyarsk. It has concentrated all its efforts on finding a scientific basis for the rational exploitation and reproduction of forest resources, and forestry protection. It is paradoxical that wood, which for many thousands of years has been used by man as a source of fuel, building materials, and so on, is still the least-studied resource of the biosphere.

The institute has worked out a set of measures which could eliminate the bad effects of extensive felling on the reproduction of timber, has evolved new methods of putting out forest fires and has produced "Tuverin", a bacteriological preparation for the elimination of the Siberian moth, which is the main forest pest.

The soil scientists of the Siberian Branch have evolved a set of measures to effectively combat soil erosion in the forest-steppe and steppe regions of the Altai, Khakasia and Transbaikalia.

A large part of Siberia lies in the permafrost zone, and this creates great difficulties for construction, for the mining industries and in the running of buildings and constructions of all kinds. It is necessary to establish thermal levels which will provide secure foundations which will not drift apart. Yakutsk has the USSR's only Permafrost Institute, which examines the distribution of permafrost, the structure of the frozen ground and the way it is affected by fluctuations in temperature. This research is yielding important practical results which are used by design and construction offices. We will soon have to lay many oil and gas pipelines in the North, and the first experience in laying long-distance pipelines in the tundra showed up the complicated problem of ensuring that the pipes stand up to the conditions. The increased scale on which power-lines, roads, etc., are being built will present more problems, and many tasks have been set for science by the building of the Baikal-Amur Railway, which passes almost exclusively over permafrost land.

Let us go even further to the East of the Soviet Union, to Kamchatka.

One might think that research by vulcanologists, who have their institute on the Kamchatka Peninsula, would have nothing to do with the urgent needs of the economy. But their interests are not by far limited to purely theoretical problems. Researchers are looking for possible ways of forecasting eruptions, and give recommendations for establishing zones with a high eruption probability. These recommendations are taken into consideration while planning construction. There has also been development of research into underwater volcanic activity, which could lead to discoveries of mineral deposits on the seabed. The comprehensive study of the reserves of thermal waters and of the volcanoes of Kamchatka has made it possible for scientists to make practical suggestions on the use of these springs to provide cheap heat and electrical power. These suggestions were of interest to the workers of the

Siberian Branch's Institute of Thermophysics with a special interest in low temperature energetics. They have evolved a method of turning the energy of geothermal springs into electricity. It was in 1968, in the Petropavlovsk-Kamchatsky area, that the USSR's first geothermal power station, Pauzhetka, was opened. Sibterranean heat makes it possible to grow vegetables in the 100,000 square metres of hotbeds in the Paratunka Hothouse Combine.

Scientists regard thermal springs as a vast source of energy which can even compete with oil. There are great reserves of thermal water. There are considerable grounds for supposing that the use of Kamchatka's geothermal springs will in time turn the area into the Far East's major producer of hothouse vegetables and fruit.

The theoretical research done by the geophysicists of the Sakhalin Research Institute has also produced some very important practical results. They are studying tsunamis—the gigantic waves formed as the result of submarine earth movements which have colossal destructive power. Scientists have evolved a method of short-range tsunami forecasting, which aids in reducing the damage caused when they hit the coastline.

The wonderful healing qualities of ginseng are well known, and chemists of the Far Eastern section of the Siberian Branch have made a great contribution to study this "root of life", and they have isolated valuable fractions from the root of *Eleutherococcus.* This discovery has led to the creation of industrial plant for the manufacture of the liquid extract of *Eleutherococcus* for use in food products.

Man's future depends on the intensive exploitation of the ocean's animal, vegetable and mineral resources. In the sea man will find protein foods, which he is short of on land, and also fuel and metal deposits. In their forecasts experts consider that man will not only settle the continental shelf and the greater part of the sea's sandbanks, but also the peaks of the enormous underwater mountain ridges of the World Ocean. Progress in science and technology, which has made it possible to discover extensive mineral resources on and beneath the ocean floor, will in time make these accessible.

With this in mind the Siberian Branch has set up an Institute of Marine Biology in Vladivostok, specialising in the study of the bioproductivity of the Far Eastern seas of the Pacific. Great discoveries await scientists in this field. Lengthy research expeditions are being organised with the aim of accumulating knowledge on marine resources and studying in nature the life-processes of fish, animals and other organisms which inhabit the boundless oceanic expanses.

In 1970 the Far Eastern Scientific Centre of the USSR Academy of Sciences was founded on the basis of a number of institutes which had formerly come under the Siberian Branch, and so could pass on their vast experience of scientific organisation to the new research centre. The centre united eight existing institutes in Vladivostok, Khabarovsk, Magadan, Petropavlovsk-Kamchatsky and Yuzhno-Sakhalinsk.

The centre will become a great scientific establishment in the Far East where the leading fields will be mathematics, physics, geology, biology, chemistry, economics, history and geography. The full list of the fields which will be studied in depth is too long to mention here, but it will include: the exploitation of the oceans' biological and mineral resources; a comprehensive study of the structure and composition of the Earth's crust; the formation of its minerals; the regulation of the rivers which still are a source of catastrophic floods; land reclamation and the cultivation of subtropical plants; and the link between production and demand on the markets of the countries of the Pacific basin.

Let us look at the way the gap between pure science and economic practice has been bridged. Special design offices, experimental industrial enterprises and implementation institutions have branched off from academic establishments. These "daughter firms" of the Siberian Branch were first set up here, in the Scientific Centre in Akademgorodok. The initiative was taken by the Institute of Hydrodynamics, which set up a design office dealing with hydroimpulse technology. In a short space of time this office has introduced a number of the Institute's discoveries into economic practice. Then another implementation firm, the Institute of Automated Planning and Management Systems, branched off from the Institute of Economics and Industrial Organisation.

The work of the first implementation organisations was successful, and in 1966 the government suggested to the ministries that, in the interest of speeding up the industrial implementation of scientific discoveries, there should be set up a number of design and technological offices and experimental enterprises under the scientific and methodological guidance of the Siberian Branch. A group of such organisations is now being set up on the banks of the Sea of Ob not far from Akademgorodok.

In not so many years' time, Akademgorodok will be ringed by satellites of specialised industrial research firms, and the "science-industry conveyor" will be working at full strength. Science can be seen as the scout of future productive forces, informing society of the best places to attack nature's strength and wealth, of the approaches to new knowledge, of new ways of reshaping technology and production techniques. The scout passes on the task to the next in line, who will carry it to the next stage — putting research findings into practice. Applied science is a foreward unit storming the bastions of future methods and technology. It paves the way for the industrial "army" to take up reconnoitred positions, in other words the final stage of scientific research — the mass production of new types of goods.

The close union of academic and applied science is a kind of catalyst which can speed up technological progress in industry. In the words of Academician M. A. Lavrentyev, the meaning of the experience of the Siberian Branch lies in "the development of a major centre of pure science into an even more important scientific and technological complex with a substantially new system of internal and external links".

In recent times the institutes and design offices of Akademgorodok have begun to set up broad and long-term contacts with Novosibirsk's large industrial enterprises in the interests of accelerating the pace of implementing their discoveries. In 1972 a plan of scientific and technological cooperation was adopted between the Siberian Branch of the USSR Academy of Sciences and the Novosibirsk Agricultural Machinery Plant, and in 1973 a similar agreement was concluded with the Chkalov Aviation Plant.

The union of academic science and industry has also meant the training of skilled personnel for the "daughter firms" of the Siberian Branch. This involved Novosibirsk University, a number of Novosibirsk higher education establishments started evening lectures in Akademgorodok and a polytechnical school was set up. Novosibirsk University has already sent many of its graduates — chemists, mechanical engineers, geophysicists and economists — to work in Akademgorodok's industrial-scientific firms. The university has begun to train experts in applied mathematics, which is having greater and greater influence upon many areas of science and industry. The scientific and technological revolution has given birth to a new profession — research engineer, which is also required by the institutes dealing with theory and practice. One of scientists' most vital and rewarding tasks is to train this kind of personnel for Siberia.

Other organisations have followed the example of the Novosibirsk Scientific Centre, and two more industrial science centres are being set up in its image near Novosibirsk, one by the All-Union Lenin Academy of Agricultural Sciences, and the other by the USSR Academy of Medical Sciences. The Siberian section of the Academy of Agricultural Sciences was set up in 1970, comprising eight reseach institutes, experimental farms and academic establishments. A new scientific town is already taking shape on the left bank of the Ob. The main task of this section will be to find a comprehensive science-based solution to the problems of Siberia's agricultural development. There are also plans to set up a Metrological Centre in Novosibirsk, comprising a number of institutes.

What benefit can be derived from this alliance between different branches of science? In the first place, cooperation itself strengthens scientific potential, as these branches enrich each other and give each other assistance. Then the concentration in one place of centres which combine theoretical research with the application of their findings to scientific projects of a practical nature and, subsequently, to planning, design and production, represents a new, added stimulus to the acceleration of scientific and technological progress in various areas of the Siberian economy, and to improving the well-being of its population.

3. INDUSTRY STRIDES AHEAD

The pace of industrial development in the coming years should be higher in Siberia and the Far East than in the USSR as a whole. We will now try to see what will be the future scale of industry, and to establish which problems in its leading sectors must be solved in the present decade and beyond. The basic contours of the economic growth of the eastern zone of the Russian Federation are laid out by five-year (middle-term) and long-term planning, and so we shall try to show not only the immediate, but also the more long-term effects of the planning decisions which have either been taken, or will be taken, according to the logic of economic development, in the near future.

There are a number of main links in the future development of the productive forces of Siberia and the Soviet Far East, which could be seen as the "carrying supports" of a new industrial boom here. They are the three long-term investment programs. Two of these (the West Siberian and the Angara-Yenisei programs) will comprise the setting up of large economic complexes whose territory will have an unusual concentration of investment. The first will involve the large-scale extraction of oil and natural gas, and the second will be concerned with the exploitation of hydropower, timber reserves, ferrous ores and chemical raw materials. In the wide expanses of the West Siberian Plain, from the Urals almost to the Yenisei, a new economic region will probably grow up—the Ob-Irtysh region. This in the near future will leave today's major oil-producing regions—the Volga and the Urals—far behind. Expenditure on setting up the economic complex in the West Siberian Plain over the estimated period will be 6 or 7 times greater than the total capital investment in the economies of the Urals and Western Siberia realised over 13 years before the war, and twice as great as the development of Eastern Siberia's productive forces between 1956 and 1965.

The scale on which the natural resources of this area are to be developed has not been seen before, and will hardly be seen in the foreseeable future, in other parts of the USSR (not including Siberia and the Soviet Far East).

A group of industrial centres and territorial-productive complexes will go up in the Angara-Yenisei basin, together forming the Angara-Yenisei industrial zone.

These two programs determine the main trends in Siberia's economic growth in the 1970s and 1980s. They are obvious examples of Siberia's "special case" in the unprecedented nature of these regional investment programs. These programs have now been joined by another—the program for building the Baikal-Amur Railway, and for the economic development of the natural resources of the adjacent territory. This program, which was put into operation in the mid-1970s, will mainly determine the scale of economic growth in the Far East, and to a lesser degree, in Eastern Siberia. Work to accomplish this enormous comprehensive program will probably continue into the next century.

The industrial output of Siberia will continue in the tenth five-year plan (1976-80) to increase faster than that of the USSR as a whole, as the task is still to ensure the continuing accelerated development of the natural resources and the consolidation of the economic potential of the Soviet Union's eastern regions. It is essential in Siberia to maintain high rates of growth in the output of the fuel industry, power, power-consuming ferrous and non-ferrous metals industries, chemicals, forestry and timber-processing industries. Increases in the volume of capital construction make it imperative for the building industry and the construction materials industry to keep ahead in development. In the Far East the extraction industries (fishery, forestry, timber-processing and ferrous metallurgy) are also intended to increase productivity, and this region will become increasingly important in providing goods for export.

This has been a very general survey of the prospects of economic growth in Siberia and the Soviet Far East, but we shall go on now to examine them in greater detail.

THE FUTURE OF SIBERIAN COAL

Man has known about coal since ancient times, but it was only the industrial revolution of the 18th and 19th centuries which really saw the beginning of the development of the coal industry. The milestones of this development are the introduction of various major coal consumers: the coal-furnace smelting of iron ore, the invention of the steam engine, the building of the railways, the development of steamships and the coming of electric power.

In recent times coal has been ousted from its leading role in the production of fuel and power by oil and gas which are cheaper to extract. In 1950 coal made up two-thirds of the fuel extracted in the USSR, but by 1970 this had fallen to a little over one-third. Does this mean that in time the absolute volume of coal mined will have to be reduced?

Naturally when man has mastered the thermonuclear production of power and heat there will be no more need to burn coal in power station furnaces, boilers, etc. But it is still premature to count on that being the case. Experts, moreover, also foresee the possibility that coal's sphere of application may increase. Some power specialists say that the demand for coal by thermal power stations will go up, and this will lead to a considerable increase in the consumption of coal, as opposed to the decreasing trend in the past. Their view was confirmed by the experience of the past few years, for when the price of oil went up, there was a revived interest in coal nearly everywhere in the world. Reserves of coal by far exceed those of oil and natural gas. Coal comprises 83 per cent of the world's accessible fuel reserves (as conventional fuel), oil 11 per cent and gas 5 per cent. Oil and gas are more profitably used as motor fuel and, particularly, for their by-products, that is, as raw materials which give an increased variety of products. This will eventually make it necessary to restrict the use of oil and gas for energy needs, and, in the words of Academician N. N. Semenov, "world power production should mainly be based on coal". Furthermore, our country's thermal electricity relies upon coal.

The USSR now mines 700,000,000 tons of coal, and it may be producing as much as 900,000,000 tons in 1980.

More than a quarter of the coal will go for the roasting of coke, and more than a half for energy production.

At present the European regions of the USSR produce more than half the country's coal, but their share will decrease in future, while the eastern regions will eventually be producing almost two-thirds of the Soviet Union's coal, for its extraction is considerably cheaper here.

It is envisaged to increase coal production in the Kuznetsk basin by about 70 per cent, and that of the Ekibastuz coalfield in Kazakhstan by several times. So there will be an inevitable leap in the location of coal mining, and it is being increasingly concentrated in the USSR's eastern zone.

The Soviet Asian regions have great potential for an economically justifiable increase in coal production. Over the last 15-20 years the previous estimates of coal reserves in Siberia have been radically revised, for between 1950 and 1970 the discovered coal resources of the Kuznetsk basin doubled, while those of the Kansk-Achinsk basin increased eight times. Two new coalfields have been opened—Aldan and Ulug-Khem, the first lying in the south of Yakutia, and the second in the Tuva Autonomous Socialist Republic, in the south of Eastern Siberia. The main value of Siberia's most important coalfield—Kuznetsk—is in its coking coals, and Kuznetsk coke is much cheaper than that produced in the Donets basin. This gives one grounds to imagine that Kuznetsk coke will oust Donets coke in the central regions of the European part of the country, where a major iron and steel industry has grown up around the iron ore of the Kursk Magnetic Anomaly. Kuznetsk will also continue to supply coke to the iron and steel industry of the Urals, Kazakhstan, and to Siberia itself, where a number of plants are to be built. Consequently the development of the country's iron and steel very greatly depends upon the development of the output capacity of the Kuznetsk basin.

The field of application of the Kuznetsk basin's power coal will relatively contract in the future, as Siberia will increasingly obtain cheaper fuels—oil, natural gas, and coal from the open pits of the Kansk-Achinsk field.

Though over the last ten years there has been only a small increase in the Kuznetsk basin's productivity of labour, the cost of extracting coal increased almost 50 per cent. This problem can be overcome in two ways: first by extending open-cast mining, and, in the pits themselves, by introducing extensive hydraulic extraction.[1] High-power hydraulic mines make it possible to double labour productivity in comparison with mechanical underground working, and building costs are 10-13 per cent lower than in "dry" mines of similar capacity. The cost of hydraulic mining is also lower. The world's first hydraulic mines were opened in the Kuznetsk basin in the 1950s, and the experience of working these mines gives an example for the future. The use of monitors, which wash coal out of the seams with their powerful jets of water, are extremely efficient and reduce labour consumption. Much work must be done, however, on perfecting the technology of hydraulic mining in order to avoid the pulverisation of coal, which accounts for considerable losses, more or less the same as those suffered with the use of traditional techniques.

A number of Soviet design offices are working on the "mine of the future", in which each worker should be able to mine 300-400 tons of coal every month, which is

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[1] The principle and technology of hydraulic coal mining were first proposed by Professor V. S. Muchnik.

considerably more than the present average production of Soviet mines, and several times greater even than the productivity of our mines which are totally mechanised.

The future of Siberia's coal industry depends greatly upon the development of the Kansk-Achinsk basin, with its colossal reserves of lignite. This is easily accessible, for the deposit lies in an old settled area. In places the seam is as thick as 60 metres, and lies so close to the surface that the coal can be mined from open pits. This means that powerful and highly-productive machinery can be used for the extraction and transportation of the coal, making it the cheapest in the USSR.

The favourable conditions in the Kansk-Achinsk coalfield makes it possible to open up super-powerful quarries which will yield between 40 to 60 million tons a year. Three or four such quarries could produce the same quantity of coal as was produced by the open-cut method in the whole of the USSR in 1970.

But this coal has some disadvantages which would limit its range of use: its relatively low heat-producing capacity, its softness and its high dampness. At the moment it is uneconomical to ship this coal over long distances. For this reason raw Kansk-Achinsk coal which has not been improved by processing cannot be used in power generators which require high-quality fuel, and can only be burned in large thermal power stations.

For this reason the decisive factor in the development of the Kansk-Achinsk basin over the present decade must be the setting up of very large thermal power stations on the spot. They are needed to fulfil Siberia's own need for power and heat. One particular result of this will be that part of the Kuznetsk power coal will be sent to the Urals. Kansk-Achinsk coal could also be used for producing power to be transmitted to the country's European areas, but this requires the building of high-voltage direct current power transmission lines.

It is planned to build 10 power stations in the western part of the Kansk-Achinsk basin, each of which will have a maximum capacity of 6,400,000 kilowatts—the most powerful in the world. Work has already begun on the gigantic open coal mine which will supply the big Beryozovo generating station.

The cost of still small yield of coal in the Kansk-Achinsk coalfield (in terms of reference fuel) is more than 50 per cent less than that of coal extracted from the Kuznetsk open pits.

When the Kansk-Achinsk field achieves a high production level, its coal will in a number of regions compete with oil and natural gas, and its advantage over open-pit mining in other coalfields will increase. Plan figures show that capital investment in the Kansk-Achinsk basin will be 5.8 times lower than that in the Kuznetsk basin, and 1.8 times less than investment in the Ekibastuz coalfield.

In addition to the direct burning in the furnaces of big thermal power stations, scientists have proposed a plan for the multi-purpose power-technological processing of Kansk-Achinsk coal. The plan, which as yet is in the purely experimental stage, envisages the setting up of power-technological combines which will produce electric power, high-calorie solid fuel (low-temperature coke, produced from lignite by thermal processing) and tar. This fuel will be very easy to transport over long distances, and the tar can be used for processing into the traditional byproducts of the coking industry (benzene, naphthalene, etc.) but at a lower cost than in ordinary coking furnaces.

Research, then, has established a fairly extensive sphere of application for Kansk-Achinsk coal (in power, chemicals, metallurgy and the building materials industries), all of which will be highly efficient.

The scale on which the Kansk-Achinsk basin will be developed depends upon the building of a group of powerful thermal power stations on the coalfield and the establishment of transmission lines to take the power to Western Siberia and further, and also upon the volume of raw and dressed coal which will be shipped outside the basin. The problem here is not the mining of the coal, but the way it will be used. Extraction is not so difficult, for the coal lies near the surface and the railway runs alongside. But the difficulties lie in the setting up of transmission lines over a long distance and finding of an economical way of processing and transporting a material which nature has not "finished off" to the satisfaction of its consumers. If coal mining in the Kansk-Achinsk basin is developed quickly, it will be possible to get Siberia's new hydroelectric stations into operetion as soon as possible, as this in turn is essential if the Siberian Integrated Power Grid is to work at full strength.

At first sight it might seem that in long-distance power-transmission the Kansk-Achinsk basin has a serious rival in the Ekibastuz basin in Kazakhstan, whose resources are planned to be used primarily for the same purpose. The Ekibastuz basin is indeed situated nearer to the centres of consumption. Distances from Chelyabinsk and Moscow are about one-and-a-half times less than the distances of these cities from the Kansk-Achinsk basin. This compensates for Ekibastuz's 25-30 per cent higher cost of mining compared with that of the Kansk-Achinsk basin. It is planned to build a grid of power stations with a total capacity of 15,000,000 kilowatts and more near Ekibastuz, and power from these will be transferred by 2,500 kilometres of transmission lines to the Volga and the Moscow areas.

However Ekibastuz's resources are relatively limited, and they will not fully meet the power needs of the country's European regions. The resources of the Kansk-Achinsk basin will also be called for. So Ekibastuz will act as a kind of first-stage booster rocket, in that the flow of electricity to the west which it initiates will in future be fed by the coal of the Kansk-Achinsk basin.

Is there any coal in the regions east and south of the Kansk-Achinsk basin? Until now Eastern Siberia's main coal supply has been coming from the Cheremkhovo-Azeia basin, but the Cheremkhovo coalfield is now becoming exhausted after being worked for many decades, and it has become essential to force the production of coal in the Azeia field and begin work on developing the Mugun field.

Transbaikalia offers the prospect of developing the relatively recently discovered Tugnui basin, where coal can be cheaply mined by the open pit method. Cheap fuel is also produced by the other trans-Baikal deposits—Kharanor and Gusinoozersk.

Much coal is also offered by the Minusinsk basin in the south of Krasnoyarsk Territory. If this were to be opened up it would make it possible to release more Kuznetsk power coal for the European regions of the country. Eastern Siberia can safely depend on its local coal resources, and this has great significance for the area's development of industries which require more electrical power and heat. Coal mining in the Far East is now increasing due to the reconstruction of the Raichikhinsk cutting, and the opening up of two new ones in Bikin and Pavlovsk. At some time in the future it may be necessary to open up the Lankovsk cutting in Magadan Region. But the greatest possibilities for increasing solid-fuel production are offered by the south Yakutian basin. The scale on which it will be worked depends on the future development of the trans-Baikal iron and steel industry and the volume of exports to Japan.

SIBERIAN OIL AND GAS— "THE DISCOVERY OF THE CENTURY"

Oil and gas have played a more dramatic role in history than even the gold rush of mid-19th century America. Oil lifted not only individual regions, like Texas, but whole countries, Kuwait for example, out of their "primitive condition" and obscurity into the ranks of the major industrial regions or made them into oases of intensive industrial development.

In Russia oil turned Baku into an important industrial region, and the rapid development of the Volga area's productive forces after the war was also in great part due to its vast oil resources.

World oil production has already risen to 3,000 million tons per year. Most of the world's oil reserves lie in the Middle East, and in future South-East Asia will become much more important in oil production than at present. For many decades oil has been the chief commodity in foreign trade, which is not only because of the high absolute consumption of oil, but also because nearly all the major oil-consumers do not have their own reserves. In the 1960s West Europe's oil consumption tripled, and that of Japan increased to a high degree. Forecasts say that by 1980 world oil production could have increased almost by 100 per cent in comparison with 1970, and it is estimated that the industrial countries will require as much oil in the next decade as was produced in the whole world up till now. It is true that the energy crisis in the capitalist world has forced many countries to limit oil consumption, but demand is increasing despite this. The Soviet Union has become the world's largest oil-producing country since it overtook the USA in 1974, and a considerable role in the Soviet Union's success goes to Western Siberia.

The search for oil and gas in the West Siberian Plain, begun before the war, was renewed in 1948. Five years later the prospectors' first success was crowned by a strike of natural gas on the Beryozovo field, and in 1960 Siberia's first industrial oil production began on the Konda river deep in the taiga. From then on new discoveries followed one after another.

For a long time gas prospectors could not find any large deposits, until in 1962 they discovered the first gasfield inside the Arctic Circle, where, as it was later to become clear, nature had generously laid down an underground store of this highly efficient resource. At the beginning of 1970 the surveyed reserves of the Siberian gas-bearing area in the categories $A+B+C_1$ were estimated to be 6,000,000 million cubic metres, and the following year this figure had risen to 9,000,000 million. The world's largest gasfields were discovered: Urengoi with an estimated 5,000,000-8,000,000 million cubic metres, Zapolyarnoye and Medvezhye with over 1,500,000 million cubic metres each. Geologists calculate that the overall potential reserves of gas in the north of the West Siberian Plain are in excess of 40,000,000 million cubic metres, and it is considered that apart from the unique gasfields which have already been discovered, another 5 or 6 will be discovered, with reserves of more than 1,000,000 million cubic metres in each.

At the beginning of 1970 geologists estimated that the whole of Siberia, including Yakutia, had reserves of almost 60,000,000 million cubic metres of gas.

We have seen that two-thirds of Siberia's expected gas reserves lie in the north of the West Siberian Plain. A survey of the reserves in Tyumen Region shows that they are greater than the total known reserves in the USA. The work of geologists in Tyumen Region far exceeded planned calculations, and they exceeded the planned finds of gas over the Eighth Five-Year Plan (1966-70) more than 9 times and doubled those of oil.

By the beginning of 1973, 11,800,000 million cubic metres of Tyumen gas were put into industrial operation. This is more than a quarter of the world's known reserves, and almost three-fifths of the USSR's reserves. The Soviet Union has substantially overtaken the USA in the volume of known reserves, and Tyumen geologists consider that in the not distant future the West Siberian Plain alone will be supplying up to 1,000,000 million cubic metres of gas a year.

The major gas deposits of Western Siberia are exceptionally productive, and so the number of gas wells needed in Siberia will be small. In order to extract 100,000 million cubic metres of gas a total of 70-80 wells will be needed in the Medvezhye and Urengoi fields, as against 600 in the Komi ASSR and as many as 1,500 in the Ukraine. The Siberian gas deposits also lie nearer to the surface and the rocks are easier to drill than in a number of other gas-bearing provinces. This has a considerable effect upon the cost of extraction, and the favourable geological conditions will compensate for other factors tending to increase costs, and the gas of the forbidding North will be more economical to produce than in the gas-bearing province of the southern belt (Gazli in Central Asia, Shebelinka in the Ukraine, etc.).

The industrial development of the Medvezhye deposit began in the spring of 1972, and by mid-March 1973 nine super-powerful gas wells were in operation. It took four months, much less than expected, to construct gas-gathering station No. 2, which is highly automated. In 1973 work was begun on developing the Urengoi gasfield.

As we noted, Western Siberia's first oilfield was discovered in 1960, and following that event the discovered reserves of oil increased extremely rapidly; by the beginning of 1970 there were 41 oilfields in operation in Tyumen Region. Western Siberia's reserves of oil by far exceed those discovered in the Volga-Ural oil-bearing province, and the extraction of oil in the West Siberian Plain is growing much faster than was expected even a few years ago. In 1966 it was planned to increase the production of oil to 20-25 million tons by 1970, but the Siberian oilmen fulfilled this plan ahead of schedule and in the last year of the Eighth Five-Year Plan production rose to 31,000,000 tons. The country's first oil centre, Azerbaijan, despite its 100 years of development, has not been able to achieve a production of more than 21,000,000 tons. Western Siberia achieved the same volume in five years. In 1965, the first million tons were extracted, and by May 1969 Baku's output was equalled and West Siberian oil was being pumped to the European regions of the country, whereas a few years before that it was thought that this would not occur before 1972. It took the Ural-Volga area 20 years to get its annual oil production up to 100,000,000 tons, while Western Siberia did so in half the time, and produced 116,000,000 tons in 1974.

At the end of the 1960s it was established that the West Siberian Plain has almost half of the USSR's known oil reserves. Geologists at first discovered deposits which they compared to those of the Ural-Volga oil- and gas-bearing province, but in a few years time further discoveries made it clear that the potential of Western Siberia exceeded all such comparisons. They found multi-layer "oases" of oil which held vast reserves at little depth. This oil is of outstanding quality, containing little sulphur and other impurities, and it can be extracted at very high speeds, much faster than in other rich deposits in other regions. The output of the Ob oil wells is nine times higher than the whole of the oil industry of the Tatar Republic and Kuibyshev Region. Therefore the gigantic oilfields of the Ob area—the Samotlor oilfields—can achieve the same output of oil as, say, the Romashkino oilfield in the Tatar Republic using 8 times fewer wells, and so oil production in the harsh, uninhabited Ob region is cheaper than in the Volga and Ural regions with their favourable natural and climatic conditions.

Though geologists are still studying the Samotlor deposit, and they still have to map its limits, its unique nature is already clear, and it is already known that it has untold reserves of oil and extremely high productivity. In 1967 it was found that a number of wells yielded as much as 1,200 tons of oil a day, and one Samotlor well has been giving a constant flow of 1,500 tons a day for several years, which has never happened on any other Soviet oilfield. The Samotlor oil wells will be capable of giving 20-30 times more oil than any well in the USSR gave on average up to the beginning of the 1970s. Some of Samotlor's wells compare favourably in productivity with those of Iraq which are the most productive in the Middle East.

This oilfield has unique development prospects. Samotlor is one of the world's largest oilfields, and its annual yield of oil has already risen to 100 million tons, which is what the whole of the Tatar Republic produced in 1970. But its output reached 1,000,000 tons as early as 1969! Samotlor will probably reach its peak output at the end of the 1970s and stay on that level for a number of years. Reserves here will make it possible to extract large volumes of oil for a number of decades. This is unprecedented in world oil history.

At present it is difficult to say with certainty which other West Siberian oilfield will be able to compete with Samotlor in productivity, but there is practically no doubt that Samotlor will not be the only major deposit in the region. It looks as though Siberia will break many records in oil and gas production.

Geologists foresee the possibility of discovering new giant oil deposits. Large reserves of oil are thought to lie within the Arctic Circle, and discoveries are expected in the south of Siberia and in a number of Far Eastern regions. The continental shelf of the Arctic Ocean also promises oil and gas.

The opening up of the oil and gas reserves of Western Siberia will have far-reaching consequences for the Soviet economy in many ways.

The West Siberian oil- and gas-bearing province is providing a firm and long-term base for the progressive development of our country's oil and gas industry. For the time being the main producer is the Ural-Volga area, where, though fuel has been extracted here for more than 30 years, some oil wells are on the way to retirement as their stocks become exhausted.

It was planned to increase the oil output of the West Siberian Plain to 100-120 million tons in 1975, and to 230-260 million tons in 1980. Then in 1975 the target was raised to 120-125 million tons. This task was based upon the uniqueness of Siberia's oil potential which made possible the rapid increase in oil production. In the first years of the Plain's oil exploitation the production doubled every year, from 3,000,000 tons in 1966 to 6,000,000 tons in 1967 and 12,000,000 in 1968.

In 1969 there was an increase of more than 9,000,000 tons, and in 1970 of more than 10,000,000 tons. There is no other oil-producing region which gives the constant increase in output over a long period of which Western Siberia is capable. In the Ninth Five-Year Plan the average annual increase of oil output in this region reached 23,000,000 tons, and this might rise to 30-32 millions in the period 1976-80. According to the latest statistics Siberia gave almost 150,000,000 tons of oil in 1975, thus exceeding the planned figure of 120-125 millions. The 25th Congress of the CPSU adopted a decision to increase Western Siberia's production of oil in 1980 to 300-310 million tons.

Western Siberia's output is growing with a snowball effect, and the reserves which have been discovered here are sufficient to allow the tempo to continue at the same rate. At the end of the Ninth Five-Year Plan, in 1975, the West Siberian Plain gave a third of the USSR's total oil production, and after 1980 it will probably contribute more than half.

Western Siberia's unique gasfields also promise a growing output over a long period, and it will be possible to create the USSR's largest gas-producing centre here with the capacity to supply a consistently vast quantity of cheap fuel and chemical raw materials to the chemical industry for a number of decades, and also exporting these on a wide scale to various European countries, and even possibly to the USA.

The opening up of the West Siberian oil and gas reserves is making it possible to raise the efficiency of the USSR's oil and gas extraction industry. Of the total expenditure on the production of one ton of oil (in terms of reference fuel) one half goes on prospecting, and the other half on the actual extraction. In the case of natural gas, as much as four-fifths of the total production costs are taken by prospecting, so it is of great importance to be able to cut back the relative expenditure on actually locating reserves. Prospecting costs are much lower in Western Siberia than on average in the USSR. In the 1960s costs of locating one ton of oil in Tyumen Region were 11 times less than average, and for natural gas 20 times lower.

Western Siberia's oil and gas are also cheaper to extract. This may seem surprising, for conditions here are difficult, with the fields lying in severe northern regions, which have long frost periods, swampland with no roads, and so on. But high cost factors are compensated by other factors: the fact that gas and oilfields are very close together, the high concentration of oil and gas in exceptionally large fields, their relatively small depth, the softness of the rock and the high productivity of the wells, which we discussed earlier. For these reasons the cost of extracting Western Siberian oil will be almost 3 times lower than the USSR average, and 1,5 times lower than costs in Central Asia.

Conditions in Western Siberia allow us to choose the best of the discovered deposits, and not simply exploit the first to be discovered, as was the practice in the past. The former procedure was that any oilfield of 10,000,000 tons was surveyed and put straight into commercial operation. The first fields to be discovered in Western Siberia followed this rule, as they were not of the incredible size of those which were later discovered. Then the situation changed radically, and now it is considered unviable to exploit Western Siberian deposits for the time being if they hold less than 50,000,000 tons of oil and are situated relatively far from the main pipeline. Until fairly recently oilfields of that size in the populated areas of the country were regarded as some of the largest, and there was no hesitation about turning them over to commercial development. Now some

Tyumen oilfields are "left in reserve" while other larger deposits nearby are developed. The same pattern is true of gas. Such a choice provided by the wealth of oil could be very important to the industry from an economic point of view.

However Western Siberia's underground treasures cannot last for ever, and there is a need to find an eventual replacement for its oil and gas reserves.

Siberian and Far Eastern geologists consider that when the West Siberian Plain passes its peak of oil and gas production, other Eastern areas will be able to take over from it. Chief among these is the Siberian platform, which lies between the Yenisei and the Lena. It probably possesses no fewer reserves of oil and gas than the West Siberian Plain, since it has twice as many promising areas. There are considerable grounds for this optimism. The newly-discovered Vilyui oil- and gas-bearing province contains an estimated 12,800,000 million cubic metres of gas. If a gas refinery of 2,000,000-ton capacity were to be built in Yakutia itself it would satisfy the needs of the republic itself and make it possible to do without the expensive fuel which is at present brought in from distant areas. Apart from the Vilyui province one should also note the Lena-Aldan and the Anabar provinces in Yakutia where promising initial exploration has encouraged the intensification of prospecting in recent times.

There will be a market for Yakutian gas not only in the republic but in other areas, including Magadan Region. It may also be exported to countries like the USA and Japan.

This will give rise to the need to build long-distance pipelines, and there is a plan to build a 2,100-kilometre pipeline to Magadan port which is open all year round where ice-breakers clear the channels in winter.

In 1971 eight large multi-seam gas and gas condensate fields were discovered. Experts also consider that Yakutia has highly promising conditions for the discovery of oil deposits.

It is also expected that large major discoveries of oil and gas will be made in the southern regions of the Siberian platform, mostly in Irkutsk Region, where the Markovo field is already being developed. In 1972 a deposit near Bratsk gave the first commercial inflow of gas (200,000 cubic metres a day). In all, Siberia possesses more than half the USSR's gas-bearing territory, according to forecasts. According to the theory of mineral formation, the most remote regions of the Soviet North-East promise extremely rich finds of oil and gas. The presence of oil and gas has been established in Kamchatka, for instance. Indications of oil and gas have been found in the south of the Far East in Khabarovsk Territory. Scientists maintain that major oil reserves are to be found in the Far East, and that all that is needed is to step up the search.

In recent years there has been increased interest in the Paleozoic deposits of the southern regions of Western Siberia, where geologists assume the presence of oil. These studies began in 1968, and in three years one of the wells in Novosibirsk Region yielded oil. These early finds raise hopes of finding commercial deposits of oil here, but only time can deny or confirm this.

The Western Siberian ocean of gas and oil is a reality, and a priority concern. But it offers its problems too; the main ones being how to penetrate this underground treasure-store, and how to exploit its wealth. And this in turn gives rise to a series of complex difficulties.

In the first place, man's freedom of action is limited by natural conditions: the climate, the thermal patterns and the thermophysical nature of the rocks, the huge water-logged areas of land, extensive swamps in many areas, and so forth. "Samotlor is not only the lake," writes a journalist, "that is also the name of the quagmire which spreads for tens of kilometres around. Your feet get stuck in the mud, so imagine trying to reach the lake with equipment and machinery. Development teams waited for the winter so that they could build an ice-road, but even the frosts did not help. The crust of snow and ice broke under the caterpillar tread, and the tractor began to sink, until it completely disappeared." To back up this vivid impression by hard facts: 60 per cent of the Samotlor deposit is covered by swamp, and 20 per cent by the lake. The building season lasts only two or three winter months — but in what conditions! Here is another description of Samotlor, this time in the winter of 1968/69, when for weeks on end the temperature did not rise above −40°C. "The engines of the bulldozers, excavators and pipe-layers refused to work in the bitter frost. The fuel froze up." Meteorological observations over a number of years show that the average daily air temperature in this area from December to March is −25°C. The non-frost period lasts only three and a half months, but then it is difficult to work because of the various winged blood-sucking insects, whose ferocious bites greatly lower the productivity of labour. But despite the difficult natural and climatic conditions and the lack of roads at the beginning, the extraction of oil got under way amazingly quickly — only three years after the first prospecting bore-hole discovered oil in 1965. By the end of 1974 the area had 175 kilometres of concrete roads, including the famous "ring-road" around the lake.

The second obstacle is the northern wilderness, with its tiny population. The industrial and social infrastructure essential for beginning intensive development of economic activity was lacking — no modern transport network, no power, no construction industry, no water supply or drainage, no accommodation, no community services, and so forth. There were no building sites prepared, or even elementary cart-tracks. The development areas were practically isolated from the outside world. There was only one transport artery, the river Ob, which linked these remote places, albeit for its short navigation season, with the industrial centres of Siberia. This meant that work on developing the oil and gas resources had to be initiated by the unusual method of landing large detachments of geologists, drillers and builders in little-known territory. These "paratroops" had to live for a long time in field conditions, denying themselves the most elementary domestic comforts.

The third difficulty was the low level of advance studies of the area's natural and geographical characteristics, biological environment, human living conditions and man's adaptability to an unusual environment, the machinery's "powers of endurance", etc. And added to that, the lack of experience of intensive development of the North's natural resources on such a scale. Much of what geologists, builders and oilmen had to deal with was unexpected discovery, and stumped them at first as it did not correlate with their accustomed ideas and professional experience.

The fourth obstacle was remoteness from the regions which supply the North with means of production, consumer goods and manpower.

This predetermined the decision to accompany the development of oil and gas extraction by the building of all the necessary support units: housing, roads, pipelines, technical networks, etc.

The first task was to build roads to serve prospectors and the assemblers of drilling equipment. Road-builders came up against permafrost, countless rivers and lakes, marshes and the lack of local road-building materials.

One kilometre of metalled road in the West Siberian oil and gas regions cost 5-8 times more than in the central areas of the USSR. Here is how roads were built in the central Ob district. First a layer of turf, usually a few metres deep, was dug out along the course of the future road (in building the Samotlor roads, as much as 15 metres of turf had to be dug in places), then the wide trench thus formed was filled with sand, followed by gravel, which was then rolled. Only then could concrete slabs be laid. These roads were naturally very costly, and a cheaper technique, therefore, was evolved. Water was squeezed out of the turf layer, thus making it solid. This eliminated the need to dig out the turf, and drastically reduced the cost of road-building.

The construction of a standard network of roads between the oil and gas wells in the West Siberian Plain would not only have been too costly, but would have required too much time. Most of them are needed not for regular everyday use, but for periodic inspection of groups of stations, oil gathering stations, etc. Therefore on these sections use can be made of cross-country vehicles which can negotiate otherwise impassable tracks.

Designers got to work on vehicles for use in roadless terrain, and one of their creations was the "Vityaz", a caterpillar-tracked bog and snow vehicle. This is a very tough automobile which can negotiate deep snow and bog at a reasonable speed on its special rubber and high-alloy steel tracks.

Naturally the organisation of mass production of roadless terrain vehicles and building of the few indispensable roads will take some time. In order to set the "oil conveyor-belt" in motion, a temporary solution to the transport problem had to be found.

Ice-roads began to be used to transport bulky and heavy drilling machinery. This was done by clearing a passage for the road in winter, snow was rolled down to a depth of one and a half metres, and then the road was allowed to freeze over. This was only a temporary solution, and permanent roads and large numbers of cross-country vehicles would follow.

The combination of permanent and reinforced roads made it possible to raise Soviet drilling work to a higher level in summer than in winter, whereas in the northern regions of Canada this work can be performed only in winter.

Ice-roads are built on soil in the permafrost zone, but could not this principle be used to construct reliable permanent roads? It is an enticing thought, but one which must be thoroughly tested in nature before a final decision can be taken on this road-building method. It must justify itself both technically and economically.

In exploratory drilling much time is taken up by dismantling the rig, transporting it to another site, and reassembling it. In the roadless Ob area these operations are very difficult and protracted. So Tyumen enthusiasts have suggested the ingenious solution to this problem of mounting the rig on a hovercraft, so that it can be transported without dismantling, giving an enormous saving in time. Tyumen Industrial Institute has designed such an original device, and it has been tested successfully. It is now the job of the manufacturers to follow up!

Other new methods have been evolved for drilling and extraction in the specific conditions of the West Siberian North. As there are relatively few "dry" places on which rigs can be set up, wells must be economically distributed. This brings savings also from the point of view of cutting down the length of roads, water-supply mains, pipelines and power lines. The high concentration of oil and gas reserves makes it possible to sink wells close together in clusters of between five to ten inclined bore-holes which "grasp" a wide area of the oil reservoir like the tentacles of an octopus. This system speeds up the development of the oilfield and reduces costs, as is the case, for example, with Samotlor. By the beginning of 1970 a cluster of wells had been sunk here, each of which yielded more than 300,000 tons of oil a year. By 1972 there were 200 wells in operation at Samotlor. Clustered inclined wells give a saving of 30,000-40,000 rubles per well as compared with straight wells. Another development was that some workteams took to working two clusters of wells at one time, which helped to reduce the former idle time of equipment.

For the first time in the world monitor bits were used with turbodrills in the Middle Ob field. This system doubles the mechanical speed of penetration.

Many wells are flooded in spring, and this used to mean a halt to drilling work, but now cluster-drilling rigs are mounted on railway trucks and rollers so that work can continue.

The West Siberian oilfields have become a testing ground for new technical systems, equipment and production organisation methods. The best ideas which have been tested on other Soviet oilfields are also used here: the radial system of gathering oil and gas, and in place of bulky and uneconomical diesel or mobile generators, gas-turbine generators running on local head gas are used. Much work is being done on automating oil wells.

The automatic and telemechanic systems already in operation at Samotlor aid in the measuring and separation processes and in injecting water into the oil beds. Whereas the pump plant used to have a staff of 16 people, now one duty operator watches over it. It is planned to use computers to centralise control over drilling.

Despite the harsh natural and climatic conditions, this area has achieved the fastest rates of boring producing wells in the Soviet oil industry and has cut down the time lag between finishing the boring of one well, and beginning work on another.

Due to their high productivity and the progressive equipment and working methods the Tyumen wells have been able to reduce their labour force to a relatively small size. In 1970 the labour required to produce one million tons of oil averaged 220 men throughout the entire Soviet Union, whereas Western Siberia required only 73 men. This great difference in labour consumption has great economic significance, for expenditure on accommodating one worker in the Middle Ob oilfield is about twice the corresponding amount in the old oil-producing regions.

Scientists have suggested new methods of increasing oil yield. Western Siberia has the world's largest supply of subterranean thermal waters, and these can successfully be used for heat treatment of the oil beds and to force an extra amount of oil out. This method could be very effective in increasing the productivity of Western Siberia's oilfields.

Design organisations have evolved an original plan for extracting and transporting West Siberian gas. The reserves are so large that it would be unfeasible to use traditional extraction methods, which would take too much time and expense. The usual initial output of a gas well is 500,000-700,000 cubic metres a day, but West Siberian wells are expected to give 3,000,000-5,000,000 cubic metres. At the Urengoi gasfield an experiment was conducted to confirm the possibility of creating such gas wells. An experimental large-bore well produced as much as 4,000,000 cubic metres of gas a day. Batteries of such high-yield wells could be sunk and controlled entirely automatically. Every gathering station could receive up to 50,000,000 cubic metres a day (as opposed to the 5,000,000-10,000,000 cubic metres produced by similar set-ups in other areas). The first high-yield extraction point is to be set up on the Medvezhye gasfield which was opened up in spring 1972. In March 1973 there were 9 powerful wells in operation here, which in two and a half months produced 1,000,000 million cubic metres of gas, which means more than 13,000,000 cubic metres a day.

These giant gasfields will be the only ones of the kind in the world. Their main effect will be the cutting of the proportional capital investment by 50 per cent and the cost of extraction by some 30 per cent, as compared with small gas wells. The speed of gas production will be almost tripled.

The resources of the West Siberian Plain are being developed on a scale unknown in any other region of the USSR.

This means that the areas in which oil and gas are being developed have already become major construction sites. This process of construction is in itself extremely complex, and so the reduction of labour costs in building various enterprises here has a great effect. The main way this can be achieved is by industrialising construction, and by making a clear distinction between the industrial functions of the North and those of the South Siberia.

Designers and builders have already suggested a number of progressive technological and organisational ways of solving the problem. Much experience was gained in the Siberian North of structural unit construction. Estimates showed that nearly all structural units of gasfield buildings could be prefabricated in factories in the southern zone of Tyumen Region. These units are then transported to the North to be assembled. Boilers, compressor and pump plants, for example, are assembled inside a building consisting of a metal skeleton and covered by some light building material, under which the plant is assembled. This greatly reduced the number of workers actually employed on the northern building sites, there was no need to build expensive ferro-concrete structures, and much less accommodation for building workers is required. In Tyumen in 1969 the first section of a prefabrication factory manufacturing structural units for housing and public utilities was put into operation. These were for assembly in the North. In 1969 an extensive experiment was held in Tyumen Region to test the advantages of the structural unit method. Two building organisations were set up, and it was found that the unit method almost halved the cost of building work and the building time was three times less by comparison with the former method of construction.

Aircraft were used to deliver the units to the assembly site. Between 1969 and 1970 this new method was used to build 11 pump plants injecting water into oil beds, 15 boilers and 10 generating stations. The Kuminsky oil-pumping plant on the Shaim-Tyumen pipeline was assembled from more than 30 prefabricated components. Tyumen pioneered the application of the complete building components method to the Soviet oil industry.

On the initiative of Y. P. Batalin, an eminent construction specialist, a complex of industrial buildings for the Pravdinsk oilfield has been designed. Nearly all the extraction plant will be built from prefabricated structural units. The assembling of the units will be the task of a mobile building team sent, with all the necessary equipment, to the North by the factory. This will avoid the need to bring in builders to work here for years on end and build large-scale housing for them.

This system will be probably used in the building of the gasfields of the North.

There are designs to build small standard settlements in the Far North. The components of these can be packed and then conveniently transported over large distances. The "packages" can be brought to the site by aeroplanes and helicopters, and could contain the components of dwelling houses, communal buildings or parts of industrial buildings which could be assembled on the spot.

Oil and gas pipelines are being built on a very large scale, and more than a third of the cost of construction in the north of Western Siberia goes on them. As a rule earlier pipelines were laid in areas of the USSR which had more favourable natural and climatic conditions and flat relief, but recently more and more pipelines have been laid in the North, where builders have to work in a harsh climate, and in roadless terrain, where one must literally force one's way through the forests of the virgin taiga and over vast swamps. Despite this Soviet people have been able in record time to build the world's most northerly oil and gas wells and pipelines. Whereas Canada's most northerly wells and pipelines lie around the 55th and 56th parallels, those of Western Siberia function in a subarctic zone north of the 60th parallel. The 1,000-kilometre Ust Balyk-Omsk oil pipeline and the Punga-Perm gas pipeline, which is even longer, have been in operation for quite a few years.

The laying of big trunk pipelines in Siberia is a highly-mechanised branch of the construction industry and makes wide use of up-to-date technology. It has its own fleet of special vehicles and machines adapted for work in swamp areas. These include rotary excavators, pipe-layers and transporters which can negotiate many types of terrain, mobile drills and pile-drivers. New insulating materials have increased the life of pipe insulation threefold, and prefabrication is widely used.

It was decided to reduce the cost of pipe-laying by minimising depth at which they are laid in the earth and to lay several pipes in one trench. In laying super-powerful gas pipelines all known methods have to be used, but the most expedient method seems to be laying the pipes above ground, either in an embankment or on supports. This promises great savings.

Now let us examine how Siberian gas and oil will be used and how it will be delivered to the consumers.

Two large rivers, the Irtysh and the Ob, dissect the West Siberian Plain from north to south. But in which direction will the new river, the oil and gas river, flow? As far as gas is concerned, it will mainly run west from Tyumen, while Tomsk will send its supply south to be used in Siberia itself.

Tyumen Region is far richer in gas than its easterly neighbour Tomsk Region. But Tyumen Region's demand for gas is small compared with the potential volume of output, which, as we said, will reach incredible figures. Tyumen Region is near the Urals, and not so very far from the Central region of European USSR, and so Tyumen gas is mainly marked down for supply to the European areas of the Soviet Union. The Urals area was the first to receive Tyumen gas by means of the Igrim-Punga pipeline which was opened in 1969. This pipeline was subsequently extended to Nadym, the area of the richest Tyumen gasfields. The Nadym-Punga gas pipeline, which went into operation in 1972, supplied the Urals with gas from the Medvezhye gasfield whose reserves will be exploited for many years to come.

Apart from the Urals, Tyumen gas is also consumed in the European areas of the USSR. The Siberia-

Moscow gasline was built in the incredible time of one year. It starts from the Medvezhye gasfield, crosses the Urals and passes through Kazan and Gorky before arriving at the Soviet capital. This over 3,000-kilometre super-gasline was opened in 1974, and will eventually deliver fuel equivalent to several thermal power stations with a total capacity of 7,000,000 kw. In order to transmit a large volume of gas, pipes of exceptionally large diameter were used in places.

The builders had to negotiate 400 kilometres of impassable swamp, 1,100 kilometres of forest and 23 rivers and lakes including major rivers like the Ob, Volga and Kama. The two main aims of this giant pipeline were to cover the growing demand for cheaper fuel in the Central regions of European USSR and to increase supplies of natural gas for export. Since 1974 the Federal Republic of Germany has been receiving Soviet gas, and this was followed by exports to the European socialist countries, and to France, Italy, Austria and Finland.

The great increase in exports of Soviet gas is one of the results of the USSR's consistent policy of extending external economic contacts and achieving active economic cooperation with the highly industrialised capitalist countries. As we suggested earlier, Tyumen gas could be exported to countries outside Europe, and the USA has shown a great interest.

Tyumen gas has many consumers, and enormous quantities will be needed to satisfy their needs, at first tens and then hundreds of billions of cubic metres a year. It must be pointed out that not one country has transmitted such large amounts of gaseous fuel and raw material over such long distances. This means designing gas pipelines of a capacity unknown in the world, and the Soviet Union has become a pioneer in this field.

Tomsk gas, on the other hand, will first go to the

Kuznetsk basin area, from where it will go to Altai and Novosibirsk Region by means of branch pipelines. The first section of this project will be 1,621 kilometres long and will transmit 8,000 million cubic metres a year. The second section will double the supply of gas. Tomsk gas will do much to increase the efficiency of industry. First of all it will be used in Western Siberia to intensify productive processes in metallurgy, chemicals and the manufacture of building materials. The use of natural gas in blast furnaces enables the same plant to produce more than 1,000,000 tons more pig iron and use up 2,000,000 tons less coking coals than at present. The cost of producing ammonia, chemical fertilisers and other chemical products will be reduced by 1,5-2 times. The production of cement will be greatly increased.

In the second place, Tomsk gas will be used to switch urban power stations from coal to smokeless fuels, which will do much to improve the health situation in West Siberian industrial centres.

Siberian gas has for a number of years been piped to the Norilsk Mining and Metallurgical Combine, the largest in the North. Gas made it possible to stop using coal, being several times cheaper, the Norilsk mines were closed and the city's power stations ceased to pollute the air with the products of coal combustion.

Gas discovered in the basin of the Vilyui river in the Autonomous Republic of Yakutia is now being supplied to Yakutsk, its capital.

Until recently Middle Ob oil was sent for processing through Omsk to Eastern Siberia. In order to reduce the distance, and hence the cost of transporting this oil another pipeline had to be built from the oilfields to the south-east, and in 1972 the first section of the Aleksandrovskoe-Anzhero-Sudzhensk pipeline was opened. The 800-kilometre pipeline cuts through ancient taiga and crosses the Vasyugan swamp, the largest in the world. The Middle Ob oil now has a direct link with the oil refineries of Eastern Siberia.

Increasing quantities of Siberian oil will also be piped to the European part of the Soviet Union. At first it was carried by the old Tuimazy-Omsk pipeline, which was originally laid to supply Bashkir oil to Siberia. So the river of oil had to change its direction.

This pipeline could not cope with the growing flow of Siberian oil, and in June 1973 the new Samotlor-Almetyevsk pipeline was opened. It stretches for more than 1,800 kilometres and was built in the record time of one year.

But even the new pipeline was not sufficient for bringing Siberian oil west, and so yet another pipeline was built, running almost parallel to the Samotlor-Almetyevsk line and terminating on the banks of the Volga.

The distribution of supplies of West Siberian oil must also be correlated with the development of the refining industry. In Siberia crude oil is refined in Omsk, and Angarsk, Khabarovsk and Komsomolsk-on-Amur also refine Siberian oil. Existing refineries can take further quantities of oil, but there are limits to this, and so a number of new refineries are planned to be built in order to process West Siberian oil. In Eastern Siberia, for example, a refinery is to be built very quickly in Achinsk where building experience and equipment is available after the construction of the alumina plant.

Up till now oil has only been exploited in the Far East on Sakhalin Island. Though its output is relatively small, Sakhalin oil is very near to its consumers, and for many years has been refined in Komsomolsk-on-Amur and Khabarovsk. Sakhalin will probably be able to greatly increase its production of oil by opening offshore deposits, but as plans for developing the seabed are still very uncertain the supply of West Siberian oil to the Far East is to be stepped up. Pipelines and railways are being built to transmit the oil over this vast distance—6,000-7,000 kilometres. Crude oil will be refined in the Far East by plants like the refinery which is to be built in the port of Nakhodka. Near the old harbour will be built a new port which is also intended for oil shipping.

The Far East has great prospects in the development of its oil and refining industries and in increasing the volume of petroleum products for export.

THE FUTURE OF CHEMICALS

The development of petrochemicals in the coming decades will be concentrated in Siberia. It will be fed by the hydrocarbons produced by oil extraction (head gases), and by gas and oil refining.

West Siberian oil is of considerably higher quality than that of the Urals and the Volga and is easier to refine, mainly due to its lower sulphur content. This is essential for refining, for sulphur is a "poison" to catalysts. Siberian oil, moreover, is outstanding for its higher yield of light oil products and head gases, which are a valuable feedstock for the petrochemical industry.

But one cannot ignore the fact that Siberian oil will also be consumed by other regions of the USSR both as fuel and for refining. The problem is to establish an economic basis for the proportional distribution of Siberian oil between its local and external consumers.

A tendency has arisen for the refining industry to gravitate towards areas of dense, or concentrated, consumption of petroproducts in the form of motor and boiler fuel, bitumen and lubricants, etc. This shows the indisputable fact that it is cheaper to pipe crude oil than to transport refined products in railway cisterns. For this reason most refineries are situated at a great distance from the oilfields.

Another kind of tendency has arisen of late, though. Refined products, as a rule, give rise to the next stages in processing — petrochemicals, which means the setting up of petrochemical complexes. The petrochemical industry is extremely power-consuming. The establishment of plant producing aromatic hydrocarbons, synthetic fatty acids and spirits, ethylene and propylene and their derivatives on the basis of an ordinary refinery with a capacity of 12,000,000 tons of oil a year would mean an increase in proportional power-consumption of 2-2.5 times. If the production of synthetic rubber is added to that, power consumption increases more than 3 times, and if production extends to synthetic fibres then the increase is as much as four times that of a single oil refinery.

So as refineries tend to be accompanied by power-consuming petrochemical plants, power becomes a more inportant factor in choosing their location, and it becomes profitable to set them up in areas with a cheap fuel supply. Moreover, the wider the range of petrochemical processes connected to the refinery, the more viable it becomes to move this petrochemical complex nearer to the source of cheap and plentiful fuel. Siberia fulfils this requirement.

Work has already begun on building the Tobolsk petrochemical complex and the Tomsk petrochemical plant in Western Siberia, and an oil refinery in Krasnoyarsk Territory.

Until recently the development of the petrochemical industry in Siberia was hindered by certain factors which made its processes costly; higher wages in comparison with most other areas of the USSR and a greater proportional capital investment. However thorough analysis shows that these factors do not have as great an effect upon the efficiency of the industry as the calculations of certain design organisations have indicated. This effect, moreover, can be further reduced by mechanisation and by reducing the costs of construction work by taking certain planning measures (producing building materials locally rather than transporting them to the site, increasing the level of mechanisation in construction, and assembly work,etc.).

But unlike a number of other regions, Siberia has the resources to back up efficient oil refining and petrochemical industries more extensively and in more favourable conditions. In this Siberia has no really serious competitors. Nature has been very generous. Hydrocarbon raw materials can be obtained locally, in all their known forms (oil, natural gas, byproducts of oil and coal). This combination and abundance of material resources cannot be found in any other part of the USSR, and is supplemented by cheap Siberian fuel, its large reserves of water and land. Refineries can easily be combined with petrochemical and chemical production, and this makes it possible to obtain a concentration of industry unique to the Soviet Union, thus reducing costs and compensating for other expense factors.

The first petrochemical complexes in Siberia are to be built at the western outlet of Siberian oil in Tobolsk on the Irtysh, and at Tomsk on the Ob at the eastern outlet. Each of these complexes will have a wide assortment of petrochemical industries, and the combination of refining and petrochemicals will considerably lower proportional capital investment and thus the cost of petrochemical production in comparison with expenditure on separate plants.

The location of the petrochemical complex in Tobolsk will provide a basis on which to develop this town. At one time it was the centre of a vast gubernia, but lost its significance when the Trans-Siberian Railway was built at a great distance from it. Until recent times Tobolsk had only a few small enterprises, mainly concerned with food products. In 1970 the population of Tobolsk did not even reach 50,000.

The town's position as far as transport is concerned has changed, and it is now served by pipelines, the Tyumen-Surgut railway, transmission lines and other communication lines.

The Tomsk refinery-petrochemicals complex offers even better conditions than Tobolsk, being near not only to raw materials, but also to cheap coal. This area has great resources of hydrocarbons: the gasfields of Tomsk Region are rich in gas condensate which is practically a ready feedstock for the petrochemical industry. The town is near to the Siberian mechanical engineering centres, and has a developed construction industry, which Tobolsk still lacks. It is easier to attract labour to Tomsk, with its schools, colleges and universities and its cultural life than to a little town like Tobolsk.

But there is no feud between the towns about the location of a new petrochemical complex. We are just making the point that the Tomsk complex will be simpler to set up, and that technically and economically its cluster of enterprises may turn out to be better than that in Tobolsk.

The abundance and cheapness of local fuel will mean that Tomsk could sustain a wider range of petrochemical production than Tobolsk. If, moreover, local feedstocks are supplemented by supplies from the Tobolsk and Achinsk refineries, then in the early stages the Tomsk complex could even do without its own refinery.

With the decisive help of Siberian petrochemicals the Soviet Union will organise the large-scale production of efficient feedstocks for the manufacture of a large range of synthetic materials. In Western Siberia it is already planned to continue the development of the industrial complex which has formed around the coke-chemicals industry, producing nitrogen fertilisers, carbamide, sulphuric acid, etc. It would seem that in time Siberia will become the USSR's main producer of ethylene and propylene.

There are plans to increase Eastern Siberia's production of a number of power- and water-consuming items, including calcium carbide, chlororganic synthesis products and viscose fibres.

The electrochemical combines which are being built in the towns of Zima and Usolye-Sibirskoye along the main Trans-Siberian Railway north-west of Irkutsk will produce large quantities of various chemicals. A mineral fertiliser plant, taking its supplies of materials from the Oshurkov phosphorous deposits, will be built in the Buryat ASSR. The East Siberian wood chemical industry has extensive potential reserves of raw materials, and this industry will eventually become one of the main branches of the area's chemical industry.

The development of the chemical industry in the Soviet Far East is being stimulated by its large reserves of natural gas, and mineral chemical and timber raw materials. There are also plans to build plants for the chemical processing of the secondary products of non-ferrous metallurgy, timber and saw-milling. There are many possible ways in which the large reserves of salt could be used. In the Far East there should be a considerable increase in industries such as mineral chemicals, pharmaceutical chemicals and hydrolysis, and in future plants producing nitrate fertilisers, artificial fibres and plastics, synthetic rubber and domestic chemicals will be established.

The development of the Far East's chemical industry still lags far behind that of other regions in the eastern part of the Russian Federation, but its potential in this field has still been little exploited. This gives grounds to believe that eventually chemicals will become an important part of the Far Eastern industrial complex.

Siberia's becoming a major chemical centre will stimulate the increased efficiency of Soviet industry and the quality of consumption on a nation-wide scale.

THE SIBERIAN POWER INDUSTRY

Though the "age of electricity" dawned not so very long ago, the speed with which it has penetrated industry and everyday life is amazing. First it forced the steam engine out of industry, becoming the main motive power in factories and plants. Later it made a powerful assault upon production technology.

The first large hydroelectric power stations in Siberia were built relatively recently, in the mid-1950s, beginning with the Irkutsk hydroelectric power station on the Angara river which was commissioned in 1956. The next large station was built on the Ob near Novosibirsk and started to generate power in the spring of 1959.

The Irkutsk and Novosibirsk stations were considerably less powerful than those which were built on the Volga at the same time. The Novosibirsk hydroelectric power station had a capacity of 400,000 kilowatts, whereas the Kuibyshev station produced 2,300,000 kilowatts.

However it was not long before Siberia's hydroelectric power stations overtook those of the European regions of the USSR in terms of capacity. Formerly unknown names began to appear regularly in the Soviet and foreign press — Bratsk, Ust-Ilim, Divnogorsk, Karlovo and so forth. Many of these Siberian places became famous for there were the first hydropower stations of their kind in world practice. The capacity of Bratsk and Krasnoyarsk stations alone equals nearly a third of the capacity of all the USSR's stations, and Siberian hydroelectric power has only just begun its development. The Yenisei, Angara, Lena and other Siberian rivers hold colossal reserves of energy. Energy experts estimate that they offer a potential 400,000 million kilowatt-hours a year, which is more than the reserves of the United States. More dams will be built all over Siberia to swell the river of Siberian electricity.

In the European part of the USSR the pressure of water in the Volga will give hydroelectric power stations a maximum power of 2-2.5 million kilowatts, whereas in Siberia the capacity of individual stations in operation at present is 2-3 times greater. The Bratsk hydroelectric power station has generators with a total capacity of more than 4,000,000 kilowatts, while the Krasnoyarsk station has a capacity of 6,000,000 kilowatts.

Such hydroelectric stations naturally require a lot of water, and the Bratsk "sea" holds more water than all the Volga reservoirs together. The Bratsk reservoir is 550 kilometres long, and when all the generators were installed Bratsk station became the world's best hydroelectric station for the technical and economic statistics of power production. The Bratsk station, and Ust-Ilim station which is under construction together form the power "heart" of a major industrial region which will be sustained by variety of natural resources. This region embraces the Korshunovo mineral enrichment plant, the Bratsk aluminium plant, the Bratsk and Ust-Ilim timber complexes, and a number of other enterprises. The aluminium plant and the complex of wood-based industries will be the largest in the world.

The Ust-Ilim station is a "sister" to Bratsk, being almost equal in capacity and fed by the same river. Work on building the Ust-Ilim station began in 1966, two years later the Angara had been dammed and at the end of 1974 its first two generators were in operation.

Let us move from the Angara, which is the driving force of Bratsk and Ust-Ilim stations to another Siberian river, the Yenisei. Local people in ancient times called the Yenisei "brother of the ocean" because of the great volume of water it carries, its amazing power and grandeur. At the beginning of the 1960s the builders came to this river to start work on the Krasnoyarsk hydroelectric power station and the beautiful town of Divnogorsk which eventually appeared on a nearby hill.

As in the course of building the capacity of Krasnoyarsk station was increased, so was its efficiency. Capital investment on one kilowatt of capacity amounts to about the same as in the most economical thermal power stations, but the cost of power produced at Krasnoyarsk will be 3-4 times less than that produced by the thermal stations. Bold innovatory methods were used in building the Krasnoyarsk station to lower the cost of construction in comparison with that of Bratsk. One method was to do away with expensive metal trestles. A little less concrete per kilowatt capacity was used in Krasnoyarsk than at Bratsk, and 2-3 times less than on the USA's largest hydroelectric stations the Grand Coulie and Boulder Dam. The site of the Krasnoyarsk dam was ideally chosen in a narrow granite canyon called the Yenisei Pipe.

The Yenisei will be given the highest dam in the world by the end of the 1970s—that of the Sayany hydroelectric power station. This will be more powerful than the Krasnoyarsk station, with a planned capacity of 6,400,000 kilowatts. It is to be fitted with the world's largest hydrogenerators, each of which will equal the power of the Dnieper hydroelectric power station which until a few decades ago was the USSR's most powerful station. Sayan's first generators should be in operation in 1978, and it will reach its rated capacity in 1983.

The Sayan station is being built near the village of Karlovo, which lies about 100 kilometres from Shushenskoye village. The station's reservoir will be built in the mountains, and so practically no farmland will suffer from flooding. Only a few small settlements will have to be moved from the flooded area. The dam will rise to 240 metres, as opposed to 120 metres of the Krasnoyarsk station and 127 metres of the Bratsk station, and will take the form of an arc with a 600-metres radius facing the reservoir and resting its ends on the rocky banks. This design will give the dam extra resistance to the head of water. In spring 10,000-12,000 tons of water per second will have to be released by the dam, and in order to protect the foundations of the dam from the destructive power of this mass of water, a toe basin will be built below the dam to absorb the colossal power of this gigantic waterfall.

Twice as much concrete will be needed to build the Sayany dam than was used at Bratsk, and so concrete factories of unique capacity have been designed. Four pipelines will supply 150 cubic metres of concrete an hour to the dam.

At some periods it will be necessary to let an enormous mass of water across the dam, so speeding up the flow of the river lower down. This could endanger shipping over a long section of the waterway. There are plans to build a smaller hydroelectric station further downriver, the 340,000 kilowatt Maina station, whose function will be to "calm" the Yenisei, make shipping conditions better and increase the efficiency of the operation of the Sayany generators.

Sayany will be the power nucleus of a vast territorial-production complex which will include an aluminium plant, a ferro-alloy plant, carriage-building works, electrical engineering works and factories producing consumer goods. Land reclamation will increase arable land and lead to intensive agricultural development. The hydroelectric station will be linked by 500,000-volt power transmission lines with the Siberian industrial centres.

The main equipment to be used in the Sayany station will be manufactured several thousand kilometres away. The turbine drive wheels (each with a diameter of 6.5 metres), part of the rotor and other heavy generator parts will be loaded onto special seagoing barges, which will be brought by the Northern Sea Route through the Arctic Ocean to the mouth of the Yenisei, from where they will pass upriver to Karlovo Stvor. Where the Yenisei is blocked by the Krasnoyarsk dam the barges will be brought up to the reservoir by means of a special ship elevator which is now being built alongside the dam.

When the Ust-Ilimsk and Sayan hydroelectric power stations have been completed, the builders will move on to other rivers.

Plans have already been drawn up for the construction of the Boguchany hydroelectric power station on the lower Angara (several hundred kilometres from its confluence with the Yenisei) which will have a capacity of 4,000,000 kilowatts. This station will be the final stage of the cascade of the Angara hydroelectric stations, and when it is completed, almost two-thirds of the Angara's hydroelectric potential will have been harnessed. Building on the Boguchany station will begin as the Ust-Ilimsk station is completed.

The Boguchany station will form the nucleus of a new major industrial region, which will probably comprise metallurgical plants, bauxite mines, timber complexes producing not only round timber and saw-timber but also other products based on wood processing. This electro-industrial region will probably start forming in the 1980s, and in time will become one of Siberia's largest territorial-production complexes. The region will be linked to the Trans-Siberian Railway by means of the Reshety-Boguchany railway.

Plans have also been drawn up for the construction of the Middle Yenisei hydroelectric power station which will be built at the confluence of the Angara and the Yenisei; this in principle makes it possible to set up a hydroelectric complex on the combined flow of both rivers.

The Middle Yenisei station is intended to be the nucleus of the Lower Angara territorial-production complex, which will outstrip the Boguchany complex in composition and scale of output. The Middle Yenisei territorial-production complex is to contain large mineral enriching plants based on the Gorevo lead and zinc deposits and the Lower Angara iron ore deposits, an aluminium plant and mines extracting magnesite, talc, antimony, salt, graphite and dyestuffs. A vast timber complex, some of whose enterprises are already in operation, will also be set up here.

Another project which may begin in the future decade is the building of the Osinovo hydroelectric power station on the Yenisei a little to the south of the confluence of the Yenisei and the Podkamennaya Tunguska. This station could well be one of the most powerful and efficient in the Yenisei cascade.

The construction of the Baikal-Amur Railway will possibly make it necessary to build the Moksk hydroelectric power station on the river Vitim to provide power for the railway itself, and for the industries and settlements which will appear in the north of Buryatia and Chita Region.

At present hydroelectric power stations provide about half of the power produced by all the power stations in the Integrated Power Grid of Siberia.

Some specialists consider that in the long run the share of hydropower will decrease and that of thermal power will increase. This is only natural given the supplies of cheap Kansk-Achinsk coal in Siberia.

Siberian power has another problem which must be solved in the long term. The creation of the Siberian Integrated Power Grid (SIPG) has made it possible to raise the efficiency of power production by concentrating it in large and extremely large power stations. At the moment the grid is providing three-quarters of Siberia's power, and by the end of this decade it will be providing nine-tenths of it. Siberia does have some large power grids which are not connected to the SIPG owing to their great distance from its power transmission lines. These are the Norilsk grid and the Chita power grid. Apart from these there are also many small generating stations at mines, river ports, timber farms, etc. They are extremely uneconomical, use expensive fuel, demand much labour for maintenance and do not work smoothly. In many cases they are needed because of great distances from sources of cheap power, but there are some generators which operate not very far from main transmission lines, but which are not connected to them by branch lines.

It is essential to evolve a more rational system of communications within the SIPG, setting up a network of trunk transmission lines which reach all areas of concentrated power consumption and which connect up with the power systems of adjacent regions, such as the Urals and Kazakhstan. This is technically a very complex problem which will require great outlay and much time.

Planners intend using high-voltage transmission cables to effect inter-system links. These would have to criss-cross a considerable area of Siberia, east to west, and south to north. In the western section of the SIPG a transmission line has been built from Omsk to Yermak (the site of a new large thermal power station) in order to link the system up with the North Kazakhstan Integrated Power Grid. A number of transmission lines will also be built to link the new hydropower stations to the SIPG. In the next decade the Chita power grid will probably be linked to the integrated grid of the southern zone of the Far East. This will make it possible to transmit power over vast distances from Vladivostok to Omsk, and the SIPG will link up, via the Urals, with the power grid of the European regions. Eventually a Soviet national integrated power grid will be created. This would be a complex and expensive project, and the world has not known the construction of a unified power grid over such vast expanses.

The other problem is to create a distributory network to connect to SIPG with all power consumers. Major thermal and hydropower stations must be linked by means of transmission lines of 220 kilovolt and lower to various areas and districts which are at present isolated. This will do much to intensify the electrification of industry and homes.

Now let us take a look at the prospective development of power in the Far East.

The first Far Eastern power station is the Zeya hydroelectric power station, with a capacity of 1,500,000 kilowatts. Its significance will not be limited to power, for it will play an important part in regulating flood waters. In the monsoon season, the rivers of the southern part of the Far East often break their banks, flooding extensive areas of the coastal zone. Particularly hard hit by flooding is agriculture which specialises in valuable crops like soy beans and rice. Shipping conditions will also be improved. The first power generating units installed in Zeya station are already in operation, and its construction will be entirely completed during the 10th Five-Year Plan period. Its power will be used on the eastern section of the Baikal-Amur Railway.

The Bureya hydroelectric power station will be the second hydropower station on the Amur cascade, and it will have a higher capacity than the Zeya station.

In 1971 work was begun on building the Kolyma hydroelectric power station, whose power will make it possible to mechanise and automate many processes in the mining industries of Magadan Region. This will lead to a lowering in the need for manual labour, and ore extraction will become much cheaper. Local people will also benefit, as it has been planned to use the power produced at this station for household heating.

The building of the Kolyma station is complicated by exceptionally unfavourable natural conditions (harsh climate, permafrost, etc.), and original technical methods have been suggested to make construction faster and cheaper. For the first time in history a rock-filled dam 130-metres high will be built in these unusual natural, climatic and geological conditions. It will be a hydropower station of an underground type, with its enormous turbine room (50 metres high, 100 metres long, and more than 20 metres across) being cut into the rocky granite bank. This will mean that the turbine room is safely protected from bad weather. Planners also gave a thought to the builders' comfort. They will work under cover, which will allow the work to proceed exactly to schedule even at low temperatures and in high winds, when it is usually impossible to work outside. In order to begin producing power as soon as possible, the turbines will go into action even before the main dam is completed, using the head of water formed by the partially finished dam. This should bring the operational date of the first units foreward by 2-3 years earlier. They will be started up in the near future.

Chukotka is the site of the Far East's first atomic power station at Bilibino, with a capacity of 48,000 kilowatts, now nearing completion. It too is being built in harsh climatic conditions within the Arctic Circle in the permafrost zone. Its first power unit went into operation in January 1974.

The Bilibino nuclear power station is a pioneer project, and experience gained during its construction and operation will be used in developing nuclear power generation in remote regions with extremely harsh natural and climatic conditions.

The Soviet Union is well-advanced in energy development. In recent years no country in the world has set up nuclear-fueled power stations on a scale to match that in the Soviet Union. And the North of the USSR is one of the testing grounds for the development of nuclear power stations.

Conventional power is also being developed in the Far East. The Primorskaya and Arkagala thermal power stations are now in operation, and a number of transmission lines have been built.

One of the most promising projects facing the Far Eastern power industry is the harnessing of its geothermal springs, which have water with a temperature of 100° C and more. These springs are abundant on Kamchatka and the Kuril Islands. On Kamchatka the Pauzhetka experimental geothermal power station is already in operation, and its capacity can be increased several times. A freon geothermal power station, using water of only 80°C is in operation on the Paratunka river. But these are merely experimental low-capacity generators, which are exploiting only a tiny part of the energy potential of the hot subterranean springs.

The Far East must speed up its development of thermal springs and begin to exploit its vast reserves of geothermal energy.

NEW METALLURGICAL CENTRES

There has recently been a tendency in the economy for the proportional consumption of metals in the manufacture of means of production and consumer goods and in building to decrease, while the absolute consumption of metals has been constantly rising. World production of steel was more than 500 million tons in 1970, but some forecasts suggest that it will rise to 1-1,200 million by the year 2000.

It is interesting to observe the balance between production and consumption of ferrous metals in Siberia. More than half the output of rolled metal is sent to other parts of the country, while Siberia depends upon the Urals and the other European regions for its supply of rolled metal. An inter-regional exchange of iron and steel products is inevitable, but it must remain within reasonable limits. Much of the present inter-regional exchanges are a result of the fact that the traditional specialisation of metallurgical plants is divorced from the patterns of local consumption. Siberian mechanical engineering requires mainly thin sheet metal, but Siberian rolled metal producers specialise in thick sheets.

Siberia simply does not produce many of the types of rolled metal which are needed for mechanical engineering, pipelines and construction. This includes various kinds of shaped metal, steel piping, wheels, etc.

There are historical reasons for this situation. Siberia's main ferrous metallurgical centre is the Kuznetsk Iron and Steel Mill, which was intended to produce metal for building purposes and rail transport, whereas the structural metal essential for mechanical engineering was produced in a relatively limited volume and variety. This was no great problem at the time, for Siberian mechanical engineering was relatively underdeveloped.

After the war, when mechanical engineering became a leading industry, the situation changed radically. There was a sharp increase in the demand for structural metal, which the Kuznetsk mill could not meet. Rolled metal was brought in from other regions in ever-increasing quantities. The situation is now being corrected, with the new West Siberian iron and steel plant specialising in the production of the many kinds of constructional metal needed by Siberian mechanical engineering, but even its output was not enough.

Of course Siberia can continue to bring in the metals it needs from other regions, but that will adversely affect the cost of Siberian machinery. This extra expense can be avoided by developing Siberia's iron and steel production to satisfy the need of the area for various kinds of metal goods. This need will grow here faster than in many other economic regions of the USSR. One can expect a real forward leap in the development of Siberia's productive forces, and there will be a demand for many more machines, piping for oil and gas pipelines, and structural units for various branches of the economy. As an example, the increased scale of geological exploration work, the creation of the USSR's largest oil and gas extraction region and the growth of the urban economy give rise to the urgent need to build tube rolling mills.

The rapid development of Siberia's iron and steel will be beneficial in raising the industrial efficiency of that sector itself and of other sectors which consume its output. Expenditure on primary metals production is lower here than in other centres of the industry. This is in great part due to the cheapness of Kuznetsk coke, which competes with Donets coke even outside Siberia. The Kuznetsk Iron and Steel Mill is only second to Magnitogorsk for the cheapness of its cast iron, which costs more to produce at all other casting centres. Iron and steel depends upon large supplies of fuel and power. The industry's share of the industrial production basic funds is 10 per cent, while it takes a 20 per cent share of the fuel and power resources, which, as we have seen, are abundant in Siberia.

So one can expect to see an increase in Siberia's contribution to the country's iron and steel production. Prerequisites for this have already been established with the building of the West Siberian iron and steel plant, which will outstrip its neighbour, the Kuznetsk mill, in volume of output. The construction of this Siberian iron and steel giant is already nearing completion. The metallurgical cycle has been completed, and it has all three processes—blast furnaces, steel-smelting and rolling. In the capacity of its basic plants the West Siberian iron and steel plant matches up to the standard of world technology. It has the world's largest coke burners, agglomerating machines, blast furnaces and oxygen-blown converters.

At least one more large iron and steel plant must be built in order to cover Siberia's growing demand for metals. Several locations for this have been proposed, but there are most arguments in favour of making the town of Taishet Siberia's second iron and steel capital. It is better sited than other locations, having a developed supply of iron ore based on the large magnetite deposits at Korshunovo, Rudnogorsk, Neryundinsk and Tagarsk (the Korshunovo deposit has an operational concentration plant of high productivity). The region is ideally situated from a transport point of view, with Taishet lying on the junction of two railways which link the region both with sources of raw materials and with an extensive consumer zone. A very important point is that the creation of the Taishet plant would represent a thrust towards the East for iron and steel, for this industry has not been established in its entire cycle east of the Kuznetsk basin. The region is also relatively conducive to rapid, large-scale construction.

Apart from Taishet, there are plans for some other iron and steel projects, and in particular the East Siberian electric steel smelting plant. In the longer term a large Trans-Baikal-Far Eastern iron and steel centre will be created, taking as a nucleus a major plant in the region of the town Svobodny in Amur Region. There are likewise plans to move iron and steel to the far north in the Aldan-Chulmansk area of Yakutia, which has a unique combination of the basic materials essential to the industry, with the iron deposits lying not more than 100-150 kilometres from the coalfield.

Where will the new plants obtain the large amounts of iron ores they need? This may seem a strange question, for Siberia has vast reserves of iron ore, and only about a tenth of the total potential has been opened up. But if, for instance, the Taishet plant is built with the ores of the Korshunovo and neighbouring East Siberian deposits in mind, then the East Siberian plant will be deprived of its raw material source, for it is now being supported by the output of the Korshunovo mining and concentrating combine.

This is only a superficial paradox. In 1970 Siberia contributed about 7 per cent of the total national iron ore production, and iron ore presents a serious problem to Siberian iron and steel industry. Why is this?

In the first place, many deposits are still underexplored. This refers particularly to the uniquely rich Bakchar deposit in Tomsk Region.

In the second place, deposits differ in the kind of ore they offer. From the technological point of view the most valuable type is magnetite, which is easy to concentrate. But Siberia's reserves of this ore are relatively small, and the more plentiful ores are harder to concentrate (brown ores, haematites and siderites).

The third point is that Siberia's iron ore deposits are scattered over a vast area, and there are dozens of them, some large and economical to develop, and others small, and as yet too uneconomical to be opened up. This dispersedness of iron deposits runs contrary to the distinct trend towards the concentration of plants with a complete cycle of metallurgical processes in a limited number of places.

Finally, many deposits are located in underdeveloped areas, with small populations, lacking railway communications with Siberia's industrial centres and having harsh climatic and natural conditions.

This points to the obvious need to intensify the exploration of those deposits which show the most promise for exploitation, but which so far cannot be opened up due to insufficient knowledge about them, and also to speed up research in mining and concentration technology.

Siberia's abundance of cheap electric power makes it an area most suited to the location of power-consuming non-ferrous metallurgical plants. They can operate here more cheaply than in regions where power is relatively short in supply.

Many non-ferrous industries are suited to Siberia not only because of the low cost of power, but because of the rich supplies of raw materials. This factor makes non-ferrous metallurgy one of the main areas in which the industry of Siberia can specialise. The regions most favourable to the location of non-ferrous metallurgy are the Krasnoyarsk, Primorye, and Khabarovsk territories, Irkutsk, Magadan and Chita regions and the Buryat, Tuva and Yakut autonomous republics.

The subsectors of the USSR's non-ferrous metallurgy which now enjoy development priority are: aluminium, copper, nickel-cobalt, zinc, titanium-magnesium, mercury and rare metals. Nearly all of them are available in Siberia, and their size and quality show great promise in the development of Siberian non-ferrous metal production. The output growth rate in this sector in 1970 noticeably exceeded that of other regions, and Siberia's contribution to national production has increased considerably. This trend will continue in the long term, and so we can expect a further increase in Siberia's production of non-ferrous metals.

We are speaking here mainly of aluminium, the demand for which is growing at a fast rate. It is mainly needed for the massive development of new regions and the power generation industry. The use of aluminium in construction in the newly opened up northern regions offers particularly attractive prospects, but there are other areas where it will be in wide demand.

Siberian aluminium is cheap, since its production is founded on the power produced by large hydropower stations. It is even profitable to use raw materials which are brought over great distances—a factor which is leading Siberia to become the country's main aluminium producer. Siberian plants are now using imported bauxite, but as there is not enough of this, they have had to look to another raw material for the manufacture of alumina-nepheline ores which are Siberia's most plentiful source of aluminium.

Nepheline ores have been found in more than 30 deposits in the northern part of Kuznetsky Alatau, the Yenisei ridge, the Eastern Sayans and the Sangilen range. The chief producer of nepheline is Kuznetsky Alatau, a deposit which has boundless reserves of the ore. The first deposit to be opened up, Kiya-Shaltyr, has the most alumina-rich nepheline ore, containing more calcium and less silica, which simplifies the extraction process. This deposit supplies the Achinsk alumina plant, whose first section was opened in 1970. This plant is a component part of an aluminium complex, supplying raw materials to the Krasnoyarsk aluminium plant. The Achinsk alumina plant produces alumina, soda lime, potash, calcium chloride, sodium sulphate and cement. This means that alumina can be produced relatively cheaply. The Kuznetsk Alatau deposit can also supply other alumina plants with nepheline ore feedstocks.

The Soviet Union is among the chief copper-producers. Copper is smelted in a number of regions, including Siberia which had plants as early as the 18th century.

Nature was generous in providing this region with copper ores, which became clear in the 1950s and 1960s when geologists discovered the uniquely rich copper deposits in Eastern Siberia. One of these, opened in 1961 near Norilsk, is the Talnakh deposit. It contains copper, nickel and other metals. Its selection of valuable ores makes Talnakh richer than other non-ferrous ore deposits in the USSR. This makes it possible to continue developing the capacity of the Norilsk mining and metallurgical combine, the more so for the fact a new copper and nickel deposit, Oktyabrskoye, possessing greater reserves than Talnakh, has been discovered not far from the town.

Norilsk metal production has gone over to natural gas produced by the Messoyakha gasfield, and in 1970 Norilsk combine first received power from the country's most northerly hydropower station, Ust Khantaika. This has meant a substantial decrease in the cost of metal production.

The Norilsk complex can rightly be called the pearl of the Yenisei North, and increased production is bringing savings of hundreds of millions of rubles. The Yenisei North's copper and nickel are the country's cheapest, and if part of the smelting plant were to be located in the southern zone of Krasnoyarsk Territory economy of expenditure and profitability would increase even further.

This makes it viable to create a railway line to be used not only for transporting out ore concentrates, but for bringing various kinds of industrial goods to the Yenisei North. Several proposals have been made on the route of this railway. One involves the construction of a North-South line from Abalakovo to Norilsk, running parallel to nature's highway—the Yenisei. Other suggestions are to link Norilsk to the national rail network by means of a line running along the Yenisei's right bank, or to lay a track from Dudinka through the gas and oil regions of the West Siberian Plain. Further research will reveal which project would be the most viable. As far as the plans for building a line along the Yenisei are concerned, both right- and left-bank versions pursue a pioneering purpose in introducing vast areas of the Angara-Yenisei region with great development potential to the economic life of the country. This line could be very important in tapping new natural resources, reducing transport costs, and facilitating the building of the gigantic power projects on the Yenisei and the lower Angara.

In the long term Eastern Siberia's copper and nickel industry will be supplemented by new plants using the materials of the Udokan deposit and those of its neighbour, the Upper Chinei copper and nickel deposit.

The Udokan copper deposit (one of the largest not only in Siberia, but in the whole of the USSR) was discovered in 1949 in Chita Region, not far from the little settlement of Chara. In 1966 not far from Udokan geologists discovered some more deposits which can be regarded as an auxiliary material supply for the mining and concentrating combine.

The Chara region lies in the far north of Chita Region, and is marked by very difficult natural conditions. It is an area of high seismic activity, frequent avalanches, water-supply problems (especially in winter) and the local relief and permafrost make the building and upkeep of railways and roads difficult. The climate is severe and this makes it impossible to establish a local food supply. The manpower needed to open up the deposit must be attracted from other regions. The creation of an infrastructure for industry and the population will require great expenditure.

In view of this it would be viable to limit operations on the deposit purely to the extraction and concentration of the ore. The metallurgical processing of copper concentrates should be located in an area which has favourable natural and climatic, working and living conditions.

The industrial processing of concentrates from the Udokan deposit could be transferred to the south of Siberia to a large copper plant where smelting and rolling could combine with the accompanying production of sulphuric acid and phosphorous fertilisers.

Despite factors tending to increase costs, the expenditure on production at the Udokan extraction and concentrating combine could be fairly reasonable. Estimates show that capital investment on the Udokan complex could repay themselves in 7-9 years.

Because labour in climatically difficult regions is tough on the workers and expensive for the state, the power supply should be much more plentiful than that of mining and concentration plants in long settled areas. The Udokan extraction and concentration combine will require a powerful energy supply, and researchers propose to base this upon the use of high-calory fuel from the South Yakutia coalfield.

There is, however, another possible power source — the connection of the area with the Siberian Integrated Power Grid by means of high-voltage transmission lines.

The building of the Udokan extraction and concentration combine, and the town which will grow up alongside it, will require the establishment of a powerful construction industry. Will it be necessary to bring an entire industry to the North? Scientists suggest that planners set the nucleus of this industry in the south, say in Chita, from where prefabricated units could be transported to the north by various means. This would speed up building work considerably.

Siberia offers great possibilities for the development of other branches of the non-ferrous metals industry. At the end of the 1950s, the young geologists Y. Glazyrin and E. Vrublevich discovered lead and zinc deposits, in a field which became known as Gorevskoye, not far from the mouth of the Angara. It turned out to be one of the biggest in the USSR. A great part of the deposit lies under the riverbed. This was a deposit unique not only in the volume, but in the quality of its lead ores. Less ore is needed to produce 1 ton of metal than on average in similar deposits throughout the USSR, and the concentrated lead ore produced at this deposit is 2-3 times cheaper than that produced at other mines in the country.

The major zinc deposit — Kyzyl Tashtyg — has been discovered in the Tuva Autonomous Republic. It would be viable to build the plants to process the ore concentrates produced at these two deposits in the south of Krasnoyarsk Territory, which would be cheaper than locating them in the Lower Angara and Tuva.

Chita Region has large reserves of molybdenum ores. Development of these is to begin at the Zhireken deposit, which has a favourable economic and geographical situation and offers good technical conditions for mining. An extraction and concentration combine is to be built here.

Until recently Siberia's non-ferrous metallurgy was mainly concerned with the initial stages of the metallurgical cycle, in other words, with mining and concentrating ores. The present task is to continue the cycle by creating powerful processing plants turning out finished non-ferrous metallic goods, which also utilise waste material for the manufacture of chemicals. This could bring great efficiency in the development of Siberian non-ferrous metals. The increase in the production of cheap power has made it possible to radically improve the inter-branch structure of the non-ferrous metallurgical industry.

In the 1970s the Far East will see a great leap foreward in the development of tin mining. The Solnechny extraction and concentration combine in Khabarovsk Territory must be enlarged, and work must be started on the Deputatsky extraction and concentration combine in Yakutia. The production of complex ores will also be significantly increased.

The Far East will continue to play a vital role in the mining of gold and diamonds.

The use of subterranean heat is bringing great efficiency to the extraction industries. On the Chukotka Peninsula this heat can be used for unfreezing ground and supplying water to dredges working the goldfields.

Modern technology is demanding more and more cobalt, wolfram, tantalum, mercury and other rare metals, and the regions of Siberia and the Far East which possess deposits of these ores will be brought into the economic cycle.

TIMBER COMPLEXES

Siberia has vast timber reserves. Krasnoyarsk Territory alone possesses about one-fifth of the USSR's timber. Still, we are making use of only a small part of Siberia's timber wealth. In Tomsk Region alone about 30,000,000 cubic metres of timber are ready for felling every year, only a third of this is logged. The mature stands of timber of the cutting areas of the Far East are exploited to an even lesser degree.

The Soviet Union has overtaken such a leading capitalist country as the USA in the volume of felled timber. Is there any point in obtaining a further rapid increase in this volume, bearing in mind our great wealth in timber? This should not be done. It is possible to achieve a considerable increase in the output of finished timber products—pulp, paper, cardboard, furniture, etc., without a great increase in felling. Forests are not only useful to industry: they protect the land from erosion, prevent the rivers from silting up, purify the air, serve as a place of recreation, a habitat for birds and animals and fulfil many other beneficial functions. The Siberian taiga is a unique "oxygen factory", supplying not only the USSR but the whole of the Northern Hemisphere with oxygen.

How can we exploit with most efficiency the Siberian forests, this boundless sea of green taiga? The basic need is a comprehensive approach at all levels of felling and processing, which can only be achieved if the processing industries are developed rapidly.

The economical attitude to the forest must begin with lumbering. Where is the best place to begin felling? Obviously where there are sufficient reserves to guarantee supplies over the long term. Thoughtless felling can lead to adverse processes.

At present the Soviet Union fells about 400,000,000 cubic metres of timber, and if the existing norms of industrial demand persist it will be necessary in the not too distant future to raise this figure to 700,000,000 cubic metres. But the proportional consumption of timber in the USSR is decreasing, however slowly in comparative terms. Experts, rightly considering that this tendency will be intensified, have come to the conclusion it will be possible to limit the scale of timber felling. This is the optimistic forecast.

The European regions of the USSR have limited possibilities, and Kazakhstan and Central Asia are completely excluded as timber producers. Seventy per cent of the country's timber supplies lie in Western and Eastern Siberia and in the Far East, and these will become the main suppliers. It is estimated that by the end of this century the eastern regions will be covering not less than the half the country's timber needs, and the volume of lumbering in Siberia will obviously increase several times.

In 1970 only 35 per cent of the available timber was felled in the eastern zone of the Russian Federation, including 29 per cent of that in Western Siberia and 43 per cent in Eastern Siberia. Thus, almost three times more timber could have been felled without disrupting the reproduction cycle of the taiga. These figures might give the impression that the timber reserves of Siberia and the Far East offer an unlimited increase in production, but this is not the case. As Academician A. B. Zhukov says, "the unexploited forests of Siberia are showing rather a low productivity and... cultivation of commercial timber is proceeding very slowly here".

This is a limitation created by nature itself, but there are some other limiting factors, among which some are concerned with the modern technology of timber felling and processing.

Felling plans are mainly fulfilled by cutting down the most valuable evergreens — pine, larch and fir, for these are what timber consumers require. Deciduous trees and larches give fellers more trouble than with tall, straight evergreens, and the processers are also not accustomed to working with them. However, two-thirds of the workable forest area of Siberia and the Far East is taken up by leafed species and larch, with evergreens only occupying a fifth of this territory.

For attaining greater rationality in forest working, it is necessary to design processing technology to eliminate waste. Modern industry can easily achieve this, and the socialist planned economy will in the long term exploit timber with increasing rationalisation. At present, however, there is much waste at all stages, from felling to the production of finished goods (furniture, houses, paper, etc.).

Many countries in the world, including the USSR, are showing a trend towards the manifold utilisation of the forests, while maintaining a rational concern for timber and its reproduction. In the forested regions of the European area of the USSR and the eastern zone (Irkutsk, Tomsk and Tyumen regions and Krasnoyarsk Territory) new timber industry complexes (TIC) are being set up. They will be oriented not only on lumbering, but also on all kinds of processing and waste utilisation operations. A number of TICs are already being opened. The first section of Bratsk TIC not only fells timber, but also produces corp pulp, cardboard, saw-timber, plywood, wood-fibre board, feed grade yeast, resin, turpentine and other items. The group of plants in the complex are capable of performing all stages from timber felling to the production of finished goods. Each cubic metre of processed timber gives several times more products than was formerly gained from lumbering and primary processing.

Another major complex — the Asinovo TIC — is to be built in Tomsk Region. Apart from saw-timber it will produce sulfate and sulfite pulp, various kinds of paper and paper bags, byproducts of the sulfate process (tall oil, turpentine), feed grade yeast, plywood and wooden board. The complex will also produce vinegar, charcoal and charcoal briquettes, etc. All the timber which enters the plants in the complex will be put to some productive use. Waste materials will be used to make blockboard and chipboard, yeast, and so on. Any waste which cannot be used because of technological limitations will be made available to the central heating and power plant. The combine will use not only high-grade evergreens but also the timber of leafed trees. To help in the running of this complex operation an automatic control system has been designed, comprising a computer, closed-circuit television and modern communications and signal equipment.

How many timber industry complexes must be built in Siberia over the next decade, what should be their patterns and volume of output with a view to the needs of the country and the relative efficiency of using the timber resources of various regions of the USSR? These questions can be answered by economic and mathematical calculations. These have helped in arranging the forested areas according to the efficiency with which their timber potential is being exploited. The scale was topped by Sverdlovsk and Perm regions in the Urals. This was only natural for these areas are adjacent to the main consumers of the timber industry. They are followed by Irkutsk Region, which comes higher than the densely-forested Karelian Autonomous Republic, which also receives competition from the Tomsk and Tyumen regions.

The overall scheme for the development of Siberia's pulp and paper industry envisaged the establishment of 13 timber industry complexes in the foreseeable future (some of which are already in operation or are being built). Priority was to be given to building complexes in Ust-Ilimsk, Asinovo, Chunsk (in Krasnoyarsk Territory), Boguchany, Kolpashevo (Tomsk Region) and Tobolsk (Tyumen Region).

TICs also have a great future in the Far East, both as far as raw timber and finished goods are concerned. The other regions of the USSR are experiencing a shortage of valuable hardwoods which are used in furniture manufacture and in house decoration. The Far East possesses 70 per cent of the reserves of this type of timber, and thus will continue to ship it to other regions. Exports of timber to Japan and other countries are also increasing. The wood-processing and pulp and paper industries have great development prospects, and a number of saw-mills, processing plants and furniture factories are being built in the southern zone of the Far East. The second section of the Komsomolsk-on-Amur pulp and cardboard combine has already gone into production. A considerable increase in output will be achieved in the young town of Amursk which is becoming a major centre for all kinds of timber processing.

The main task which Siberia faces in the exploitation of its timber reserves is to radically change the structure of its timber-processing industry and to organise waste-free production. This requires, in the first place, the rapid development of those branches concerned with thorough chemico-mechanical and chemical processing (pulp and paper, hydrolysis and wood chemical industries), and secondly, a changeover of plants to technological systems which allow them to process cheap timber (deciduous trees and fuel timber) and also secondary material which is produced in the course of sawing and processing. The priority areas for the development of lumbering and processing should be those forests which lie close to the railway building projects and the planned hydropower stations. A timber industry complex, which will produce more than 500,000 tons of sulphate pulp a year, saw-timber, wood-fibre board and chemicals is being built near Ust-Ilimsk. This is being constructed jointly by a number of CMEA countries, and French firms will assist in the technical equipment of the complex.

In conclusion let us look at a future project—the construction of a floating lumbering plant which will operate in areas to be flooded by hydropower station reservoirs. As we noted earlier, the creation of permanent lumber enterprises in future flooded areas calls for much time, and then part of the plant which has been set up will be lost underwater, and so on.

Scientists have suggested the use of mobile lumber plants, floating units which consist of machinery for timber lumbering and transportation (electrical saws, mobile lathes, instruments, lumber tractors of great mobility, transporters, machinery for sorting trees and making rafts, cranes, mobile generators, repair shops, etc.). Comfortable living quarters are also provided on the vessels for the plant's staff.

These floating timber enterprises can be entirely built, assembled and equipped by factories. This requires less capital investment, manpower and time than the setting up of permanent plant. The mobile lumber plants easily adapt themselves to the gradual flooding of the reservoir area, moving around as the water rises, felling one section of forest after another. There is a drastic reduction in losses, which are unavoidable when permanent timber farms are flooded. It is technically not such a complicated business to set up mobile lumber plants with highly mechanised basic and ancillary processes. Considerable experience has been gained in the Soviet Union and in other countries, and there is no doubt about the economic benefit of using these mobile plants.

Siberia is an area where hydropower is undergoing intensive development, and enormous stretches of forest lie in the basins of the reservoirs of hydropower stations which are planned or being built. This forest can only be felled in time if highly efficient and quick working methods are used. So the future belongs to mobile lumber plants.

MECHANICAL ENGINEERING AND OTHER INDUSTRIES

There are sound economic reasons for the increase in Siberia's contribution to the production of certain kinds of finished goods which are used as new fixed capital assets and consumer goods to satisfy growing demand in

Siberia itself and in adjacent regions (Kazakhstan, Central Asia).

In the first postwar decades Siberian mechanical engineering and light industry achieved growth mainly by increasing production in existing plants and by redesigning them. This all took place very slowly and hardly any new enterprises were built in this sector.

Recently, however, the situation has been changing. It is now planned to spend more resources on setting up new mechanical engineering industries, and on building enterprises for the light and food industries in Siberia. Let us look at the basis for this decision.

The development of iron and steel and organic chemicals will provide a reliable source of raw materials for mechanical engineering. Siberia must give priority to the development of sectors which require much metal and little labour: heavy, automobile and tractor, agricultural, chemical and oil, and road-building engineering, and the production of fabricated metal structures and parts. This will make Siberian mechanical engineering more suited to the area's needs. In towns possessing sufficient reserves of manpower it will be possible to develop relatively labour-consuming industries, such as precision engineering. The proportional expenditure of manpower can be considerably lowered by the intensive electrification of technological processes using cheap Siberian power.

The demand for machines, equipment, apparatus and metal goods is growing at a persistently rapid pace. Mechanical engineering is the main investment sector, and it is the end products of mechanical engineering (machines, machinetools and instruments) that are mainly used in capital development.

The eastern regions' share of capital investment is substantially increasing. Siberia is already producing more than half of the Soviet East's mechanical engineering output. In the long term there will be a considerable increase in the output of those existing enterprises which work efficiently and which possess the necessary capacity for stepping up production. Siberia will continue to develop mechanical engineering in the field of power (including the manufacture of large hydraulic and thermal power generators, hydraulic turbines and steam boilers), the production of boiler, chemical and foundry equipment, steel and cast iron fittings, tractors and other agricultural machines, machinery for the timber, paper, and timber-processing industries and hoisting machines and carriers. Here we are dealing with sectors in which Siberia has been specialising for a relatively long time, and which have consumers in many parts of the country and abroad.

What new developments can we expect to see in Siberia's mechanical engineering? Researchers and planners suggest that there are grounds for a considerable change in the structure of the region's mechanical engineering complex and for the creation of a great number of plants producing instruments of labour and metal goods. In the near future it is expected that several times more mechanical engineering enterprises will be built here than in the past decade, and a number of new industries will also make their appearance. For this reason we can speak of the beginning of a new stage in the development of Siberian mechanical engineering.

The development level of mechanical engineering is greater in Western Siberia than in Eastern Siberia. Research has shown that the overall cost of locating mechanical engineering plants in Western Siberia is equal to capital investment and running costs in the Central region, and less than in the Baltic regions and in the Donets and Dnieper region. West Siberian mechanical engineering goods will still be cheaper than locally-produced goods not only in nearby Kazakhstan, but also in the distant Baltic, Donets and Dnieper regions. Even including transport costs, Siberian expenditure per ton of mechanical engineering output is less than in those regions.

It is more profitable to produce many kinds of goods for the eastern regions in Western Siberia than in the European parts of the country. These include prospecting equipment, machinery for the coal, gas, oil and chemical industries, for power stations, road-building and agricultural machines, tractors and heavy duty vehicles, fabricated metal structures, etc. It is profitable to produce many kinds of goods in Eastern Siberia, where there are plenty of machinery consumers and the cheap metal of the Kuznetsk basin is not far away. Other construction materials (timber and plastics) are also available here.

In the long term existing mechanical engineering complexes will be joined by other new ones. Work on this has already begun, and at present a mechanical engineering complex is being built in the south of Krasnoyarsk Territory which has extremely favourable conditions for the setting up of such an undertaking. The town of Abakan has been chosen as the site of a large carriage-building plant with a planned capacity of 40,000 freight cars a year. The plant will also produce 320,000 tons of cast steel to supply both its own needs and those of other plants. At present the Soviet railways are being supplied with four-axle 63-ton freight cars, but these are already too small to cope with the increased volume of freight turnover. So the Abakan plant will turn out eight-axle all-metal cars with a capacity of 125 tons. A train of such cars could haul 6,000 tons of freight.

The Abakan carriage-building plant will use modern technology including extensive electronics and automation.

A plant producing trailers for vehicles and tractors is being built not far from Krasnoyarsk. The first section is already in operation, and this plant, along with the Chita autoassembly plant which is already producing vehicles, heralds the beginning of a major automobile industry in Siberia.

Work has begun in Krasnoyarsk Territory on the building of the Minusinsk complex of electrical engineering plants. For the first time in the history of Siberian mechanical engineering 12 plants of the same industry are being built at one construction site. The first one to be completed will be a cable factory. The first section of this complex is planned to be built during the Tenth Five-Year Plan. Minusinsk will eventually be producing powerful generators, and many other kinds of machinery and equipment.

A number of mechanical engineering plants are planned for Altai Territory, where the development of a major mechanical engineering industry was begun several decades ago. It would be profitable to set up a tractor-building plant here (Altai is Western Siberia's largest agricultural region) and also an automobile plant. Altai lies near to supplies of raw materials and fuel needed by the automobile industry: the coal mines, metallurgical and chemical plants of the Kuznetsk basin and the woodworking industry of Tomsk Region. Altai Territory possesses rich water resources and a number of ideal industrial construction sites. The region is well served by arterial railways which connect it with potential consumers of mechanical engineering output, the neighbouring regions of Siberia and Kazakhstan.

In Kemerovo Region it would be viable to set up a chain of mining engineering plants producing mining, concentrating, prospecting equipment and excavators. Mining engineering products are mainly required by the coal industry of the Kuznetsk basin. It is particularly essential to increase the labour productivity of miners by producing large number of machines which are maximally adapted to mining underground Kuzbas coal seams and to the natural conditions of quarries.

There are also firm grounds for the setting up of a metal-consuming industry like the production of road-building machinery in Siberia.

Siberian mechanical engineering is geared to the production of machines and equipment which can work reliably in the severe natural and climatic conditions of the North, move about in swamps and negotiate steep slopes. Siberia needs to develop mass production of cross-country vehicles (snow and bog vehicles, hovercars). With a view to the coming boom in the development of the Siberian North's natural resources, we can say that the following forecast by well-informed specialists is in no way exaggerated: "It would seem that by 1980 Siberians will be riding in cars produced at Siberian factories, and designed in a 'Northern version'". The setting up of a large number of mechanical engineering plants will without doubt stimulate the rapid development of the eastern part of the Russian Federation.

In the Far East the development of this sector will come more and more to depend upon the internal demand of the region. Mechanical engineering will be called upon mainly to serve the fishing and forest-based industries, agriculture and road-building. In the long term the foreign market will be very important as a consumer of Far Eastern mechanical engineering products, as many South-East Asian countries are consistently increasing their purchases of foreign machines, equipment and instruments, and the Soviet Far East could cover much of this demand for the developing countries. The termination of military activity in Indochina has allowed those countries to undertake the re-establishment of the economy and to set up new plants in its various sectors. This has led to an extra demand for mechanical engineering products. Cooperation between the Soviet Union and these countries is highly conducive to the development of mechanical engineering in the Soviet Far East.

The building-materials industry is also an investment area. As the scale of the exploitation of Siberia's natural wealth increases, so does the demand for building materials. Particularly great demand is arising as a result of the creation of a world-scale oil and gas industrial complex in the West Siberian Plain, and of the building of the Baikal-Amur Railway. Development in this sector will involve the assimilation of tens of billions of rubles in capital investment. Ten or fifteen years ago this would have seem fantastic, but now it is becoming a reality.

The basic construction in the West Siberian oil and gas province mainly depends upon supplies of fabricated structures, parts and raw materials from distant regions. It would be far more profitable to orientate these operations on the nearby Siberian factories and plants. It would be viable to use the potential of the developed areas of Siberia to supply the oil and gas fields with materials, fabricated structures, parts and also complete units, rather than setting up new plants for their manufacture in the extraction areas. Natural and climatic factors make it more than twice as expensive to set up a building industry in the North than in the South of Siberia. The North does not possess enough heat energy and natural resources to produce building materials.

This is also true of the Baikal-Amur Railway. The southern regions of Eastern Siberia and the Far East could become a "supply base" for this massive project, by providing cement, ferro-concrete and metal structures, walling, etc. A number of new building materials plants are being constructed here with the aim of supplying the Baikal-Amur Railway.

The realisation of the capital investments in the production of goods and services depends upon the availability not only of metals, timber and fabricated structures, but also of a developed building industry.

Up till the present the building industry has developed by means of the creation of large groups of permanent, i. e. immobile building depots, possessing the necessary plant in areas of massive construction work. These depots will continue to be used in the future, but scientific and planning organisations have proposed supplementing them by mobile building units with the essential minimum of building equipment which could move from one region to another. These units could make use af waterways and roads, and also deliver fabricated structures by means of aerial transport, creating an air-lift system from the construction area to the permanent building depot. The "Guidelines for the Development of the National Economy of the USSR for 1976-1980", adopted by the 25th Congress of the CPSU, envisage the setting up of mobile construction units in Siberia's newly developed areas (especially in the North).

There are great possibilities for the setting up of an efficient building industry in Siberia.

Siberia has considerable potential for increasing its production of consumer goods. Of course one must take into consideration the efficiency of locating the appropriate enterprises in Siberia against the consumption of goods brought in from other regions, and also the capacity to provide these enterprises with manpower. If these two conditions are fulfilled, then the construction of light and food industries in Siberia will be justified. Availability of raw materials would make it possible to set up new textiles, knitwear and leather and footwear plants. Siberia's hydrocarbons make it profitable to develop the production of the staple fibres which are extensively used in the cloth manufacture.

Siberia is second only to the North Caucasus in producing fine and semi-fine wool, and second only to the Ukraine in the production of animal fats. Cheese-making is also highly developed in Western Siberia. The growth of agricultural output and the development of the taiga's rich resources (cedar nuts, wild rose and sea buckthorn, etc.) will create the necessary conditions for the steady increase in the output of food products.

Siberia's food industry will give increasing priority to those sectors which cater for local demand (in the production of milk, meat products, flour milling and groats manufacture, confectionary and brewing). Siberian food-processing industries will be developing at a more rapid rate during the Tenth Five-Year Plan.

In light industry there will be most development in the production of goods in greatest demand (silk, linen, and woolen textiles, knitwear and hosiery).

Not all sectors of Siberian industry will be contributing to the stepped-up development of the productive forces. Development in some areas of mechanical engineering and the light and food industries will proceed at a moderate pace, due to the fact that Siberia's needs for a fairly wide range of goods is profitably satisfied by inter-region trade. Rapid growth in production can be expected in those sectors concerned with the extraction and processing of the mineral wealth of the region, by which we mean the power-consuming iron and steel and non-ferrous metals industries, chemicals, forest-based industries, woodworking, pulp and paper, the fuel industry and power.

THE BAIKAL-AMUR RAILWAY—THE PROJECT OF THE CENTURY

The construction of the Baikal-Amur Railway, the "project of the century", and the economic development of the territory adjacent to it, is the logical continuation of the investment programs which went before. Let us recall that the first program was based on the Ural-Kuznetsk project, the second was based on the Angara-Yenisei project and the third was the implementation of the idea of making Siberia the USSR's main oil-producing region.

The idea of the viability of building the Baikal-Amur Railway was expressed long ago, during the early stages of socialist industrialisation, and was regarded as the embodiment of the Communist Party's policy of the all-round transformation of the economy of Siberia and the Soviet Far East, and of the social relations, culture and way of life of the people who inhabit this vast area of the country. As early as 1932-37 research and survey work was carried out to determine the choice of the railway's route, and then the first plan was drawn up. On the eve of the Great Patriotic War building work got under way, and a railway line was built from Volochayevka east of Khabarovsk to Komsomolsk-on-Amur. This line connected the recently-built Amur industrial centre with the Trans-Siberian Railway. During the war the line was continued from Komsomolsk-on-Amur to Sovetskaya Gavan, which created a second railhead on the coast of the Sea of Japan. Here Vanino, a new seaport, was built to provide an economic link between Sakhalin Island and the mainland.

The next stage in the implementation of the plan for the construction of the Baikal-Amur Railway came at the end of the 1960s, by which time vast deposits of valuable minerals had been discovered in the planned building zone, the forest and hydropower resources had been thoroughly investigated, and information had been gathered on the building conditions from the climatic and geological points of view. The USSR's economic potential had greatly increased, and new building technology had appeared on the scene. The time had come to begin work in earnest. In July 1974 the decision was made to build the Baikal-Amur Railway, with a view to completing it by 1982 or 1983.

Why is this railway being built, and what are the foreseeable consequences of its construction?

In the first place the railway will lead to more extensive development of the natural resources which lie to the east of Lake Baikal and, most important, make available to industry the minerals of the northern regions of the Buryat Autonomous Republic, Chita Region and the south of Yakutia.

Secondly, it will link Eastern Siberia and the south of Yakutia with the Pacific coast, which in turn will both strengthen economic ties between Eastern Siberia and the Soviet Far East, and between their southern and northern regions, and, on the other hand, will open the way to extending the USSR's economic contacts with the countries of the Pacific and with South Asia.

Thirdly, the Baikal-Amur Railway will serve as the eastern "siding" of a future, new trans-Siberian railway which will eventually dissect Siberia and the Far East from the North Urals to the Tatar Strait. This will mean the creation of a new "industrial belt" 800-1,000 kilometres to the north of the "industrial belt" which has been formed along the first Trans-Siberian Railway since the 1930s and 1940s. This belt will lie in the so-called Near North of Siberia and in the Far East. Moving eastwards from Ust-Kut, the starting-point of the Baikal-Amur Railway, one can regard the Near North as being part of the hinterland, the corridor 300-400 kilometres across which stretches along either side of the railway. West of Ust-Kut, the Near North must be seen as that belt through which the railway from the North Urals to the beginning of the Baikal-Amur Railway will pass, including the Lower Angara, and the Middle Ob (from Kolpashevo in Tomsk Region to Khanty-Mansiisk in Tyumen Region). In this corridor industrial centres have either already grown up (the oil regions of Middle Ob) or are planned or being built (Maklakovo—the Yenisei timber industry complex and the Boguchany territorial-production complex). The area of the Daikal-Amur Railway zone is as great as 1,200,000 square kilometres.

Fourthly, the Baikal-Amur Railway and the industrial belt which is forming along it should be seen as a springboard for the more extensive development of the Far North, including the subarctic and arctic zones of the Far East.

Vast technical resources and large workforces have been involved in the railway construction. For the period 1975-77 about 1,120 excavators, more than 400 bulldozers, about 7,600 vehicles and many other machines have been assigned to the project. Along the main Trans-Siberian Railway numerous plants for the production of building materials, structural units, welding equipment, etc. have either been built or are under construction.

Since 1975 tens of thousands of workers, technicians and engineers have been engaged in the building of the

Baikal-Amur Railway. Vocational technical schools are turning out skilled labour for the railway and the core of the workforce is made up of young people who have come here from all parts of the Soviet Union.

In order to complete the project as soon as possible, the railway is being built simultaneously from east, west and from about the middle of the line. The taiga, which the line will run through, has been invaded by powerful technology: heavy-duty excavators dig trenches, cuttings and put up embankments, bulldozers cut through the forest, modern heavy tippers carry gravel, drills bite into the rocky ground and track-laying machines are busy at work. The foundations of houses are being laid in new settlements or future towns which have either not yet been named or have inherited the names of old small settlements. The design of these new towns envisages the provision of covered walks to allow the inhabitants to do their shopping or take their children to the creche without having to go out in the bitter winter cold.

The railway builders' "capital" is the settlement of Tynda, and this is where construction headquarters have been set up. In the spring of 1975 the first test train made a symbolic journey from Bam station on the existing Trans-Siberian Railway to Tynda.

4. THE ECONOMIC DEVELOPMENT OF THE SIBERIAN REGION

Long-term forecasts estimate the probable volume of resources of the future which can be used to provide the consumer. These forecasts tell us what we can count on in the near and more distant future. They show the composition and dimensions of mineral deposits, of animal and vegetable raw materials, water, farmland, accumulated material wealth (basic resources, durable consumer goods), labour resources and scientific knowledge which society can use to meet its productive and non-productive needs in the foreseeable future.

Estimates of future resources are a starting-point for the drawing up of long-term plans of social and economic development and programs dealing with various aspects of that development, for instance, programs for raising living standards and those for setting large territorial-production complexes. These estimates must also be referred to in establishing the basic principles of the long-term development of the productive forces, in other words, in drawing up our strategic plan of action.

The aims of the long-term economic development of Siberia, with a view to its probable role in achieving the goals of Soviet masterplans as a whole, and taking into account its resource potential and certain general limitations, can be set out roughly in the following way:

1) The all-out exploitation of those natural resources which Siberia can extract and process more efficiently than other regions of the Soviet Union (including minerals in high demand), and on the basis of this to set up uniquely large extracting and processing industries. The combination of the extraction and processing sectors should be attained in the first place by establishing relatively complete production cycles: forestry, oil and gas refining and chemicals, agriculture and the complete conversion of ferrous ores. There is also justification for the creation of a large-scale metallurgical and mechanical engineering complex producing a wide selection of rolled metal for construction, pipes and building metal, with the main accent on low labour-consumption (production of metal-consuming equipment).

Even without considering external trade, the achievement of these aims has a number of beneficial results. Firstly, the national expenditure on forming reserves of fuel and power and on obtaining basic materials (aluminium, copper, nickel, lead, etc.; hydrocarbon fractions, chlorine and their derivatives; timber and wood products) is drastically reduced. Secondly, location closer to cheap and abundant sources of power and water makes it possible to distribute power-consuming industry more rationally throughout the country. And thirdly, the economically-justified replacement of goods transported over large distances by those produced locally brings more rationality to the interregional exchange of the output of the processing industries.

2) The consistent orientation of Siberian and Far Eastern industry on extending production of goods for export. At first it will probably be necessary to concentrate on exporting mainly fuels and raw materials, but eventually it will be possible to increase the proportion of processed goods going overseas (chemicals, pulp and paper, mechanical engineering).

This export orientation will have a number of effects. First, it will be possible to provide the socialist countries with fuel and raw materials. Secondly, the possibility of obtaining a stable supply of fuel and raw materials from Siberia will raise the interest of a number of capitalist countries in extending their long-term economic and scientific contacts with the USSR, will stimulate them to increase their provision of credits, equipment, licenses and to extend technical cooperation in developing Siberia's natural wealth. In the third place, large-scale exports of Siberian goods will substantially increase the country's foreign exchange reserves. Increased scale of production for export will have a certain effect upon the efficiency of expenditure on the development of industry and transport in Siberia.

And so, Siberia's export orientation will have many and various beneficial consequences.

3) The creation of a highly-developed industrial and scientific basis for the opening up of the natural resources of development areas. The present stage of the development of Siberia's productive forces is founded upon the extensive industrial exploitation of natural resources in the new areas, which mainly lie in the northern zone. The scale of this process has risen sharply in comparison with that in the past, and it also differs qualitatively from the previous scale and forms of economic activity in the North. The concentration of small numbers of isolated industrial centres in the vast

virgin wastes of the taiga and tundra is more giving way to the policy of planned development of large areas and the formation of territorial-production complexes of various types. The forms of territorial organisation are also undergoing various changes. In the past new regions were opened up by establishing isolated industrial groups which were based on one source of raw material and had a minimal practical effect on their surrounding area (Norilsk, Igarka and Aldan, for instance) whereas now intersector complexes are being set up here, and large areas are being brought into modern economic activity (the Bratsk-Ilimsk territorial-production complex, the oil and gas regions of the West Siberian Plain and the zone along of the Baikal-Amur Railway).

In future the development of North Siberia will be extended considerably, since the establishment of industrial plant and of fuel and raw material surpluses for export will increasingly depend upon the exploitation of the area's natural resources (the oil and natural gas of the Siberian platform, the iron ores of the Angara-Pit and the Bakchar basins, the bauxite, lead-zinc and other polymetallic deposits of North trans-Urals and Krasnoyarsk Territory, the copper ores of Udokan, and the forest masses, etc.).

Until now the industrial labour force and science and technology of the European part of the USSR have been the main instruments in opening up the natural resources of the new regions of Siberia and the North, and they will continue to play a vital role in the future. There is a need, however, to reduce expenditure on the transportation of equipment and construction materials and to locate designing, adjusting, manufacture research and development functions nearer to their sphere of application. This could be achieved by setting up the various industries which are to serve the North mainly in the southern regions of Siberia, which would be in keeping with the general policy of shifting productive forces to the East of the USSR.

The creation in Siberia of a developed economic, technological and scientific base for the opening up of the natural resources of the pioneer regions is helping to speed up and increase the efficiency of the economic development of the new regions. This is mainly being effected by replacing materials brought in from afar by local resources and by developing extensive economic and other links between North and South on the basis of a rational territorial division of labour. The composition of the southern belt's economic complex is also being improved by introducing sectors which have up till now been lacking. This means that the structure of production and services is coming more into line with the region's needs.

4) Extensive cooperation in natural resources and production potential between Western and Eastern Siberia and the Far East, between Siberia and Kazakhstan and part of Central Asia, the implementation of a consistent policy of strengthening the economic ties between the regions of the Soviet East by means of increasing the territorial division of labour between them. This involves the setting up of powerful plant specialising in producing specially for interregional exchange.

The main features of the interregional exchange of natural resources and primary products in the foreseeable future could include the following: a) the diversion of part of the water of the Ob-Irtysh basin to Kazakhstan and Central Asia; b) supplies of Siberian oil, timber, rolled iron and steel, aluminium, cement, grain and potatoes in exchange for vegetables and fruit, Karatau phosphorites and other raw materials.

The output of primary material processing could also be extensively brought into the interregional exchange. Siberia could supply Kazakhstan and Central Asia with metal-consuming mining, drilling and generating equipment, road-building machinery, vehicles, petrochemical and chemical plant, fabricated metal structures, furniture parts and paper, some chemicals and other industrial goods. Kazakhstan and Central Asia could reciprocate by supplying Siberia with equipment for earth-moving, land reclamation and the textile industry, with sugar, fabrics and other goods.

Western and Eastern Siberia could serve the Far East as producers of a wide range of industrial and agricultural goods; oil and petroproducts, ferrous and non-ferrous rolled metals, synthetics, various kinds of machinery, consumer goods, grain, etc. The Far East has a much smaller range of possibilities in return: seafoods, ore concentrates, rare kinds of timber and certain kinds of equipment.

In the foreseeable future the potential of Eastern and Western Siberia should become the main prop of the further development of the Far East's productive forces.

This orientation in the development of productive forces will, in the first place, do more to satisfy the needs of the economy and the population of the eastern macro-region of the USSR by using its own resources of reproduction and by rationalising the mutual economic links between the two macro-regions of the country (the European and the Asiatic parts of the USSR); and in the second place, to increase production efficiency by concentrating production of goods and services surplus to local demand; and in the third place, to strengthen the Far East's economic potential.

The attainment of the above aims of the long-term development of Siberia's productive forces will stimulate a relatively high pace of economic development in this area and will lead to the formation of a more versatile and efficient economic complex in this area. It will be founded on the raw material sectors, which are orientated on the exploitation of highly-economical natural resources, and will consist of a wide range of intermediate and final stages of production, in the processing raw materials and the output of a wide variety of goods.

Now let us examine which objective conditions in economic growth must be taken into consideration in evolving concrete principles on which to plan the future development of the region's productive forces.

Among these must be numbered, firstly, present level of development of the productive forces and the national wealth which is being accumulated in this initial period of development. By this we mean industrial personnel and plant, the social and domestic infrastructure (facilities and public amenities), durable consumer goods, scientific knowledge and professional experience. This basically determines the pace of development of the regional economic complex in the long term, and also provides a foundation for economic strategy.

In the second place, it is essential to define the scale on which it is possible to draw the natural resources of the regional complex, including the new sources of raw materials, into the economic cycle. This does not mean all the resources which a region possesses, but only those which are justified by their economic efficiency.

The potential reserve of natural resources in any territory can only serve as a general guideline. The main task is to define the approximate scale on which they can and should be exploited in the foreseeable future. This in turn depends on the country's demand for the resource in question and upon the efficiency with which the available supply of the resource in the area can satisfy that demand, taking into consideration possible improvements in extracting technology, primary processing and transport. To make this clearer: the North-East of the USSR (Magadan Region, Yakut ASSR and Kamchatka) possess the greatest potential reserves of coal, but it is hardly likely to become viable to exploit these extensively in the near future, for the necessary amount of coal can be mined in other areas at lower costs.

In the third place, it is essential while formulating the basic principles of development strategy, to consider the extent to which the extraction industries can be combined with the processing industries within the region's economy. The demand for primary and secondary industrial raw materials in any regional complex (fuel, metals, timber, etc.) determines the level of development of the corresponding raw material producing sectors. If, moreover, raw materials can be efficiently processed within the region, then the availability of such natural resources could promote the formation of a complex multi-sector group of industries. If powerful refineries for processing oil and also associated gas and gas condensates are to be set up, then Siberia, also possessing supplies of cheap fuel and enormous water reserves, will become the Soviet Union's major producer of hydrocarbon materials, on the basis of which a uniquely large complex of power-consuming chemical industries could be established in the East of the country. This trend in the exploitation of primary raw material resources will stimulate the transfer of power-consuming enterprises to Siberia from the European regions of the USSR which suffer from shortages of fuel and water. According to the inexorable logic of economic development, consumers of their output and machinery and equipment suppliers could grow up around these power-consuming sectors of industry.

Consequently the scale of development of the natural resources and the degree to which they are industrially processed locally (which depends greatly upon the range of processing industries) in great measure determines the structure of the economy and the overall level of economic development in any particular regional complex in the long term. This is also important to note in determining a strategy for developing its productive forces.

The fourth point which must be taken into consideration is the future supply of labour resources in the area. At present the shortage of manpower in the Eastern part of the Russian Federation is retarding development of a number of processing industries and in the services sector.

The interregional exchange of labour goes some way towards making up the local shortage, but not far enough. Experience, moreover, has shown that planned migration flows are not yet fully achieving their aims.

All through history Siberia has depended upon a constant flow of population from other regions in order to achieve development in its economy, and this need will continue in the future.

The reason for this is in great measure to be found in the need to set up in Siberia the country's largest oil and gas extraction area, to build the Baikal-Amur Railway and to economically develop its zone. It would seem possible to make up this additional requirement for manpower. At present the population of Tyumen Region is rapidly increasing, mainly as a result of an influx from other regions. However, one must not think that the flow of migrants will constantly satisfy Siberia's manpower needs. The main accent should be on the universal intensification of industry in the East, as this will relatively decrease Siberia's need for extra labour resources.

The fifth and last important factor is the economic-geographic situation and the degree to which the territory has been economically developed. For example the remoteness of a number of Siberian regions, such as Tuva and Gorny Altai, from industrial and cultural centres, their lack of transport arteries and their harsh climate are tending to retard their economic development.

In the long term the degree to which these factors affect the scale of development of the natural resources and the structure of the economy of various regions could change due to scientific and technological progress. For this reason, when one is analysing these factors one must pay great attention to all foreseeable results of scientific and technological progress which could be implemented in the period under consideration and which in the final analysis could affect the overall level of development of the regional economic complex.

In this way the increasing importance of synthetic types of goods in the economy and consumption is stimulating the economic development of regions which possess the necessary conditions for the location of fuel, raw material and processing industries: local availability of large deposits of oil and gas, cheap coal and water, and sufficient proximity to these resources to make them economically transportable to potential consumers.

Let us look at another example. It is planned shortly to begin the mass production of vehicles and equipment adapted to the specific natural and climatic conditions of the Far North: powerful bulldozers, high-capacity dredgers, and heavy-duty excavators, snow and swamp vehicles and various other means of transport with extremely high load capacities and good cross-country ability, mobile drilling equipment, etc. This will make it possible to exploit new material resources and will lead to a drastic reduction in the expenditure of manpower on opening up natural resources, and consequently will extend the scale of this work.

At the same time it is practically impossible when one is drawing up the basic principle of the development of the productive forces to take into consideration those results of the scientific and technological revolution which will have a radical effect upon production and consumption in the longer term. Thermonuclear power, for instance, will provide fantastic possibilities for producing cheap power and thermal energy. This will limit the demand for oil, coal and gas, since these will be used only as materials for refining, and it will also make it possible to locate power-consuming enterprises without necessarily basing them on deposits of conventional fuels.

We are still not in a position to forecast with sufficient accuracy when thermonuclear power will be put into industrial use, and for that reason it is impossible to make a quantitative estimate of the effect of this factor upon the future pace of development and any structural changes in the economy of this region. From this fact alone, we become convinced that principles of the development of productive forces of the regional complex are necessarily limited by time.

Our plan of action in the East can be defined in the following basic principles.

Firstly, in Siberia it is essential (and possible) to organise industry on an unprecedented scale, that is on a scale which cannot be achieved in the other Soviet regions, which are less well provided with power and raw material resources. It is essential to organise production on a particularly large scale because that will make the exploitation of Siberia's natural resources more economical.

The West Siberian Plain has a favourable combination of many kinds of natural materials: oil and gas, timber and various kinds of chemical raw materials, iron ore and peat, fresh water and subterranean thermal springs; and the rivers and lakes possess large numbers of valuable kinds of fish. This is an extremely rich area. We have already talked about the unique reserves of oil and gas, but we must also mention the unique reserves of peat to be found here. Tomsk and Tyumen regions have immeasurably large quantities of high-quality timber. The Bakchar iron ore deposit possesses vast raw material resources for the iron and steel industry. Deposits of easily-concentrated lead ores, bauxites and other minerals have been discovered on the eastern slopes of the Ural range, within the boundaries of Tyumen Region.

The population of large horned cattle in the water meadows of the Ob and the Irtysh can be greatly increased at relatively low cost. The north of the West Siberian Plain is a major supplier of furs.

All this makes it possible to organise the all-round and multi-purpose exploitation of the natural resources of the West Siberian Plain on a vast scale. The planned development of various raw material sectors can lead to a greater volume of production than if a relatively narrow range of sectors were to be developed. According to estimates drawn up by the eminent Soviet economist A. G. Aganbegyan, the maximum possible extraction of oil and natural gas, timber-felling and the exploitation of the other natural resources of the West Siberian Plain will in the long term make the output of this region exceed the contemporary volume of industrial output of the whole of Siberia.

We have already talked of the scale of production at the enterprises of Siberia's extraction and about its large power stations. But we are not referring merely to the primary stages of industry: a number of sectors of the processing industry can also be organised on a large-scale basis. The abundance and cheapness of power and fuel in Siberia make it possible to create uniquely large power-consuming enterprises — aluminium, copper and nickel, lead and zinc, oil refineries, petrochemical and woodworking complexes. Large-scale production can also bring great economic efficiency to the plants of various other sectors of industry based on natural resources.

This principle has already become fundamental in the planning and construction of many new plants. Siberia is becoming an area of enormous oil and gas fields, oil refineries and coal mines, timber industry combines and power stations.

The second vital principle in the exploitation of Siberia's natural resources is the consistent orientation of industrial development towards the maximum possible combination of the extraction of the natural resources with their stages of processing. In other words the sectors of industry which produce primary raw materials and primary semi-finished products, must develop in conjunction with those sectors which produce a wide variety of finished products. We have already discussed this in connection with Siberia's non-ferrous metal industry and timber. But this can only be applied to a number of other industrial sectors which employ chemical raw materials, wool, etc.

This line of development, which Siberian industry has already embarked upon, also makes it possible to attain a considerable increase in production efficiency.

The combining of extraction with processing is also envisaged within the framework of the new territorial-production complexes (TPC), which are either now being set up in Siberia, or will be established in the long term. The TPC is a multi-purpose economic formation which comprises mutually-dependent stages in the step-by-step transformation of primary materials into intermediate and finished products. In other words, some of the TPC plants produce primary materials for other plants. TPCs will be able to more fully and more economically exploit raw materials in comparison with mutually-linked plants, which are developing separately in different regions.

The TPC system means that the plants of which they are composed will make joint use of building sites, engineering communications, a common building base and so forth. The Bratsk-Ilimsk TPC is taking shape in Siberia at the moment. It will be based on power and aluminium production, iron ore extraction, timber felling and woodworking. This complex possesses a large construction organisation. When completed during the Tenth Five-Year Plan period, it will have the Ust-Ilimsk hydropower station and a large pulp factory working at full capacity. The Sayan TPC is also being built at the moment. This will contain various industrial plants, producing electric power, ferrous and non-ferrous metals, carriage-building, electrical engineering and the light and food industries. The most important projects in this TPC will be the hydroelectric power station, a group of electrical engineering plants and the Abakan carriage-building plant. The Sayan TPC will comprise a total of 120 large industrial enterprises.

These projects vividly demonstrate how the area's resources are successfully combined within the framework of the TPC. The Abakan plant will be a large consumer of cast steel which will be produced from metal supplied by Novokuznetsk, which lies not far from Abakan. The cast steel will be smelted in high-powered electric furnaces which will be fed by cheap power from the Sayan station. The complex will need a large water supply, and it is conveniently situated right next to the reservoir of the Krasnoyarsk power station. Local labour resources are also available. The Sayan power station is being built together with the main consumer of its power — the aluminium plant. The beautiful marble of the Kirbik-Kordon deposit is being used as the material for the country's largest stoneworking combine Oznachensky. Plants processing non-ferrous metals will supply materials to the cable factory. The availability of large areas of land and favourable climatic conditions will make it possible to expand agriculture and the food-producing industry in the south of Krasnoyarsk Territory.

The third principle involves giving Siberia priority in the pace of increasing its labour productivity, and consequently in exploiting the latest achievements in modern technology and new progressive methods in production and labour management. This means that the East of the RSFSR should have priority over the regions which do not have the same deficit of manpower, and where expenditure on the reproduction of the labour force is lower.

These regions should be supplied with machinery, equipment, instruments, materials, fuel and also technical patterns which are particularly suited to the regional conditions of economic life.

The main point is that machinery, equipment, fabricated structures, materials, etc. must be capable of withstanding powerful frosts and winds and be adaptable to mountainous relief, swampland, water-logged areas and permafrost. Vehicles must have extra-powerful motors, higher load capacity, and equipment must be produced in assemblable units. Structures such as drilling rigs must be light and mobile.

Considerable experience has already been accumulated in the mining industries of the North and the Soviet Union's transport construction industry in the exploitation of highly-productive technology. Big dredges are extensively used on the goldfields, and in earth-moving, ore and coal mining, powerful excavators have performed very well. A number of highly-productive machines and appliances are used in pipe-laying. New models of other powerful Soviet machines have stood up well to tests. Tractors produced for Antarctic expeditions have proved very reliable. The mass production of caterpillar tractors, excavators, cranes, automobiles, and buses adapted to Northern conditions is ready to begin. All these vehicles have engine- and cabin-heaters.

In 1970 Voronezh began to produce excavators designed to dig out frozen soil in temperatures as low as 60°C. The use of this sort of machinery makes it possible to extend the period of earth-moving work in winter and to excavate larger quantities of ore for processing.

Special technology has been developed making it possible to work at open-pit goldmines all the year round. This will have a tremendous economical effect.

The additional capital investment which is mainly demanded by the expensive machinery and equipment used in the North relatively quickly repays itself in savings of manpower. Hence the importance of increasing the proportion of equipment, machinery and apparatus in the overall expenditure on the extraction of minerals in the Siberian North.

Long-distance heavy road haulage is increasingly taking over from small fleets of conventional vehicles adapted to northern conditions. The super-large vehicles, for instance in Magadan Region, have produced impressive results. It is vital to produce means of trasport which combine high load capacity with high cross-country capacity. The use of super-large vehicles in the North lowers proportional investment, demands less expenditure on repairs, needs fewer drivers, etc. in comparison with the use of conventional heavy vehicles.

The radical re-equipping of the Siberian economy demands the extension of applied research and design work, and the stepping-up of the mass production of new technical means.

Siberia needs specialised plants which have design offices and which orient their production to meet regional demand. Specialisation makes it possible to maintain a high scientific and technological level in production and labour organisation. Increased scale of output and permanent consumers are important for achieving optimal economic efficiency in the industry. Western Siberia must be seen as the priority area for locating this sort of enterprise for here the metal-consuming sectors of mechanical engineering can be efficiently developed. In the long term the construction of the Taishet iron and steel works will mean that heavy mechanical engineering will be moved further to the east.

In order to provide a high scientific and technological level in the production of new means of labour, structures and materials, a number of territorial scientific and production centres, mainly in the mechanical engineering field, will be set up in Siberia. It would be sensible to include in this not only leading assembling plants, but also experimental centres and plants, research and design institutes, design offices, information and computing centres, professional vocational schools, technical schools and institutes of higher education.

It would be possible to set up in the territory of the Kansk-Achinsk basin a scientific-industrial centre, specialising in excavators (including rotary excavators) and other earth-moving machinery. In the trans-Baikal area whose dominating industry is non-ferrous metals, it would be natural to set up a similar centre to serve the needs of that sector of industry, and in Irkutsk and Khabarovsk it would be feasible to set up centres serving the timber-felling and woodworking industries.

The fourth principle which must be taken into consideration while planning our course of action in Siberia is involved with implementing a special kind of "socio-economic protectionism" of the population and economy of this zone of the USSR. There must be a consistent balance between the moral stimuli, the sense of adventure which draws young people to Siberia to explore and develop these faraway lands and the material incentive of working here. The most effective way of attaining planned and controlled resettlement is to offer a higher standard of living to people coming to the East.

There is a need to make wider use of the "economic mechanism" in order to stimulate further capital investments in a number of sectors of the Siberian economy. In order to interest industrial ministries in locating processing industries in Siberia it is advisable to transfer a certain amount of the initial investment in regional development from the estimate of expenditure of the projects financed by those ministries to the national budget.

It would also be advisable to provide favourable conditions for financing and providing of credits to enterprises which lie in remote regions and also to offer easier terms of payment for the purchase, development and installation of modern technological equipment. It would be beneficial to lower transport tariffs for perishable goods (early vegetables and fruit), in the consumption of which Siberia is lagging behind the majority of other regions of the country.

The fifth principle which is being applied in opening up Siberian resources is that of achieving a rational division of labour between the north and south zones of Siberia. The production and technical, scientific and cultural services of the North and the training of qualified personnel could be more extensively entrusted to centres in the south. This would make it possible to limit the amount of large-scale building in the North and also the size of the flow of the population, thus achieving considerable savings in expenditure on industrial development in this area. The social aspect of this approach should not be overlooked.

* * *

In order to decide which are the best methods of developing the Siberian North we must make a small historical detour, and examine the reasons for certain problems which have arisen.

The Siberian North's natural resources began to be relatively widely exploited in its national economy from the beginning of the '30s of this century. At this time the Soviet Union possessed large reserves of manpower provided by the people who had left agriculture and other sectors of the economy. These reserves were intensively used in capital construction and in industry. Expenditure on attracting labour to the areas where the industrial centres were being set up was relatively small. The ore deposits which were opened up were rich in metal, and this meant that the mining industry could guarantee profitability while being extremely labour-intensive. Moreover, the level of transport development did not make it possible to support a reliable all-year contact between the industrial centres and the North, and made long-distance haulage extremely expensive. This made it essential to autonomise the North's economy to a great extent.

It was necessary not only to extract and process materials in great demand (mainly the primary stages of processing), but also to create a fairly wide range of servicing and anciliary branches of industry (coal mining, thermal power stations, machine-building and metal-working, repair services and the production of consumer goods). This in turn called for a relatively developed transport system within the limits of the industrial centre itself. The large scale of industrial construction made it necessary to set up large local building organisations, and also plants producing building materials, fabricated structures, etc. Hardly any of these goods could be brought in from the southern regions owing to the lack of railways leading to the northern regions, the shortage of seagoing vessels and the low capacity of the ports.

This system, based on the principle of maximum self-sufficiency, gave rise to an additional demand for manpower as basic production increased.

These historical factors in the development of the Siberian North's natural resources have not diminished in effect today.

Nowadays the state's material resources and the advanced level of transport and construction technology make it possible to replace local production in the North by consumption of goods and services coming from other regions. A number of northern industrial centres could be linked by means of transmission lines with the power grids of the southern regions. Several northerly ports in the Far East are now open all the year round, and this makes it possible to maintain a regular contact between them and ports in the southern zone. The Siberian North is now being linked up to the country's railway network. The use of heavy jet aircraft has made it more profitable to use aircraft to lift freight to the North. The creation of a barge fleet has played a similar role in river transport. The building industry has amassed experience in assembling structures and units brought in from other regions. In the long term progress in science and technology will have an increasing influence on the location of industries.

But there are still many problems in the labour field, since many towns and regions are experiencing a shortage of manpower and it is becoming more difficult to attract workers to the North.

It is becoming more and more vital for the natural resources of the Siberian North to be used to make the economy more efficient.

New methods of exploiting natural resources must be found. More and more acceptance is being won by the idea that the composition of the economic complex in the Siberian North must be planned over the long term in order to limit plants serving the basic industry, and also those producing consumer goods to the smallest possible number. The need for this is especially evident if one evaluates the efficiency of the exploitation of the resources of the Siberian North not from the point of view of its main sectors, that is the specialised sectors which form national material balances, but from the point of view of the size and the return on expenditure of the whole industrial complex which grew up in a given region in connection with the development of a sector or of several specialised sectors. In order to gain a fuller picture of the efficiency of the exploitation of the natural resources of the Siberian North from such a broad viewpoint, one must employ a criterion like the economic balance-sheet of the region. In this balance the result of the exploitation of the natural resources of this region (the industrial output) is juxtaposed with the expenditure society makes on its development (the input of material, labour and financial resources).

The first attempts at setting up experimental balance-sheets for the North East of the USSR and the oil and gas regions of Western Siberia were made by the Institute of Economics and Industrial Organisation.

It was found that the excessive investment was not necessitated by the non-ferrous metallurgy of the North-East but by its ancillary industries. And this is also characteristic of a number of other regions of the Siberian North in which new natural resources are being intensively developed. In the final analysis the volume of overall expenditure everywhere depends on the number of ancillary plants which have to be set up. The more of these plants there are the higher would be the cost. So by limiting the range and the development level of the ancillary sectors to a rational minimum, we will reduce additional expenditure and raising the overall efficiency of industry in the North.

An analysis of the make-up of economic expenditure on the development of the natural resources of the Siberian North unambiguously demonstrates that the main potential for increasing the economic efficiency of the development of the productive forces lies not so much in the lowering of costs and the proportional capital investments in specialised sectors, as in reducing these additional expenses. The main way of cutting them down would be to achieve a rational division of labour between the northern and southern regions of Western and

Eastern Siberia and the Far East. An essential role in this interregional cooperation of social labour could be played by the Urals, which possess a powerful industrial base, planning and design services, scientific establishments, all of which have long been working for the North.

This task must be the dominating factor in planning and design work, research and the working out of recommendations for the development of the Siberian North, settlement and town-building, the creation of a transport network and consequently, the practice of the planning of capital investment in the development of the Siberian North's productive forces.

In order to more accurately define the optimal proportions between the level of the development in the North, its specialised sectors, and the ancillary areas of the economy, it is essential to consider thoroughly and objectively the various patterns the economy and population of the North could adopt and decide to what degree and in what concrete forms this task can be solved with the help of local resources or those of other regions. Highly accurate estimates, for example, could show planners what branches of the building industry necessary for developing the northern deposits of fuel and raw materials could be feasibly set up locally and which would be more profitably located in regions adjacent to the North and situated in more favourable climatic, geographical and economic conditions.

In these technical-economic investigations the expenditure on the production assets of the sectors of the economy essential to the creation and servicing of the basic sector of production and the provision of sufficiently high living standards for the population of the region must be compared with similar expenditure in its "counterpart" region.

If one were to make such a comparison on the basis of actual expenditure on the development of social production in the northern zone and expenditure on analogous ancillary sectors in the southern zone, then one can clearly see the economic benefit to be gained by creating southern support bases for servicing the North. These support bases could fulfil quite a large variety of functions, producing many kinds of machines needed in the North.

Further these support bases could supply the North with food products and consumer goods which are especially needed (warm clothing, footwear, etc.). It would be rational to concentrate the production of food products for the North in those regions of Siberia where large agricultural production complexes will be set up in the long term. One of these regions could be the trans-Baikal area, which is now a large supplier of animal products to other regions. Irrigation, the setting up of a developed agricultural machine-building industry, the production of mineral fertilisers, feed grade yeast, etc. will make it possible to attain a great increase in the agricultural output of this area. A large food base for the north of the West Siberian Plain could be set up in its southern regions. In the Far East great possibilities for the production of vegetables, and to a certain extent, of fruits, are offered by the Kamchatka Peninsula, where the abundance of thermal springs will make it possible to develop cheap hothouse farming on a large scale.

Certain methods of organising capital construction, which are customary for long-settled areas, are not applicable to the northern regions of Siberia. In many parts of the Siberian North, and particularly where building will be scattered over a wide area, it is not rational to set up permanent construction bases designed to fulfil a complete building and assembly cycle. In the first place this is extremely expensive, in the second place the need for them disappears as soon as the well or mine has been built, and as it is not feasible to build any more projects on the site, the capital investment on building this base becomes redundant long before the end of its useful life. For example, many mining and drilling structures on the West Siberian Plain will not be in use for all that long. The same is true of certain gold mines.

What should replace the permanent building bases in the North? First of all, they should be replaced by construction industry centres in other regions. Their function will be to produce prefabricated buildings and standards of light materials along with the equipment to go with them, to manufacture, in the first place, prefabricated houses and communal services for settlements of geologists, builders and workers, and to establish mobile building bases, including bases that can move along rivers. These external building bases could send special teams of workers to the North in order to superwise more important building and assembly work.

Our building industry has already managed to develop and produce such units and also ready-to-use buildings, such as oil gathering stations and plants. These can be transported fairly easily by various means.

Rational methods of organising building services for the North and of building and assembly work have bring economic efficiency, and make it possible to lower costs by tens and maybe hundreds of millions of rubles.

A strictly coordinated approach to construction and extensive implementation of progressive building methods are indispensable in this context.

Another economically expedient function of the southern support bases would be the maintenance of the machinery and equipment being used in the North. In a number of cases exceedingly high costs make it totally unviable to overhaul machinery. In the southern regions machinery repair and refitting is much cheaper than in the North, even including transport costs. In the North itself it would be more rational to make relatively simple repairs and to replace individual units and parts of machines. To this end the southern support bases should possess plant producing spare parts and complete machine units. Experience of this way of servicing machinery in northern regions has been accumulated abroad, and is being built up in the USSR.

Siberia's southern support bases should also develop a network of scientific research and design organisations working for the North, and also academic institutions (vocational schools, technical colleges and colleges of higher education), training qualified personnel for its plants and organisations.

In order to reduce the North's demand for a permanent population and for the creation of more comfortable facilities for the workers who live here, it would seem a good idea to make extensive use of labour organisation methods in building and operating production plants such as the short-term and expedition methods. These are not fundamentally new ideas for the USSR. The expeditions method is used by geologists, the merchant fleet, ocean fisheries, in construction (student building teams, builders fitting out equipment on remote building projects), gold mining, etc. The short-term method is being used for oil drilling at Neftyaniye Kamni in the Caspian, and also for building certain pipelines and power transmission lines, etc.

A modification of these methods is that of taking workers from the building base to the site by high-speed transport, with a travelling time of one or two hours. Another method is more radical; the workers live permanently outside the North in base settlements or towns in one of the populated areas of Siberia and are taken to the building site by the aircraft for a relatively short period (the "airlift" method). These periods could be as long as two or three weeks.

There are various areas in which the short-term and expeditions methods can be used in exploiting the natural resources of the Siberian North. The first of these, for example, could be used in boring wells, certain kinds of building work, machine and equipment repairs, work at power stations, on transport, etc. In other words, we are talking about work which is not of a seasonal nature.

In a number of cases, however, labour could be used only at certain times of the year, for instance when putting up drilling rig supports, washing sands or pipe-laying. This is where the expeditions method comes in, whereby the labour force is brought out, not for a short period, but for the whole season of the job in hand.

The short-term method of building and working industrial and other projects, and also to a certain extent the expeditions method are labour organisation forms which organically fit into a set of measures providing a national division of labour between the southern and northern regions.

It would be wrong, however, to overestimate the scale on which the short-term method could be used. It can probably not be used for all the nothern regions. It is relatively simple to use this method for sending people to the oilfields of the Middle Ob from the areas of Tyumen and Novosibirsk: there are no drastic differences in the natural and climatic conditions and air journeys are really not too long. We already have some experience of this. It would be a different matter to organise short-term service in the Arctic area. Here you have the complicated problem of letting the human organism adapt to a frequent change of natural and climatic zones. This frequent change of regime might be relatively simple in the summer, but undesirable in winter.

There are a number of other limitations on the use of the short-term method of exploiting the North's natural resources, and only thorough research will allow us to establish the area and scale on which this method could be used.

Transport construction is playing a great pioneer role in the North of Siberia. It must always stay ahead of the construction of leading sectors in the recently opened-up regions. It is economically very important to keep to the policy of distributing capital investment between industry and transport: this speeds up and makes cheaper the construction and opening up of basic industrial enterprises, the ancillary branches and services. The transport factor probably plays the decisive role in achieving the rational division of labour between the North and South of Siberia. The Baikal-Amur Railway will play just this sort of pioneer role.

Transport is one of Siberia's problems and much remains to be done to solve it. The scale of transport construction in Siberia should be greatly enlarged.

The methods of exploiting the natural resources of Siberia which we have examined could be very efficiently realised in the new areas, where until recently there were no major industrial and mining centres, in those places where large natural resources lie untopped. Large amounts of investments have already been made in the Siberian North, but much remains to be spent in the future. Extremely great savings could be made putting optimal planned solutions into practice.

An increased cost of production in the North has been brought about by objective conditions, but economic, social and technical policies can dampen this tendency. Moreover, the production of a number of industrial goods in the North is cheaper than in other regions. This is due to the wealth of the Siberian reserves and the favourable geological and mining conditions for the exploitation of many deposits.

Siberia is striving towards the future. What will she become? What will be new in her economy? What important changes will take place in her natural environment? Which new territories will become settled, developed regions? How will the little and big Siberian towns and other centres of population in various parts of this enormous region look?

Scientists and experts in all sorts of areas of science and industry are now steadfastly working on forecasting the answers to these questions. They are striving to chart the trends and scale of Siberia's economic development as fully and objectively as they can, considering them in the context of future plans for the whole country, regarding Siberia as one of the most important areas where work is going on to create the material and technical basis of Communist society.

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Siberia is a vast territory stretching thousands of kilometres from the Far East to the Urals with immense and diverse natural wealth.

A favourable combination of natural and economic factors is leading to the setting up there of large production complexes of national and world significance. The key to the natural wealth of the remote and almost inaccessible regions of Siberia is the Baikal-Amur Railway to which the long-term plan for exploiting the Eastern part of the Soviet Union is linked.

This book covers the distribution of productive forces, the construction of major industrial enterprises and electric power stations, the development of transportation, the laying of gas pipe-lines and the emergence of new cities.

The author, Prof. Boris Orlov, D. Sc. (Economics) has lived and worked in Siberia for many years which accounts for the vivid and absorbing narration.