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FUELS AND RELATED EQUIPMENT

UDC 622.691.4

ECONOMICS, ORGANIZATION, ADMINISTRATION OF SOVIET GAS INDUSTRY

Moscow GAZOVAYA PROMYSHLENNOST', SERIYA: EKONOMIKA, ORGANIZATSIYA I UPRAVLENIYE V GASOVOY PROMYSHLENNOSTI in Russian No 2, 1979 pp 1-27

[Monograph by T. I. Bogopol'skaya, L. F. Linetskaya, et al., VNIIEgazprom]

[Text] The dynamics of the basic technical-economic indices pertaining to the development and operation of the system for transporting natural gas in Tyumenskaya Oblast are discussed in this survey. It cites an analysis of the structure and effectiveness of capital investments and fixed assets; provided an evaluation of the influence exerted by the basic trends in scientific-technical progress in the transportation of gas upon the level of the economic indices under the conditions of Western Siberia. It defines the future prospects for the further development of the system of the mainline transportation in the region being considered.

Authors of the survey: T. I. Bogopol'skaya, L. F. Linetskaya, V. V. Tandalov, G. N. Deribo, V. G. Prokopets

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During the current five-year period and in the long-term view Tyumenskaya Oblast will be our country's basic supplier of gas, a region which, practically speaking, will provide the entire increase in gas extraction. This gives importance to the influence exerted by the technical-economic indices pertaining to the development of this region upon their level for the entire branch.

This work is devoted to an analysis of the level and dynamics of the technical-economic indices pertaining to the mainline transporting of gas under conditions of Western Siberia. Since the volumes of transportation of casing-head gas are insignificant, this work will consider the basic technical-economic indices pertaining to the operation of that system without a detailed analysis.

General Description of the Development and Operation of the Gas-Transportation System During 1970-1977

During recent years a typical feature in the development of the gas industry has been the worsening of a number of the basic technical-economic indices. This is explained by a decrease in the volumes of gas extraction in the central and southern rayons and by the shifting of the basic centers of gas extraction to the eastern part of the country, with its unfavorable natural and climatic conditions and its weak economic development. Mainline transportation of gas is no exception in this regard.

During 1970-1977 the return on investments in the branch decreased by almost one-half; the costs of transporting 10,000 cubic meters of gas increased by 1.5 times; and labor productivity, practically speaking, remained at the same level. The same situation was created with regard to the Tyumentransgaz Association (Table 1). With an increase in labor productivity during 1971-1977 by a factor of almost 2, the return on investment dropped by 42 percent, the costs of transporting 10,000 cubic meters of gas increased by 55 percent, and the costs per unit of transportation work has had a tendency toward reduction.

It should be noted that the worsening of the basic technical-economic indices occurs despite the high rates of development of the gas-transporting systems. For Mingasprom as a whole, the volume of the gas to be transported increased during 1970-1977 by a factor of 1.8; for the Tyumentransgaz Association, by a factor of 6.9. Usually an increase in the volumetric indices leads to a relative improvement in the economic indices. However, in the transportation of gas this does not occur. This is explained by the increase in the distance in transporting the gas, and by the construction and activation of systems in rayons with unfavorable conditions from the point of view of economic geography.

The development of the system of gas pipelines "Northern Rayons of Tyumenskaya Oblast (SRTO)-Urals" in Western Siberia began with the activation

in early 1966 of its first sector -- the Igrim-Serov gas pipeline, which was intended for supplying the industrial enterprises and cities in the Northern Urals. The gas was fed from the Punginskoye, Berezovskoye, and Igrimskoye Deposits. The gas pipeline was constructed of pipes with a diameter of 1020 millimeters, and had a total length of 525 kilometers. The second sector of the SRTO-Urals system -- the "Serov--Nizhniy Tagil" gas pipeline, with a total length of 223 kilometers and with pipes 1020 millimeters in diameter, and the "Nizhnyaya Tura--Perm'" pipeline, with a total length of 114 kilometers and a diameter of 1020 millimeters -- were activated respectively in 1966 and 1969; the third sector of the system -- the "Medvezh'ye-Nadym-Punga" gas pipeline -- was activated in 1972. A 571-kilometer sector of the Nadym-Punga gas pipeline was made of pipes with a diameter of 1220 millimeters. During the construction of the sector of the Medvezh'ye-Nadym gas pipeline, with a total length of 101.3 kilometers, pipes with a diameter of 1420 millimeters, designed to operate at a working press of 75 kilogram-force per square centimeter, were used for the first time in the Soviet Union.

The Medvezh'ye-Nadym-Punga gas pipeline, together with the existing gas pipelines -- Igrim-Serov--Nizhniy Tagil and Nizhnyaya Tura--Perm' -- formed the completed first phase of the system, which, in 1972, began to transport gas from the Medvezh'ye deposit. The construction of the second phase of the system was begun in 1972, with the Punga-Urals sector, with a total length of 616 kilometers and diameter of 1220 millimeters. The Nadym-Punga sector, with a lenth of 538.8 kilometers and a diameter of 1220 millimeters, was handed over for operation in 1974. The third sector of that phase -- the Medvezh'ye-Nadym gas pipeline -- with a diameter of 1420 millimeters, was turned over in 1975.

In 1975 a third phase was activated. This phase includes the Punga--Nizhnyaya Tura sector, with a 1220-mm diameter and a length of 573 kilometers and the Nadym-Punga sector, with a 1420-mm diameter and length of 596 kilometers. In 1976 one branch of the Punga-Vuktyl gas pipeline was activated. Thus, as of 1 January 1978, 5533.3 kilometers of gas pipeline were in operation (Table 2). The natural gas of Tyumenskaya Oblast is transported over a system of pipelines from the Medvezh'ye deposite to Punga, then some of the natural gas is sent to the Urals and from there to the European part of the country, and the rest of it to Ukhta.

In 1977, 13 compressor stations with a capacity of 1,541,600 kilowatts were in operation in the West Siberian gas-transporting system. The KS [compressor stations] have been provided, for the most part, with units of the GT-750-6 and GTK-6-750 type, but during the current five-year period the newly activated shops are being supplied with units with increased capacity: 10,000, 16,000, and 25,000 kilowatts. The indices pertaining to the KS are shown in Table 4. The receipts of gas and its distribution to the customers are shown in Table 4.

In addition to the transportation of natural gas in Western Siberia, since 1975 there has been carried out the transportation of casing-head gas in

insignificant quantity (Table 5). The total length of the system is 194 kilometers.

Table 1

Basic Technical-Economic Indices Pertaining to the Tyumentransgaz PO [Production Association]

(1) Показатели (1)	(2) Годы							
	1970	1971	1972	1973	1974	1975	1976	1977
Объем транспортируемого газа, млрд.м³(3)	8,7	8,7	10,7	14,6	21,7	31,5	41,8	59,3
Объем транспортной работы, 1000 млрд.м³·км (4)	6,3	6,4	8,9	17,1	26,3	39,4	51,9	69,7
Протяженность магистральных газопроводов, км (5)	1306	1556	2260	3051	3559	4443	5160	5533
Средняя дальность транспорта газа, км (6)	693	696	798	1105	1148	1191	1250	1175
Количество:(7)								
КС (8)	5	5	7	8	9	9	10	13
компрессорных цехов (9)	5	5	7	11	16	22	28	34
ГПА (10)	25	28	39	64	106	136	161	204
Мощность КС, тыс.кВт (11)	123,7	141,8	207,8	357,8	573,6	753,6	1087,6	1541,6
Численность - всего, чел. (12)	1143	1261	1482	1818	2235	2732	3415	4330
В том числе в транспорте газа(13)	879	943	1120	1411	1706	2018	2486	3143
Производительность труда, (14)								
млн.м³/чел.	9,8	9,2	9,5	10,4	12,7	15,6	16,8	18,9
млрд.м³·км/чел.(15)	7,1	6,7	8,0	12,1	15,4	19,5	21,3	22,2
Фондоотдача, м³/руб. (16)	50,7	56,6	28,0	26,6	25,4	25,4	25,8	29,3
Себестоимость транспорта газа, (17)								
руб/10000 м³	15,28	15,03	20,69	25,36	25,64	25,08	24,56	23,68
руб/млрд.м³·км (18)	2,13	2,07	2,48	2,17	2,12	2,01	2,00	2,02

Key: 1. Indices
2. Years
3. Volume of gas transported, billion cubic meters
4. Volume of transportation work, 1000 billion cubic meters x kilometers
5. Total length of main gas pipelines, kilometers
6. Average distance of transporting the gas, kilometers
7. Number of:
8. KS [compressor stations]
9. compressor shops
10. GPA [gas-pumping units]
11. Capacity of KS, thousands of kilowatts
12. Total number of personnel
13. Including, in the transportation of gas
14. Labor productivity, millions of cubic meters per person
15. billions of cubic meters x kilometers per person
16. Return on investment, cubic meters per ruble
17. Cost of transporting the gas, rubles per 10,000 [sic] cubic meters
18. Rubles per billion cubic meters x kilometers

Table 2

Total Length of West Siberian System for Transportation of Natural Gas, as of 1 January 1978

(1) Газопровод	(2) Год ввода	(3) Протяженность, км, при диаметре, мм				
		1420	1220	1020	720	всего (4)
(5) Медвежье-Надым I	1972	101,3	-	17,1	-	118,4
(6) Надым-Пунга I	1972	9,7	579,0	53,4	12,4	655,7
(7) Надым-Пунга II	1974	-	543,3	27,7	-	571,0
(8) Игрим-Пунга	1966	-	-	36,6	-	36,6
(9) Игрим-Серов-Н.Тагил	1966	-	106,9	755,7	23,3	885,9
(10) СРТО-Урал II	1974	-	762,7	30,1	-	792,8
(11) Н.Тура-Пермь I и II	1969	-	-	114,0	-	114,0
(12) Медвежье-Надым II	1975	97,0	-	18,1	-	115,1
(13) Надым-Пунга-Н.Тура III	1975	541,8	611,8	57,9	-	1211,5
(14) Пунга-Вуктыл II	1976	289,0	-	5,2	-	294,2
(15) Уренгой-Надым I	1977	83,4	-	6,6	-	90,0
(16) Надым-Пунга IV	1976	541,3	-	27,4	-	568,7
(4) В с е г о ...		1663,5	2603,7	1150,1	36,0	5533,3*)

(17) *) В том числе отводы и газопроводы диаметром 529 мм и меньше- 80,02 км.

Key: 1. Gas pipeline
2. Activation year
3. Total length, kilometers, with diameter, in millimeters:
4. Total
5. Medvezh'ye-Nadym I
6. Nadym-Punga I
7. Nadym-Punga II
8. Igrim-Punga
9. Igrim-Serov--Nizhniy Tagil
10. SRTO-Urals II
11. Nizhnyaya Tura-Perm' I and II
12. Medvezh'ye-Nadym II
13. Nadym-Punga--Nizhnyaya Tura III
14. Punga-Vuktyl II
15. Urengoy-Nadym I
16. Nadym-Punga IV
17. Including offsets and gas pipelines with a diameter of 529 millimeters or less -- 80.02 kilometers.

Table 3

Information Pertaining to Compressor Stations in the Tyumentransgaz PO, as of 1 January 1978

(1) Компрессорная станция	(2) Цех	(3) Время ввода (месяц, год)	(4) Тип установленных агрегатов	(5) Количество ГПА (6) всего	(7) установлено	(8) Мощность КС, тыс.кВт
(9) ГКС-Пангоды	А	I2.I977	ГТК-I6	4	-	64
(10) Надым	А	I0.I976	ГТК-25И	3	3	75
(11) Лонг-Юган	А	I2.I973	ГТ-6-750	6	6	36
	Б	0I.I975	ГТ-6-750	6	6	36
	В	0I.I977	ГТК-I0-4	6	6	60
	Г	I2.I977	ГТК-I0	6	6	60
(12) Сорум	А	08.I974	ГТ-6-750	6	6	36
	Б	09.I975	ГТ-6-750	6	6	36
	В	I0.I976	ГТК-25И	3	3	75
(13) Казым	А	I2.I972	ГТ-6-750	6	6	36
	Б	07.I975	ГТ-6-750	6	6	36
	В	0I.I977	ГТК-I0-4	8	6	80
	Г	I0.I977	ГТК-I0	7	6	70
(14) КС-I Пунга	А	I2.I97I	ГТ-6-750	6	6	36
	Б	0I.I975	ГТ-6-750	6	6	36
(15) КС-3 Комсомольская	А	I2.I967	ГТ-6-750	5	5	30
	Б	I2.I972	ГТ-6-750	6	6	36
	В	I2.I975	ГТ-6-750	6	6	36
(16) КС-4 Пелым	А	09.I970	ГТ-6-750	5	5	30
	Б	I0.I974	ГТ-6-750	6	6	36
	В	07.I976	ГТ-6-750	6	6	36
(17) КС-5 Ивдель	А	04.I967	ГТ-700-5	5	5	2I,25
	Б	02.I973	ГТ-750-6	9	9	54
	В	02.I976	ГТ-6-750	6	6	36
(18) КС-6 Краснотурьинск	А	06.I967	ГТ-700-5	5	5	2I,25
	Б	09.I974	ГТ-750-6	9	9	54
	В	I0.I976	ГТК-I6	3	3	48

Key: 1. Compressor station; 2. Shop: A = "a", B = "b", V = "c"; G = "d"; 3. Activation time (month, year); 4. Type of units installed; 5. Number of GPA; 6. Total; 7. Installed; 8. Capacity of KS, thousands of kilowatts; 9. GKS-Pangody; 10. Nadym; 11. Long-Yugan; 12. Sorum; 13. Kazym; 14. KS-1 Punga; 15. KS-3 Komsomol'skaya; 16. KS-4 Pelym; 17. KS-5 Ivdel'; 18. KS-6 Krasnotur'insk.

Table 3, continued

(1) Компрессорная станция	(2) Цех	(3) Время ввода (месяц, год)	(4) Тип установленных агрегатов	(5) Количество ГПА всего (6)	(5) Количество ГПА установлено (7)	(8) Мощность КС, тыс.кВт
(9) КС-7 Н.Тура	А	I0.I968	ГТ-700-5	5	5	2I,25
	Б	08.I973	ГТ-750-6	6	6	36
	В	I0.I975	ГТ-750-6	6	6	36
(10) ДКС (в Пунге)	-		МК-8	9	9	I7,8
(11) Приполярная	Б	09.I977	ГТК-I0	8	6	80
(12) Сооьвинокая	Б	I2.I977	ГТК-I0	6	6	60
(13) Перегребное	Г	04.I977	ГТК-I0	8	6	80
(14) И т о г о ...	34			204	I84	I54I,6

Key: 1. Compressor station
2. Shop: A, B, V, G respectively = "a," "b," "c," "d"
3. Activation time (month, year)
4. Type of units installed
5. Number of GPA
6. Total
7. Installed
8. Capacity of KS, thousands of kilowatts
9. KS-7, Nizhnyaya Tura
10. DKS [supplemental compressor station?] (in Punga)
11. Pripolyarnaya
12. Sos'vinskaya
13. Peregrebnoye
14. Total

Table 4

Receipts of Gas and Distribution of It to Customers, Millions of Cubic Meters

(1) Показатели	(2) Годы							
	I970	I97I	I972	I973	I974	I975	I976	I977
(3) Поступление газа, всего	9236,0	9I27,5	II2I4,7	I5454,3	22900,0	33078,8	43677,7	62099,9
(4) В том числе из месторождений:								
(5) Игримская группа	9236,0	9I27,5	9289,I	6520,6	4500,0	3458,7	2637,0	2328,I
(6) Медвежье	-	-	I925,6	8933,7	I8450,0	29620,I	4I040,7	59772,8
(7) Распределение газа, всего	9236,0	9I27,0	II2I4,7	I5454,3	22900,I	33078,8	43677,7	62099,9
(8) В том числе:								
(9) собственные нужды	444,0	377,0	4I2,7	672,0	I099,8	I456,3	I747,5	2575,9
(10) потери	I35,I	20,0	I00,I	I20,0	78,0	I07,7	I77,I	229,0
(11) изменение остатка в газопроводе	-	+24,7	+28,2	+50,4	-4,6	+37,7	+I3,2	+II4,8
(12) Товарный газ	8656,9	8705,8	I0673,7	I46II,9	2I7I7,7	3I477,I	4I749,9	59I80,2
(13) В том числе по потребителям:								
(14) Тюменская обл.	4,I	4,98	4,8	I95,9	2I9,I	27I,4	267,4	259,I
(15) Свердловская обл.	I08I,2	III0,0	I672,6	I698,6	2259,6	22I6,8	2I47,I	2620,8
(16) Горькийтрансгаз	540I,3	4942,7	6209,5	9I26,7	22I7,3	I24I6,0	I8058,4	20370,6
(17) Уралтрансгаз	2I39,0	249I,0	2602,7	3523,0	I3647,8	I6572,9	20004,I	2I285,4
(18) Комигазпром	-	-	-	-	-	-	I272,9	I4644,3
(19) Прочие потребители	9I,3	I57,I	I84,I	67,7	3373,9	234,9	-	-

Key: 1. Indices; 2. Years; 3. Receipts of gas, total; 4. Including from deposits: 5. Igrimskaya group; 6. Medvezh'ye; 7. Distribution of gas, total; 8. Including; 9. Own needs; 10. Losses; 11. Change of balance in gas pipeline; 12. Commercial gas; 13. Including, for customers; 14. Tyumenskaya Oblast; 15. Sverdlovskaya Oblast; 16. Gorkiytransgaz; 17. Uraltransgaz; 18. Komigazprom; 19. Other customers

Table 5

Technical-Economic Indices Pertaining to the Development and Operation of the System for Transporting Casing-Head Gas

(1) Показатели	(2) Годы		
	1975	1976	1977
(3) Объем транспортируемого газа, млрд.м^3	0,773	1,682	2,062
(4) Объем транспортной работы, млрд.м^3·км	150,0	326,0	400,03
(5) Численность работников, чел.	35	74	96
(6) Удельная численность (на 100 км), чел.	18	43	45
(7) Производительность труда, млрд.м^3/чел.	22,1	22,7	21,5
(8) Стоимость основных производственных фондов, млн.руб.	27,0	27,4	29,0
(9) Фондоотдача, м^3/руб.	28,7	61,4	71,1
(10) Себестоимость транопорта 1000 м^3 газа, руб.	15,66	10,83	11,42
(11) Объем реализованной продукции, млн.руб.	6,2	13,4	41,3

Key: 1. Indices
2. Years
3. Volume of gas transported, billions of cubic meters
4. Volume of transportation work, billions of cubic meters x kilometers
5. Number of workers
6. Specific number of personnel (per 100 kilometers)
7. Labor productivity, billions of cubic meters per person
8. Value of fixed production assets, millions of rubles
9. Return on investment, cubic meters per ruble
10. Costs of transporting 1000 cubic meters of gas, rubles
11. Volume of sold output, millions of rubles

Throughout the period of existence of the system, there has been no change in its total length. Gas is fed from the petroleum deposits in the Central Ob' area to the city of Surgut. The Surgutskaya GRES is the consumer of the casing-head gas. That GRES will be the basic consumer of the casing-head gas within the immediate and distant future. When operating at full capacity, the Surgutskaya GRES will consume approximately 12 billion cubic meters of gas.

As a result of the fact that the total length of the system and the volumes of transporting casing-head gas are insignificant, no detailed analysis of its technical-economic indices is provided in this survey.

Analysis of the Use of Material-Technical and Manpower Resources

Fixed Assets

The transportation of gas pertains to the capital-intensive subbranches of industry. In the value of the production assets, fixed assets constitute 98.5-99.5 percent (Table 6). The effectiveness of the use of the fixed assets determines the level of costs of gas transportation. Therefore we shall dwell in more detail in the analysis of their use.

Table 6

Structure of Production Assets of the Tyumentransgaz PO

Показатели	На начало года									
	1972		1973		1974		1975		1976	
	тыс.руб.	%	тыс.руб.	%	тыс.руб.	%	тыс.руб.	%	тыс.руб.	%
Производственные фонды- всего	241033	100,0	452740	100,0	711125	100,0	1205987	100,0	1526168	100,0
В том числе:										
основные	237498	98,5	448857	99,1	706109	99,3	1200645	99,5	1519033	99,5
оборотные	3535	1,5	3887	0,9	5016	0,7	5342	0,5	7135	0,5

Key: 1. Indices
2. As of the beginning of the year
3. Thousands of rubles
4. Production assets, total
5. Including:
6. Fixed
7. Working

1977		1978	
тыс.руб.	%	тыс.руб.	%
2035849	100,0	2419949	100,0
2026476	99,5	2407044	99,5
9373	0,5	12905	0,5

As of the beginning of 1978, the value of fixed assets at the Tyumentransgaz PO constituted 2,407,000,000 rubles, which is 10 times greater than in 1972, and 24 times greater than in 1966. The average annual rate of increase was 148 percent.

This high rate of activation of fixed assets of enterprises in mainline transportation is linked with the economy's growing need for natural gas. However, it should be noted that the rate of growth in the value of the fixed assets is considerably outstripping the rate of growth in the volume of gas being transported; this is linked with the increase in the distance required for transporting the gas. Whereas, prior to 1972, gas was fed from the Igrimskaya group of deposits (693 kilometers), since 1972 it has been fed from the Medvezh'ye deposit: the average distance for transporting the gas has increased to 1175 kilometers.

The outstripping rate of growth of value of the fixed assets, as compared with the growth rates for the volume of gas to be transported, has had an undesirable

effect upon the indices pertaining to their use (Table 7). First of all, there has been a drop in the index pertaining to return on investment. Whereas in 1970 it constituted 50.7 cubic meters per ruble, in 1977 it was only 29.3 cubic meters per ruble, that is, dropped by a factor of $\frac{1}{1.7}$. In monetary terms, this index constituted, respectively, 0.86 and 0.25 rubles per ruble, that is, the decrease as compared with the physical index of return on investment is even more considerable. The nonconformity of the growth rates for the volume of gas to be pumped and the value of the fixed assets was influenced not only by the increase in the distance required for transportation of the gas, but also by the lag in the activation of the compressor-station capacities behind the activation of the line part itself, and, as a result, the use of the gas pipeline at less than full capacity. For example, in 1975, when the lowest level of return on investment was obtained, practically all the sectors of the gas pipeline were being used at less than full capacity as a consequence of the incomplete providion with compressor stations and the insufficient use of the existing capacities.

When considering the structure of the fixed assets of Tyumentransgaz Association (Table 8), it can be noted that the share of the assets (gas pipelines and gas-pumping units [GPA]) in the total value of the enterprise fixed assets is very large -- 70-80 percent. The effectiveness of the use of this part of the funds, basically, is what determines the level of return on investment.

An analysis of the structure of the fixed assets by the production-line administrations for the main gas pipeline (LPUMG) indicated that a relatively large percentage (from 3 to 10 percent) is occupied by the fixed assets of the auxiliary and maintenance services. On the average for the association, the percentage of the fixed assets in those services as of 1 January 1978 constituted 3.7 percent. These services include: steam-and-water supply, electrical supply, transportation, and communication. Also carried on the enterprises' balance sheet are roads with a total value of more than 45 million rubles (1.9 percent of the total value of the production assets).

This is explained by the weak economic development of the area, the lack of centralized providing of various types of services, and, as a consequent, the necessity of developing the corresponding services at the gas-transportation enterprises. For example, as much as 6.5 percent of the fixed production assets can be transferred to the balance sheet of the enterprises in the electrical-engineering industry and specialized transportation and other enterprises; that would make it possible to achieve a corresponding increase in the return on investment at the gas-transportation enterprises. Despite the considerable increase in the value of the fixed assets under conditions of Tyumenskaya Oblast, the level of return on investment in the Tyumentransgaz PO, thanks to the use of pipes with increased diameter and those operating at high pressure,is higher than the average for the branch.

Table 7

Indices of Use of Fixed Assets of Tyumentransgaz PO During 1970-1977

(1) Показатели	(2) Годы							
	I970	I97I	I972	I973	I974	I975	I976	I977
Среднегодовая стоимость основных производственных фондов, млн.руб. (3)	I44,6	I60,I	38I,7	560,5	854,7	I239,7	I624,I	2022,6
Фондоотдача промышленно-производственных фондов: (4)								
руб/руб.(5)	0,86	0,43	0,30	0,32	0,28	0,23	0,24	0,26
$м^3$/руб. (6)	50,7	56,6	28,0	26,6	25,4	25,4	25,8	29,3
тыс.$м^3$·км/руб.(7)	43,0	39,7	23,4	30,5	30,8	3I,8	3I,9	34,5
Фондоотдача активной части фондов: (8)								
руб/руб.(9)	I,I9	0,6I	0,43	0,36	0,32	0,27	0,30	0,32
$м^3$/руб.(10)	63,0	77,7	33,3	28,9	30,7	29,5	32,3	36,6
тыс.$м^3$·км/руб.(11)	59,6	56,5	27,9	33,8	37,2	37,I	40,I	43,I

Key: 1. Indices
2. Years
3. Average annual value of fixed production assets, millions of rubles
4. Return on investment of industrial-production assets:
5. rubles per ruble
6. cubic meters per ruble
7. thousands of cubic meters x kilometers per ruble
8. Return on investment of assets [as opposed to liabilities]
9. rubles per ruble
10. cubic meters per ruble
11. thousands of cubic meters x kilometers per ruble

It should be noted that the level for return on investments, as computed on the basis of the volume of transportation work, that is, with a consideration of the gas-transportation distance, has been rising since 1972. During the five-year period it increased by 54 percent. In this connection one should support the hypothesis expressed by a number of economists [1, 2] concerning the use, in the mainline transportation of gas, of the index of volume of transportation work as being the index that reflects most completely the efforts exerted by the collective at the enterprises and that excludes the influence exerted upon the technical-economic indices by the distance of gas transportation, and one should change over to the permanent planning and statistical accounting of the level of this index for all associations and UPUMG.

For purpose of locating reserves for increasing the volume of gas to be transported, a more detailed analysis was made of the fund assets: the line part of the gas pipelines and the gas-pumping units.

As is shown by an analysis of the use of the capacity of the gas-transporting

system as of 1 January 1978, the handling capacity of the system of gas pipelines, expressed in terms of complete capacity (three separate lines), on individual sectors of the Nadym-Punga gas pipeline is different: from 191 to 172 million cubic meters per 24-hour period. Actually, however, the gas pipeline can handle on each sector 172 million cubic meters per 24-hour period, plus the expenditure of gas for the own needs of the preceding KS.

According to data provided by the Gas-Transportation Section of Tyumennii-giprogaz, the computed efficiency with regard to the capacity of the sectors varies from 0.90 to 0.94 (Table 9). Considering the fact that the gas fed into the system is not quality-standardized, the actual productivity of the system of its efficiency will be even lower. In 1978 the efficiency of the sectors which characterizes the dirt content in the interior cavity of the pipe changed from 0.81 to 0.96. Putting it another way, one of the directions to be taken in improving the operating conditions of the gas pipelines and increasing their handling capacity is the improvement of its preparation in the oil field and the careful cleaning of the pipe cavity by the handling sectors. However, for the Medvezh'ye deposit, where the gas contains an insignficant quantity of heavy hydrocarbons, the expenditures to extract them prove to be so great that they do not repay themselves by a reduction in the expenditures in the transportation of the gas. Computations have shown that the additional expenditures to improve the preparation of the gas for the Medvezh'ye deposit will be substantiated if the hydraulic efficiency for that reason will be increased by no less than 4 percent.

A reserve for increasing the handling capacity of the system is the installation of air-cooling apparatus (AVO). As has been shown by computation for the three individual lines of the SRTO-Urals gas pipeline (Table 10), an insignificant increase in the productivity of the gas pipeline (increase by 3-5 percent) is accompanied, practically speaking, by the same increase in expenditures. If the productivity of the system is increased by less than 3 percent, the level of specific expenditures with the use of AVO is higher. There is practically no benefit from the cooling of the gas. However, in view of the improvement of the operating conditions for the KS equipment and the gas pipeline, the use of air-cooling units should be considered to be desirable.

A special place in the analysis of the fund assets is occupied by the gas-pumping units. During 1971-1977 in the Tyumentransgaz Association, 29 shops with 179 GPA having a total capacity of 1,362,000 kilowatts were activated. As of 1 January 1978 at all the KS in the association there were 204 GPA of various types, with a total capacity of 1,541,600 kilowatts (see Table 3). The increase in the installed capacity of the GPA by a factor of 12 is linked with the introduction of new KS and the expansion of the existing ones. For example, from 1970 through 1977 the number of KP increased by a factor of 2.6, and the number of compressor shops by a factor of 6.8. In addition, the increase in the overall installed capacity is linked with the increase in the number of GPA in a single shop (from 5 to 6 and 9) and the share of units with increased individual capacity. Whereas in 1971 the only units

operated had a capacity of 4,250 and 6000 kilowatts (GT-700-5, GT-6-750), since 1976 units have appeared with a capacity of 10,000, 16,000, and 25,000 kilowatts (GTK-10, GTK-16, and GTK-25). As a result there has been an increase in the capacity per 100 kilometers of gas pipeline: from 9,500 in 1970 to 27,800 kilowatts in 1977, as well as the capacity per 1000 cubic meters of transported gas: from 14.300 to 26,000 kilowatts.

As a result of the installation of units with increased capacity, the average installed capacity per operating unit is constantly growing. Whereas in 1971 it constituted 5,100 kilowatts and in 1975 5,500 kilowatts, as of the end of 1980 the planned figure is 9,400 kilowatts, which is 84 percent more than in 1971 and 70 percent more than in 1975. The increase in the individual capacity of the units is making it possible to reduce the capital investments and the operating expenditures per unit of capacity and per 1000 cubic meters of gas to be pumped (Table 11).

Thus, with the increase in the individual capacity of the GPA from 10,000 to 16,000 kilowatts, the specific capital investments per kilowatt of capacity under conditions of Western Siberia are reduced by 11.0 percent, and per 1000 cubic meters of pumped gas, by 26.0 percent. Thus, the installation of units with increased capacity on the main gas pipeline makes it possible to save the capital investments in KS and the expenditures to operate them. For example, when a KS with a capacity of 75,000 kilowatts was being built in the city of Nadym, that would have required eight units of the GTK-10 type. What was installed, however, was a total of three GTK-25 units with the same capacity; this will make it possible to save 3.9 million rubles of capital investments and to effect an annual saving of 1.4 million rubles of operating expenses.

As has been indicated by computations, during the entire period of 1976-1980, thanks to the installation at KS of units with increased capacity instead of GPA of the GT-750-6 type, the saving of capital investments will constitute 138.3 million rubles; operating expenses, 22.6 million rubles; and the level of return on investment will rise by 2.6 percent.

In order to analyze the use of the units that are in operation, the following indices are used: coefficients of readiness and operational reliability; frequency and complexity of forced outages. Since, for the LPUMG of the Tyumentransgaz Association, these indices were computed by means of different formulae, thus making them impossible to be compared, and, in addition, certain indices were not computed at all, the authors carried out a computation of all the enumerated indices according to a uniform methodology [3] (Table 12).

From the data cited, it follows that for the association as a whole, the operating time for the units under load constitutes 61-73 percent of the calendrical time of operation of the GPA. Therefore, the coefficient of operation of the GPA is rather low -- 0.613-0.728 -- although, during the period being considered, it rose by 12 percent. For individual KS, the coefficient of operation varied within broad limits.

Table 8

Structure of Fixed Assets for Tyumentransgaz PO

(1) Показатели	(2) I970 г. млн.руб.	%	I97I г. млн.руб.	%	I972 г. млн.руб.	%	I973 г. млн.руб.	%	I974 г. млн.руб.	%	I975 г. млн.руб.	%	I976 г. млн.руб.	%	I977 г. млн.руб.	%
(3) Промышленно-производственные фонды - всего	I50,3	98,6	228,8	96,3	5I5,8	98,I	73I,0	98,3	II78,7	98,2	I493,6	98,3	I983,7	97,9	2356,3	97,9
(4) В том числе:																
(5) здания	7,3	4,8	7,9	3,3	I3,3	2,5	I8,2	2,4	37,6	3,2	45,6	3,0	67,I	3,3	I04,3	4,3
(6) сооружения	6,8	4,5	8,4	3,5	I5,2	2,5	I9,8	2,7	36,9	3,I	54,7	3,6	52,9	2,6	68,6	2,9
(7) передаточные устройства	4,6	3,0	5,9	2,5	I0,2	I,9	I9,5	2,6	42,I	3,5	60,I	4,0	70,0	3,5	80,7	3,4
(8) машины и оборудование	I2,0	7,9	I8,4	7,8	33,6	6,4	59,7	8,0	I03,5	8,6	I46,4	9,6	239,0	II,8	24I,9	I4,2
(9) транспортные средства	II9,5	78,4	I88,I	79,2	433,3	82,4	6I3,7	82,6	958,4	79,8	II86,7	78,I	I554,4	76,7	I760,I	73,I
(10) прочие	0,I	-	0,I	-	0,2	-	0,2	-	0,2	-	0,3	-	0,4	-	0,7	-
(11) Производственные фонды других отраслей	0,2	0,I	0,4	0,2	0,4	0,I	I,2	0,2	I,7	0,I	2,6	0,2	6,0	0,3	7,4	0,3
(12) Непроизводственные фонды	I,9	I,I	8,3	3,5	9,5	I,8	I0,7	I,4	20,2	I,7	22,8	I,5	36,8	I,8	43,3	I,8
(13) В с е г о ...	I52,4	I00,0	237,5	I00,0	525,7	I00,0	742,9	I00,0	I200,6	I00,0	I5I9,0	I00,0	2026,5	I00,0	2407,0	I00,0
(14) Активная часть основных фондов:																
(15) • газопровод	96,8	63,5	I34,I	56,5	406,5	77,3	6II,5	77,2	850,0	70,8	II78,4	70,9	I388,I	68,5	I634,0	67,9
(16) • ГПА	II,6	7,6	I7,9	7,5	26,I	5,0	45,9	6,2	7I,I	6,9	I02,9	6,8	I9I,0	9,4	249,I	I0,3

Key: 1. Indices
2. Million rubles
3. Industrial-production funds, total
4. Including
5. buildings
6. structures
7. transmission devices
8. machinery and equipment
9. transportation means
10. other
11. Production funds of other branches
12. Nonproduction funds
13. Total
14. Fund assets
15. gas pipeline
16. GPA

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Table 9

Indices Pertaining to the Use of the Handling Capacity of Individual Sectors of the SRTO-Urals Gas Pipeline in 1978 (Three Individual Lines)

(1) Участки газопровода	(2) Суммарная пропускная способность, млн.м³/сут	(3) Расчетный коэффициент использования	(4) Фактический коэффициент использования по месяцам					
			(5) январь	(6) февраль	(7) март	(8) апрель	(9) май	(10) июнь
(11) Надым-Лонг-Юган	I9I,0	0,90	0,73	0,75	0,76	0,76	0,75	0,78
(12) Лонг-Юган-Сорум	I87,8	0,9I	0,80	0,82	0,85	0,85	0,82	0,83
(13) Сорум-Казым	I82,8	0,94	0,82	0,84	0,87	0,87	0,84	0,85
(14) Казым-КС-I	I7I,9	I,00	0,9I	0,93	0,96	0,96	0,92	0,92
(15) Итого ...	I7I,9	0,95	0,88	0,8I	0,87	0,85	0,82	0,83

Key:
1. Sectors of gas pipeline
2. Total handling capacity, millions of cubic meters per 24-hour period
3. Computed efficiency
4. Actual efficiency by months
5. January
6. Feburary
7. March
8. April
9. May
10. June
11. Nadym-Long-Yugan
12. Long-Yugan-Sorum
13. Sorum-Kazym
14. Kazym--KS-1
15. Total

Table 10

Technical-Economic Indices Pertaining to Transportation of Gas with the Use of AVO

(1) Показатели	(2) Без охлаждения	(3) С охлаждением
(4) Участок Надым-Пунга		
(5) Объем транспортируемого газа, млрд.м^3/год	53,1	55,2
(6) Удельные затраты, руб/1000 м^3 газа:		
(7) капиталовложения	15,6	15,3
(8) себестоимость	1,05	1,04
(9) приведенные	2,92	2,87
(10) Участок Пунга-Н.Тура		
(5) Объем транспортируемого газа, млрд.м^3/год	38,5	39,7
(6) Удельные затраты, руб/1000 м^3 газа:		
(7) капиталовложения	10,1	10,3
(8) себестоимость	1,07	1,09
(9) приведенные	2,89	2,94

Key: 1. Indices
2. Without cooling
3. With cooling
4. Nadym-Punga sector
5. Volume of gas to be transported, billions of cubic meters per year
6. Specific expenditures, rubles per 1000 cubic meters of gas:
7. capital investments
8. production costs
9. converted
10. Punga--Nizhnyaya Tura sector

Table 11

Technical-Economic Indices for Various Types of GPA

(1) Показатели	(2) Тип ГПА					
	ГТК-5	ГТ-750-6	ГТК-10	ГТК-16	ГТК-25	СТД-12500
(3) Мощность, тыс.кВт:						
(4) ГПА	4,4	6,0	10,0	16,0	25,0	12,5
(5) КС	79	72	80	80	75	75
(6) Производительность ГПА:						
(7) млн.м^3/сут	13,0	20,0	29,0	32,0	50,0	36,0
(8) млрд.м^3/год	4,7	7,3	10,6	11,7	18,3	13,1
(9) Производительность КС, млрд.м^3/год	28,2	29,2	31,8	35,1	36,6	26,2
Капиталовложения в КС:						
(10) всего, тыс.руб.	24292	19532	18280	16376	14350	7480
(11) в 1 кВт мощности, руб.	307,4	271,2	228,6	204,8	191,4	59,8
(12) в 1000 м^3 газа, руб.	0,86	0,66	0,58	0,46	0,40	0,28
Эксплуатационные затраты:						
(13) всего, тыс.руб.	6711	5796	6261	5325	4819	8819
(14) на 1 кВт мощности, руб.	84,9	80,6	78,2	66,6	64,2	117,6
(15) на 1000 м^3 газа, коп.	23,7	19,8	19,6	15,2	13,2	33,6

Key: 1. Indices
2. Type of GPA: [left to right] GTK-5, GT-750-6, GTK-10, GTK-16, GTK-25, STD-12500
3. Capacity, thousands of kilowatts
4. GPA
5. KS
6. Productivity of GPA
7. millions of cubic meters per 24-hour period
8. billions of cubic meters per year
9. Productivity of KS, billions of cubic meters per year
10. Capital investments in KS: total, thousands of rubles
11. per kilowatt of capacity, rubles
12. per 1000 cubic meters of gas, rubles
13. Operational expenditures, total, thousands of rubles
14. per kilowatt of capacity, rubles
15. per 1000 cubic meters of gas, kopecks

Table 12

Technical-Economic Indices Pertaining to the Operation of the GPA at the Tyumentransgaz PO during 1971-1977

	(1) Показатели	(2) Годы							(3)
		I97I	I972	I973	I974	I975	I976	I977	I977 к I97I, %
(4)	Количество ГПА в эксплуатации	25	30	58	80	II0	I42	I84	736,0
(5)	в том числе резервные	5	6	I6	I8	30	44	58	II60,0
(6)	Работа под нагрузкой, маш.-ч	I34278	I76550	26I082	427546	590085	746307	9378II	698,4
(7)	Время, маш.-ч:								
(8)	планового ремонта	I897I	I4II8	20057	33072	56694	6282I	8394I	442,4
(9)	резерва	52642	5798I	I06442	II9438	I86499	246025	229840	436,6
(10)	Календарное время работы, маш.-ч	2I8980	257232	404926	587548	850256	I082879	I328I73	606,5
(11)	Количество вынужденных остановок	I05	I2I	204	I37	I35	I77	5I6	49I,4
(12)	Коэффициент:								
(13)	эксплуатации	0,6I3	0,686	0,645	0,728	0,694	0,689	0,706	II5,I
(14)	готовности	0,854	0,9I8	0,908	0,93I	0,9I7	0,9I6	0,924	I08,I
(15)	эксплуатационной надежности	0,940	0,967	0,957	0,987	0,984	0,974	0,942	I00,2
(16)	частоты вынужденных остановок	0,782	0,685	0,885	0,320	0,229	0,337	0,550	70,3
(17)	сложности вынужденных остановок	I24,3	7I,0	75,I	54,7	I00,0	I56,6	I49,3	I20,I

Key:
1. Indices
2. Years
3. 1977 in percentage to 1971
4. Number of GPA in operation
5. including reserve
6. Operation under load, machine-hours
7. Time, machine-hours, of:
8. planned repair
9. reserve
10. Calendar time of operation, machine-hours
11. Number of forced outages
12. Coefficient of:
13. operation
14. readiness
15. operational reliability
16. frequency of forced outages
17. complexity of forced outages

The low figures for the coefficient of operation attest to the large underloading of the GPA. The large share of reserve time that is formed as a result of the reserve units at the compressor stations considerably reduces the indices pertaining to their use. However, the comparatively frequent equipment outages and the large volumes of repair work lead to the necessity of installing them at the KS.

A considerable share of the time for repair operations (4.8-8.6 percent) and the forced outages (1.3-6.0 percent) in the calendrical time fund for operation of the GPA also has a detrimental influence upon the level of use of the units. The coefficient of operational reliability, which depends upon the forced-outages time, and the coefficient of readiness of the units for operation, which depends upon both factors (during the period being studied), as a whole increased for the association.

The reduction in idle-time periods is aided by the reduction of forced outages. In 1977, as compared with 1971, the frequency of forced outages per 1000 machine-hours worked dropped by 30 percent. And although the complexity of each forced outage increased by 20 percent, the share of their time in the overall time fund for operation of the GPA dropped from 6 percent in 1971 to 5.7 percent in 1977.

The basic reason for forced outages is the disappearance of voltage. The number of outages for this reason constitutes 19-39 percent. And although their share during the period being considered was decreased, their percentage still remains considerable (31 percent).

The second reason, from the point of view of importance, for the forced outages of the GPA is the poor working condition of the KIPiA [control and measuring instruments and automation equipment] (18-35 percent of all forced outages). This attests to the fact that the employed relay scheme for the KIPiA is not yet sufficiently reliable and the elaboration of measures by the appropriate services to prevent them is necessary.

A relatively large number of outages (1.0-12.7 percent) of the units are linked with failure to observe technological discipline. The large percentage of outages for "other reasons" (10-39 percent) attests to the fact that this group of reasons has been studied insufficiently.

In order to locate reserves for reducing the number of forced outages and their total time, it is necessary to improve the system of accounting for them. At the present time, the only factors being analyzed are the reasons for the number of outages, but it is also necessary to keep record of the total time involved, since, not always, the largest part of the outages for some reason corresponds to the maximum time expenditures to eliminate them. In addition, by analogy with the other branches of industry, it is necessary to monitor the activities of the guilty services and the services that are responsible for the duration of work to eliminate the outages. The introduction of this kind of accounting will increase the responsibility borne by the services for the number and duration of the forced outages of

of the GPA and will aid in reducing them, and this, in the final analysis, will make it possible to raise the coefficient of operational reliability of the units.

Thus, analysis of the use of fixed assets indicated:

-- the basic reason for the sharp drop in the level of return on investments in the mainline transportation of natural gas in Western Siberia is the increase in the transportation distance. With a consideration of the transportation distance, the index of return on investements during 1972-1977 rose by 54 percent;

-- a large percentage in the structure of fixed assets is occupied by other branches (6.5 percent); this is influenced by the weak economic development of the region and reduces the level of return on investments;

-- the basic direction for increase in return on investments is the increase in the handling capacity of the gas-transporting system, and therefore the efforts of the technical services to locate production reserves must be concentrated in this direction. One of these directions is the increase in the handling capacity of the system by means of an improvement in the preparation of the gas at the oil field;

-- a characteristic peculiarity of the development of the gas-transporting system is the increase in the individual capacity of the GPA. The installation of units with increased capacity, as compared with the GT-750-6, will make it possible, during 1976-1980, to reduce capital investments by 138.3 million rubles, operational expenses by 22.6 million rubles, and to raise the level of return on investments by 2.6 percent;

-- in order to improve the indices pertaining to the use of the GPA, it is necessary to improve the system of accounting for the forced outages for various reasons.

Manpower Resources

The rapid growth of the volumes of gas transportation and the total length of the gas-transportation system has been one of the reasons for the considerable changes in the indices pertaining to the use of manpower resources. During 1970-1977 the number of maintenance personnel increased by a factor of 3.6; the wage fund by a factor of 5.6; and the labor productivity rose by a factor of more than 1.9 (Table 13).

This increase in labor productivity during the past seven years was caused by the fact that the growth rates for volume of gas transported exceeded the growth in the number of maintenance personnel; this was influenced, chiefly, by the use of large-diameter pipes and GPA with increased capacity.

An index which merits special attention is the index of labor productivity,

computed for the volume of transportation work and taking into consideration, in addition to other factors, the degree of labor-intensity of the delivery of gas to the customers, the distance required to transport it. During the period being analyzed, this increased by a factor of 3.1. The increase in labor productivity is also expected in the future.

An analysis of the structure of the number of personnel at the Tyumentransgaz Production Association during 1970-1977 indicated that the share of workers employed in basic production, that is, directly in transportation of gas, constitutes, all told, 72-77 percent (Table 13). During recent years one has observed a relative reduction in that index. At the same time the share of workers in auxiliary production and the maintenance sphere increased by 4.3 percent and in 1977 constituted 27.4 percent of the total number of workers. This is explained chiefly by the increase in the degree of wear and tear of the fixed assets, which was one of the reasons for the increased in the number of workers engaged in the capital repair of the equipment.

The increase in the number of workers at the Tyumentransgaz Association was accompanied by a change in the social composition of the collective. During 1970-1977 the number of workers increased by a factor of 4.8 and in 1977 constituted 73 percent of the total number of workers employed in the transportation of gas. The percentage of other categories of workers -- engineer-technical workers, employees, junior service personnel -- dropped, although their total number increased in 1977, as compared with 1970, by a factor, respectively, of 2.1, 1.9, and 3.2. An analysis of the skill composition of the workers indicated that in 1970 the share of highly skilled workers (Category V-VI) and skilled (Category III-IV) workers constituted 91.6 percent. During 1970-1977 their percentage dropped by 9.2 percent. This is explained by the increase in the number of workers in the nonbasic occupations, among which the share of relatively lowly skilled workers (Category I-II) is large.

Changes also occurred in the makeup of the engineer-technical workers and employees. In late 1977, 81.2 percent of them had higher or secondary special education. During the past three years their percentage increased by 11.6 percent.

One's attention is also attracted by the fact that the category of workers includes specialists with higher or secondary special education. Moreover, their number during 1974-1977 increased and in 1977 constituted 2 percent of the total number of workers.

A study of the structure of workers by services indicates that the number of workers at the gas-compressor services (GKS) constitutes 35-53 percentage and has a tendency toward increase. During the past five years alone, it increased by a factor of more than 3.3. This large increase is explained by the activation of new compressor stations (Nadym, Sorum, Kyzym, Peregregnoye, Pripolyarnoye, Sos'vinskaya) and by the increase in the capacity of the

already existing ones as a result of the construction of new turbocompressor shops (TKTs), the number of personnel at which constitutes more than half the number of personnel at the GKS.

Table 13

Indices Pertaining to Use of Labor Resources at the Tyumentransgaz PO

	(1) Показатели	(2) Годы								(3)
		I970	I97I	I972	I973	I974	I975	I976	I977	I977 к I970,%
(4)	Численность работников объединения – всего, чел.	II43	I26I	I482	I8I8	2235	2732	34I5	4330	378,8
(5)	В том числе:									
(6)	в транспорте газа,									
(7)	чел.	879	943	II20	I4II	I706	20I8	2486	3I43	357,6
(8)	%	76,9	74,8	75,6	77,6	76,3	73,9	72,8	72,6	–
(9)	в подсобно-вспомогательных подразделениях,									
(7)	чел.	264	3I8	362	407	529	7I4	929	II87	–
(8)	%	23,I	25,2	24,4	22,4	23,7	26,I	27,2	27,4	–
(10)	Производительность труда:									
(11)	млн.м³/чел.	9,8	9,2	9,5	I0,4	I2,7	I5,6	I6,8	I8,9	I92,8
(12)	млрд.м³·км/чел.	7,I	6,7	8,0	I2,I	I5,4	I9,5	2I,3	22,2	3I2,7
(13)	Удельная численность, чел/I00 км газопроводов	7I	62	57	50	55	53	60	64	90,I
(14)	Фонд заработной платы – всего, млн.руб.	2280,0	2524,5	3224,9	4370,2	6I30,6	7782,0	I0I59,8	I3249,I	58I,I
(15)	в том числе в транспорте газа	I906,0	2074,3	2688,9	368I,0	5I24,2	6336,3	8II3,6	I0682,I	560,4
(16)	Среднемесячная заработная плата, руб.:									
(17)	по объединению	I66,2	I66,8	I8I,3	200,3	228,6	237,4	247,9	255,0	I53,4
(18)	в транспорте газа	I80,7	I83,3	200,I	2I7,4	250,3	26I,7	272,0	283,2	I56,8

Key:
1. Indices
2. Years
3. 1977 in percentage to 1970
4. Number of association workers, total number of persons
5. Including
6. in transportation of gas
7. persons
8. percentage
9. in subsidiary-auxiliary subdivisions
10. Labor productivity
11. millions of cubic meters per person
12. billions of cubic meters x kilometers per person
13. Specific number of personnel; persons per 100 kilometers of gas pipeline
14. Wage fund, total, millions of rubles
15. including in transportation of gas
16. Average monthly wages, rubles:
17. for association; 18. in transportation of gas

Also representing a considerable percentage in the overall number of personnel at the GKS are the power-and-water-supply services (EVS) and the control and measuring instruments and automation equipment (KIPiA). The share of the latter has risen noticeably (from 13 percent in 1973 to 18 percent in 1977).

The number of workers in the line-operations services (LES) who are engaged in providing maintenance directly for the line part of the gas pipeline, despite the considerable increase in the total length of the main gas pipelines, rose by just 14.5 percent. But the share of those services in the overall total of association workers during the indicated period dropped by 9.6 percent. One of the reasons was the fact that the line-operations services are not adequately staffed. For example, according to NIS VPO Tyumengazprom, for individual LPUMG the LES are staffed only by 37-81 percent.

The developing network of mainline and technological communications requires the increase in the number of maintenance personnel. During the period analyzed, the number of workers in the communications services increased by a factor of more than 2.2, and constituted 8.7 percent of the total number of workers employed in the transportation of gas.

The percentage of workers in the administration apparatus and the dispatcher service, all total, constitued, in 1977, 12.0 and 2.1 percent, and dropped respectively, as compared with 1973, by 5.7 and 3.2 percent.

A study of the composition of the workers by services, in terms of 100 kilometers of gas pipelines, indicates that the largest percentage is represented by the gas-compressor service (34 out of 64 persons) and the line-operations service (13 out of 64 persons).

It should be noted that, since 1973, the number of personnel per 100 kilometers of gas pipeline has not been decreasing. This is explained by the fact that, with the comparatively small increase in the total length of main gas pipelines, during recent years there has been a considerable increase in the pool of gas-pumping units. For example, during 1973-1977 the number of GPA increased by a factor of 3.2; the number of personnel maintaining them, by a factor of 2.2; and the total length of the gas pipelines, by a factor of 1.8. As a consequence, the specific number of personnel increased during the same period by 14 persons and in 1977 constituted 64 persons per 100 kilometers.

The level of that index for Tyumentransgaz is somewhat higher than the average for the branch. This is explained by the influence of two factors: the large individual capacity of the system (the diameter of the gas pipelines is larger and the capacity of one KS is greater) and by the historical and economic peculiarities of the region. Whereas the former factor, with a negative influence upon the specific number of personnel, has a positive influence upon the labor productivity, the later has a negative effect upon both indices. A detailed study of the composition of the KS workers indicates

that for the association as a whole, in 1977, with the existence of centralized power and water supply, the number of workers could be reduced (based on norm lists) by 180 persons, that is, the specific number of personnel would be 60 persons per 100 kilometers (instead of 64), and the labor productivity could be 7 percent higher.

A large influence upon the technical-economic indices is exerted by personnel turnover. An analysis of personnel movement in the Tyumentransgaz PO showed that the coefficient of personnel turnover at the enterprises engaged in the transportation of gas is relatively high, with the largest turnover rate being observed among [ordinary] workers. Over the course of a year, approximately half the workers [of all categories] at the enterprise are replaced (the coefficient of replaceability in 1977 constituted 40.1 percent, and in 1976, 39.4 percent). It must also be noted that the persons who are separated are, for the most part, [ordinary] workers who have worked at the association less than three years, and therefore the chief attention should be devoted to the permanent asssignment of that category of workers, and to the ascertaining of the reasons for separating them.

The basic reason for separations is dissatisfaction with the wages or the everyday or working conditions. However, a large percentage of the total number is made up of separations for "other reasons." Research studies by a number of authors [4] have shown that 79 percent of the workers in that group are separated because of dissatisfaction with the living conditions (lack of housing, kindergartens, nurseries, etc.). The creation of favorable working and everyday conditions will substantially reduce the personnel turnover rate for these reasons.

Research studies have shown [5] that the high level of wages in the North resolves only one part of the problem of labor resources -- the problem of attracting personnel -- but it does not resolve the problem of assigning them permanently. When the factors pertaining to the permanent assignment of personnel were being studied, a clear-cut natural law was ascertained: the categories which are the most stable are the low-paid categories of workers, 46 percent of whom intend to remain as permanent residents, whereas among the high-paid categories that figure is only 27 percent. This attests to the fact that insufficient attention is being paid to the development of the projects in the infrastructure.

An example of permanent assignment of personnel, despite the several climate, can be provided by Komi ASSR, where a network of large-scale inhabited points has been created -- cities and settlements. The average amount of housing provided is 11.1 square meters per person, and the cultural and everyday services are on a par with those in the middle latitudes.

In the Tyumentransgaz PO in 1977 there was a total of 99,900 square meters of housing. With a consideration of the coefficient of family structure, the amount per person is 5.8 square meters. As of 1 January 1978, 926 persons were living in railroad-car housing. At the same time it is known

that the severe climatic conditions make it necessary, in northern settlements, to provide increased norms for housing (10-12 square meterss) and other projects in the social infrastructure, that is, the creation of highly comfortable settlements and improved conditions will compensate for the inevitable difficulties and deprivations involved with living in the North and will contribute to personnel stability.

An important factor for resolving the question of providing people with housing is, in addition to the total housing area, the consideration of the family structure. Studies have shown that, in the total number of persons working in the north of Tyumenskaya Oblast, single persons constitute 17-20 percent; families consisting of two persons constitute 9-10 percent; consisting of three, 35-40 percent; four, 28-30 percent; and five and more, 5-6 percent. These relationships should be taken into consideration when designing the housing accommodations and determining the structure of the housing fund.

Unfortunately, within the confines of this study it is impossible to carry out a more detailed sociological analysis of the use of labor resources.

A study of the wage fund has indicated that, during the period being analyzed, it increased by a factor of 5.3; the average annual wages increased by 39.0 percent; their growth for persons employed in the transportation of gas constituted 40.9 percent. The increase in the wage fund is linked basically (by 65-70 percent) with the increase in the number of workers. It should be noted that that fact that level of average wages for the association exceeds the average for the branch is linked with the natural and climatic conditions, which are reflected by means of the territorial coefficient and the northern wage differentials.

The increase in the annual wages is accompanied by changes with respect to the increase in labor productivity. During 1970-1974 the growth rates for the average wages of workers at the association exceeded the growth rates for labor productivity. During recent years one has noted a tendency toward a substantial improvement in this relationship. Whereas in 1970-1974, per percentage of increase in labor productivity, the increase in the average wages constituted, on the average, 1.3 percent, during the past three years it has been 0.26 percent. But if the labor producitivity is measured according to the volume of transportation work, this correlation between the indicated indices has been steady ever since 1971.

Thus, when analyzing the use of the labor resources at the Tyumentransgaz PO, it was ascertained that:

-- the indices pertaining to the use of labor resources at the Tyumentransgaz PO during 1970-1977 rose. The same tendency will continue into the future. With respect to the level of branch indices, the labor productivity at the Tyumentransgaz PO is higher by a factor of 1.5-2, while the number of workers, in terms of 100 kilometers of gas pipelines, is lower;

-- the largest percentage in the structure of the total personnel strength is occupied by workers at the compressor stations, and therefore the development of measures to reduce their number is the basic trend to be taken in improving the indices of using the labor resources in the transportation of gas;

-- the percentage of workers at services whose existence is influenced not by the nature of the production process, but by the economic and geographical conditions of the region (lack of centralized electric-power supply, water supply) constitutes 6-8 percent of the total number of workers in the transportation of gas;

-- in the transportation of gas, there is a high rate of personnel turnover (25-30 percent) and replacement of personnel (39-45 percent). The basic condition for the permanent assignment of personnel in the regions that are being newly assimilated is the high level of development of projects in the social infrastructure.

Development of the Gas-Transporting System
of Western Siberia Up Until 1980

The basic indices for the development and operation of the systems for transporting natural gas during the Tenth Five-Year Plan (Table 14) have been computed in conformity with the plan for the development of the gas-extracting industry. In order to transport the extracted gas during the ive-year plan, it is necessary in Western Siberia to activate 7,300 kilometers of gas pipelines. There will more than a threefold increase in the number of compressor shops, and the capacity of the compressor stations will increase by a factor of almost 6.

In order to service this gas-transporting system it will be necessary to have a substantial increase in the number of workers (from 2000 persons in 1975 to 5,700 persons in 1980). This considerable increase in the number of personnel has been caused by the fact that during that period a new sector in the transportation of gas will appear -- Urengoy-Surgut-Tyumen'-Chelyabinsk.

It should be noted that the question of the further development of the Surgut sector for the transportation of gas, taking into consideration the gas reserves in Nadym-Purskiy Rayon and the necessity of assuring the operation of the system at full capacity over a prolonged period of time, requires thorough substantiation.

Provision is made for the further development of the system of transporting casing-head gas. Whereas at the present time the basic consumer of that gas is the Surgutskaya GRES, within the foreseeable future casing-head gas will be supplied to the Kuzbass. The development of this system will require 500-550 million rubles of capital investments.

Table 14

Technical-Economic Indices Pertaining to the Development and Operation of the Gas-Transporting System of the Tyumentransgaz PO for 1978-1980 (Natural Gas)

(1) Показатели	(2) Годы			(3)
	I978	I979	I980	I980 к I975, %
(4) Протяженность магистральных газопроводов, км	7800	I0000	II800	267
(5) Количество:				
(6) КС	2I	27	32	330
(7) компрессорных цехов	46	55	69	3I4
(8) ГПА	298	370	445	327
(9) Мощность КС, МВт	2478	3238	4333	575
(10) Объем транспортируемого газа, млрд.м^3	82,5	I0I,7	I3I,0	4I6
(11) Численность работников, занятых в транспорте газа	3900	5000	5700	278
(12) Производительность труда, млн.м^3/чел.	2I,I	20,3	23,0	I48
(13) Стоимость основных производственных фондов, млн.руб.	3400	4500	5600	453
(14) Фондоотдача, м^3/руб.	24,3	22,6	23,4	94
(15) Капиталовложения, млн.руб.	II07	I276	895	I93
(16) Себестоимость транспорта 10000 м^3 газа, руб.	24,4	25,6	26,5	II2

Key: 1. Indices
2. Years
3. 1980 in percentage to 1975
4. Total length of main gas pipelines, kilometers
5. Number of:
6. KS
7. compressor shops
8. GPA
9. Capacity of KS, megawatts
10. Volume of gas to be transported, billions of cubic meters
11. Number of workers employed in the transportation of gas
12. Labor productivity, millions of cubic meters per person
13. Value of fixed production assets, million rubles
14. Return on investments, cubic meters per ruble
15. Capital investments, millions of rubles
16. Costs of transporting 10,000 cubic meters of gas, rubles

For Western Siberia as a whole one expects a substantial increase in only the labor productivity, with an insignificant reduction in the specific number of personnel. With an increase in the return on investments for individual sectors in the transportation of gas one expects a reduction in that return on investments by almost 10 percent for the Tyumengasprom VPO [All-Union Production Association] as a whole. This is linked with the development of the new gas-transporting system -- Urengoy-Surgut-Tyumen'-

Chelyabinsk -- which is of great length and which, during the first years of operation, has not been used at full capacity. The level of costs of transporting gas has a tendency to increase. This is explained chiefly by the increase in the distance of transporting the gas. However, for individual sectors all the indices are improving noticeably. It should be noted that these indices have been computed on the basis of an analysis of the existing GTS [gas-transporting system] with a consideration of the influence exerted by the following basic trends in scientific-technical progress: the increase in the diameter of the gas pipeline, and in the pressure, and the capacity of the GPA: change in the distance between KS; the cooling of the gas. The introduction of other measures will require the corresponding recomputation of the indices.

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FUELS AND RELATED EQUIPMENT

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PRELIMINARY RESULTS OF GEOLOGIC EXPLORATION WORK

Moscow GAZOVAYA PROMYSHLENNOST'. SERIYA GEOLOGIYA, BURENIYE I RAZRABOTKA GAZOVYKH MESTOROZHDENIY in Russian No 10, 1979 pp 22-27

[Article by I. A. Blinnikov, USSR Ministry of Geology, G. P. Volkova, Ye. V. Kudryashov and G. A. Podkina, All-Union Scientific Research Institute of Economics, Production Organization and Technical-Economic Information in the Gas Industry]

[Text] It was stipulated in the State Plan for Development of the National Economy of the USSR that geological prospecting for gas would be intensified in 1976-1978 of the Tenth Five-Year Plan in the northern part of Tyumenskaya Oblast, in Eastern Siberia, in the Yakut ASSR, Arkhangel'skaya Oblast, the Komi ASSR, Soviet Middle Asia and the Kazakh SSR (the border regions of the Caspian Basin).

In addition to new and highly promising territories, searches and prospecting for deposits have been in progress in the older gas-producing territories of the Ukrainian SSR, the Northern Caucasus, Uralo-Povolzh'ye and elsewhere.

According to preliminary data, geological prospecting has resulted in 103.9% fulfillment of the quota for increase in natural gas over the entire nation.

The major increase (76.1%) has been attained in the northern territories of Tyumenskaya Oblast, and chiefly through completion of surveys on previously discovered deposits. The quota for increasing gas reserves has been met by prospectors in the Ukrainian SSR, Uzbek SSR, Kazakh SSR and elsewhere.

In these three years, 103 new deposits have been discovered (Table 1): 60 gas deposits, 34 gas-condensate deposits and 9 petroleum-gas deposits.

Geographically, 56 of the deposits are in the European part of the country, and 47 are in the Asiatic part. Most of the deposits in the European part of the nation have been found in the Ukrainian SSR and Uralo-Povolzh'ye.

TABLE 1

Gas Deposits Discovered in the USSR in 1976-1978

Territories	Number and type of deposits			
	Total	Gas	Gas-condensate	Petroleum-gas
USSR:	103	60	34	9
European territories	56	30	20	6
Asiatic territories	47	30	14	3
RSFSR:	47	28	16	3
Northwest	4	2	1	1
Uralo-Povolzh'ye	15	9	5	1
Northern Caucasus	10	5	5	—
West Siberia	12	7	4	1
East Siberia	1	—	1	—
Far East	5	5	—	—
Ukrainian SSR	23	14	7	2
Kazakh SSR	7	2	3	2
Azerbaijan SSR	1	—	—	1
Soviet Middle Asia	22	16	6	—
Caspian Sea	3	—	2	1
Azerbaijan sector	1	—	1	—
Turkmen sector	2	—	1	1

All are small, with the exception of the Astrakhan deposit, located to the north of the city of Astrakhan and confined to the extensive Astrakhan Anticline. The gas is of multicomponent makeup, containing 20-26.5% hydrogen sulfide, and 11-24.3% carbon dioxide.

The Volozhkovsk gas-condensate deposit was discovered in this same area in 1977.

A fairly large gas-condensate deposit (Intinsk) was discovered in the northwest part of the USSR. This is the first deposit to be found in the Kos'yu-Rogovsk Basin in the territory of the Komi ASSR. Gas flows have also been found here on the Lemvinsk prospecting territory. Small deposits have been discovered in the Northern Caucasus and in the shelf regions of the Caspian and Black seas.

Extensive deposits have been discovered in the Asiatic part of the USSR, and particularly in Tyumenskaya Oblast: the Yen-Yakhinskoye, South Samburg and East Urengoy gas-condensate deposits, and the Kruzenshternovsk, Upper Lurneysk, Antipayutinsk and Gydan gas deposits.

The last two are the first discoveries in the new gas fields in the north of Tyumenskaya Oblast.

The Middle Tyungsk and Viluysko-Dzherbinskoye gas deposits were discovered in the Yakut ASSR, and the Chonskoye gas-condensate deposit was discovered on the boundary of Irkutskaya Oblast.

Twenty-two deposits were discovered in Soviet Middle Asia, six of them being very promising: the Uchadzhinskoye, Seyrabskoye, Dauletabatsskoye, Gagarin and Donmez gas deposits in the Turkmen SSR, and the Alanskoye gas-condensate deposit in the Uzbek SSR.

The gas deposits discovered in the Kazakh SSR (7) and Azerbaijan SSR (1) are small, with estimated reserves in the range of 5 million cu. m.

Isolated gas pools have also been found in previously discovered deposits, appreciably enhancing the outlook for gas show. For example in the northern part of Tyumenskaya Oblast (Yamal Peninsula), new gas traps have been discovered in Lower Cretaceous formations of the Bovanenkovskoye and Kruzenshternskoye deposits, considerably increasing their gas reserves.

A number of traps have been found in the Yakut ASSR on the Mastakhskoye, Middle Tyungsk and Upper Vilyuchanskoye deposits. Further prospecting of the northern periclinal has expanded the main developed trap on the Vuktyl'skoye deposit (Komi ASSR).

A trap has been discovered in Middle Jurassic formations on the Kuznetsovka deposit in Krasnodarskiy Kray. Visual estimates set the gas emission from the Bathonian stage at 8-10 million cu. m per day. At present the well is yielding 350,000-8,100,000 cu. m per day.

Also of fundamental importance are industrial gas flows from basalt formations of the Lower Cretaceous on the Beysug deposit of the Ukrainian SSR. A gas trap has been discovered in the chemogenic stratum of the Lower Permian on the West Kresishchenskoye deposit (gas yield was 398,000 cu. m per day on a pipe 22 mm in diameter), and on the Golitsyn deposit in Paleocene-Danian formations. A new trap has been discovered on the Shurtanskoy deposit (Uzbek SSR) in Upper Cretaceous formations in a depressed block of the structure.

In addition, a considerable number of small gas traps and condensate traps have been found in deposits of Kazakhstan, the Ukraine, Turkmenia and Azerbaijan that have increased their reserves to a fair extent, or have indicated areas for searches and prospecting.

Gas flows discovered in the Gremyachinsk and Ul'kentabinsk prospecting regions of the Kazakh SSR, and in the Lobodinsk and Tashlinsk prospecting regions of Uralo-Povolzh'ye confirm once more the prospects for petroleum and gas show of Paleozoic formations in the border region of the Caspian Basin.

Most territories of the nation show a tendency to a reduction in volumes of drilling as compared with the preceding five-year plan. In old gas fields

(Uralo-Povolzh'ye, Northern Caucasus, Kazakh SSR) this is due both to the deficit of prepared local structures and to their small dimensions, as well as to low estimated reserves, and in the new fields of East Siberia and the Far East it is due to difficult geological engineering conditions. There has been some increase in the volume of exploratory drilling in such promising territories as West Siberia and Soviet Middle Asia.

Analysis of the volumes of drivage and the corresponding increases in gas reserves shows that it is most difficult to increase reserves in old gas-producing territories. Considerable volumes of drivage are expended for relatively small increases. For example in the European territories of the nation the increase in gas reserves was 8.7%, with 63.4% of the Soviet-wide drivage, and of this increase, 3.1% fell to the Ukrainian SSR, 2.4% to Uralo-Povolzh'ye, 2.1% to the Northwest, 0.7% to Azerbaijan SSR and 0.4% to the Northern Caucasus (Table 2).

TABLE 2

Technical-Economic Indices of Exploratory Drilling for Gas in Three Years of the Tenth Five Year Plan

Territories	Drilling volume, thous. m	Drilling effectiveness, thous. cu. m/m	Cost of 1 m of drivage, rub.
USSR:	4535.1	1534	438
European territories	2876.1	209	406
Asiatic territories	1659.0	3830	499
RSFSR:	2063.7	2844	532
Northwest	300.9	479	766
Uralo-Povolzh'ye	599.6	277	419
Northern Caucasus	485.5	56	280
West Siberia	206.1	25795	544
East Siberia and the Far East	471.6	456	805
Ukrainian SSR	1357.4	158	329
Azerbaijan SSR	132.7	372	735
Kazakh SSR	101.0	356	312
Soviet Middle Asia	880.3	894	344
Miscellaneous expenditures	—	—	—

In the Asiatic territories, which account for 36.0% of the volume of drivage completed, there was a 91.3% increment in natural gas reserves, most of it (76.4%) coming from West Siberia; the increase for Soviet Middle Asia was 11.3%, in East Siberia and the Far East 3.1%, and in the Kazakh SSR 0.5%.

The index of effectiveness of exploratory drilling for gas is given as the increment in gas reserves in thousand of cu. m per meter of drivage.

The goal for effectiveness of exploratory drilling throughout the USSR was 1,399,000 cu. m/m, and the figure actually reached was 1,534,000 cu. m/m.

Drilling was most effective in West Siberia, where the increase in gas reserves per meter of drivage was 25.8 million cu. m. Drilling was also effective in Soviet Middle Asia, the Ukrainian SSR, Azerbaijan SSR and Kazakh SSR.

The reason for the considerable expenditures on geological prospecting on the territory of the Ukrainian SSR is that the increase in new reserves in this area comes from regions that are difficult to reach.

The cost of preparing 1000 cu. m of gas reserves (specific expenditures on preparation of reserves) was planned at 0.40 rub./1000 cu. m on the average throughout the USSR; the actual expenditures were 0.38 rub./1000 cu. m.

Thus despite an increase in the cost per meter of drivage, the cost for preparation of 1000 cu. m of gas was 5% below plan, which is the result of an increase in the effectiveness of exploratory prospecting.

The most important results of geological prospecting for the first three years of the Tenth Five-Year Plan are:

1. Discovery of the Antipayutinsk and Gydan gas deposits on the Gydan Peninsula. These are the first deposits within the limits of the Gydan Mega-Arch. Their discovery marks a new direction for exploratory prospecting for gas in Tyumenskaya Oblast.

2. Confirmation of gas show for the border regions of the Caspian Basin, particularly in the vicinity of the Astrakhan Anticline, where the Astrakhan and Volozhkovsk gas-condensate deposits were discovered in Paleozoic subsalt formations, which is of great importance for the future direction of prospecting for gas in Povolzh'ye.

3. Getting a strong gas flow in Middle Jurassic formations on the Kuznetsov deposit opens up a great outlook (a new prospecting facility) for the future direction of geological prospecting in Krasnodarskiy Kray.

4. Discovery of the Intinsk gas-condensate deposit and acquisition of gas flow on the Lemvinsk prospecting territory within the limits of the Kos'yu-Rogovsk Basin confirms the presence of a new gas-bearing region in the Komi ASSR.

5. The discovery of new traps on the Kruzenshternovsk and Bovanenkovskoye deposits, besides increasing reserves, confirms the promise of the gas show of the Gothian-Aptian sedimentary complex on the territory of Yamal.

6. The discovery of the Uchadzhi and Seyrab deposits confined to the extensive Uchadzhi-Kulach Arch with a number of local rises along the

regional Repetek break gives every basis for counting on the discovery of new gas deposits in this region of East Turkmenia, both in Lower Cretaceous and in Jurassic formations.

Of fundamental importance is the discovery of the Gagarin deposit within the limits of the East Uchadzhi Arch of the northern part of the Amudar'insk Syneclase.

7. Despite the increased cost per meter of drivage, the cost of preparing gas reserves was lower than the plan, which is a result of the increased effectiveness of exploratory prospecting.

Thus as a result of geological prospecting in 1976-1978, a real base has been developed that ensures an increase in gas reserves in the Tenth Five-Year Plan.
[8144/1817-6610]

6610
CSO: 8144/1817

FUELS AND RELATED EQUIPMENT

UDC 622.244.442:66.063.612

INVERTED-EMULSION DRILLING MUDS URGED FOR TYUMEN' OILFIELDS

Moscow BURENIYE in Russian No 7, 1979 signed to press 26 Jul 79 pp 19-21

[Article by A. V. Kaz'min, Yu. F. Loginov and L. K. Mukhin of SibNIINP [Siberian Branch of the Scientific-Research Institute of the Petroleum Industry] and MINKh i GP im. I. M. Gubkina [Moscow Institute of Petrochemical and Gas Industry imeni Academician I. M. Gubkin]: "Effectiveness of the Use of Inverted Emulsion Muds While Sinking Wells in West Siberia"]

[Text] Raising drilling-in quality at reservoir collectors of Tyumenskaya Oblast oilfields is an urgent problem. An analysis made by Tyumennefte-geofizika [Tyumen' Trust for Oilfield Geophysics] of the inflow profile by high-precision flow-metering of more than 1,000 facilities at various oilfields indicates that, as a rule, only 40-60 percent of the thickness of the productive bed is being utilized usefully in the perforation interval. A characteristic feature of most petroleum reservoirs at West Siberian oilfields is their lithological inhomogeneity with respect to thickness. Drilling-in with the use of water-base drilling mud leads to a sharp reduction of the permeability of rocks in the critical zone, especially of rocks with low permeability.

In order to improve drilling-in quality of the productive reservoirs, the Drilling-Muds Laboratory of SibNIINP developed an inverted-emulsion mud (IER), which was used while sinking wells at the Salym oilfield, where anomalously high reservoir pressures and a bottom-hole temperature of 145 degrees C. were characteristic for the productive reservors. Thirty wells have now been drilled through into productive horizons with the use of IER's at eight West Siberian oilfields. Collectors of various types with low permeability--5-50 millidarcys were selected--for drilling with the use of these muds.

Exploratory wells often have been drilled in zones of low productivity, where insignificant inflows of oil (2-5 m^3/day) were obtained from neighboring wells under various dynamic conditions. In all cases, when the productive reservoirs were drilled in with the use of IER's, gushing oil was obtained, and withdrawals from the wells increased, but the opinion was expressed that, in so doing, the wells could prove to be in zones of high permeability, because of the great lithological inhomogeneity of the

collectors in cross-section and in area. In order to show convincingly the effectiveness of IER use, it was decided to drill a bore parallel to the bore of a well that had been drilled in to the reservoir-collector, using a water-base mud.

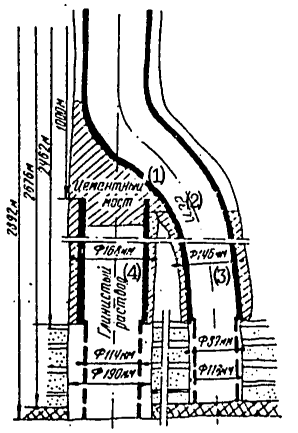
The experiment was conducted at the Pal'yanovskaya area of the Krasnoleninsk arch during the drilling of wells R-48 and R-49. The productive part of the deposit was made up of Jurassic sediments of the Tyumen' suite (at the 2,400-2,700 meter interval). Three oil-bearing intercalations with thicknesses of 3-10 meters each were singled out. The permeability of the collectors varied greatly both as to area and as to cross-section. In this connection, the oil inflows that were obtained during drilling-in, using water-base muds, fluctuated from 150 m^3/day to a few hundred liters under various dynamic conditions. The reservoir temperature was 145-150 degrees C, and reservoir pressure was 280-300 kg-force/cm^2. The collectors were of the granular type.

During drilling in of the reservoir collectors, clay muds with the following indices ordinarily are used: ρ = 1.24 g/cm^3; specific viscosity T = 30-35 cp, according to an SPV-5; water recovery V = 5-7 cm^3 for 30 minutes, according to a VM-6; and static shear strength in 1-10 minutes $SNS_{1/10}$ = 10/20 mg-force/cm^2.

Well R-48 was drilled through to a depth of 2,692 meters with a bit 190 mm in diameter, after which a "hanging" 168-mm production drill string was lowered to the roof of the Tyumen' suite at a depth of 2,462 meters (see figure). The productive reservoir in the 2,500-2,600 meter interval was drilled in, using a clay mud with the following indices: ρ = 1.20 g/cm^3; T = 28 cp; V = 6 cm^3 in 30 minutes; and $SNS_{1/10}$ = 12 mg-force/cm^2.

Design of a Well for the Drilling-in of a Reservoir Collector with the Use of a Clayey Inverted-Emulsion Mud.

Key:
1. Cement plug.
2. IER [inverted-emulsion mud].
3. F146 mm.
4. Clayey mud.



A sample was raised from the indicated interval and then a slotted filter was lowered into the well and it was tested with flushing by water (there was no inflow) by reducing the dynamic level to a depth of 800, 1,400 and 1,909 meters, to which inflows of 0.41, 1.5 and 2.59 m^3 per day corresponded. After this, with reverse flushing, an inflow of reservoir fluid--oil with a total volume of about 5 m^3--was obtained. At this the test was concluded.

The production string in R-48 was shot at a depth of 1,000 meters, and the upper part of it was raised to the surface. A cement plug was installed at the 400-1,000 meter interval, after which a parallel bore was cut at a depth of 600 meters. Well R-49 was drilled to the roof of the Tyumen' suite by a bit 190 mm in diameter, using a clayey mud. A 146-mm production string was lowered into it. Drilling, with flushing by an inverted-emulsion mud, was conducted under the shoe of the drill string. The Tyumen' suite was drilled in with a bit 118 mm in diameter (see figure) to the basement (2,676 meters).

The dispersion medium (the IER) was oil of the Pal'yanovskoye oilfield, a water component--a calcium-chloride solution, an emulsifier--SZhK [synthetic fatty acids], a stabilizer--NaOH, and a weighting agent--iron-ore concentrate. The IER was additionally treated with a thermal stabilizer and a water repellant.

IER indices were as follows: ρ = 1.24 g-force/cm^3; T = 170 cp; V = 0 cm^3 for 30 minutes; $SNS_{1/10}$ = 49/107 mg-force/cm^2; and the breakdown voltage was 500 V.

During the drilling process (15 cutting operations) the mud indices remained unchanged. Drilling time was 1 month. No complications were observed. The required set of geophysical studies, with instruments brought continually to the bottom hole, was carried out.

A slotted filter 89 mm in diameter was lowered into the exposed part of the bore. A stable inflow (gushing) of oil was obtained--45 m^3/day with a flow bean 10 mm in diameter, a buffer pressure of 18 kg-force/cm^2 and a pressure of 45 kg-force/cm^2 in the annular space.

Horizontal offset of well R-49 from well R-48 along the roof of the Tyumen' suite was 80 meters. At this distance the productive reservoirs were lithologically homogeneous.

Based on the results of the test, and also taking into account the results of drilling-in with the use of IER's at other poorly permeable reservoir collectors at many Tyumenskaya Oblast oilfields, it can be confirmed that the effectiveness of use of IER's for these purposes is high.

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FUELS AND RELATED EQUIPMENT

UDC 622.24.063

METHODS FOR SELECTING DRILLING-MUD TYPES

Moscow BURENIYE in Russian No 7, Jul 79 signed to press 14 Nov 78 pp 17-19

[Article by N. I. Krysin, Yu. M. Sukhikh and R. M. Minayeva of PermNIPIneft' [Perm' State Scientific-Research and Design Institute of the Petroleum Industry]: "The Status of and Methods for Promoting Work on the Regulation of Drilling Mud Types in Permneft' [Perm' Petroleum Industry Association]"]

[Text] The theory and practice of developing formulas for and using drilling muds indicate that the greatest difficulty is not so much the preparation of high-quality muds as the prevention of change in their properties during drilling as a result of interaction with reservoir fluids and the cuttings.

The effect of rocks on drilling mud properties is a function of their solubility in water and the valence of the cations formed as a result of dissolution. Thus, unlike sulfate rocks, carbonaceous rocks are practically insoluble in water, as a consequence of which ion exchange is absent, and, where hydrated-ion layers develop on the surface of clayey and carbonaceous particles, no essential deterioration of the drilling mud's properties is observed. At the same time, the transfer of finely dispersed particles of clayey, carbonaceous and other rocks into the mud makes their removal in the cleaning system difficult and causes a high content of solid phase in the mud, an increase in viscosity, a thickening of the filter cake, a colmation of the rocks in the critical zone, and a worsening in the breaking off of rock particles from the bottom hole when there is a positive pressure differential in the well-reservoir system.

Obviously, prevention of the deviation of the drilling mud's properties from those specified will be determined to a great extent by how correctly the geological and economic conditions of sinking the wells have been assessed.

While drilling wells in the Permian Kama region, the following types of drilling solutions were used: process water and clayey, clayey-carbonaceous, oil-emulsion clayey, oil-emulsion carbonaceous-clayey, clayey with natural polysalt mineralization (YePSM), calcium-chloride (KhKR), sodium

chloride, inverted-emulsion and weighted muds. Calcium-chloride and polymer-calcium muds are in the test phase.

Process water, which is used mainly for drilling in stable sediments, is applied most widely as an agent for cleaning out bottom holes. Permneft' is paying major attention to expanding the amounts of drilling with process-water flushing. Also, emulsion muds (emulsion clay mud (EGR) and emulsion carbonaceous-clay mud (EGKR)) are used very widely, and in second place in volume of use is carbonaceous-clay mud (GKR).

In recent years, during drilling that combines complications in the form of rock caving and inflows of mineralized brine, the use of inhibited muds--KhKR and clay mud with YePMS [sic]--has been expanded.

When drilling wells in cross-sections that include zones of anomalously high reservoir pressure (AVPD), weighted muds with a density of ρ = 1.3-1.8 g/cm^3 are used.

Sodium chloride and inverted-emulsion muds have limited application.

The following procedure is used in analyzing the appropriateness of mud types for the drilling conditions.

Holes selected for analysis purposes are divided into groups, depending upon the geological and engineering conditions for drilling, the depth, the drilling interval with flushing by the given mud, and the density and type of mud. Wells, during the drilling of which accidents or complications have occurred for causes that do not depend upon the quality of the mud, are excluded from the analysis.

The influence of mud types on drill-bit operating indices is studied at analogous stratigraphic horizons by using identical, standard-size drill bits.

The specific share of expenditures for materials and chemical reactants for preparing and processing the mud (C_{sp}, in percents of the cost of building the wells) and expenditures for materials and chemical reactants referred to 1 meter of penetration (C_1) are adopted as basic indices during the analysis.

The lowest values of C_{sp} and C_1 were obtained where a clay mud of reduced density, carbonaceous-clay emulsion mud and carbonaceous-clay mud were used to sink wells in the Baklanovskiy, Kokuy and Orda areas.

The use of drilling muds of reduced density (1.10-1.12 g/cm^3), relatively uncomplicated geological-engineering conditions for drilling, particularly a small drilling interval with flushing by the specified solution, and comparatively low intensity of inflow of mineralized brine water helped to reduce expenditures for materials and chemical reactants for preparing the mud at the Baklanovskiy area.

The reduction of the mud's density, moreover, exercised a positive effect on the bit's operating indices. Thus, for the Baklanovskiy area as a whole, penetration per bit rose 28 percent, mechanical penetrating speed by 41 percent.

The high effectiveness of use of EGKR and GKR was occasioned by their suitability to the drilling conditions and by the simplicity of the technical preparations.

It was established that expenditures for materials and chemical reactants with flushing by emulsified carbonaceous-clay mud were a function of the mud's oil content. Thus, for wells of the Kokuy and Orda areas, where the EGKR's oil content was 4-6 percent, C_1 = 6.35 rubles per meter, and for wells of these same areas where the oil content in the EGKR was 10 percent, C_1 = 3.35 rubles per meter. Where clay muds with natural polysalt mineralization were used, the values of C_1 and C_{sp} were higher than when fresh-water muds were used. The conversion of clay muds with natural polysalt mineralization into emulsified muds also enables expenses for materials and chemical reactants to be reduced. It is recommended that these muds be used only in those cases where complications arise when fresh-water muds are used during drilling (particularly during the caving of clays, argillites and broken limestones, and also during inflows of mineralized brine waters).

For flushing wells that have been complicated by intense falls of clays, argillites and aleurites of the Saraylin series and the Eocambrium complex and broken-up limestones of the Oksu-Serpukhov superjacent horizons, it is planned to use calcium-chloride and calcium-polymer drilling muds.

In order to assess the effect of the drilling mud's oil content on bit operating indices, an analysis was conducted, as a result of which it was established that a rise in oil content of from 4-6 percent to 10 percent enables penetration per bit to be increased by 8.6 percent.

On the basis of the analysis that was conducted, a study of the peculiarities of the geological and engineering conditions for drilling, and experimental research, it was established that in the Permian Kama region, it is rational to use both fresh-water and mineralized drill muds. In selecting types of drilling muds, recommendations developed in PermNIPIneft' were used.

Drilling with flushing by fresh-water drilling muds is recommended where wells are drilled into dense, stable, carbonaceous and sulfatic rocks with small intercalations of clays and argillites whose stability is achieved during drilling by flushing with noninhibited muds, and reservoir brine hardness changes over the range of 0-20 mg-equiv/liter where the backpressure at the reservoir is 5-10 percent higher than the hydrostatic pressure.

Drilling with flushing by mineralized muds (clayey with YePSM, KhKR and calcium-chloride mud) is recommended where wells are drilled into thick beds of clays and argillites or broken-up limestones, the caving of which

was not prevented by drilling with flushing by fresh-water muds of the required amount, and the hardness of the brine waters fluctuates over the range of 20-50 mg-equiv/liters or more and where the backpressure at the reservoir is 5-10 percent higher than the hydrostatic pressure.

It is recommended that oilfields or a portion of a cross-section thereof that is made up of thick salty strata be drilled over with flushing of the corresponding salts with saturated salt brines or with hydrogels.

It is recommended that productive reservoirs that are represented by porous or cracked carbonaceous or terrigenous sediments whose composition includes clayey rocks be drilled in with flushing by oil-based muds.

The technical regulation on drilling solutions was developed basically in accordance with procedural instructions [1, 2]. They were made up in accordance with the results of experimental researches, industrial tests and advanced production experience in sinking wells in the Permian Kama region and in other regions.

Regulation of the types of drilling muds will enable the question of which muds and which properties should be used during well sinking to be solved at all areas and oilfields that are being drilled over in Permneft'.

Another important aspect of these regulations is the characteristics of their development and approval.

Initially, based upon the results of an analysis that has been made and on directive-type materials, preliminary solutions are developed, which are examined at expanded engineering councils of the drilling-operations and exploratory-drilling administrations, and then by the association's technological service, and they are presented for the approval of the deputy-general director of the association and the deputy director of the institute for scientific work.

It should be noted that, during examination of the preliminary solutions, at all stages, only those changes are introduced that will help to raise drilling speed and reduce the cost of well construction.

The basic trends for further improving regulations on drilling muds are to develop procedures for choosing the type of drilling mud and to accumulate information for each oil-bearing region about the characteristics of the rocks and their interactions with the working agent for cleaning the bottom holes of wells.

The next important step in developing the work on regulations is to improve the setting of norms for the consumption of drilling mud, materials and chemical reactants for the construction of wells.

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11409
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.311.4.001.2

ITAT-NOVOKUZNETSK 1150 KV EXPERIMENTAL ELECTROTRANSMISSION SUBSTATION

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 7, Jul 79 pp 53-56

[Article by G.K. Vishnyakov, A.A. Voynov, A.M. Nazarov and Yu.A. Yakub, engineers]

[Text] In connection with the necessity of mastering a new voltage class--1150 kV--it became necessary first to erect an experimental setup and then an experimental industrial 1150 kV electrotransmission system.

In 1973 an experimental 1150 kV setup was put into service at the Belyy Rast substation and in 1978 was begun the construction of the Itat-Novokuznetsk experimental industrial 1150 kV electrotransmission system with two substations.

Below are discussed the key decisions made in designing these substations.

Electrotransmission Systems

The Itat-Novokuznetsk experimental industrial electrotransmission system is the first link in the Siberia-Kazakhstan-Urals intersystem electrotransmission system. At the first stage of operation it will link the GRES of the Kansk-Achinsk Fuel and Power Complex (KATEK) with the power system of the Kuznetsk Basin and will operate according to an autotransformer-line-autotransformer system (fig 1).

For the purpose of conducting research work and testing, adjusting and repairing the equipment of 1150 kV substations without interrupting the electric power supply, the capability is provided of switching the electrotransmission system over to 500 kV voltage.

The number of autotransformers, shunting reactors and synchronous phase modifiers installed in substations, as well as of electrotransmission lines connected to them, is shown in table 1.

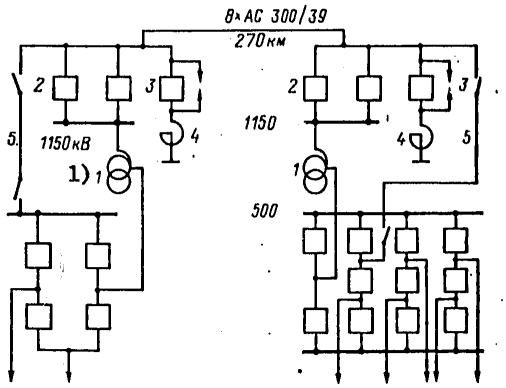

Figure 1. Diagram of Itat-Novokuznetsk 1150 kV Experimental Industrial Electrotransmission System: 1--1150/500 kV, 2000 MV·A autotransformer group; 2--air-break switch; 3--closing and cutoff switch; 4--group of 1150 kV, 900 MV·A shunting reactors; 5--repair jumper

Key:
1. 1150 kV

Table 1.

Item	First stage of development	Reference period	Future
Itat Substation			
Group of single-phase autotransformers:			
1150/500 kV, 2000 MV A	1	1	2
500/220 kV, 500 MV·A	1	1	-
Group of single-phase 1200 kV, 900 Mvar shunting reactors	1	2	4
Electrotransmission line for voltage of, in kV:			
1150	1	1	2
500	4	3	1
220	2	-	-

[Table continued on following page]

Table 1. [Continued]

Kuznetsk Basin Substation

Group of single-phase autotransformers:			
1150/500 kV, 2000 MV·A	1	1	-
500/220 kV, 800 MV·A	-	2	-
Group of single-phase 1200 kV, 900 Mvar shunting reactors	1	2	2
350 Mvar synchronous phase modifier	1	2	-
Electrotransmission line for voltage of, in kV:			
1150	1	1	1
500	3	1	-
220	-	8	2

Electrical Connection Circuits of Substations

For the first stage of operation of both substations identical 1150 kV RU [distribution system] circuits are employed: a line-autotransformer assembly with two switches connected in parallel. This makes it possible to ensure operation of the electrotransmission system at 1150 kV when testing or repairing one of the switches.

The charging power of the 1150 kV VL [overhead line] is compensated by installing at each substation one group of shunting reactors which are connected to the line via a closing and cutoff switch.

With completed development, at the Kuznetsk Basin substation will be installed two groups of 1150/500 kV autotransformers and three 1150 kV VL's will go out from it. For such a number of connections a bus-transformer system is employed, with connection via two switches.

With completed development, to the 1150 kV RU of the Itat substation will be connected four VL's and four autotransformers. In selecting the 1150 kV RU arrangement, an analysis was made of several variants, on the basis of the results of which an arrangement of "two coupled" squares was deemed advisable. This arrangement is not only economical, but also makes possible both a minimal area for the RU and stage-by-stage development.

The 500 kV RU's of both substations are executed with sesqui-circuits. Taking into account the great number of RU connections and the considerable magnitude of short-circuit currents with total development of the Itat substation, the 500 kV buses will be divided into two sections.

Key Equipment

The characteristics of the equipment of the Itat-Novokuznetsk 1150 kV experimental industrial electrotransmission system have been determined on

the basis of general conditions of its operation in electrotransmission systems of this voltage class. The proposal is that the characteristics will be refined after the performance of a set of studies and on the basis of experience gained in the operation of this electrotransmission system.

In connection with the fact that all equipment has been placed under conditions of an unpolluted atmosphere, the outside insulation has been selected in accordance with the length of the leakage path (1.5 cm/kV) at the maximum operating line voltage.

Busing, Insulation and Air Gaps of 1150 kV Distribution Systems

In selecting the phase design for the installation of 1150 kV RU buses, the maximum permissible electric field strength on the surface of leads must equal approximately 30 kV/cm (by analogy with 500 and 750 kV ORU's [outdoor distribution systems]). The phase design consists of five PA-500 hollow aluminum leads arranged at a distance of 40 cm from one another. The permissible load on this phase is 13.2 GV·A.

The installation distances (in meters) for 1150 kV RU's with this phase design are given below, selected to take into account safety engineering conditions, repair and maintenance servicing requirements and the limitation of the influence of the electric field:

Between various phases with rigid bus installation	11.4
From current carrying parts to grounded structures (gantry pedestals) with rigid bus installation	7.5
From current carrying parts to the external dimensions of transported equipment	7.55
From current carrying parts to permanent internal barriers	9.25
From disconnecting switch contacts to current carrying parts	10.2
Between current carrying parts of different circuits with a serviceable or unserviceable lower circuit and an undisconnected upper (in different planes)	6.3
From unprotected current carrying parts to the ground or to the roofs of buildings with maximum slack in wires (without taking into account the influence of the electric field)	12
Between current carrying parts of different circuits with one circuit being serviced and the other not disconnected (horizontally)	11.9
From current carrying parts to the top edge of an external barrier	11.7
Between current carrying parts and buildings or structures	11.3

In keeping with conditions for mechanical strength and reliability, the busing system is suspended on double chains of 58 PS-16B glass insulators, 56 PS-22A insulators or 58 PS-22 insulators.

Layout and Design of Outdoor Distribution Systems

The layout of the ORU is determined by the electrical system at the completed development stage, taking into account stage-by-stage addition, employing simpler circuits.

The designs of 1150 kV ORU's have been developed on the basis of employing equipment with air insulation of the support type. In connection with the fact that 1150 kV ORU's occupy a great area, one of the main problems is the maximum reduction of this area.

For intermediate stages in development simpler ORU arrangements have been employed, such as a line-autotransformer assembly, a triangle and a square. In development of 1150 kV ORU's it was necessary to provide for the ability to change from simple systems to more complex with the employment of permanent system elements and ensurance of reliable relay protection. In addition one of the requirements for the design of 1150 kV ORU's was the maximum reduction of the influence of the electric field on maintenance and repair personnel.

Taking these requirements into account, in the design process several variants of ORU arrangements were considered. Preference was given to an arrangement with a two-row placement of switches and three systems of buses. Such an arrangement, firstly, eliminates the laying of an upper busing system above the equipment of sections with circuit breakers and closing and cutoff switches, and secondly, line equipment (capacitive voltage transformers, dischargers and high-frequency wave traps) and the electrotransmission line can be repaired simultaneously with the absence of voltage in the busing system. The advantage of this design consists in the fact that not only is the influence of the electric field reduced, but the height of busing gantries is also reduced drastically, since there is no necessity to maintain repair distances to the upper point of equipment requiring servicing with the line switched on, i.e., the height of the busing system above the line equipment can be lowered practically to the height of the equipment. On this basis, in 1150 kV ORU's high gantries have been used for collecting mains and low gantries for section buses.

In turn, the employment of high gantries for collecting mains makes it possible substantially to reduce the length of ORU sections and the number of support insulators, as well as to improve the operating reliability of collecting mains (the busing system of the VL, as a rule, passes beneath them). The collecting mains are located at the outer ends of the ORU, and therefore one of them can be repaired with the other operating.

In installing high collecting mains the bus disconnecting switches can be placed closer to the collecting mains, which makes it possible to reduce the number of bus supports and the length of the ORU from embankment tracks to the exit gantry.

Vehicle roads have been provided along rows of circuit breakers as well as between equipment phases (inside sections). Cable trenches and troughs

covered with ferroconcrete slabs can be used by maintenance and repair personnel for passing over the ORU.

Outdoor Distribution System Construction Structures

The amount of construction work which must be done at the first stage in the development of substation systems is shown in table 2.

Table 2.

Indicators	Substation	
	Itat	Kuznetsk Basin
Extent of excavation, thousand m^3:		
Excavation	794	863
Backfilling	506.7	635.4
Volume of monolithic ferroconcrete structures, thousand m^3	9.9	10.6
Volume of precast ferroconcrete, thousand m^3	16.8	19.8
Weight of steel structures, thousand tons	4.3	4.9
Area of asphalt covering, thousand m^2	11.8	9.9
Volume of gravel fill, thousand m^3	6.1	4.9
Length of conduits, thousand m	28.5	25.4
Labor costs for erecting substations, thousand man-days	256.4	304.1

The structures supporting the 1150 kV busing system are in the form of single-span gantries with cantilever cross members. The elements of the gantries have been designed in the form of solid lattice type galvanized structures. Individual elements are interconnected by means of bolts, cross members are fastened to pedestals in articulated fashion, and pedestals are fastened to foundations rigidly.

Foundations are designed in the form of mushroom-shaped unified pedestals with inclined supports. In planning, the requirements of metal structure fabrication plants were taken into account with regard to the maximum utilization of standard elements and their unification. It should be mentioned that gantry supports were designed with the partial utilization of the pedestal of a standard U-220-2 support (since the pull of leads to a stage reaches 120 kN, it is necessary to strengthen the chords by replacing VStZPS steel with 14G2-6 steel).

For purposes of unification, the geometrical dimensions of a cross member (length of 46 m) for all gantries were selected to be identical. Special bolts are provided on each pedestal for climbing to the gantries.

Common Substation Control Center

With completed development, at each substation it is necessary to accommodate a few hundred control, signaling, relay protection and automatic device control

panels. The optimal variant (in connection with the large areas occupied by substations) is the decentralized distribution of protection and automatic device panels. Here panel equipment is located both at common substation control centers (OPU's) for substations, as well as in separate relay panel buildings located in the direct vicinity of a 1150 and 500 kV ORU. Installed at the OPU are all panels for controlling elements of the substation, and panels for central signaling and for the common elements of substations, remote control devices, as well as panels for the protection and automatic devices of elements of 500 kV ORU's located near the OPU. On 1150 and 500 kV ORU relay boards are placed, in addition to panels for the protection and automatic devices of ORU elements, also d.c. and a.c. panels.

The OPU building is a three-story building made of series II-04 precast ferroconcrete structures. On the first floor are located coupling equipment, storage batteries, a.c. and d.c. power boards, the electric boiler room and maintenance personnel areas; on the second, the cable area for the control board and areas for installing air conditioning system equipment and ventilation equipment; and on the third, control boards. In addition, at the OPU are technology, laboratory and auxiliary areas.

Arrangement of Substation Structures

The arrangement solution is governed as a rule by the relative position of ORU's, taking into account the entry of VL's and the shortest electrical connections between ORU's.

In spite of the fact that at the Kuznetsk Basin substation there are ORU's for three voltages (1150, 500 and 220 kV), and at the Itat substation, only two (1150 and 500 kV), optimal for both substations proved to be variants with a front arrangement of 1150 and 500 kV ORU's. For the purpose of shortening the length and electrical connections, as well as for the efficient utilization of the area occupied, a 1150 kV ORU has been designed with a two-row circuit breaker arrangement, and a 500 kV with a single-row arrangement. Taking into account the fact that the width of substation areas is quite limited (with regard to local conditions), in a 500 kV ORU section equipment is arranged not across, but along collecting mains.

At both substations there is the capacity for future one-way expansion of ORU's of all voltages. On the permanent face side of the substation, in the area of auxiliary structures, are located a transformer oil service building, combined with a united building and workshop for the repair of switches, and an oil storeroom, pumping stations for all purposes, tanks, cleaning facilities, warm and cold storage areas, a fire station, etc. Between 1150 and 500 kV ORU's are located three-story OPU's, relay panel buildings, a building for the 10 kV closed distribution unit for internal needs, and compressor stations. The development density of substation areas is greater than 80 percent.

Organization of the Equipment Repair Service

For the purpose of speeding the repair of air-break switches, performed at the point of their installation in an ORU are only the disassembly of modules to be sent for repair and the assembly of standby modules delivered from the repair shop.

The repair of oil-filled equipment is to be carried out in the transformer workshop, designed for the simultaneous servicing of one phase of a 1150 kV autotransformer or reactor.

The TMKh [transformer oil supply] building, of course, is the most complex building facility in the substation's complex. It is in the form of a united block of buildings with a different number of stories and height (fig 2).

The tower for inspecting transformers is equipped with an electric overhead traveling crane with a load lifting capacity of 50/10 tons. Provided in it is a system of rail traverses along which transformers are delivered to the repair and inspection point and are also moved crosswise. On the ORU side, in the tower have been designed sliding gates through which it is possible to move a completely assembled autotransformer.

At the zero mark in the tower are located areas for preparing oil and a chemical laboratory, whose spans are used for holding a bell from an autotransformer being inspected or repaired, as well as a bench for repairing leads.

The transformer tower has a steel frame with rigid joints for attaching the collar beam to the pillars. The pillars are made of welded I-beams and channel bars made of three sheets. Girders with a span of 24 m and a system of stays for the upper and lower chords have been used in conformity with series 1.460-2 v.I, and simply supported beams under the crane, with series KE-10-57 v.V.

Foundations for the TMKh building have been designed from precast ferroconcrete elements installed on a fill base. Adjoining the transformer tower is a workshop for the repair and maintenance servicing of air-break switches.

For the convenience of servicing equipment in the TMKh building there are platforms, balconies and bridges, which are located at different levels and are interconnected by stairs.

In the workshop are installed an electric overhead traveling crane with a load lifting capacity of five tons and a swinging jib with a load lifting capacity of one ton. The frame of the workshop, just as the frame of the transformer tower, is of metal. Girders are supported on pillars in articulated fashion.

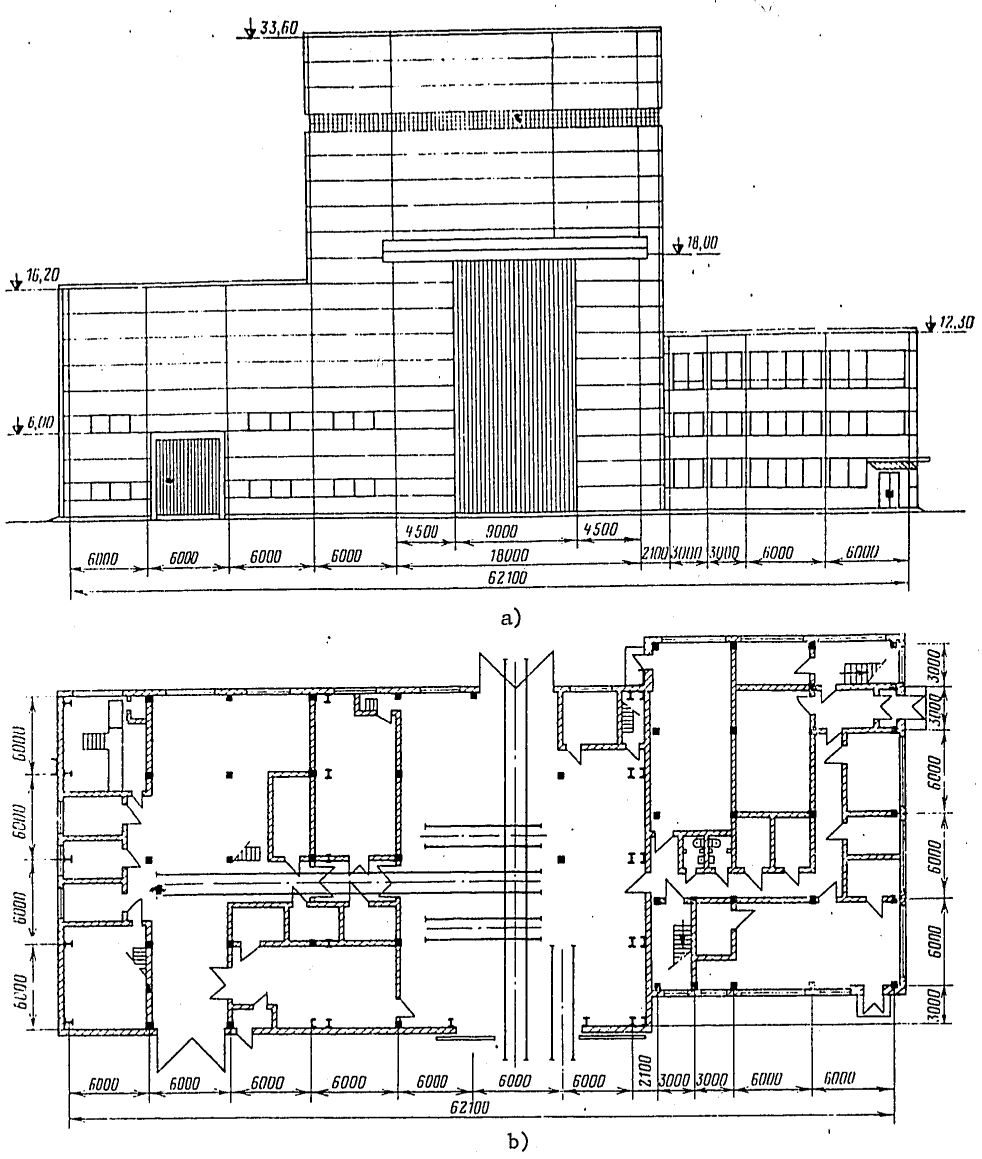

Figure 2. TMKh Building: a--section; b--plan

The united building, made of series II-04 (linked variant) structures is a three-story building. It is separated from the transformer tower by a keyed expansion joint and is offset three meters in the plane.

In the Soviet Union a great amount of scientific research and design work has been done, which has made it possible to embark upon the practical mastery of a new voltage class--1150 kV. The experience gained in the design, construction and entry into service of the Itat-Novokuznetsk electrotransmission system will make it possible in the very near future to embark upon the construction of industrial electrotransmission systems for this voltage class.

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ELECTRIC POWER AND POWER EQUIPMENT

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NEW TRANSFORMERS FOR COAL MINE POWER SUPPLIES

Moscow PROMYSHLENNAYA ENERGETIKA in Russian No 7, Jul 79 pp 28-29

[Article by V.I. Sizonenko, E.P. Nabokov and A.D. Shipilov, engineers, Institute of Mining imeni A.A. Skochinskiy]

[Text] The improvement of existing electric power supply systems is being accomplished on the basis of implementation of the principle of an independent power supply, which excludes an electrical connection between the surface and underground electrical detectors of the mine.* An independent power supply, used for the purpose of isolating underground high-voltage electrical units from units with a heightened fault rate or a low level of insulation resistance, makes it possible to employ effective means for monitoring and protecting from leakages (faults) to ground in a 6 kV network. For the purpose of improving the safety of electrical units, automatic monitoring is performed, as well as the cutting off of leakage currents and faults to ground by means of entire-line or selective protection devices, the limitation of potential in the housing of electrical equipment, and improvement in the continuity of the power supply for electrical units.

Thus, the employment of an independent power supply in mines is one of the measures for improving the safety and reliability of the electric power supply for underground electrical units. It should be provided for in designing and reconstructing 6 to 220 kV electric power supply systems for mines, as well as in cases provided for by the "Rules for Safety in Coal and Shale Mines." Independent power supply circuits are executed, as a rule, on the basis of modified three-winding transformers, transformers with a divided bottom-voltage (6 kV) winding and isolation transformers. The latter are used in reconstructing the electric power supply of mines when the feasibility has not been confirmed by technical and economic estimates of replacing existing two-winding transformers with transformers with a divided winding or with modified three-winding transformers.

*Nabokov, E.P. and Shipilov, A.D. "Prospects for Improving Electric Power Supply Systems for Coal Mines," PROMYSHLENNAYA ENERGETIKA, No 1, 1978.

Table 1.

1)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13) 14)	15)	16)	17)
2)	10	115	6,3	6,6	17,0	10,5	6,0	23	76	57,1			
	16	115	6,3	6,6	17,0	10,5	6,0	26	96	74,6			18)
	25	115	6,3	6,6	17,5	10,5	6,5	42	140	76,2			
	40	115	6,3	6,6	17,5	10,5	6,5	63	220	100,4			
3)	2,5	6,0	—	6,3	5,5	—	—	4,6	23,5	7,86			19)
	4,0	6,0	—	6,3	6,5	—	—	6,4	33,5	13,09			
	6,3	6,0	—	6,3	6,5	—	—	9	45,5	16,35			

Note: Transformers with a capacity of 16 MV·A are manufactured by the "Transformator" [Transformer] SPVO [Special Production All-Union Association] in Tol'yatti, and the remainder by the Zaporozhtransformator [Zaporozh'ye Transformer] PO [Production Association].

Key:

1. Type of transformer
2. TDTNSh
3. TMSh
4. Rated power, MV·A
5. Rated no-load voltage, kV, per side
6. High voltage
7. Medium voltage
8. Low voltage
9. High voltage - low voltage
10. High voltage - medium voltage
11. Medium voltage - low voltage
12. Short-circuit voltage
13. Losses, kW
14. No-load
15. Short-circuit
16. Weight, tons
17. Winding connection system and group
18. $U_{}/D/D-11-11$
19. $U/D-11$

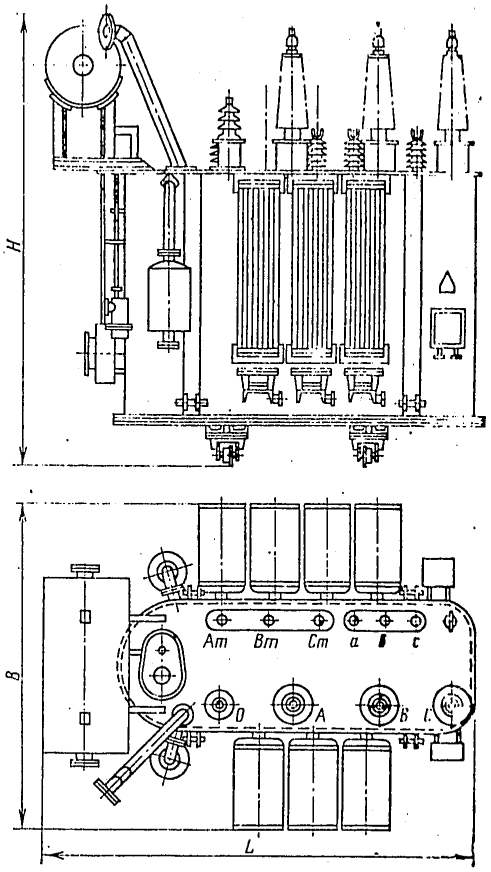
Table 2.

1) Тип трансформатора	2) Габаритные размеры, мм		
	L	*B*	*H*
ТДТНШ-10/110 3)	7160	3800	6180
ТДТНШ-16/110	7070	4470	5620
ТДТНШ-25/110	7700	4600	6100
ТДТНШ-40/110 4)	7550	4840	6250
ТМШ2,5	3340	2260	3560
ТМШ4,0	3900	3540	3870
ТМШ6,3	3410	3680	3985

[Key on following page]

Key:

1. Type of transformer
2. Overall dimensions, mm
3. TDTNSh-10/110
4. TMSh2,5



As of 1979 the USSR Minelektrotekhprom [Ministry of the Electrical Equipment Industry] has planned the series production of transformer equipment for mine electric power supply systems with an independent power supply for underground electrical detectors. The key parameters of this equipment are shown in tables 1 and 2. In the figure are given the designations of the overall dimensions of a type TDTNSh three-winding transformer. The utilization of this equipment should be provided for in planning electric power supply systems for new mines and those being reconstructed.

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ELECTRIC POWER AND POWER EQUIPMENT

AGRICULTURAL ELECTRIFICATION ACHIEVEMENTS, PROBLEMS NOTED

Moscow GIDROTEKHNICHESKAYA STROITEL'STVO in Russian No 7, Jul 79 pp 1-4

[Article by D.T. Komarov, chief engineer, USSR Ministry of Power and Electrification Administration for Electrification of Agriculture: "Electrification of Agriculture"]

[Text] The course implemented by our party toward the intensification of agriculture and improvement in the efficiency of agricultural production requires further strengthening of its materials and equipment base. In addition to overall mechanization, electric power is one of the important elements in improving the efficiency of agricultural production. Because of the steady concern of the CPSU Central Committee and the Soviet government, in the country a powerful electric power base has been created, which has made it possible more intensively to solve problems in the further electrification of agriculture.

The modern stage in the development of the electrification of agriculture marks its beginning from the March 1965 Plenum of the CPSU Central Committee, in whose decision was stressed the importance of creating a plan for the extensive electrification and electrical mechanization of processes of agricultural production, especially in animal husbandry, the effective development of which requires arranging for electrification enterprises and farms of the industrial type, furnished with modern high-efficiency equipment, which would utilize to the full extent the valuable characteristics of electric power.

In summarizing the results of the implementation of the party's agrarian policy produced by the March 1965 Plenum of the CPSU Central Committee, CPSU Central Committee General Secretary, Comrade L.I. Brezhnev in his report at the July 1978 Plenum of the CPSU Central Committee stated: "The power capacity of agricultural enterprises was increased during these years from 232 million to 525 million horsepower, or twofold plus, and the power-worker ratio on kolkhozes and sovkhozes was increased 2.5-fold. The process of the electrification of agriculture has been continuing actively."

During the past 14 years in the development of the electrification of agriculture a new big step has been made and much work has been done on the

development of electrical lines and the broadening of the employment of electric power in agricultural production, in everday life and in the area of serving the farm population. For the electrification of the countryside 2.7 million km of electrotransmission lines have been constructed and put into service. In operation by the end of 1978, for the purpose of furnishing electric power to the countryside, were a total of 287,000 km of 35-110 kV LEP's [electrotransmission lines] for agricultural purposes, 16,000 transformer substations for this same voltage class, with a total capacity of 66 million kV·A, 3.6 million km of 0.38-220 kV distributing networks, and 700,000 10/0.4 kV transformer stations, with a capacity of more than 80 million kV·A. The development of rural electrical networks has made it possible to complete an important step in the electrification of agriculture--the joining to State power systems of kolkhozes, sovkhozes, interfarm and other enterprises and organizations on the countryside, as well as the residences of kolkhoz personnel and sovkhoz workers.

In addition to electricity, to the countryside have come radio, television and home electrical appliances and machines. Electrification and the mechanization of production processes carried out on its basis have altered the nature of agricultural labor, have converted it into a variety of industrial labor and have drawn together the recreational and daily living conditions of the urban and rural population. In agricultural production the number of motors as of the beginning of 1979 had increased as compared with 1965 by a factor of 5.8 and reached 12 million with a total capacity of 63 million kW, and the number of electrical units in technological processes had grown 30-fold and reached 2.25 million with a total capacity of 16.5 million kW. Furthermore, the pace of the introduction of motors and electrical units was 1.5 times faster than the pace of the growth of other power capacities, and quantitatively they equal one half the size of the tractor fleet. There was a noticeable rise in the level of electrical mechanization of processes in animal husbandry, where the level of the electrification of milking cows was raised to 85 percent versus 26 percent in 1965, and of the water supply on longhorn cattle farms, to 84 percent versus 41 percent, and on poultry farms, to 93 percent versus 39 percent.

On the basis of rural electrification at the present time the overall electrical mechanization of production processes is being carried out, to provide maximum savings. In 1965 there was no total electrical mechanization, and as of 1978 it had been accomplished at 58 percent of pig breeding farms, at 63 percent of poultry breeding farms and at 33 percent of longhorn cattle farms.

The extensive electrical mechanization of production processes has been responsible for high rates in the consumption of electric power. In 1978 agriculture consumed 95 billion kWh of electric power, or 4.5 times more than in 1965. The power-worker ratio on kolkhozes and sovkhozes had risen from 381 kWh per worker to 2280 kWh, or sixfold; the consumption of electric power for municipal and personal needs per rural inhabitant had risen 3.6-fold. All this has made it possible substantially to improve labor productivity in agricultural production and to elevate the quality of production and life on the countryside.

The 25th CPSU Congress has set the goals of accomplishing further specialization and concentration of production and of creating large production complexes on kolkhozes and sovkhozes. Called for are further accelerated growth in the power-worker ratio and improvement in the level of mechanization and consumption of electric power in agricultural production and in daily life.

For the purpose of providing for the growing need of agriculture for electric power, in the current five-year plan period it is necessary to construct more than 100 million km of electrical networks, including 123,000 km of 35-110 kV LEP's, which is 25 percent more than in the Ninth Five-Year Plan period. Called for is the ensurance by the end of the five-year plan period of 100 percent electrification of the water supply on all animal husbandry and poultry breeding farms, and the ensurance of a 65 to 90 percent level of electrification in the distribution of feed, 75 to 90 percent in the collection of manure, 90 percent in the milking of cows and 95 percent in the shearing of sheep. Electric power will be used extensively in microclimate apparatus, in different kinds of irradiation and, what is especially important, in land reclamation.

In fulfilling the decisions of the 25th CPSU Congress, building and erection and operating subdivisions of Minenergo [Ministry of Power and Electrification] during the three years of the 10th Five-Year Plan period have constructed and put into service for supplying agriculture with power the following: 54,000 km of 110 kV LEP's, transformer substations for this voltage with a total capacity of 16.2 million kV·A, and 470,000 km of 0.38-20 kV distributing lines. The realized volume of capital investment for the construction of electric power network projects for the "Agriculture" sector has equaled 1.67 billion rubles.

Operating subdivisions of Minenergo have done a great deal of work on improving the repair and maintenance servicing of rural electrical networks. For the purpose of improving the reliability of power supply systems, the effective radius is being reduced, subdividing is being performed, along with sectionalization and equipping with automatic equipment (APV's [automatic reclosers] and AVR's [automatic reserve switches]) for feeders, and radio communications complexes are being installed. At transformer stations 55,000 overloaded transformers are being replaced, and at 110-35/10 kV substations standby power has been created and secondary transformers have been installed. More than 2000 substations are remote controlled. New progressive forms have been introduced for the repair and maintenance servicing of rural distributing networks by centralized repair crews and by immediate-response maintenance and immediate-response traveling crews. In five years more than 380,000 people have been trained, including 45,000 for kolkhozes and sovkhozes.

The work done on carrying out measures aimed at improving the reliability of the power supply for rural users has created a steady trend toward a reduction in accidents in distributing networks. In 1978 the number of accidents was reduced 61 percent as compared with 1975, and of failures in the operation of first-degree equipment, by 76 percent, and of failures in second-degree, by 57 percent, and the total number of disruptions in 1000 km of networks was reduced by 61 percent.

In addition, in the development of rural electrification there are shortcomings, difficulties and unsolved problems which have been retarding the introduction of electric power into agricultural production and a growth in the power-worker ratio on kolkhozes and sovkhozes. For example, in spite of the fact that the level reached in the development of electrical networks still does not satisfy the increased growth in the consumption of electric power in agriculture, the requirements of rural electrification are not being provided to a sufficient degree with materials, electrical equipment, apparatus and cable products. The electrical equipment being produced for supplying agriculture with power does not conform in terms of quality ratings to the conditions of agricultural production. The development of new electrical equipment conforming to the standards set is going on at a slow pace. It is necessary to improve the supply of maintenance and construction and erecting subdivisions of Minenergo working on the electrification of agriculture with the necessary machines, gear and motor vehicle transportation and repair and maintenance centers, which will make it possible to improve efficiency in eliminating damage in electrical networks and to reduce interruptions in the electric power supply of rural users.

The July 1978 Plenum of the CPSU Central Committee wrote in its decree: "A major objective in agriculture is to be considered its thorough dynamic development and considerable improvement in the efficiency of all of its sectors, and the reliable furnishing of the country with foodstuffs and agricultural raw material, for the purpose of making possible further improvement in the lifestyle of the people. Efforts are to be increased in every way possible for the purpose of solving the problem of drawing closer the material and recreational and living conditions of life in the city and country." An especially important role belongs to electrification in solving this problem. The objectives of supplying the countryside with power are based on an established growth in the gross output of agriculture and in labor productivity, taking into account a reduction in the rural population. These objectives were formulated specifically in the decree of the CPSU Central Committee and USSR Council of Ministers adopted in Jan 79, "Measures for the Further Development of Electrification of Agriculture."

Attaching great importance to the development of the electrification of agriculture as the most important means of speeding technical progress in agricultural production and improving the recreational and living conditions of the rural population, the CPSU Central Committee and the USSR Council of Ministers have designated that the consumption of electric power in agriculture be brought in 1985 to 170 billion to 190 kWh. This means that, as compared with 1978, the consumption of electric power on the countryside must be doubled. Called for in 1981-1985 is a 1.6- to 1.8-fold increase in the power-worker ratio in agricultural production and a 1.8- to twofold increase in the consumption of electric power per rural inhabitant for municipal and personal needs.

The consumption of electric power in irrigated agriculture will grow at a rapid pace, where, on average for the country, per each hectare are required

more than 1 kW of electric power and 3000 kWh of electric energy per year. For the purpose of solving these problems, called for are the construction and entry into service of 988,700 km of high-voltage and low-voltage lines and 40 million kV·A of 35/10 kV transformer substations. Furthermore it is necessary to construct at a rapid pace LEP trunk lines and 35-110 kV substations, in order to eliminate the disproportion which has been created with 6-20 kV distributing networks. The increase in the percentage of 35-110 kV lines is due also to the necessity of furnishing the most important users with a duplex power supply, primarily animal husbandry complexes and poultry farms.

Called for is the construction of repair production centers and maintenance and repair stations at enterprises and in areas of electrical networks for the purpose of maintaining rural electrotransmission lines and transformer substations. The intent is to carry out the reconstruction of 182,000 km of 0.38-20 kV overhead electrotransmission lines for the purpose of increasing their carrying capacity.

For the purpose of providing for the increasing extent of electrical network construction, called for is an increase in the output of and delivery to agriculture of power transformers, distributing units and equipment, uninsulated wire, cable products and other materials and electrical equipment.

It is necessary to do a great deal of work on the thorough automation and remote control of distributing networks. For the purpose of solving this important technical and economic problem it is necessary to develop and produce special automation and remote control equipment, devices and facilities.

The effectiveness of the utilization of electric power in agricultural production depends to a considerable degree on the level of organization of the engineering maintenance service. In a number of krays, oblasts and autonomous republics in recent years a form of organization for this service has been found in the form of "Sel'khozenergo" interfarm maintenance production associations, which on a contract basis carry out scheduled preventive maintenance and equipment servicing of power and electrical equipment units and electrical plants. It is necessary to expand and strengthen these associations, to carry out measures for the further improvement of their production and economic activity, and to arrange for centralized furnishing of them with material and equipment resources.

The development of the electrification of agriculture is a new manifestation of the concern of the party and Soviet government for a further rise in agriculture, and it has been playing an enormous role in the job of further improving its efficiency.

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