UNDERGROUND MINING OPERATIONS IN ZONGULDAK COAL MINES

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ABSTRACT. — The object of this article is to present all the aspects of underground mining activities in Zonguldak coal mines, the history of the mines, geological conditions, coal seam characteristics and general layout of the districts.

Emphasis has been paid to mining methods, old and new, the available machinery and rates of output. Genera considerations for the future expansion programme are mentioned, and basic existing problems of the coal basin are discussed with personal recommendations for their possible solution, by the author.

I. INTRODUCTION

Since the birth of Modern Turkey, industrialization is one of the important assets that has led towards this nation becoming one of the most progressive in the Middle East.

The discovery of Zonguldak coalfield with its bituminous coal reserves amounting to 1,356 million tons overlying an area of over 100 sq. km, revolutionized the country, as now, readily available was a basic fuel to provide for the needs of the proposed industries. Since exploitation began in 1848, annual coal production has steadily increased to 7,000,000 tons r.o.m. in 1965. Underway is a programme that aims to increase the production capacity of the coalfield to 10,000,000 tons per year by 1972.

Today, conventional longwall advancing and retreating methods with caving or pneumatic stowing, and hydraulic stowing methods are widely applied throughout the area, as they have been found suitable to the faulted and folded conditions of the basin. Mechanization is still limited, but constructive steps are being taken towards further mechanization in order to achieve a higher rate of productivity.

II. HISTORICAL REVIEW

At the end of the Eighteenth Century, coal was imported into the country in order to provide steam energy for the Ottoman Imperial Navy. In the hope of finding indigenous sources in Turkey, sailors were given small specimens of coal and told to search for similar pieces in their own hometown. The first specimen of Turkish coal was brought from Ereğli (Heraclee) on the Black Sea coast, to İstanbul in 1822, but nothing was done for exploration and exploitation of this coal. However, in 1829, another specimen of coal was brought to Istanbul by Uzun Mehmet, a sailor and native of the village of Kestaneci, near Ereğli. This time attention was given to the discovery and the sailor received a reward of a life pension, but before he could benefit from this reward he was murdered.

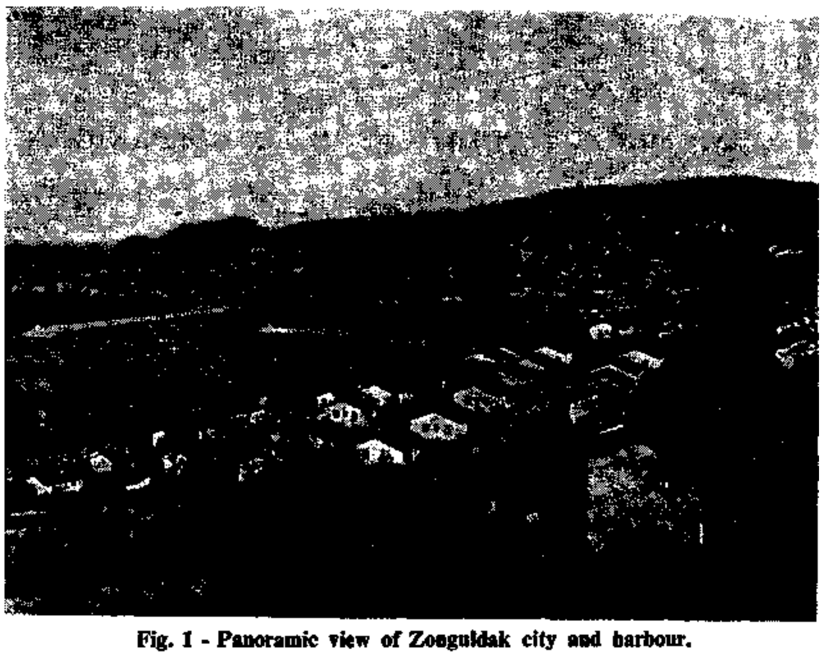

Fig. 1 - Panoramic view of Zonguldak city and harbour.

Since mining operations began in 1848, several periods of administration can be observed during the following century.

1. The Imperial Treasury Department (1848-1865) : During these early years actual exploitation of the coalfield was under the control of various foreign and private interests. Only 40,000 tons of coal was mined in five years, using primitive methods such as quarries and employing imported skilled miners. Rational exploitation began with the outbreak of the Crimean War, when an English company obtained a concession to develop the coalfield in order to provide coal for the Turkish and British Navies. For the first time machinery was utilized, engineers were brought from England and Turkish miners received training.

2. The Ottoman Imperial Navy (1865-1908) : Administration was under the control of the Turkish Admiralty, but the mines were mainly operated by foreign companies, such as British, Belgian, Italian, German and Tsarist Russia. The region was surveyed, a railroad built and slowly, with the technical improvements, production rose. However, even then many of the mines could not be made to pay.

3. The Ministry of Public Works and later by the Ministry of Agriculture and Commerce (1908-1920) : Except for the years of World War I, when the coalfield was under German command, this period was dominated by French and Italian companies, the foremost being the Societe Française d'Heraclee. Production fell to 158,000 tons in 1917 from over 900,000 tons in 1911. After the war, output again rose in the hands of French companies.

4. The National Government and Private Enterprises (1920-1940) : Following the foundation of the Turkish Republic in.1923, the National Government endeavoured to encourage the private companies to further development to meet the increasing needs of the country. The İş Bankası was authorized to invest in coal development when the companies proved reluctant. Immediately production rose to 2,300,000 tons with the

expansion of operations, half of which was mined by the Societe Française d'Heraclee, the remainder by Italian and French-Turkish companies. Coal production still did not meet the country's need and a long-term programme of development was needed. The individual companies were not eager to comply, and it was realized that the only solution would be nationalization.

This move was also logical when other points were considered. Concessions had been granted haphazardly and within the mines various levels were being mined simultaneously and lower seams worked out before upper seams, thus resulting in loss of coal. Heavier equipment was needed as the mining went deeper, and no company was willing to undertake such investments. Lastly, because of the illogical granting of concessions, to prepare an all-over plan was impossible.

In 1936, the Turkish Government took steps towards nationalization by buying the concessions of the French company, the Societe Française d'Heraclee, and placing them under the financial direction of Etibank, a national bank, who then established a national coal company, Ereğli Coal Mines, EKI (Ereğli Kömürleri İşletmesi) in Zonguldak. Some private enterprises remained in mining operations until 1940, but as no capital investment was made to increase production, complete nationalization of the coalfield occurred in the same year.

5. Etibank and later Turkish Coal Enterprises, TKI (1940 - present) : After nationalization a preliminary development programme, was prepared. This resulted in the realization that if the coalfield was to produce the desired output, new modern methods and equipment must be adopted. Progress was slow as, during the years of World War II, mining exploitation machinery, equipment and spare parts were difficult to obtain, and the mines were only able to operate because of the efforts of the mine operators. By 1947, in order to prevent a serious decline in output it become obvious that a major rehabilitation needed to take place.

In 1957, the Turkish Coal Enterprises was established, whose duty it was to prospect and operate bituminous coal, lignites and peat deposits.

III. LOCATION AND GEOLOGY

The Zonguldak coalfield, which extends for 50 miles along the Black Sea coast, lies between Ereğli in the southwest, and Çatalağzı in the northeast (Fig. 2). It is approximately 250 km by sea and 375 km by road from Istanbul, and 480 km by rail from the capital, Ankara. The major part of the product is transported by rail or by sea to industrial areas in Anatolia and Istanbul.

For the most part, the North-Anatolian coast ranges, between Ereğli and İnebolu (Fig. 2), are composed of folded and faulted Mesozoic rocks. Carboniferous rocks appear on the surface in several places where erosion has occurred.

At the present time, it is known that a belt of Carboniferous rock, some 160 km long, underlies the Cretaceous. Many of the Carboniferous inliers are too small to be of any economical importance. In some areas the Carboniferous must have eroded before the Cretaceous was deposited, e.g., Cretaceous overlies discordant Devonian and Silurian rocks south of Ereğli; and west of Amasra and east of İnebolu Devonian rock is found on the surface.

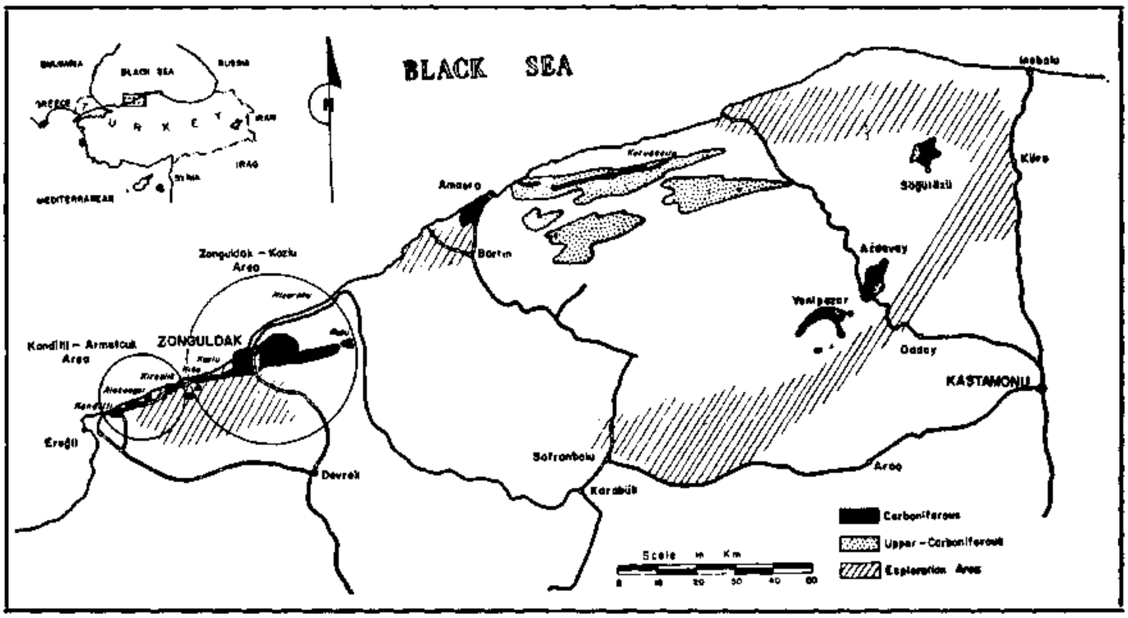

Fig. 2 - Location map of Zonguldak coalfield.

In some places only the Visean, i.e., limestone or Lower Namurian formation, which contains no workable coal seams, has not undergone pre-Cretaceous erosion. It cannot be expected that there is a productive zone under the Cretaceous; however, several inliers indicate the presence of Westphalian-A with exploitable seams.

The North-Anatolian coast range can be divided into two parts: the Western Coalfield, between Zonguldak-Kozlu and Kandilli-Armutçuk areas, and the Eastern Coalfield which includes inliers east of the River Filyos. Exploitable seams at Azdavay and Söğütözü in the Eastern Coalfield are known to exist, but due to lack of geological research the reserves and possibilities are yet unknown. Deep drilling is necessary in order to provide such information. Examination of the Carboniferous below the Cretaceous is necessary, as much depends on the depth at which the productive seams will be reached. In the Filyos Valley, where there are many depressions, the Carboniferous will be beyond a depth possible for exploitation.

The Carboniferous belt is very complicated and the geology of the belt is still unknown. In the Zonguldak-Kozlu area where there is production of coal, geology is better known, but still there are questions that remain unsolved. The identification of the seams is made difficult because of disturbances due to mountain-building movements and more so because of the unstable conditions of the earth's crust during sedimentation.

Coal seams have been exploited belonging to the Middle and Upper Carboniferous, which underlie faulted and folded Cretaceous rocks. The seams occurring in this area are frequently disturbed by faults. In the area are four main types of faults which may be summarized as follows:

a. The Midi-Fault : This is most probably the oldest fault, and runs out in an eastern direction, in steep-dipping Namurian shales, about parallel with the strike of shales. This fault has generally a large crushed zone and the dip of this zone is about

70-80 degrees towards the north. It is possible that Midi-Fault had already had its first movement during the sedimentation of the Carboniferous.

b. The Great North-South Faults (Damlar and Ömertarla Faults) : Towards the west the Gelik anticline is cut by two faults running in a north-south direction. Both faults have a downthrow to the west of about 600-800 m. The Kozlu district lies west of the Damlar Fault, and Ömertarla Fault separates İkinci Makas from the İnağzı Mine. These faults came into existence as a consequence of strain in the anti-clinal axis during folding.

c. The Transversal Faults : These faults, e.g., the Boyacıoğlu, Karamanyan, Öküşne and Dilaver, have horizontal displacement along the planes of maximal shearing stress.

d. The Great East-West Faults : These faults are of post-Cretaceous age and run parallel to the axis of the anticline, e.g., Adnan Bey Fault between Damlar and Midi-Faults in Çaydamar, having a downthrow to the south of about 850 m, and No. 1 Fault and Kuzey Fault in the north flank; the former having a southern downthrow, the latter a northern downthrow.

The Kandilli-Armutçuk area is the most western coal outcrop of the North-Anatolian coal basin. The Carboniferous outcrops over a distance of approximately 4 km in length by 1 km in width. Most of the inlier is of Namurian formation and in some areas Westphalian-A is visible on the surface. This formation consists of large conglomerates and sandstones with little or no shale present. Over the working areas the dip of the strata is almost vertical and at lower levels turns towards the north. The seams form a syncline at lower levels and the axis of this syncline dips towards the west.

IV. COAL SEAMS AND RESERVES

In the Zonguldak-Kozlu area arc totally 52 coal seams, some of which belong to the Kılıç and the remainder to the Kozlu coal series. The Kılıç series contains three workable coal seams, namely, Büyük Kılıç, Civelek and Ömerağa in the Lower Westphalian. There are more seams, but these are not counted valuable because of the steep position and the squeezed parts in this disturbed area. The coal average of Büyük Kılıç is 4.5 m and it is cut off in the east by the Midi-Fault, while Civelek and Ömerağa are more regular seams with about 1 and 1.5 m coal average over the whole length of the area.

The Kozlu series contains 40 seams, ranging in thickness between 0.7 and 10 m, of which 15 to 22 are exploitable in the Westphalian-A; however, the exact workable number varies in the individual districts. Cay and Acılık are the most important coal seams having a thickness of 6 and 4.5 m respectively, other valuable ones are Sulu, Hacımemiş, Domuzcu and Büyük whose thicknesses range from 1.5 to 2.5 m. Most production of the Zonguldak coalfield conies from coal seams in the Kozlu series.

In the Kandilli-Armutçuk area are four coal seams in the Westphalian-A formation, but only two of them, Büyük and Üçköylü, are exploitable. These seams vary in thickness between 1 to 30 m, the coal average thickness of Büyük being 6 m, and Üçköylü, 3 m. The dip of the strata over the Whole area is vertical on the surface, turning towards the north at a lower level.

The complex geology and stratigraphy, and badly faulted nature of the region have made evaluation of the reserves difficult, even in the areas under production. Stratigraphic study and structure indicate that the coalfield extends to the east and south. Towards the east, the productive coal seams may be thinner, but south of the present productive area, study has shown that there may be further productive coal seams,

Possible exploitable areas towards Amasra, Alacaağzı and certain parts of the productive area are under investigation by deep drilling.

In the light of the latest data, 1966, total reserves of the coalfield under production are estimated at 1,356 million tons, of which 17 % is proven, 20 % probable, and 63 % possible. These figures, however, give only an approximate idea of the magnitude of the coalfield. Consideration should be. given to the fact that about 1/3 of the Kozlu and 1/5 of the Armutçuk district reserves are under the Black Sea. Distribution of the coal rezerves and the depth of the seams are shown in Table 1.

Table - 1

Coal reserves of the Zonguldak coalfield (Reserves, thousand metric tons — in place)

Districts	*Below sea level (m)*	*Proven or measured*	*Probable or inferred*	*Possible or indicated*	*Total*
	— 160	29,093	—	—	
Karadon	— 360	—	47,792	—	521,785
	— 1,200	—	—	444,900	
	— 425	17,014	—	—	
Kozlu	— 425	—	25,434	—	316,448
	— 1,200	—	—	274,000	
	— 200	114,877	—	—	
Üzülmez	— 400	—	102,765	—	296,942
	— 1,200	—	—	79,300	
	— 500	41,688	—	—	
Armutçuk	— 850	—	62,050	—	103,738
	— 850	—	—	—	
	— 200	24,477	—	—	
Amasra (non-operational)	— 200	—	38,387	—	117,033
	— 200	—	—	54,169	
Zonguldak coalfield	— 1,200	227,149	276,428	852,369	1,355,946

V. COAL CHARACTERISTICS

Only bituminous coal is found in the Zonguldak coalfield; however, the quality of the coal varies at different mines. Due to the friable nature of the coal, most of the production is in the finer sizes. This presents a major problem in the recovery of the coal from the dirt.

In the Zonguldak - Kozlu area the coal is medium volatile, about 30 %; low in sulphur, less than 1 %; shows strong coking properties giving a gray, bright, well-

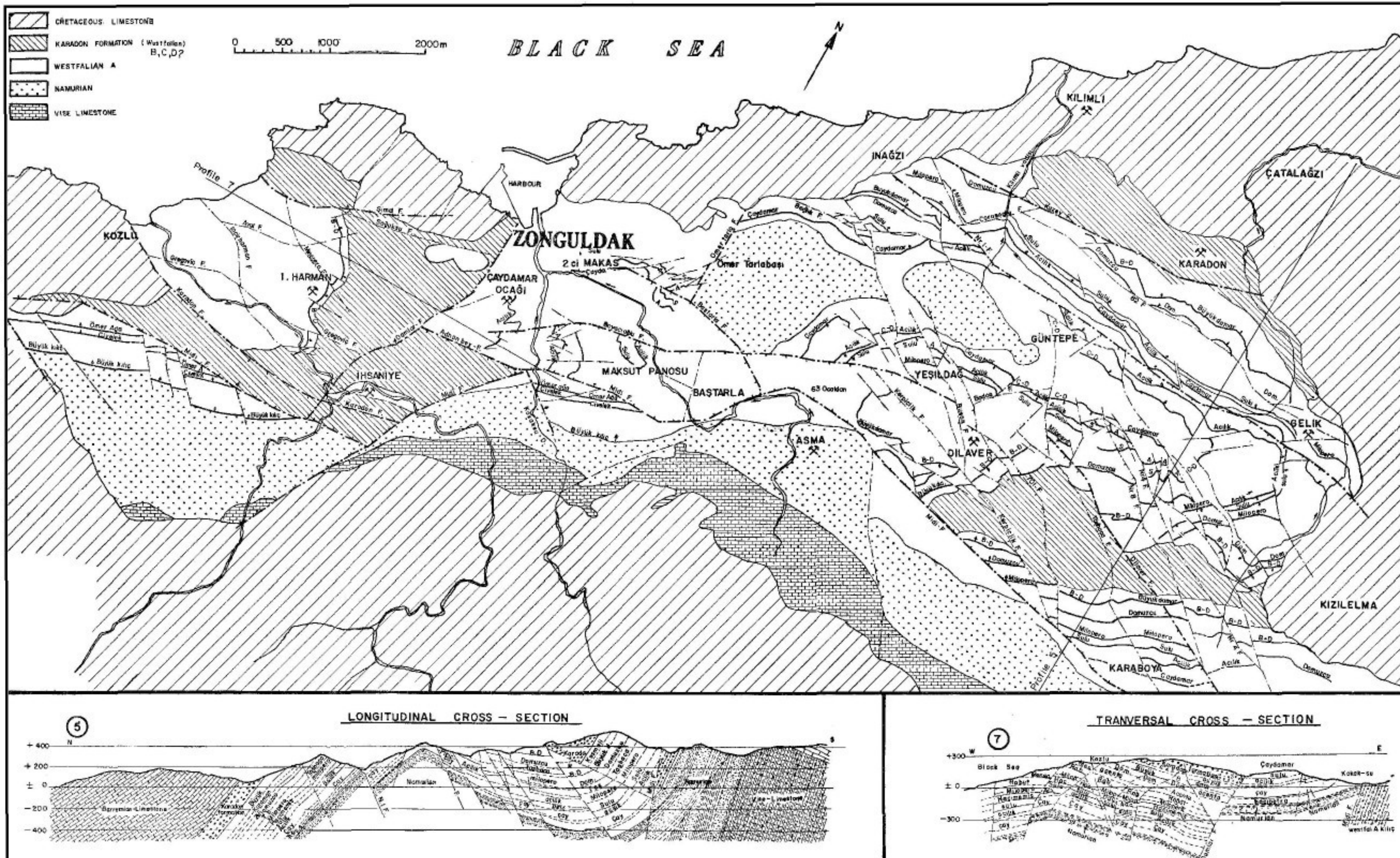

Fig. 3 - Geological map of Zonguldak Coalfield.

fused, swollen coke. The run-of-mine coal has an ash-content of 20 % • 48 % which is cleaned to 14 % ash for consumption and trade. The calorific value of run-of-mine coal ranges from 4,500 to 6,000 kcals, per kg, equivalent to 8,100 to 10,800 B.Th.U. per pound.

In the Kandilli-Armut9uk area the coal is highly volatile, about 35 % with a slightly higher sulphur content than the others and they are good gas coals. The ash-content in the run-of-mine coals is from 15 % to 25 %, and calorific value is a little above 5,000 kcals, per kg, approximately 9,000 B.Th.U. per pound.

Typical coal characteristics are illustrated, according to the International Classification System of hard coals by type, in Table 2.

Table - 2

Characteristics of Zonguldak coal

District and coal seam	*Volatile matter «moisture and ash free basis»*	*Ash melting point*	*Swelling index*	*Caking properties*	*Dilatation or contraction*	*High-calorific value «moisture and ash free basis»*	*Low-calorific value «moisture and ash free basis»*	*Code numbers*
	%	°C				Kcal/kg.	Kcal/kg.	
Gelik-Acılık	33.5	1325	8.5	+25	+134	8554	8244	634
Gelik-Milopera	33.8	1350	8.5	+25	+150	8532	8236	635
Gelik-Acenta	33.7	1230	8.5	+25	+169	8569	8259	635
Üzülmez-Acılık	30.8	1340	7.5	+25	+ 64	8317	8217	534
Üzülmez-Sulu	30.8	1395	8.0	+18.5	+157	8592	8288	535
Kozlu-Çaydamar	29.7	1355	6.5	16.6	+ 76	8537	8255	534
Kozlu-Acılık	29.6	1340	4.5	12.0	+ 8	8479	8187	533
Armutçuk-Büyük	35.5	1180	1.5	10.5	— 31	8278	8079	611

VI. GENERAL LAYOUT

1. General

In the coalfield four districts are operated by the Ereğli Coal Company, these are: Karadon, Üzülmez, Kozlu and Armutçuk. The first three districts are located within a 10-km radius of Zonguldak, on the northeast range of the basin; while Armutçuk is about 65 km from Zonguldak, on the southwest range. Mining operations are concentrated in nine collieries of the four districts. Extraction is carried out simultaneously at several horizons within the collieries, but all production is hauled through common drifts, slopes and more often shafts to the surface, and is transported to the centrally located washeries in Zonguldak, Çatalağzı and Armutçuk.

From the illustration (Fig. 3), it can be seen that the area is badly faulted, inclined and complex in nature; this gives rise to problems of some magnitude in projecting mine development. The main objective is to establish one main haulage and hoisting level at each colliery and mine all the coal seams above this horizon before work commences on the next lower horizon. The vertical intervals between the mining horizons are generally 100 meters. Gravity is used where possible to transfer coal produced from intermediate levels to main haulage levels.

Each of the four districts is self-sufficient in regard to surface and underground installations and facilities. However, major repair and maintenance workshops and central warehouse depots for supplies and material are located at or near Zonguldak.

2. Karadon district

The Karadon district consists of three collieries, Gelik, Karadon and Kilimli, occupying a 35 sq. km production area. It is planned to produce 8,800 tons per day from a series of coal seams averaging in thickness from 1 to 7 m with slight to moderate dip. Originally the collieries were individual mines, later they were reorganized and centralized at Karadon. Due to this fact, a very complicated horizon mining system with horizons at 50 and 100 m intervals, can be observed. Generally there are relatively few faults and strata conditions are good in this area, but it tends to be wet. The seams are worked by the longwall advancing or retreating method with controlled caving or stowing of mined-out areas. Application of pneumatic stowing in this district is on a large scale. The present production level depth varies from + 140 to —160 meters.

Coal produced from the three collieries is brought to the 250-ton capacity Karadon Transfer Station by main haulage drifts at the drainage level from Gelik, and through Shaft No. I (Fig. 4) from Kilimli and Karadon. Goal arrives at the Çatalağzı washery by a 650-ton per hour capacity belt conveyor system from the transfer station. Shaft No. I is equipped with a two-deck cage system having a hoisting capacity of 300 tons per hour from a depth of 210 m, and is used for men-riding, material, dirt and coal winding. Other available shafts in this area are, five in Gelik, four of which are staple; five staple shafts in Kilimli and two others in Karadon, one for ventilation and the other for stowing material transportation. A new shaft, Çatalağzı No. II, has been sunk to a depth of 400 m, in order to provide adequate hoisting capacity for the future—360 main haulage level. It will be furnished with a skip-winding system

Fig. 4 - Shaft No. 1, Karadon district.

having 680 tons per hour hoisting capacity. To be installed in a 40.5-m high concrete tower are a 2.8-m Koepe drum with a 4-rope system, which will be driven by a 1170-KW, 3-phase DC motor at a speed of 8 m per second.

Underground haulage is by five 16-ton, 160-HP Moes and five 14-ton, 100-HP Deutz diesel locomotives pulling 5-ton capacity mine cars on a 1067-mm rail gauge. Trolley locomotives run on the +55 level, Gelik-Karadon drift and on —160 level trolley haulage road in Kilimli. Diesel locomotives are in operation on the +55 level Kilimli - Karadon and —160 level Karadon main haulage roads. For the purpose of auxiliary transportation some 45, diesel and battery powered, 6 to 8-ton, 30 to 60-HP locomotives, manufactured by Ruthaller, Deutz and Diema are employed. These locomotives, running on a 600-mm rail gauge, pull 1-ton cars of broken coal from gates to the main haulage roads.

Air circulation of the three collieries tends to be complicated because of the original layout of the mines. The area is not ventilated as a whole yet, Karadon and Kilimli having one common system and Gelik having its own. Two Aerex fans each with 250,000 cu. m per hour capacity at 15 mm WG are installed at Karadon, and two Vedag fans with 250,000 cu. m per hour capacity at 80 mm WG are in operation at Kilimli. Gelik is supplied with two Aerex fans of 250,000 cu. m per hour capacity at 46 mm WG, and a domestic-made fan of 61,000 cu. m per hour capacity at 30 mm WG. Two further Aerex fans each of 200 mm WG, one of 270,000 and the other 500,000 cu. m per hour capacity are installed, available for the future expansion programme.

Three main compressors are installed in the surface compressor house, near to Shaft No. I in Karadon. These are, one AEG turbo-compressor with a capacity of 34,000 cu. m per hour at 3,400 KW; and two Demag turbo-compressors, each with a capacity of 30,000 cu. m per hour at 2,800 KW. Additional to these are two piston-type Ingersoll Rand compressors in Gelik used as reserves, one of which has a 150, the other 90 cu. m per minute capacity. Approximately a combined rated capacity of 2,000 cu. m per minute is ready to be delivered to the mine workings through 400 to 100 mm steel pipes. In continual service are two large capacity compressors, the others working when necessary.

Large quantities of water are pumped as the seams are wet. At Karadon, the drainage level is established at—160 level, there being three sumps, each with a capacity of 1,500 cu. m, employed alternately. In use are five Worthington and Sulzer centrifugal pumps with 380 and 200 cu. m per hour capacity against 200 and 250 m heads. To overcome the wet conditions in Gelik and Kilimli, AEG, Harland and Ingersoll Rand pumps of 350 and 150 cu. m per hour capacity against 500, 200 and 150 m heads are employed. After completion of the new Çatalağzı Shaft No II, the main drainage level will be at —360 level. From here three Halberg centrifugal pumps with 360 cu. m per hour capacity against a 250 m head will pump mine water, first to —164 level, then to the surface.

3. Üzülmez district

Üzülmez district with its three collieries, Asma, Dilaver and Çaydamar, having a production area of 28 sq. km, has been reorganized to produce an estimated output of 6,500 tons of coal daily. Conditions at Asma and Dilaver, which can be considered an adit mine even though there are a few staple shafts, are about the best in the coalfield. Seams are on lighter pitches, faults, are less frequent and conditions are generally better. At Çaydamar, roof conditions are weak and the methane content encountered is excessively high. A series of 1 to 4-m thick coal seams, with an average dip of 30 degrees, are worked out by longwall advancing methods with caving and gravity stowing. It is planned for future years to adopt pneumatic stowing methods in the hope of increasing productivity. The average production levels of mined-out seams are between +100 and —100 meters.

The underground method of transportation is by belt conveyors, from the gates to a loading point at the bottom of the slope at —100 level and then to +50 main haulage level. Employed to transfer broken coal from Dilaver and Asma collieries to the 200-ton capacity Asma Transfer Station are five 16-ton, 150-HP, Goodman and one 16-ton, 160-HP Jeffrey trolleys. From here to the Zonguldak washery 50-ton railroad cars are in use. For auxiliary transportation in Çaydamar colliery, thirty 4 to 8-ton, 30 to 60-HP Ruthaller, Deutz, Skoda and Diema diesel and battery-powered locomotives are used on the haulage roads.

Separate ventilation circuits must be considered for Asma-Dilaver and Çaydamar collieries. At Çaydamar colliery, movement of air current is obtained by two Fournier fans supplying 108,000 cu. m per hour at a pressure of 50 mm WG each, while Asma-Dilaver area has two axial-flow Aerex fans working on the surface, each furnishing 198,000 cu. m per hour at 50 mm WG pressure. Some small fans circulate air in other parts of the mine adequately for mine workers.

A compressor station is located near to the opening of each of the three mines. Two new Demag turbo-compressors with 20,000 cu. m per hour capacity are housed in a brick building at the Asma colliery, where a new shaft is under process of being sunk for the future expansion programme. Six piston-type Ingersoll Rand compressors, each with the capacity of 150 cu. m per minute and supplying compressed air at 6-8 kg/sq. cm pressure are installed at Dilaver colliery. Finally, six Sullivan piston-type compressors having 60 cu. m per minute capacity each, are located at Çaydamar. Four of these are in service all the time, the others acting as reserves.

Each individual colliery has its own pumping station for lifting mine water from working places to the surface. At Asma, two Sulzer centrifugal pumps each with 200 cu. m per hour capacity against 200 m head and one Ingersoll Rand with 160 cu. m per hour against 150 m head are situated at the —100 level. Mine water is pumped through staple shaft no. 48 to the +50 main haulage level where it finds its way out by the drainage adit. At Çaydamar mine, five Halberg and Ingersoll Rand centrifugal pumps with the capacity of 100 and 200 cu. m per hour against 200 and 250 m heads are employed to pump the water from —200 level to +10 at the pit collar. At Dilaver, six centrifugal Halberg and Sulzer-made pumps lift the mine water to the surface. To be installed at Asma and Çaydamar for the expansion programme, are four Halberg centrifugal pumps with a capacity of 200 cu. m per hour against 75 and 250 m heads.

4. Kozlu district

The two collieries, İhsaniye and İncir Harman of the Kozlu district, cover an area of 10 sq. km, and produce a planned output of 5,500 tons per day. Coal is mined from two series of coal seams with a dip of 10 to 80 degrees, and ranging from

Fig. 5 - Uzun Mehmet hoisting installatión, Kozlu district.

08 to 4.5 m in thickness. For the main development of both collieries, horizon mining has been adopted with horizons at —100, —200 and —300, and for future development —425 level is under preparation. Roof and seam conditions and faulting in Kozlu make working difficult. Mining is partly by longwall advancing and retreating with caving and gravity stowing in slightly to moderate pitching coal seams, and by diagonal stepped longwall with gravity stowing in areas with very steep pitching. Pneumatic stowing method is considered for the future expansion programme. At the present the working levels range from —200 to —300 meters.

Eight shafts are available, the two main ones Uzun Mehmet No. 1 and No. 2 (Fig. 5) each 6.5 m in diameter, are equipped one with a two-deck 9-ton capacity cage and 240 tons per hour hoisting capacity used for men-riding, material, dirt and occasionally coal winding; the other with a 10-ton capacity skip and 550 tons per hour hoisting capacity employed solely for coal winding. The other six shafts, two of which are staple, are used for various purposes such as men-riding, ventilation, stowing material, equipment and dirt transportation.

The haulage methods on the main haulage level are highly mechanized and efficient. Four 16-ton, 160-HP battery powered Jeffrey trolley locomotives and twelve 12-ton, 120-HP General Electric battery locomotives are in operation to pull 5-ton capacity mine cars on a 1067-mm rail gauge. The broken coal from loading points is hauled to the 200-ton capacity bin at the pit bottom and then wound to the surface through shafts. For the auxiliary transportation some 35 Deutz, Ruthaller and Atlas 6 to 8-ton diesel and battery locomotives, ranging in HP from 30 to 80, are employed in the intermediate levels of the collieries.

Special attention has been paid to the ventilation system in the Kozlu district owing to the high content of methane. Effective air circulation is attained by using

No. 1 and 2 shafts as downcast and the remainder as upcast. Erected on the surface are six axial-flow Aerex, two Buffalo and two Fournier fans supplying 198,000 cu. m per hour at 50 mm WG, 210,000 cu. m per hour at 60 mm WG, and 180,000 cu. m per hour at 50 mm WG respectively. Additional to these, on the future development level, —425, there is a 100-HP domestic-made booster fan with the capacity of 3600 cu. m per hour. In development areas and on the faces are 42 small auxiliary fans to ensure proper ventilation for mine workers.

The latest ventilation survey indicated that the volume of air entering the mine and exhausting are not equal. The difference is thought to be lost in the mined-out areas and through minute fractures in the strata. Daily, 19 million cu. m of air is exhausted from the mines, of which 105,000 cu. m is methane; this is equivalent to 3,800 cu. m air and 21.5 cu. m methane for each ton of coal produced.

Compressed air is furnished by one 3,400 KW AEG turbo-compressor, with 34,000 cu. m per hour capacity; one 2,800 KW Demag turbo-compressor with 30,000 cu. m per hour capacity; and three piston-type Ingersoll Rand compressors, each with 9,000 cu. m per hour capacity. The small-type compressors are erected in a compressor house, while the two large ones are in the hoisting equipment brick building for Shaft No. 2. In continual operation are one large and two small compressors, the others being in reserve. Compressed air, after leaving the coolers is transported to the pit-bottom by 400 and 300-mm steel pipes which are deeply galvanized against corrosion. In the water tower, hot circulating water is cooled from 28°C to 23°C for AEG and from 33°C to 27°C for the Demag compressors.

The average quantity of water pumped out of the mine is rather high, approximately 7,200 cu. m a day or 2,600,000 cu. m per year. This may fluctuate slightly depending on the season, spring and early summer having the heaviest flow. The water from present and old workings, cavings and strata drains through the mine workings into one of the two sumps each of 1,200 cu. m capacity at the pit-bottom, —300 level. From here it is pumped via —200 level to the surface in two-lift stages. In the pumping rooms are Sulzer centrifugal pumps, two at the —300 level with a lifting capacity of 450 cu. m per hour against 104-m head, and three at —200 level with the same lifting capacity but against a 204-m head. One further similar pump with 200 cu. m per hour against a 200-m head is at the İhsaniye slope bottom.

5. Armutçuk district

The Armutçuk district, with a production area of 30 sq. km, has only one colliery producing a capacity tonnage of 1300 daily. The whole mine is planned on a variation system of horizon mining with 50 and 100-meter level intervals. The coal seams, usually thicker than in any other district, are mined out by hydraulic stowing methods and at the present the working levels range from +115 to —250 meters.

Broken coal is brought to the —200 main haulage road through three staple shafts. Other available staple shafts are used for transportation of stowing material, men-riding, ventilation and equipment winding. A new shaft has been sunk to a depth of 490 m and is in the process of being equipped with a cage-winding system. A 2.8-m friction drum and a 4-rope Koepe hoist is being mounted in a concrete tower (Fig. 6), 28 5 m in height. Hoisting capacity, for coal and dirt is 390 and 405 tons per hour respectively. A 925-KW, 3-phase DC electric motor will drive the hoist with a speed

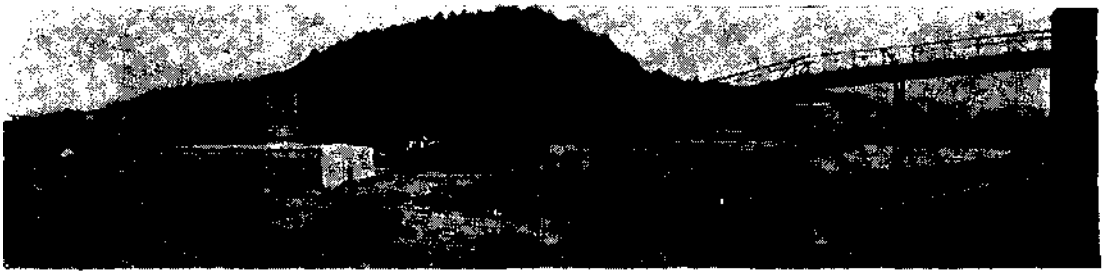

Fig. 6 - New Koepe-winding installation, under Construction, Armutçuk district.

of 6 m per second. The purpose of this shaft is to increase output capacity and concentrate the produce from lower levels. Eventually all coal produced from the colliery will be hoisted through this new shaft to the 1000-ton capacity bunker near the washery.

Underground transport in the main haulage roads is by means of locomotives and 5-ton cars running on a 1067-mm rail gauge. Three Deutz-made diesel locomotives, each weighing 13.5 tons and with 100-HP, pull twenty loaded cars. For intermediate and auxiliary transportation thirteen 6-ton, 30-HP small-type diesel locomotives manufactured by Deutz and Diema are in operation. They pull thirty, 1-ton cars on a 600-mm rail gauge.

Air circulation is induced by two 115-HP blower-type Aerex fans supplying 3,600 cu. m per minute against a pressure of 100 mm WG. These fans are directly driven by three 730-rpm, 550-v flame-proof motors, one of which acts as a reserve. Small auxiliary fans, each with a capacity of 8 to 10 cu. m per minute made by Joy, Meco, Aerex and Korfmann are employed in parts of the mine. The colliery is rated excessively gassy and critical areas, such as faces, mined-out areas, draw points, are adequately ventilated.

Compressed air is supplied by three Atlas and one Ingersoll Rand piston-type compressors, which are installed in the surface compressor house delivering a total of 1.8,000 cu. m per hour. In the cooling tower, water temperature is reduced from 60°C to 20°C and this cools the compressed air before it passes via 300- and 200-mm steel pipes into the working levels of the mine.

Due to the existing mining system there is a considerable amount of water encountered in the mine. All the water from the hydraulic stowing faces drains to the lower levels and collects in 1,000 cu. m capacity sumps at the bottom of the shaft. Three Worthington centrifugal pumps, two working and one as a reserve, each with a lifting capacity of 350 cu. m per hour against 500-m head, are installed in the pumping room located at the main shaft. Motor effect is 800 HP, 3300 v and 2,980 revolutions per minute. When the new Koepe hoist is in operation, three 450-HP with 1,480-rpm Halberg centrifugal pumps, each with a capacity of 360 cu. m per hour against 275-m head will be installed at the —300 level.

VII. PREVIOUS AND PRESENT MINING PRACTICES

1. General

Due to the varied characteristics of the coal seams and roof and floor conditions in the individual mines, no one mining method can be solely employed to obtain a high percentage extraction. Prior to 1950, 63 % of the production within the coalfield

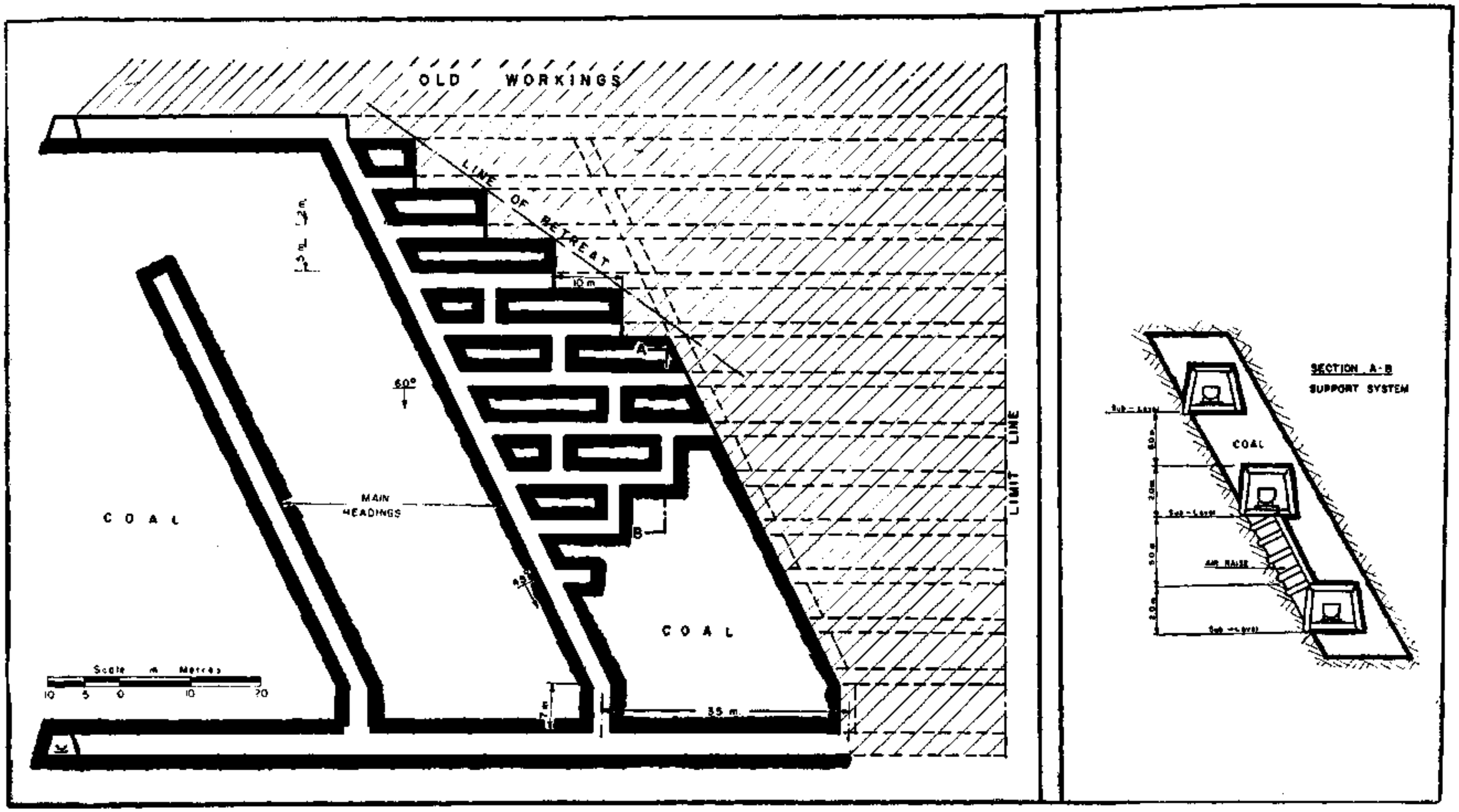

Fig. 7 - Plan and section of sub-level caving method.

was mined by a variation of sub-level caving (sometimes referred to as roonvand-pillar method) to reduce mining costs and maintain high productivity. This method was applied to steep seams having a moderate thickness. Excessively thick and vertical coal seams were mined by a modification, namely, sub-level caving with flat shortwall. Occasionally the latter method is still applied.

In recent years because of difficulty in application of face mechanization and prevalence of mine accidents and fires, most sub-level caving methods have been abandoned. Generally conventional longwall advancing and retreating methods are in operation, but depending on the specific conditions of the strata, surface installations and material available, either controlled caving or backfilling (gravity or pneumatic stowage) systems using wooden or metallic face supports are applied throughout the coalfield, and 90 % of the entire production comes from seams where these methods are used. The other method, only employed in the Armutçuk district, is a hydraulic stowing method.

2. Sub-level caving method

During early years most of the output from Kılıç section mine in the Kozlu district was produced by sub-level caving method which was applicable to the highly pitching coal seams, more than 60 degrees, of moderate thickness (Fig. 7). The method consisted of driving sub-level drifts in the coal seam along the floor to the boundary, then retreating to the central raise. The coal left between two sub-levels caved down due to the weight of the coal and the pressure of the overburden.

Considerable preliminary development, in the form of driving gates at 100-m vertical intervals, sub-level headings with 45 degrees inclination 35 m apart along the gates, and sub-level drifts, 2 X 2 m in cross section and 5 m apart, was required. The sub-level heading or central raise served for ventilation, transportation of coal and men-riding. Within the panel, sub-level drifts were driven in descending order to the limit line, then retreating operations began towards the central raise and coal was recovered by the caving of the top slice. When retreating had progressed to some extent from the limit line, the next slice below was allowed to cave. In order to ensure safe working conditions a line of retreat of 30 degrees was maintained. Between the drifts small raises were sometimes driven on the floor for the purpose of handling timber, for proper ventilation and safety.

Sub-level drifts were supported by a 3-set timbering system. Depending on the thickness of the seam, crib timbering was sometimes applied in caving operations. Coal was mined mostly by hand or pneumatic picks and gravity caving. Broken coal was shoveled into 0.5-ton mine tubs and drawn to the central raise which was used as a chute. Cars on the haulage gate roads were filled in this manner, and diesel locomotives were employed for the main transportation in the haulageways.

This method was rejected in favour of the diagonal stepped longwall with gravity stowing method, as there were several disadvantages, mainly, it was a dangerous system with a high accident rate due to caving of coal, ventilation system for this method was inadequate and this caused fires by spontaneous heating, recovery of coal was around 70 % as it was diluted with dirt, and lastly, consumption of timber was high because of the heavy timbering needed to support the coal slices.

3. Sab-level caving with flat shortwall method

Formerly the sub-level caving with flat shortwall method, which is a combination of sub-level caving and classical shortwall mining (Fig. 8), was applied to the 8 to 30-m thick, very steep coal seams of Armutçuk mine.

The application of this method consisted of driving rock drifts at 50-m vertical intervals in the floor and then forming a panel by cross-cutting the coal seam 100 m apart. Two central raises in the coal seam along the floor and roof were driven to intersect two levels. The first central raise along the floor had two compartments serving as coal chutes, menways and ventilation, and the other on the roof was used for material handling and ventilation. When the two parallel drifts running along the floor and roof in the coal seam reached the limit line of the panel, they were connected to establish a shortwall face. The length of the shortwall depended on the thickness and inclination of the coal seam.

Extraction of the seam progressed by the shortwall retreating towards the central raises, then the coal on the top of each slice was recovered by caving. After the first slice retreated about 10 m, work began on the next lower slice, and these operations continued in descending order until all the coal panel had been extracted.

Support of the face was by props and bars, while wooden cribs behind the face established a breaking-off line, thus safe and controlled caving was achieved. Usually pneumatic picks were used for breaking the coal, but occasionally light blasting was needed. Broken coal was loaded into chain conveyors or specially made 500-kg front dump mine tubs, transported and dumped into chute from which the cars were loaded on the main haulage level.

This method was abandoned in favour of the hydraulic stowing system, because of the following drawbacks : unsuccessful attempts at face mechanization, only 60 % recovery, high percentage of fatal accidents due to the roof falls, gob fires caused by spontaneous combustion and finally large consumption of timber and lagging.

4. Longwall advancing and retreating methods

Conventional longwall advancing and retreating methods are the most common systems applied throughout the coalfield because of their adaptability to the existing coal seams and roof conditions. Approximately 75 % of the whole production is obtained by these methods, which are found suitable for gentle or semi-steep pitching seams up to 3 m in thickness, where the roof can be caved easily behind the face. Generally, longwall advancing method with controlled caving is in use; however, where danger arises through spontaneous combustion and to save the cost of maintaining gate roads, retreating method is in operation.

When the advancing system is considered, each panel is developed by driving a pair of gates, then connecting them near to crosscuts. From this heading faces are worked to the limit line. For the retreating method, the gates are connected immediately at the crosscut with a heading for ventilation, and one on the limit line from which a working face is established.

Mining commences following the establishment of the faces, through the limit line in the direction of the strike in advancing, and through the shaft in the retreating method. Coal is broken by means of hand or pneumatic picks, and where seams are

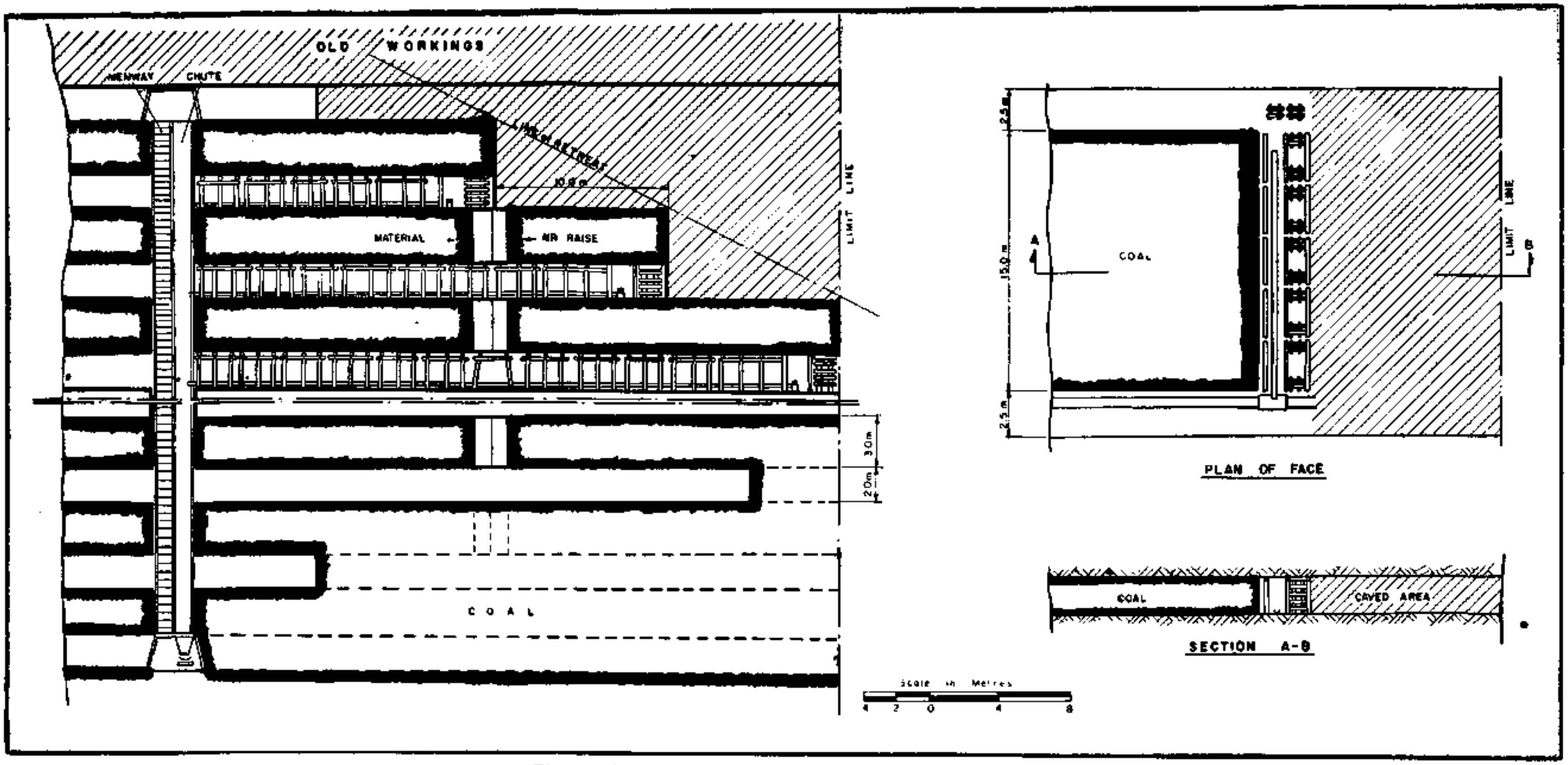

Fig. 8 - Sub-level caving with flat shortwall method.

of a strong character light blasting is used. For face transportation a chain conveyor system is assembled to haul broken coal to the Ioading point at the lower gate. In the longwall face, the roof is supported either by timbering or steel prop sets. Timber set units consist of a 4-m long bar and four 3-m high posts placed in two rows parallel to the coal face. To prevent accidents from the roof falls of the friable coal, lagging is necessary. A breaking-off line induced by means of wooden cribs, controls the roof caving in mined-out areas. When steel props are in use, two bars rest on the heads of three props. Support units are perpendicular to the face and are usually spaced 1 m apart. Where heavy roof conditions are encountered timber cribs are built so that roof pressure is minimized on the longwall face.

A typical longwall retreating face of 100 m in length and of average thickness 3 m with a cutting advance of 1.20 m, has a total deployment of man-power of 104. From this, the rate of productivity achieved for face and underground workers is 4.525 and 2.630 tons per man shift.

5. Diagonal stepped longwall with gravity stowing

This method is mainly applied to the coal seams with steep pitching from 50 degrees to vertical having a moderate thickness of 1.5 to 4 m. This type of coal seam is mostly found in the Kılıç Mine, Kozlu district. The diagonal stepped longwall with gravity stowing («gradins renverses» on the Continent) has replaced sub-level caving (Fig. 9). This method, similar to overhand stoping in metalliferous mining, has been successfully adapted to the local conditions, minimizing the rate of accidents and increasing productivity.

Panel development is by means of opening a pair of gate roads at vertical intervals of 50 or 75 m, after driving crosscuts to reach the coal seam. In order to diminish the high pitching of the coal seam to a suitable angle of repose of 40 to 45 degrees, a diagonal face is established by driving an inclined heading from the lower gate road, turning away at an angle to the dip. The step working faces are perpendicular to the strike of the coal seam, and the steps are 2 m in width and 2.5 m apart, advancing along the strike of the seam.

Explosives are not necessarily used as the coal is soft and friable; therefore, the only method of extraction is by means of pneumatic picks. The broken coal slides down the diagonal face to the lower gate road where it is loaded in mine tubs and transported to the pit bottom and wound to the surface. Hazardous conditions arise because of the weakness of the roof and floor, and to ensure safe working conditions for the miners, very heavy timbering by props with wooden wedges are set up under the roof of the step face. Square protection pillars, 5 by 5 m, are left to maintain proper protection of the gates. The supply of an adequate volume of air is directed from the lower crosscut into the lower gate road, through the working faces and returned via the upper gate road to the upper crosscut.

A gravity stowing system is applied to pack the mined-out areas. In the first place, refuse from waste-heaps was used as stowing material; this, however, proved unsuccessful because of the dryness and shape of the shales. Washery refuse was found suitable, so this material is transported from the Zonguldak washery by 50-ton cars, then transferred to one-ton mine tubs and brought to the upper gate road where it is dumped into the face and the mined-out areas are packed by the help of gravity. Platforms

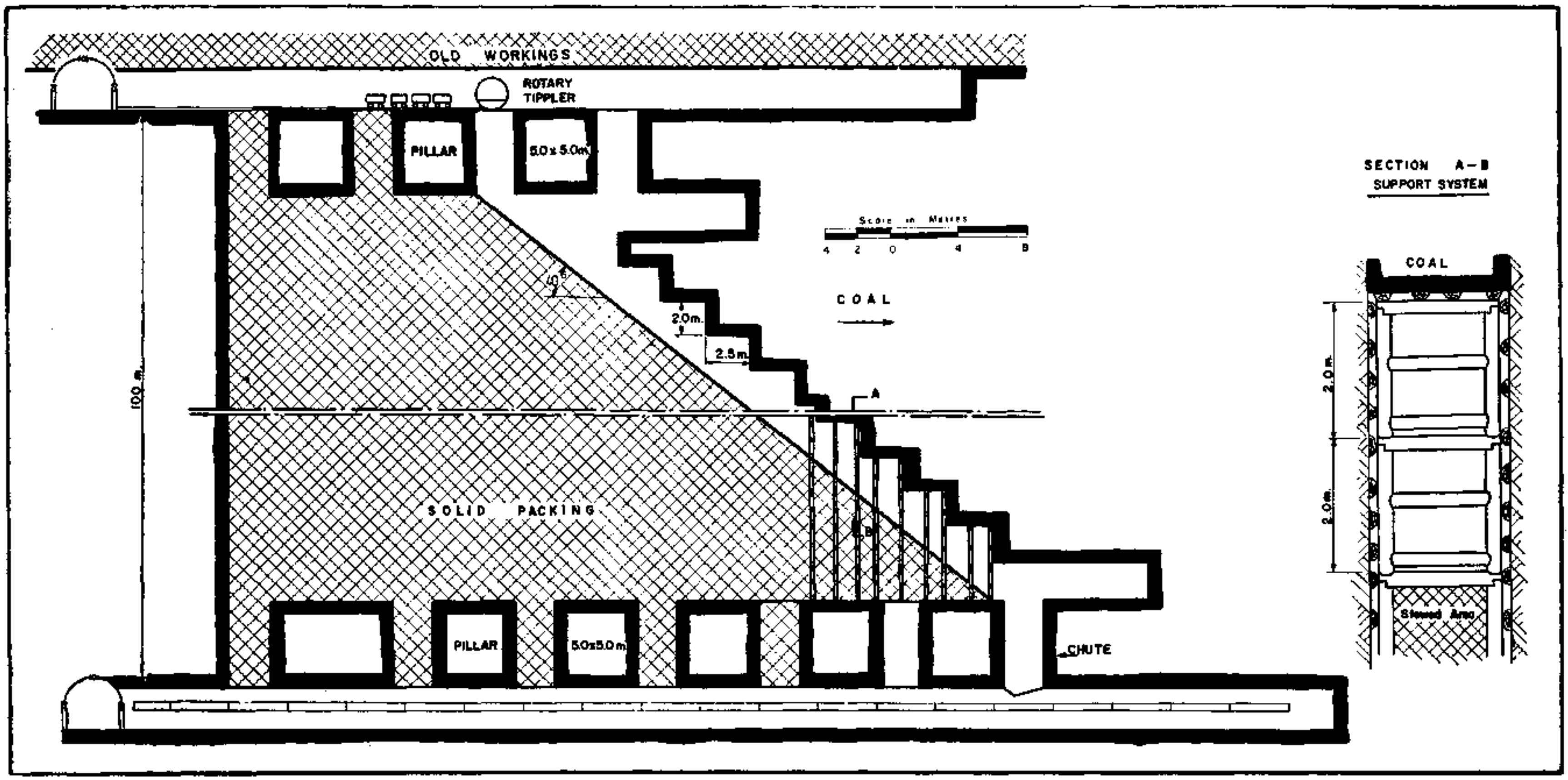

Fig. 9 - Working steep seams by diagonal stepped longwall with gravity stowing, «gradins renversés».

are erected at certain intervals along the face length to break the fall of stowing material, thus preventing injury to the miners and damage to the pack-walls.

When similar conditions in the mine are considered, the total number of miners employed on the working face with the new method is 159, compared with 253 needed when the old sub-level method was applied. The rate of productivity for face and underground workers is now 3.012 and 1.572 tons per man-shift, compared with 2.079 and 1.103 tons on the previous system.

6. Longwall with pneumatic stowing method

The classical longwall advancing and retreating with caving in slightly steep and sub-level caving in steep coal seams arc gradually being replaced by pneumatic stowing and at the moment the percentage of coal production on the coalfield coming from faces with pneumatic packing is increasing. Present tendency promises even more appliance of this method because of its suitability to the local circumstances : protection of the surface plants and residential areas against subsidence, higher efficiency in ventilation air currents and allowing the possibility of undisturbed continuous mining at the face. This method has proved successful in coal extraction of moderately thick seams with an incline up to 50 degrees.

The panel development is similar to classical longwall operations. A longwall face, about 100 to 150 m in length, is established in the coal seam. Cutting is performed by pneumatic picks and each cut has a depth of 1.20 m. Explosives are seldom in use. The hanging roof is supported by steel props and bars. Where disturbances, such as faults or squeezes are present in the seam, cribs are set up behind the face against the excessive top pressure. At the face, coal is shovelled onto a single chain conveyor and transported to the haulage gate.

The pneumatic stowing machines are manufactured by Messrs. Karl Brieden and Co. of Germany. Two cellular wheell-type stowing machines with horizontal and vertical shafts, KZ 80 and KZS 150, are driven by compressed air motors. Each machine has an operational pressure of 4 atü and the air consumption, at full capacity, is 5,500 and 7,500 cu. m per hour respectively. Naturally, specific air consumption varies according to the length of blast line, the number of bends, the kind of stowing material used and the stowing method whether continuous or interrupted processes.

Reuss or Brieden's cast-basalt stowing pipes, each 3 m long and 150 or 175 mm diameter, with centrally split camper clamps, are used for the stowing line on the gate road, but at the face 150-mm diameter with 3-m long steel pipes are in use. The total length of the stowing line is about 150 to 200 m. The pneumatic stowing wall comprising of wire-netting is installed by hand.

Communication between the machine operator and stowing crew at the face is by telephone. By this, efficiency is raised, as the machine can be stopped if any blockage exists at the face.

As stowing material, dirt from old heaps or washery refuse is employed. To make the material of suitable size for the machines, it is passed through a 50-mm screen. Oversize is crushed to the specified size in 50-ton per hour capacity Hazemag crushers. At this point any foreign material, such as iron or timber, is extracted to prevent damage to the stowing machines and pipes. Generally, 300-mm diameter by 7-m long pipes are used to transfer the material from the Hazemag crusher plant to underground bunkers. One or 5-ton mine cars carry the material to the gate roads where rotary tipplers are located, and finally it is brought to the feeder funnel of the stowing machine by double-chain conveyors. Compressor air forces the material along 3-m long by 150-mm diameter stowing pipes to the faces.

With employment of pneumatic stowing, less man-power is needed at the face for packing operations. Efficiency and economy of the system, and labour employed are illustrated below. A typical longwall face with characteristics as follows should be considered: 96 m in length, 3 m thick, dip of 30 degrees, and a cutting advance of 1.20 m. On this face the stowing crew comprises of one man to handle the rotary tippler, four men to extract large pieces from the stowing material, three men to operate the stowing machine, three men to move the conveyor, nine men to stow, decouple and reinstall the stowing line, eight men to set up the timber and two foremen to control working operations.

The rate of productivity attained for face and underground workers is 4.790 and 2.730 tons per man-shift respectively.

Although output has increased with the application of this method, still certain problems, listed below, must be solved if full efficiency is to be acquired :

— Under certain conditions it is necessary to change the stowing material source from old heap dirt to washery refuse or vice versa; thus the type and size of material varies and trouble arises in the movement along the pipes and sometimes they become blocked.

— Moisture content of the stowing material cannot be kept constant due to the use of variable material.

- Shortage of clay in the stowing material and inconsistent turning of the pipes on the gate is the main cause of rapid wearing away of the basalt, lining the stowing pipes.

—- Handling of three meter-long steel pipes on the inclined face is difficult.

— The transportation system between the Hazemag crusher and stowing machine is complicated. The time interval is long because of many transfer points. This has arisen because formerly the mine was not developed especially for this method.

— Lack of training of the miners makes the rate of productivity less than planned.

7. Hydraulic stowing method

This method is solely used in Armutçuk district to win the coal, with a high percentage recovery, from very thick, moderate to vertical coal seams. The coal seams in this area contain a large quantity of volatile matter and are inflammable, so the mined-out areas are susceptible to spontaneous combustion and also as methane emission is high explosion$ occurred occasionally. When the previous method, sub-level with flat shortwall, was applied there was loss of life, coal and machinery. These reasons were mainly responsible for the change to hydraulic stowing practices.

The panel development for the coal seams is similar to that of the old method. To form a 50xl00-m coal panel, rock drifts parallel to the coal seam at intervals of

50 m, and crosscuts 100 m apart are driven. Individual panels are further developed by driving raises and drifts in the coal and then establishing a flat shortwall.

All the stowing material comes from a quarry on the surface consisting of sandstone and conglomerate. This quarry, with an estimated reserve of 300 million tons, will suffice for the entire life of the mine. The quarry is worked out in single-bench of 30 to 40 meters in height. In operation are three Keystone churndrills, two Bucyrus Erie 54-B power shovels with 2.5-cu. yard bucket capacity and three 15-ton Euclid dump trucks. Daily, 450 cu. m of stowing material is brought to the preparation installations where it is passed through a vibrating screen with 30-mm openings. Oversize goes to a 175 ton per hour capacity Simons cone crusher, where it is crushed to a size of 25 to 30 mm. All the material is transported to a 500 - cu. m bunker by a belt conveyor. Prior to this, the material is passed through another screen which controls the final size and separates out any foreign material that may be present. From experimental results it has been proved that for proper settling 93 % of the material should consist of pieces between 30 mm and 0.5 mm in size. From the quarry 25 % of the material is under the specific size, so there is a large wastage.

Directly under the bunker is a mixing room which contains a mixing cone, 70-mm diameter water pipes and telephones. The stowing material and water is mixed together with a ratio of 1:1. As there is no mechanical device to control the proportion, it is done by an experienced man. To ensure the correctly proportioned mixture the telephone system is of great value, especially for communication between the stowing area and mixing room. This mixture is sent through 150-mm diameter special manganese steel stowing pipes to the face which is approximately 2 km from the mixing room. Following the precipitation of stowing material, water drains to the lower drainage level, then through ditches to sumps at —200-m level, from which it is pumped to a 500-cu.m capacity water reservoir at +256-m level.

Two methods, one applying to very steep, thick coal seams with flat shortwall (Fig. 10); the other to semi-steep, thick coal seams with flat shortwall (Fig. 11), are in operation.

For very steep and thick coal seams: Following panel development a shortwall is established between the roof and floor of the seam. Mining commences retreating to the central raise. Goal is won by means of hand or pneumatic picks and is transported by conveyors to the tubing which has two compartments, one for men and equipment, the other for coal transportation. The roof along the shortwall face is supported by props and bars parallel to the face. Timber support units consist of a 4-m long bar and four props of 2 m each. After the second slice has been mined out explosives are not necessarily used.

When three cuts have been completed, wire netting and jute sacks are placed on the timber set nearest to the face. The sacks, held in place by the wire - netting, help to free the water from the mixture, and so stowing material is kept in the mined-out areas. Within a shift the material has settled and formed a floor compact enough to work on.

For semi-steep and thick coal seams: Following panel development, three raises, one at the centre, the others along the limit lines, and three level drifts starting at the central raise to the boundary are driven. For the purpose of draining water away, an

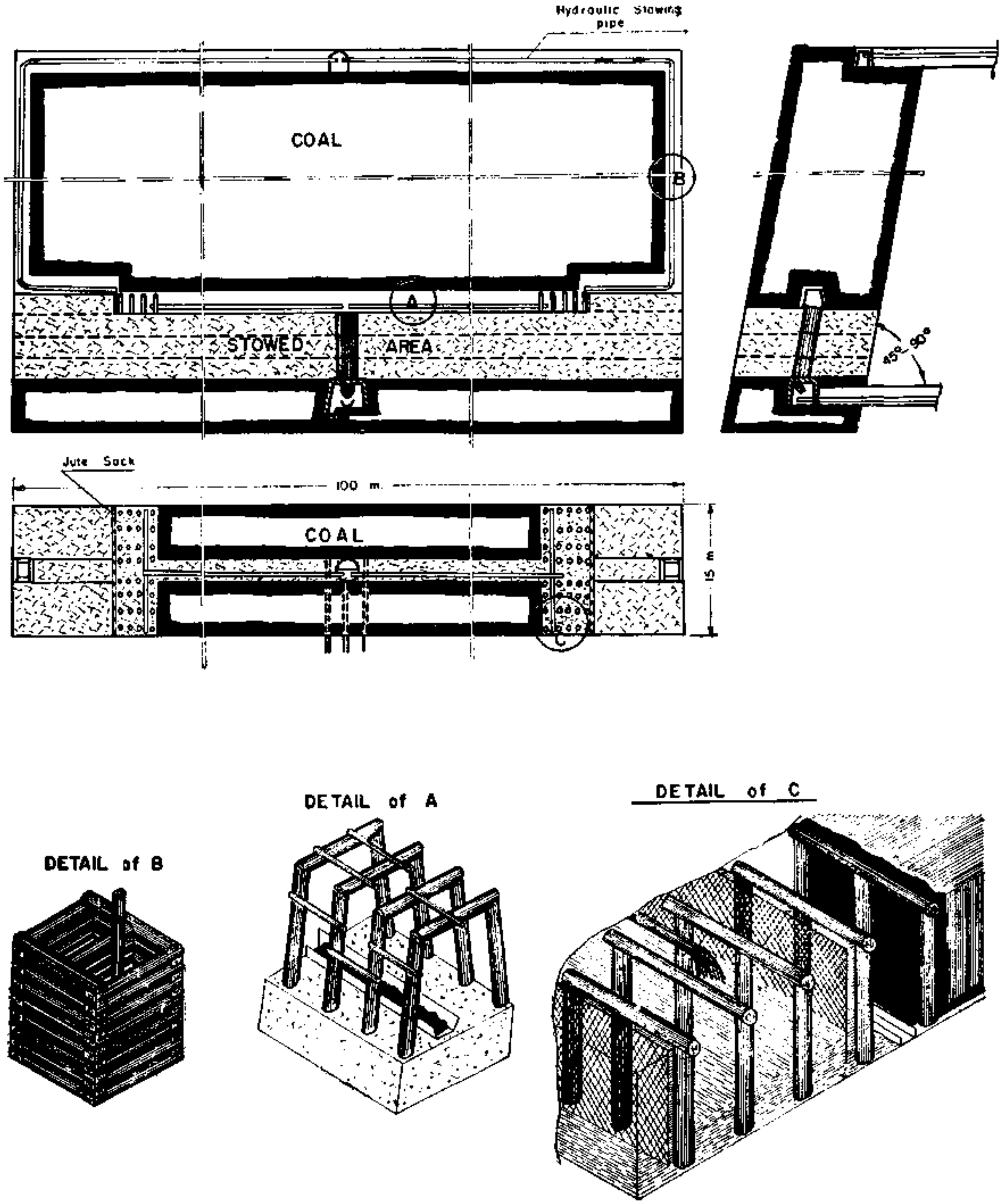

Fig. 10 - Hydraulic stowing method for very steep, thick coal seams.

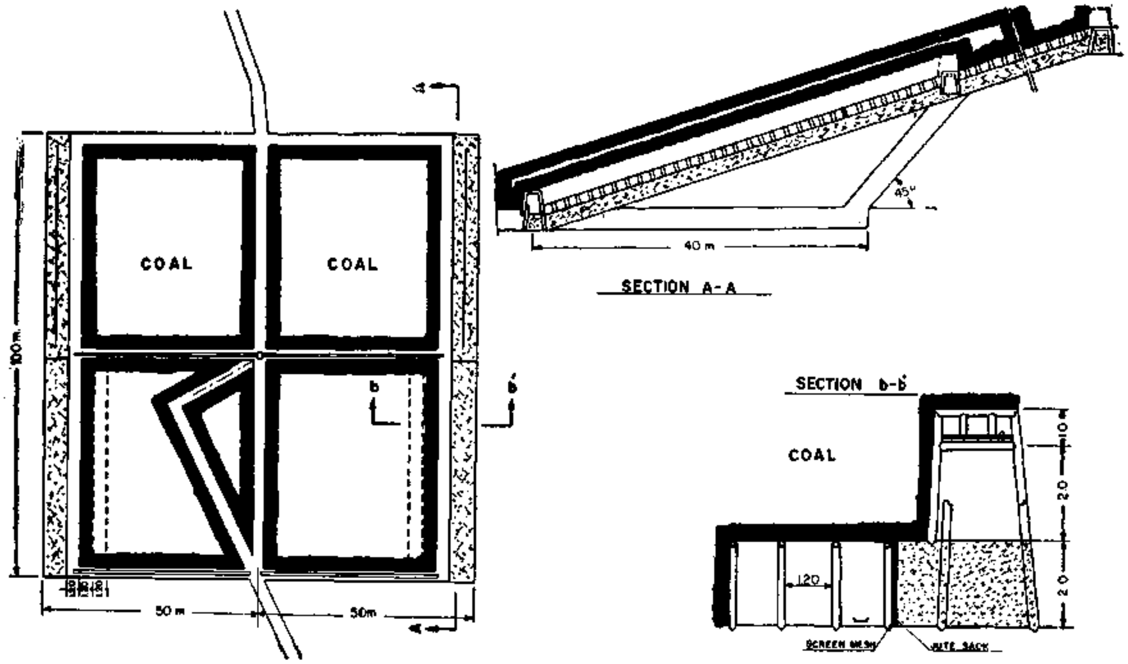

Fig. 11 - Hydraulic stowing method for semi-steep, thick coal seams.

incline is connected to the lower level by means of a drift in the rock. Stowing pipes are laid in the two outermost raises which also act as return airways.

The last stage of development is the formation of two shortwall faces, one on each side of the bottom - block. Mining operations and hydraulic stowing processes are similar to those of the first method mentioned.

As well as the existing labour allocation body there are further small crews under the supervision of the colliery engineer. One crew is responsible for the following services :

a. Preparation of stowing material,
b. Stowing of mined-out areas,
c. Cleaning water ditches and pumping water to the surface.

The normal cycle of operations for both methods is as follows:

First shift (production stage) :

— Goal getting,
— Setting timbering,
— Transportation.

Second shift (preparation stage) :

— Placing of wire-netting and jute sacks.

Third shift (stowing stage) :

— Stowing mined-out areas.

The work-cycle is irregular in that, when a coal seam of 10 to 15 m is considered, the production stage covers three shifts in which 1-m cutting advance is achieved in each shift. The mined-out area is prepared for stowing in less than one shift, while the actual stowing time can be completed within one shift including the settling of the material. The total number of miners employed, including all mining operations, is about 146 and the rate of productivity for face and underground workers is 2.927 and 1.727 tons per man-shift respectively.

The main advantages of this method over the old method are :

— Rather small dilution and higher recovery of coal, about 90 %,
— Prevention of mine fires, explosions and roof falls,
— Increase in rate of productivity,
— Reduction in consumption of timber and explosives,
— Possibility of face mechanization,
— Minimizing of subsidence.

It must be emphasized that these mining methods are still in the experimental stages and to overcome the main drawbacks, namely, to control the density of the mixture (proportion of material to water), to decrease the amount of fine particles passing into the water ditches and water sump, thus creating a problem to cleaning and pumping, and finally to train the miners adequately to run the system efficiently, more experimental time is needed and some changes and modifications may be necessary before the system works effectively.

VIII. MINE MECHANIZATION

Mechanization, as applied in England and on the Continent, is not applicable to the Zonguldak coalfield, due to: the disturbed geological conditions, natural and those caused by subsidence from old workings; variable thickness of seams with pitching from 0 to 90 degrees inclination; lack of foreign exchange; and inefficiency of experienced labour and technical management.

Prior to 1952, when metal supporting was introduced into the mines, only wooden supports of faces, gate roads and galleries were in existence. The first steel props and caps were imported from Austria during the years 1949-1954, and have been successfully established in many longwall faces. At present 2,500 props and caps in use at the productive faces and 11,000 in stock available for progressive mechanization, have been imported mainly from Germany. Steel arches for support of rock galleries and gates are manufactured in the workshops of the company. Annual consumption of steel is around 17,000 tons, from which 61,000 sets are produced.

Previously coal at the face was won by means of handpicks, with or without the use of explosives. Today, pneumatic picks are widely employed for coal breaking; this and mechanical or pneumatic stowing constitute the only form of face mechanization. Coal cutters and ploughs have been, in experimental use in the mines, but because of the disturbed strata and lack of enthusiasm to mechanization, extensive use is not foreseen in the immediate future.

Until 1950, the only means of haulage were mules, shaking conveyors and diesel locomotives. These have been slowly replaced by single or double-chain conveyors at the face; belt conveyors and 1-ton mine tubs pulled by diesel locomotives on gate roads and intermediate levels; and 5-ton mine cars pulled by battery, diesel and trolley locomotives on main haulage levels.

In order to achieve a higher, more profitable production further mechanization is necessary, especially at the face, on gate, roads and intermediate levels; where haulage is insufficient compared to the capacity of the main haulage levels, hoisting and surface installations. As Turkey manufactures no mining equipment and machinery, a modern standard of mechanization can only be achieved when the problems concerning importation are overcome.

IX. COAL PRODUCTION AND OUTPUT

Coal production began for the first time in 1848, and the earliest known recorded production of bituminous coal between 1902-1921 was estimated at roughly 600,000 tons. This figure rose to an annual 1,870,000 metric tons between the years 1923-1939. In 1940, the year of nationalization, thirty-one mines were operational with individual outputs ranging from 5 to 1500 metric tons per day. After nationalization, the production was 3,019,600 metric tons in 1941 and this has steadily increased to an annual production of 7,007,000 metric tons in 1965. Annual run-of-mine production, saleable coal, consumption and output rates are shown in Table 3.

Table - 3

Run-of-mine coal production, saleable, consumption and output rates

Year	*Run-of-mine (metric ton)*	*Saleable (metric ton)*	*Consumption (metric ton)*	*Underground output Kg/man-shift*
1925	950,000	570,000	500,000	—
1930	1,600,000	960,000	850,000	—
1935	2,340,000	1,400,000	1,250,000	—
1940	3,020,000	1,984,000	1,984,000	0.721
1945	3,718,800	2,524,000	2,149,500	0.698
1950	4,360,600	2,832,300	2,554,800	0.850
1955	5,495,700	3,500,200	3,221,400	0.970
1960	6,307,100	3,653,000	3,622,000	1.046
1961	6,382,000	3,772,600	3,459,700	1.113
1962	6,485,300	3,892,800	3,809,900	1.172
1963	6,793,500	4,153,000	4,069,900	1.245
1964	7,140,900	4,448,800	4,425,900	1.321
1965	7,007,100	4,389,600	4,231,600	1.354

In comparison with other European countries the output per man-shift underground is low, due mainly to three facts: geological nature of the coal seams, lack of extensive mechanization and shortage of sufficient skilled and technical labour. In future years, when complete mechanization is realised, increased productivity may be expected.

The distribution of annual production, planned and actual run-of-mine and saleable coal for the year of 1965, and percentage of total production for each district, can be seen in the following table (Table 4).

Table - 4

Distribution of annual production (planned and actual) to the districts for the of 1965

Districts		*Production, planned (ton)*	*Production, actual (ton)*	*Percentage of total production, actual*
Kozlu	R.o.m.	1,820,000	1,763,700	25
	Saleable	1,158,500	1,130,200	
Karadon	R.o.m.	2,765,000	2,729,100	38
	Saleable	1,285,900	1,273,100	
Üzülmez	R.o.m.	2,100,000	2,074,700	30
	Saleable	1,285,900	1,273,100	
Armutçuk	R.o.m.	437,500	439,600	7
	Saleable	318,900	316,600	
Zonguldak	R.o.m.	7,122,500	7,007,100	100
	Saleable	4,452,400	4,389,600	

X. MINING COSTS

Production costs are higher in Turkey than on the Continent, because of the employment of large numbers of workers, difficulty of application of mining systems to the folded and faulted coal seams and incomplete mechanization. The mining costs even vary in the different collieries and districts, depending on the method applied and prevailing local conditions. Longwall operations with stowing are generally more expensive in labour, as a large number of miners are required for mining operational activities.

During past years production costs have fluctuated considerably. They rose gradually until the end of 1954, then rose steeply between 1955 and 1960 because of a high increase in the wage scale. Since 1960, costs have been comparatively stable, due to face mechanization and increase in moisture content of saleable coal. The wage scale rose during these years, but did not have any drastic effect on production costs

An analysis of the cost of producing 1-ton coal mined on the basis of major subdivisions of cost, in percentage of total cost, is illustrated in Table 5. As the price of saleable coal is stipulated by the Government to lower living costs, for many years the mines have been operated at a loss.

Table - 5

Mining cost elements with percentage rates

Cost elements	*1950 (%)*	*1955 (%)*	*1960 (%)*	*1965 (%)*
Direct labour	30.8	32.4	31.1	36.5
Supplies and power	24.4	20.5	24.8	23.7
Social expenses	11.2	13.0	12.3	10.3
General expenses and fixed charges	33.6	34.1	31.8	29.5
Total:	100.0	100.0	100.0	100.0
Production cost	26.43 TL	35.20 TL	103.94 TL	118.63 TL
F.o.b. cost	28.42 TL	38.16 TL	110.74 TL	122.51 TL
Final cost (commercial)	30.44 TL	46.19 TL	132.09 TL	133.73 TL
Selling price	27.65 TL	33.52 TL	105.50 TL	118.24 TL
Operational loss per ton :	—2.79 TL	—12.67 TL	—26.59 TL	—15.49 TL

XI. INVESTMENT COSTS

In 1950 a programme to be completed within ten years was begun with the intention of increasing annual production to 7,000,000 tons of r.o.m. coal. In order to achieve this, the four districts were to be provided with the necessary underground and surface installations. It was suggested that as coal consumption would be less than the proposed increase, 750,000 tons washed coal would be available for export as a source of foreign exchange; and as at that time Europe was short of coal, it was an attractive aspect to the Organization for European Economic Cooperation (OEEC).

In order to achieve the goal of 7,000,000 tons r.o.m. coal, it was necessary to consider underground mechanization, construction of washeries and a harbour in Zonguldak, development galleries in the rock, transformer sub-stations and the opening of new shafts, etc. The programme began well, but due to problems of foreign exchange finances, delays in contracts, custom formalities and late deliveries of mine equipment, the programme fell behind schedule. Finally, so that the programme could be completed a project was submitted by EKI, to the Development Loan Fund (DLF). This stated that a loan of $14.5 million from DLF and an additional $1 million from the Export-Import Bank would be provided in order to purchase the necessary mine equipment. The financial situation during the years of the programme can be seen below.

1. Domestic investment expenses		
Prior 3.12.1957	TL	250,056,000
(Converted at TL 2.80=$1)	$	89,500,000
1.1.1958 to 31.12.1960	TL	151,280,000
(Converted at TL 9.00=$1)	$	16,800,000
1.1.1961 to 31.12.1964	TL	140,230,000
(Converted at TL 9.00=$1)	$	15,580,000
Total :	TL	541,566,000
	$	121,695,600
2. Foreign investment expenses		
Prior 1958		
European Payments Union	$	18,400,000
Other Non-USA	$	4,073,000
Direct USA Aid (Marshall Plan)	$	20,249,000
Export-Import Bank	$	1,632,000
Current Programme (1961 to 1965)		
D.L.F. Loans	$	14,500,000
Export-Import Bank	$	1,000,000
Total :	$	59,854,000
Grand total expenditure :	TL	1,633,946,400
	$	181,549,600

Now in 1966, six years behind schedule, all mine installations, equipment and machines are complete and the coalfield produces the proposed 7,000,000 tons r.o.m. coal. However, due to increased industrial expansion, consumption demands are higher than was expected and Turkey, at the moment, cannot meet its own needs, so no possibility of exportation can be foreseen.

XII. CONSUMPTION AND TRADE

During the last few years, consumption of coal for internal uses has increased considerably. The main consumers and percentage consumed, in brackets, in the year of 1965 are: iron and steel (39.8), state railways (19.6), power plants and gasworks (25.5), heating (2.3), textile and other factories (6.4), copper smelters (0.5), merchant marine (2.4), miscellaneous (3.2), and export (0.3).

The low percentage of Zonguldak coal used domestically can be explained by the fact that it has been the policy of the Turkish Government to use, wherever possible, sub-bituminous or lignite coals for this purpose. Objections have been made to this plan, but as there is not sufficient excess production to meet the domestic demand, it is necessary to do so.

Source of fuel includes not only Zonguldak coals and lignites, but also wood and manure. Turkey's per capita consumption and heat value measured in kilogram-calories is low compared with other European countries. Table 6 shows the population growth, per capita consumption of Zonguldak coals and lignites, and kilogram-calories per capita for years between 1925 and 1965.

Table - 6

Kg coal and kg calorie per capita figures

Year	*Population*	*Kg coal/capita*	*Kg calorie/capita (in thousands)*
1925	11,500,000	50	275×10^3
1930	14,250,000	70	408
1935	16,158,000	80	473
1940	17,821,000	110	662
1945	18,860,000	132	834
1950	20,000,000	150	975
1955	23,500,000	210	1320
1960	26,750,000	300	2000
1965	30,000,000	310	1900

It has been a desirable plan of Turkey to produce excess coal for export, and so help to balance imports. For a few years this was achieved and up to 200,000 tons saleable coal was exported. It was planned to export more coal to some Mediterranean countries, but because consumption has increased with the completion of new industrial plants, exportation was prevented, and at the present time demand is higher than production.

XIII. OTHER MINING OPERATIONS

1. Coal preparation plants

Before 1957, there were several washeries distributed in the coalfield dealing with coal preparation. The washeries were located as follows, with the output in tons per hour: Kozlu (2), 100 to 120; Zonguldak, 90; Üzülmez-Asma, 60; Karadon, 50; Kilimli, 70; Gelik, 100; and Kandilli (Armutçuk), 50 tph. Today, all these have been replaced by three central washeries, in Zonguldak, Çatalağzı and Armutçuk areas with the following advantages: (1) the washing capacity has doubled, (2) greater economy has been achieved through higher productivity, (3) under 0.5 mm coal can be recovered by means of flotation cells installed in the new centralized preparation plants.

The Zonguldak coal washery is located-near the harbour and has a capacity of 750 tph of- 0-100 mm coal in three parallel units. All production from the collieries of Kozlu and Üzülmez districts is transported to the washery by 50-ton standard gauge railroad cars. First, run-of-mine coal is passed through 100-mm size screens and from the over-product, slate is hand-picked and lump coal sent to bins. The 100-mmraw coal is passed through a Baum-type washbox and three end products are obtained: washed coal, middling (coal+shale) and refuse Middling is crushed to —6 mm size, then the 0.5 mm X0 mm material of the crushed middlings is cleaned by 120 tph flotation cells and the 6 mm x0.5 mm material is washed in jigs. After completion of preparation processes 0-10, 10-18, 18-50-mm and lump coal sizes are collected in separate coal bins.

Refuse and sludge are disposed by a 2,200-m belt conveyor and a pump system to the sea. Some part of the refuse disposal is sent to Kozlu district, where it is used for gravity stowing. Cleaned coal is transported to the harbour where there are loading facilities in the form of three ship loaders, each with a capacity of 500 tph, which are capable of loading three ships simultaneously.

The Çatalağzı washery has the same working characteristics as the Zonguldak washery, but differs in that it consists of two parallel units of 250 tph each and flotation cells of 90 tph capacity. Coal produced in the collieries of Karadon district is delivered to the top of the washery by means of a belt conveyor from Karadon Transfer Station. Washing and disposal process are identical to those explained for the Zonguldak washery. Similarly some refuse is sent to the collieries in Karadon as a stowage material to use in gravity and pneumatic stowing. Most of the coal cleaned at this washery is directly transported to inland consumers by rail.

The Armutçuk washery has a capacity of 200 tph, and cleans all the raw coal mined from the Armutçuk collieries. The working characteristics are dissimilar to other washeries, but the end product has the same heating properties. The refuse is transported by a belt conveyor system to the Neyren Valley, where it is disposed and washery product is transported to stock-piles at Ereğli harbour by a standard gauge railroad line.

2. Power source

For many years electrical energy was supplied from the local plant at Kozlu, with a capacity of 10,000 KVA. The power supply was insufficient for the entire coalfield and so a new coalfired plant was installed at Çatalağzı with a capacity of 120,000 KVA. This supply of energy is amply adequate for the demands of the electro-mechanization programme, present and future.

Power is transmitted to the coalfield at 66,000 volts totally, and internal power network is distributed through four transformer sub-stations, one supplying each district. High primary voltage current is transformed on the surface, first to 15,000 volts and then to 3,300, 550 and 400 volts alternating current for transmission into the mine. Alternating current is converted into direct current where trolley locomotives are in operation. Instantaneous current breakers and relay systems are used as a safetly protection of power lines and mine equipment powered by electricity, and machines are doubly protected from overloads and short circuits by fuses.

Entire electrical consumption of the mines annually was 229,490,600 and 248,336,400 KWH in 1960 and 1965 respectively. For each ton of saleable coal the cost of power consumed was 6.97 TL at a rate of 11.7 kuruş per KWH in 1965.

3. Mine organization

The General Directorate offices of Turkish Coal Enterprises (TKI), which deal with all financial, prospecting and operational aspects of coal and lignites, are in Ankara. The headquarters of the Ereğli Coal Mines (EKI) are situated in Zonguldak. A General Manager supervises the assistant general managers, who in turn control all mine operations and administration. General planning, development and production are under the management of two technical assistant managers, and the third is responsible for the administration of the company.

Each district, according to its size and production capacity, is divided into two or three collieries which are supervised by a District Manager, who is under the direction of the Production Manager. The District Manager is assisted by a Technical Assistant, who controls the chief engineers of planning, production, electro-mechanization and safety. A colliery engineer, who directs the section and production engineers, is responsible for each colliery. All mining activities and miners are under the direct supervision of mine foremen whose duties are cooperative and overlapping with the production engineers.

4. Labour force and wage-bonus system

The first labour employed in the mines were brought from Ottoman Empire possessions, such as Croatia, Montenegro and Serbia. When local villagers were trained for mine operations importation stopped. Today, the total man-power in the mines is approximately 33,600, which can be divided into three categories. Firstly, alternative workers who come from the surrounding villages and work for one month then return home for one month. Most of these are productive face-men (hewers). Secondly, semi-permanent workers who are mostly unskilled and work for transportation and development. They come from all over Turkey, most from the East and along the Black Sea coast and work for one or two years only. Lastly, the permanent workers of whom the majority are skilled workers or supervisors and who live in the locality with their families.

Percentage distribution of workers on the basis of job classification, excluding the technical and administrative body of about 1500, is as follows:

	Number of workers	Percentage of total
1. Coal-face : Hewers	3,200	9.5
2. Underground : Face workers, development haulage, etc.	16,650	49.5
3. Pit-head Workshop, lamp-houses, auxiliary installations, surface transportation, etc.	2,250	7.6
4. Coal preparation and delivery : Washeries, coal handling and loading, port operations	900	2.6
5. Production auxiliary services : Workshops, warehouses, power plant, etc.	3,350	10.0
6. Welfare services : Housing, feeding, hospitalization, etc.	4,950	14.8
7. Miscellaneous services	2,000	6.0
Total :	33,600	100.0

All employees are on a straight daily basis, except for the management and office personnel, who are on salary. Since 1941 the average wage daily has increased from 1.65 to 31.00 TL in 1965. In practice, it may be observed that productivity and wages have not increased at the same rate, this being a major cause of the sharp raise in production costs.

Since the mine was nationalized, there has been in existence a bonus-system which enables a good worker to earn a bonus, above the daily wage, according to his ability. Bonus prices are calculated on a similar basis to the normal wage, and a standard price paid for each unit of production in excess to the normal planned output, i.e., tons of coal mined at the face and hauled, meter of advance in development galleries, linear meter of timbering with different standard sizes, etc. The company specifies the size of galleries or other units of production, the number of men on the bonus crew, the quality of work, and the services that will be provided either by the company or bonus crew. Bonus is measured and paid monthly.

5. Safety and mine-rescue organization

The Safety Department, located in the headquarters at Zonguldak, acts as a planning and advisory institution; coordinates the accident-prevention programme, organizes the mine-rescue programme and periodically inspects the mines. Primary responsibility for safe mining operations in the mines falls upon the colliery safety engineer and foreman, who are under the direction of the district chief safety engineer.

The colliery safety engineer investigates working conditions and prepares recommendational reports on accidents in the mine, while the safety foreman in charge is responsible for maintaining a safe operation. At least once during the day the foreman is obliged to check all danger spots and gassy areas, so fulfilling the recommendations of the Safety Department. When serious conditions arise in the mines, safety meetings are held for the supervisors in order to discuss safety problems, interchange ideas and to make recommendations.

During the last decade mine-rescue and first-aid stations have been built throughout the coalfield. A mine-rescue team of 10 men at each district is trained for first-aid, mine-rescue and fire prevention and suppression, in accordance with the Mine Safety Regulations. In attempts to prevent accidents and increase the efficiency of the workers, a Man-Power Training Department was established recently to train all employees.

Accident statistics of mining operations indicate that the coal industry is one of the most dangerous of all the occupations in Turkey. This rate unfortunately is higher than in European countries. The principal causes of fatal accidents underground and percentage occurrence (in brackets) during the year 1965 are: falls of roof and coal (55.9), mine haulage (17.7), suffocation by gases and explosions (17.7), electricity and machinery (1.5), explosives (2.9) and all other causes in the mines (4.3).

Current data on number of injuries (fatal and non-fatal), frequency and severity rates, related employment and production data, during years 1960 to 1965, are illustrated in Table 7.

The coal industry of Turkey showed an overall injury frequency rate of 112.60 per million man-hours in 1965, 4 % more than in 1964, and 33 % higher than the

Table - 7

Statistics on injuries

Number of injuries	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*
Fatal	94	69	70	60	66	75
Non-fatal	8028	8278	8506	8307	8578	8768
Total injuries :	8122	8347	8576	8367	8644	8843
Injury Rotes						
Frequency per million Man-hours						
Fatal	0.97	0.78	0.84	0.74	0.83	0.95
Non-fatal	83.26	94.16	102.01	103.00	107.47	111.65
Total :	84.23	94.94	102.85	103.74	108.30	112.60
Frequency per million Tons						
Fatal	14.90	10.81	10.79	8.70	9.24	10.70
Non-fatal	1272.85	1295.51	1311.58	1222.79	1201.25	1251.30
Severity per million Man-hours Total injuries :	8852	7613	8334	7732	8323	9531
Man working daily	37977	34633	32713	31625	31264	32510
Man-hours worked	96 425 128	87 911 080	83 383 056	80 647 536	79 819 808	78 534 216
Actual days lost for Total injuries :	853 491	669 154	694 663	623 620	664 349	748 127
Production annually	6 307 100	6 382 000	6 485 300	6 793 500	7 140 900	7 007 100

low record of 84.23 in 1960. The severity rate of all injuries was 9531 per million man-hours for the year 1965, 14 % higher than in 1964. Relative severity of accidents are generally difficult to calculate, as only after compensation is awarded can the status of the severity be ascertained.

XIV. FUTURE EXPANSION PROGRAMME

By 1947, a development programme had been planned and divided into two consecutive periods of five years each. The aim of the programme was to increase production to 5,040,000 tons r.o.m. coal with an estimation of , 3,700,000 tons of cleaned, marketable coal by 1952, the first stage of development; and 7,000,000 tons r.o.m. coal with an expectation of 5,100,000 tons cleaned, marketable coal during the second stage, due to end in 1958. The target was not achieved until 1965, due mainly to delay in financing and foreign exchange.

A further development programme is now underway to increase annual production to 10,000,000 tons r.o.m. coal or 6,000,000 tons saleable coal by 1972. The principal components of the project are :

1. Opening up and development of a new colliery in Alacaağzı, near Armutçuk, with a planned production of 1500 tons/day, and driving underground rock galleries to connect with the main shaft in Armutçuk.

2. Extensive development of the Amasra colliery, in the northeast, with an estimated production of 2000 tons/day, or 430,000 tons saleable coal annually; sinking a shaft and constructing necessary installations on the surface and underground.

3. Extensive development of undersea coal seams in Kozlu district.

4. Driving rock galleries for —425-m level development in Kozlu district.

5. Sinking a —300-m shaft to centralize Asma-Dilaver collieries in Üzülmez District.

6. Extension of Çatalağzı washery for 750 tons/hour capacity.

7. Completion of Çatalağzı Koepe-skip winding installations to centralize Gelik-Karadon-Kilimli collieries, and driving main haulage level rock galleries at —360 m.

8. Completion of Armutçuk Koepe-cage winding installations.

XV. CONCLUSIONS

In Turkey's industrial development and growth, coal as a source of heat and power, is assuming command over other fuels. It is anticipated that state railways, power plants and some domestic consumers of coal will change over to fuel oil, but even then demand for Zonguldak coal will be insufficient to meet the requirements of the other users, especially the metallurgical industry which is expected to be the main consumer in the near future. Therefore, it may safely be predicted that coal will play an increasingly important role in the economic progress of the country.

To meet the industrial requirements, coal reserves appear to be adequate to allow increased production, and in the author's opinion special attention should be paid to this end. It is a recognized fact that inefficiency of underground mechanization and inadequate working methods are the main defects of the Turkish coal industry. Basic problems and personal suggestions for their possible solution are summarized below:

Labour

Insufficient, migratory and unskilled labour supply affects the rate of productivity. To encourage a more permanent and skilled labour force, working and living conditions must be improved and an adequate section of miners should receive training.

Engineering

Up to the present time, all engineering services have been supplied by foreign consultant firms and their engineers. Extensive training of technical staff is needed to enlighten their knowledge to the modern techniques in mining.

Administrative organization

The administrative body is too large with little or no coordination between the various departments. It is necessary to simplify and reorganize the General and District Managements.

Geological data

Lack of complete geological information of the area hinders extensive development. Deep-drilling geological exploration in the east and south of the coalfield must be expedited.

Face mechanization

Men are still the main force of power at the face to win the coal. In order to establish a modern mechanized coalface, proper equipment and machinery should be provided and to do this the necessary foreign exchange allocations should be secured.

Face and intermediate level transportation

The capacity of the coal-handling system between the face and main haulage is insufficient and uneconomic. This should be improved by reorganization of the system and replacing the present mode of transportation by high capacity mine cars or belt conveyors.

Complete reorganization

The opening of new collieries with small uneconomic reserves and poor heating characteristics of coal will prove to be less beneficial than the complete reorganization by mechanization of mines already in operation.

Safety

The accident rate is exceptionally high for fatal and non-fatal incidents. To maintain safer working conditions, some serious measures should be taken into consideration.

Research department

In the near future it is imperative that coal and lignite resources are used to the full advantage. To do this, a technical organization should be set up to determine the correct beneficiation and utilization of the coal.

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