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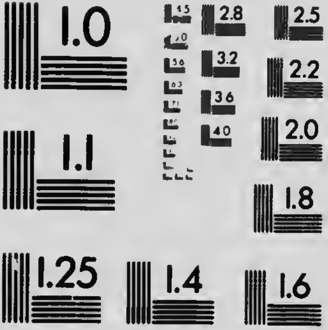

CANADA

DEPARTMENT OF MINES

HON. ES. L. PATENAUDE, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

MINES BRANCH

EUGENE HAANEL, PH.D., DIRECTOR.

BULLETIN No. 15

The Mining of Thin-Coal Seams as Applied to the Eastern Coal-Fields of Canada

BY

J. F. Kellock Brown.

OTTAWA
GOVERNMENT PRINTING BUREAU
1917

No. 432

PLATE I

Entrance to one of the thinnest seams mined in Canada, 13½ to 16 inches.

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No. 432

LETTER OF TRANSMITTAL.

EUGENE HAANEL, Esq., Ph.D.,
Director Mines Branch,
Department of Mines,
Ottawa.

SIR,—

I herewith submit a bulletin dealing with the subject of "The Thin-Coals of Canada," in the hope that this attempt to outline the problems involved in the mining of these coals, may prove of interest not only to the mining profession, but to all those who have at heart the economic development of the coal resources and ndustry of the Maritime Provinces.

I have the honour to be,
Sir,
Your obedient servant,
(*Signed*) **J. F. Kellock Brown.**

Sydney, N.S.,
April 18, 1916.

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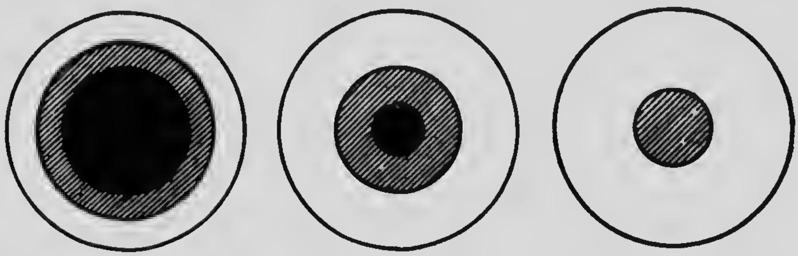
THE MINING OF THIN-COAL SEAMS AS APPLIED TO THE EASTERN COAL-FIELDS OF CANADA.

THE MINING OF THIN-COAL SEAMS AS APPLIED TO THE EASTERN COAL-FIELDS OF CANADA.[1]

INTRODUCTORY.

Popularly, the expression "coal resources of a country" is conceived to mean the total tonnage the land contains, usually stated in billions of tons, and commonly assumed to be inexhaustible. But this conception leaves out of calculation two essentials, namely, competition and cost.

A country's coal production generally passes through three stages: (1) From the commencement of coal mining operations, to the time of reaching the maximum output: a productive period which provides the cheapest coal, with the maximum of profit; (2) An intermediate period, during which the ratio between mining cost and selling price approaches unity, since the cost of production continually rises, and competition steadily encroaches on the markets hitherto supplied; and (3) The period, wherein it becomes cheaper to import coal than to mine it.



Period No. 1. Period No. 2. Period No. 3.

Black inner ring—market controlled by production of country.
Shaded ring—competitive area.
White outer ring—market controlled by outside competition.

Fig. 1. Diagrammatic representation of commercial periods.

A country's coal reserves are, therefore, more properly described as the total tonnage which can be profitably extracted. This definition is of great importance to the Maritime Provinces.

Naturally, in any estimate of total tonnage, the thin-coals have their place; and their use and abuse is a commercial problem productive of much controversy: generally based on the theory of holding intact the greatest possible acreage for future demand. To ensure the continuous, industrial life of Nova Scotia and New Brunswick as coal producing provinces, the conservation of their thin-coal seams is essential, since their greatest, and

[1] In the preparation of this bulletin, I received kindly help from Mr. C. W. Dean of Adamsville, N.B., operating what is, perhaps, the thinnest coal seam mined in Canada; Mr. J. S. Barton of River Hebert, N.S., mining one of the thinnest inclined coals; and from Mr. J. W. McLeod, Director Greenwood Coal Co., Ltd., Thorburn, N.S. Acknowledgment is also due to Mr. Nigel MacFarlane, Mining Engineer, and to Mr. Mark Hurll, both of Glasgow, Scotland, from whom much useful data on thin-coals was obtained. In addition, I am indebted to Mr. D. B. Dowling, of the Geological Survey, Ottawa, for valuable criticism.

most formidable competitor possesses reserves which will outlast those of eastern Canada, by very many years—even allowing for differences in consumption and production. In other words, the Maritime Provinces may have reached period No. 3, before their competitor begins to show signs of exhaustion; and consequently, if it is desirable that the coal industry be maintained and upheld for as long a period as possible, the preservation of the thin-coals must necessarily be considered.

The problem of how to make the best of the thin-coals, even from this viewpoint, is not a conservation project that can be left to solve itself more or less generally along lines that will develop as the years go by. On the contrary, since so large a proportion of the available areas are undersea coals, or seams occurring at great depth—areas that can only be entered at relatively few places in relation to the size of the workable territory, and tonnage to be extracted—a definite policy must needs be arrived at in regard to the development of every one of the seams in such areas. Moreover, before the one and only means of entrance to these coals, undersea, becomes disturbed, and perhaps destroyed, the development of the thin-coal seams will require to be adjusted in proper place and sequence. The gathering of information for the preparation of properly co-ordinated plans for economically developing the thin-coals of the Maritime Provinces, will, probably, take from ten to twenty years.

While, however, consideration along the lines indicated is inevitable, there is yet another channel through the medium of which the thin-coals may prove to be an important contributory factor in the material progress of the eastern provinces. The thin-coals can, under certain conditions, be looked upon as a means to the preservation of the thicker and more profitable coal seams.

A plea for projected efficiency and conservation, on the lines outlined above, could not be lightly dismissed in any country which depends largely on its coal industry, and in which the continuous operation of a comparatively small or moderate supply of thick coal seams, producing cheaply as a condition of holding the markets, is essential to the welfare of the country. These conditions exist in Nova Scotia. It is proposed to consider the economic utilization of thin-coals, along the following lines:—

I. The present workability of thin-coals, in order that a considerable portion of the thicker and better coals may be conserved.

II. The preservation of the thin-coal seams, with a view to maintaining the tonnage of the general coal resources as far into the future as possible.

LIMIT OF WORKABLE THICKNESS.

The determination of the present lowest workable thickness in any seam is deduced from a simple comparison of the cost of operation and the value of the product in any particular district. From tha e—whatever it may be—there is deducted a few inches for future imp ment in methods, and the limit of thickness is thus reached. In the extreme cases of the "Torbanite" mineral in Scotland, and the "Albertite" mineral in New Brunswick—both occurring in the same geological system as coal—the former was valuable enough to make extraction profitable down to a thickness of 4 inches. With coal seams, however, the value is fairly well established, within reasonable and calculable limits not subject to fluctuation that in turn would cause the limit of workable thickness to vary from time to time. The local cost of working is, therefore, the proper standard of measurement.

Taking hand operation at its best, the actual height in which a man, for physical reasons, can mine coal, must be in the neighbourhood of 18 inches, and he can only do so where the means to take his coal away are close at hand. This physical limit may become a few inches lower under special circumstances, as in some machine sections cutting 16 inches. Below this, the coal has, generally, to be worked in conjunction with a foreign stratum, either above or below, or in the seam, which thus allows the needed height. With thin-coals the percentage of round coal recovered in hand mining becomes an important item; and in addition, breakage occurs in the course of casting the coal to the roadhead. Where the coal has to be sold as lump coal, or screened coal, these conditions might cause failure of a seam of small thickness; on the other hand, a coking coal of this height would, probably, be a profitable operation. With pillar methods, wherever stone above the coal is most commonly taken down, the breakage is not so severe.

The British Royal Commission on Coal Supplies adopted 12 inches as the lowest possible workable thickness, and based their calculations of available tonnage on that limit. It is interesting to note that the first Royal Commission adopted a somewhat higher figure, and that the second Commission, some years later, demonstrated the existence of greater coal resources, consequent upon the adoption of a lower thickness limit, due to the improvements in mining methods (greater introduction of underground machinery) that had taken place in the interval.

The following are usually the conditions that limit thickness, as well as being the factors which govern success in any operation:—

(a) Cost of mining.
(b) Price obtained for the fuel.
(c) The class of fuel mined—almost synonymous with (b).
(d) The method of mining.
(e) The class of roof and pavement.

It is necessary to emphasize the fact that, there are operators who cannot make a 6-foot seam pay, while others have made a success of 18 inches. Consequently, if a company in a district is so burdened and managed that a 3-foot coal does not produce economic returns, the cost of mining need not, in this case, fix the possible lowest thickness at 3 feet. By "cost of mining" is meant, the cost under the greatest attainable economy of management, with capital, and capital charges, in proper proportion.

The sanest method of arriving at a reasonable understanding of this question of lowest workable thickness would be through the delineation of a curve of costs, plotted for different thicknesses. This has been done, and every care has been taken to see that the conditions which determine the

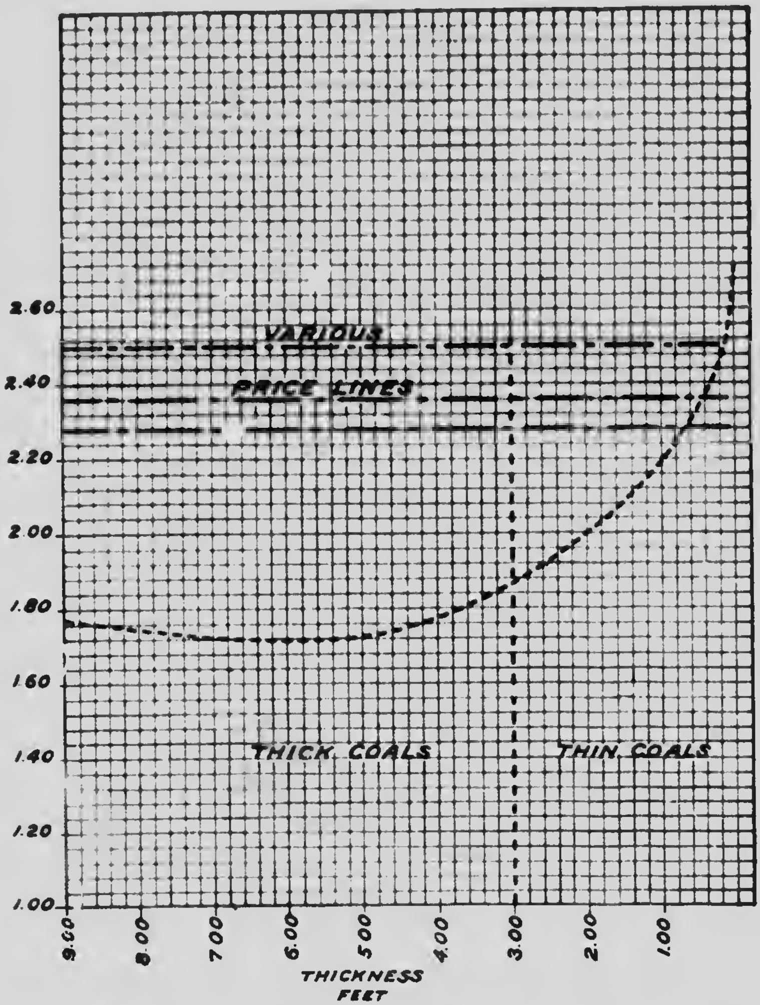


Fig. 2. Curve showing rise in costs due to decrease in thickness.

figures given, are, in each case, approximately the same. That is to say, one item given does not omit capital charges, another royalty, another management and so on: the results are in equitable proportion The line representing the change from thick to thin-coals crosses the cost curve at 3 feet.

It is evident from this diagram that there would be a difference in the present limit of workable thickness between New Brunswick and Nova Scotia, owing to the difference in value of the coal; which serves to illustrate the bearing which the price of the product has on the point below which profit disappears. It requires no great reasoning to perceive that both provinces could go as low as 12 inches, and still show a few cents to the good. Eight cents may appear "a drop in the bucket" to some concerns, but even allowing reasonable capital depreciation and interest charges, it should, on a reasonably capitalized operation designed for the purpose, be capable of producing 7% on the investment. This is, of course, low, but it is at least equal, as regards profits, to some existing operating companies. Twelve inches can, therefore, without stretching the possibilities to inconceivable limits, be accepted as the lowest thickness, which, if not at present mined in eastern Canada, will, and could be, reached in the future.

THE THIN-COALS OF EASTERN CANADA.

In the search for information bearing on either the whole or some part of the above subject, it was found that the useable knowledge which should be public property is not openly available in any place in the Maritime Provinces. In making this general statement, however, it is with the reservation that invaluable data does exist, hidden in individual notebooks and private drill records, in maps, notes, reports, men's memories, and vague recollections of work conducted years ago. Much information which mainly deals with the character, quality, and thicknesses of various seams in numerous coal-fields is perishable, and once lost, it means considerable expenditure to again acquire it. And yet this is knowledge which must, in the nature of things, have a very direct and pertinent bearing on the whole question of preservation and future operation of the eastern Canadian coal-fields: valuable knowledge that should, without doubt, be public property, and as such, should be filed in Government records.

It is obvious that there can be no efficient conservation, i.e., "keeping or protecting from loss or injury," without a practical knowledge of past results, based on information collected, analysed and applied: information gathered bit by bit, over many years, and from numerous sources. Technical data dealing with present operations can be acquired cheaply, but reliable particulars of past performances become, like old editions, yearly more difficult of acquisition.

Further, it should not be forgotten that, the period during which the required technical data is obtainable will not last forever. The formation of the coal-fields precludes this; for practical knowledge can only be gained through the land areas. It is impossible to drill and work and experiment in the undersea areas, or in the deep coals; and yet it is on the knowledge acquired and thought over during the period of working the easy and more accessible seams, that such important questions as (1) precedence in working the various seams in the undersea areas; (2) the amount of subsidence that certain seams will produce; and (3) the effect of the overlying strata in arresting such movements, can be settled. In many cases, it takes years to procure this necessary data. Experiments on subsidence questions have been known to extend over fifteen years; and yet year after year is allowed to pass by, without any serious thought being given to securing the available data, so easy to collect now, but which will be so difficult to gather and compile at later stages of coal production.

The inquiries should be governmental in their scope, and, for many reasons, not left to the individual tastes and efforts of any operating company. A commercial organization is, very naturally, mainly concerned with attaining the greatest tonnage results for its shareholders; whereas a government authority is responsible to the community for the preservation of its coal areas.

Modern industrial history is replete with striking instances of the folly of neglecting the necessary precautions already pointed out. Other coal producing countries also started out guided by empirical experience and observation rather than scientific knowledge, and with little regard for future ways and means. Generalizing from limited facts, they imagined that they possessed unlimited resources, but ere long, passed through a startling and disturbing experience. They realized, when almost too late, that had certain unappreciated discoveries and facts been carefully noted at the time of their occurrence, much useless expense, trouble, and waste would have been prevented.

A typical instance is the case of the Lanarkshire coal-field, in Scotland. In the decade beginning 1870, this coal-field was popularly considered to be inexhaustible. It covered an area of 500 square miles, and contained an average of over 34 feet of coal. One of the seams was 6 feet thick, standard in quality, and known as the "Ell" coal; the other, the "Splint" coal, influenced the design of the Scottish blast furnaces, since this coal was used direct, in the furnaces, for reducing the iron ore. At the present time—36 years later—these thick seams are exhausted, and the average thickness now being worked is under 36 inches.

It was somewhere between 1895 and 1905 that coal operators suddenly perceived that the time had come to work some of the thinner seams, or otherwise consider the advisability of abandoning certain areas altogether. It was when facing this economic crisis that a startling discovery was made, namely, that certain old, hitherto disregarded, and dust-covered drill records, were of unsuspected value and importance. A regular scramble for their acquisition ensued, because they contained much data on the thicknesses and relative positions of the thinner coals. The writer well remembers being employed for months in the search for information on thin seams: comparing and examining drill records, and determining their supposed, or known, position on geological sheets; and can recall the elation with which the discovery of a 26-inch, 18-inch, or even smaller seam was hailed.

This experience in older coal countries—well within the memory of practical mining men—should be an object lesson to the coal producing provinces of eastern Canada, and should lead to the inauguration of a policy that will lead to the systematic collection of every available scrap of technical data bearing on the preservation of coal. Those responsible for the execution of this important duty of collecting, classifying, and determining the relative values of the facts and data gathered together, should be men with wide practical experience in coal mining; have actual acquaintance with research work of a like character; and be capable of co-ordinating and presenting the information gleaned, in a comprehensive and attractive form.

In compiling the following paragraphic remarks on the occurrences of coals less than, or of 3 feet thickness, every available publication has been examined, and extracts made from a number of private records, which were kindly placed at my disposal; and even yet the list cannot be considered as complete. No seam has been specified on mere hearsay evidence; and in most of the cases, both the position and authority have been given. In this compilation, some cases of overlap will doubtless be found: the same seams being noted twice; but this could easily occur, where, as in many cases, coal areas have been examined by a number of mining men, and seams named and re-named by different investigators.

NOVA SCOTIA.

CAPE BRETON COUNTY.

Sydney Coal-Field.—

Beyond the mere statement that thin-coals exist, there is very little available information on the thickness, position, and quality of such seams in the Sydney area. The general geological section[1] forms the most complete summation of the number of thin-coals in the district. This is divided into nine sub-sections, commencing at Boularderie, and terminating at Mira Bay. In the first—Boularderie—there are ten coals under 3 feet in thickness, intermixed with the better known seams. Sydney Mines section, the next in order, yields nine coals, all under this thickness. With the exception of the Glace Bay section, the Victoria district—the next going eastward—gives the least, showing only five seams, all under 3 feet; but three of these border on 2′–6″, and over. Lingan shows eight coals, and Bridgeport, nine; Table Head, thirteen; and Glace Bay, five—with these five just over one foot; Long Beach, four; Mill Brook, five; and Mira Bay, five.

It is extremely probable that there are other coals within the actual Coal Measures that are worth recording, as well as a number outside the coal strata proper. An example of this is the 15-inch coal three miles upstream from Sydney River bridge, whose position does not seem to be marked on the geological sheets. From the state of the opening, it is probable that the coal was found after the geological survey was made. The

[1] See geological sections, commencing page 102.

Sydney Mines section shows, as stated, nine coals under 3 feet; but only one of which, and that the lower, just reaches 2 feet; the others are less. Borehole No. 2, Drill No. 5, at Cashans Brook bridge, Sydney Mines, shows two coals 2′–6″ and 2′–9″ thick, respectively. It is manifest therefore, that there are a number of gaps, inconsistencies and discrepancies, that need immediate adjustment, before they are hidden in greater mystery.

Glengarry.—

On page 44, of Memoir No. 59, "Coal-fields and Coal Resources of Canada"—based, presumably, on data gathered by Hugh Fletcher, the coal discoveries at Salmon river, Loch Lomond, Cape Breton, N.S., are said to consist of an exposure showing 36 inches of coal, with stone parting, varying from a few inches to four feet; and one other occurrence of 18 inches. Both are marked on the geological map dated 1877-1884.

Since 1887, further work in this area has been carried on, and with interesting results. The outcrops of two coal beds, with indications of possibly a third, have been opened up 3 miles to the northeastward of the Salmon river, with an outcrop towards the other side of the basin, dipping almost southeast. The first is 2′–10″, clean coal, of exceptional quality, and proved so far, to be consistent, by means of a borehole almost 700 feet to the dip, which gives a thickness of 3 feet. The lower coal is badly upturned and broken against the Pre-Cambrian strata, and may possibly represent Mr. Fletcher's 36 inches of coal—but on the other side of this isolated basin. Between these two beds there are indications of a third seam—in all likelihood, a dirty coal; while above the first mentioned, is a fourth, but erratic bed, of much poorer quality. The last two are of little value.

Between the first and third seams there is, approximately, 1,500 feet of unknown and unproved strata. This implies that the lowest known seam will probably exist in the centre of the basin at a considerable depth—probably 2,000 to 3,000 feet at the deepest point. At one point there is an inlier of Lower Carboniferous strata that cuts up the area, and there may be others; but present indications point to fair regularity, although the district cannot be considered as proved.

Taking the best known seam, and carefully mapping its possible square area of 4 miles, this would give 11,000,000 tons, and the lower one at 9 square miles, another 17,000,000 tons: a total of 28,000,000 to add to the coal resources of this district.

River Inhabitants.—

The River Inhabitants upper area contains one coal 18 inches thick. This was passed through a drillhole (Drill No. 1, Hole No. 2), in the year 1902, but is also recorded in a much earlier section.

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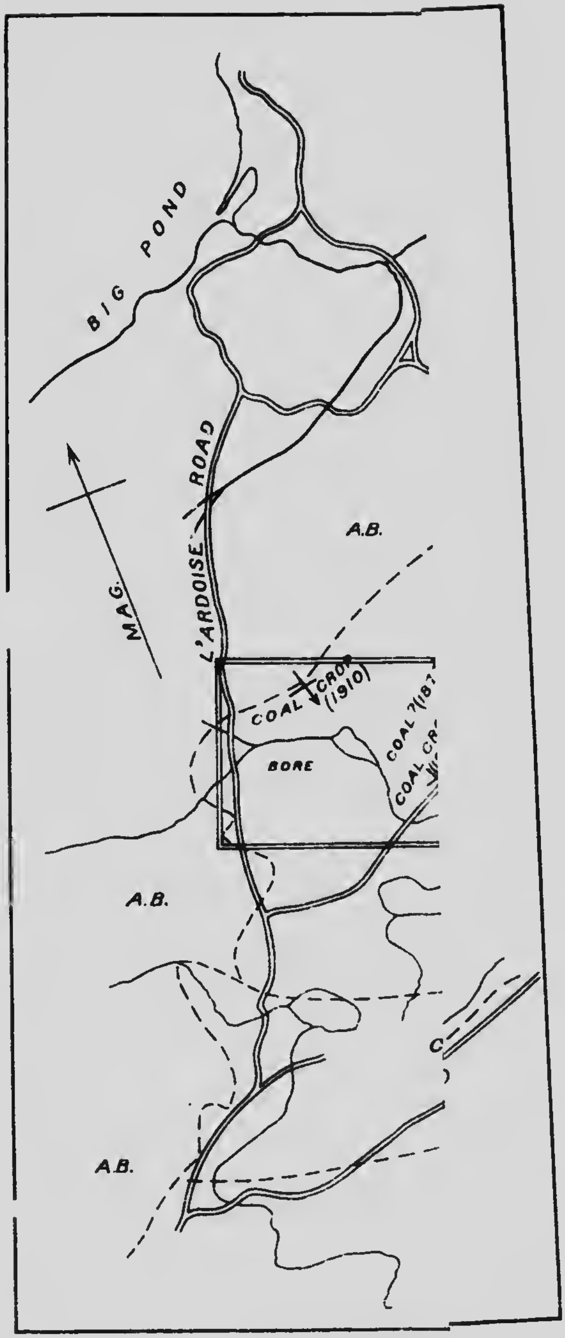

Fig. 3. Glengarry d
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AB = Pre-Ca
C_1 = Coal M
C_2 = Lower (

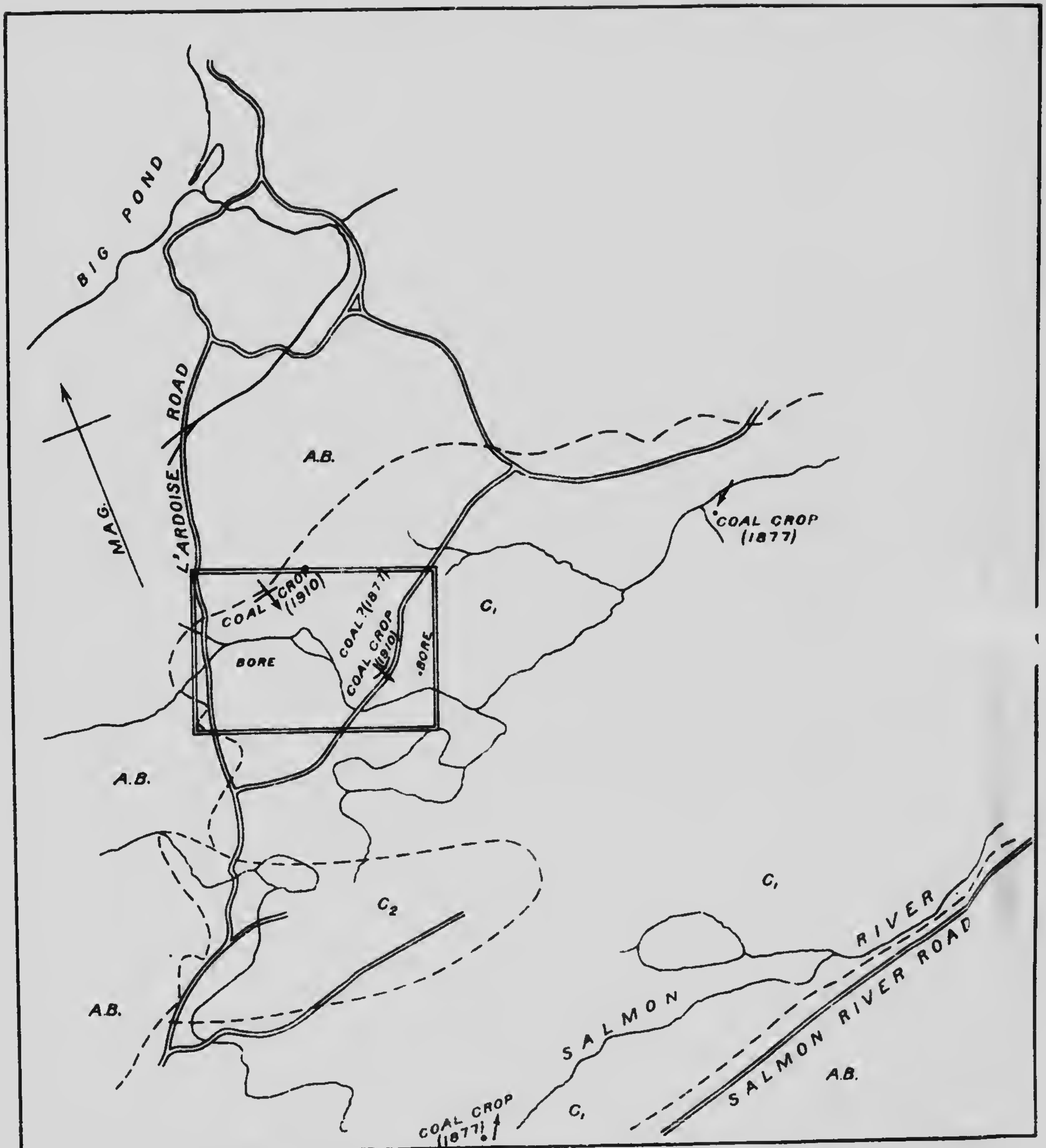
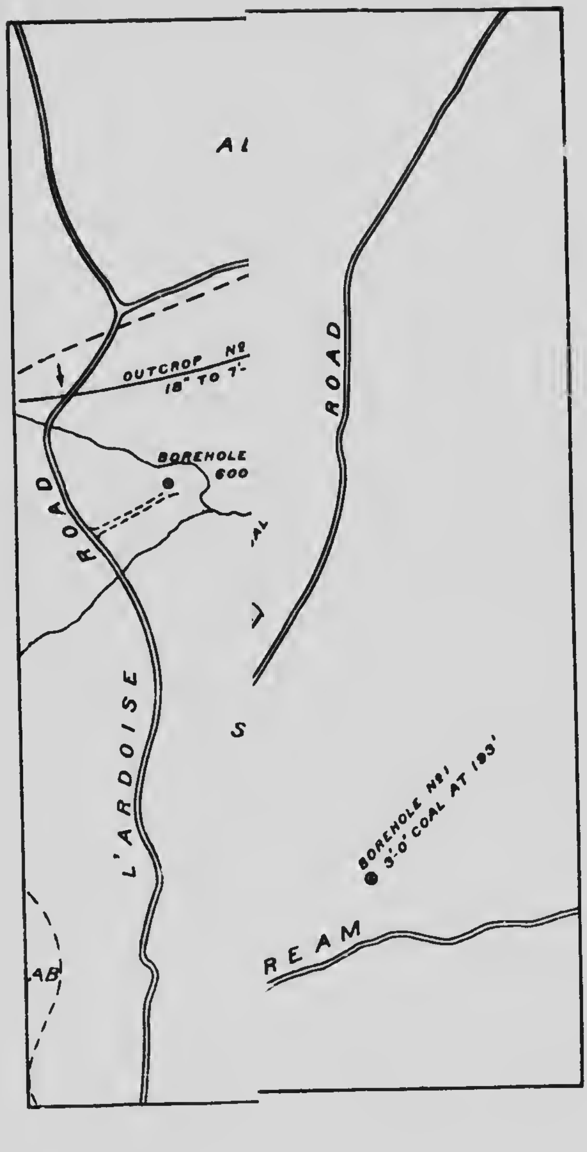


Fig. 3. Glengarry district, Cape Breton county--one inch map. Part within square is enlarged on map Fig. 4 to show advantages of plotting details.

AB = Pre-Cambrian.
C_1 = Coal Measures.
C_2 = Lower Carboniferous.


AL
OUTCROP No
18" TO 7'
BOREHOLE
600
ROAD
ROAD
L'ARDOISE
S
BOREHOLE No 1
3'-0" COAL AT 193'
REAM
AB

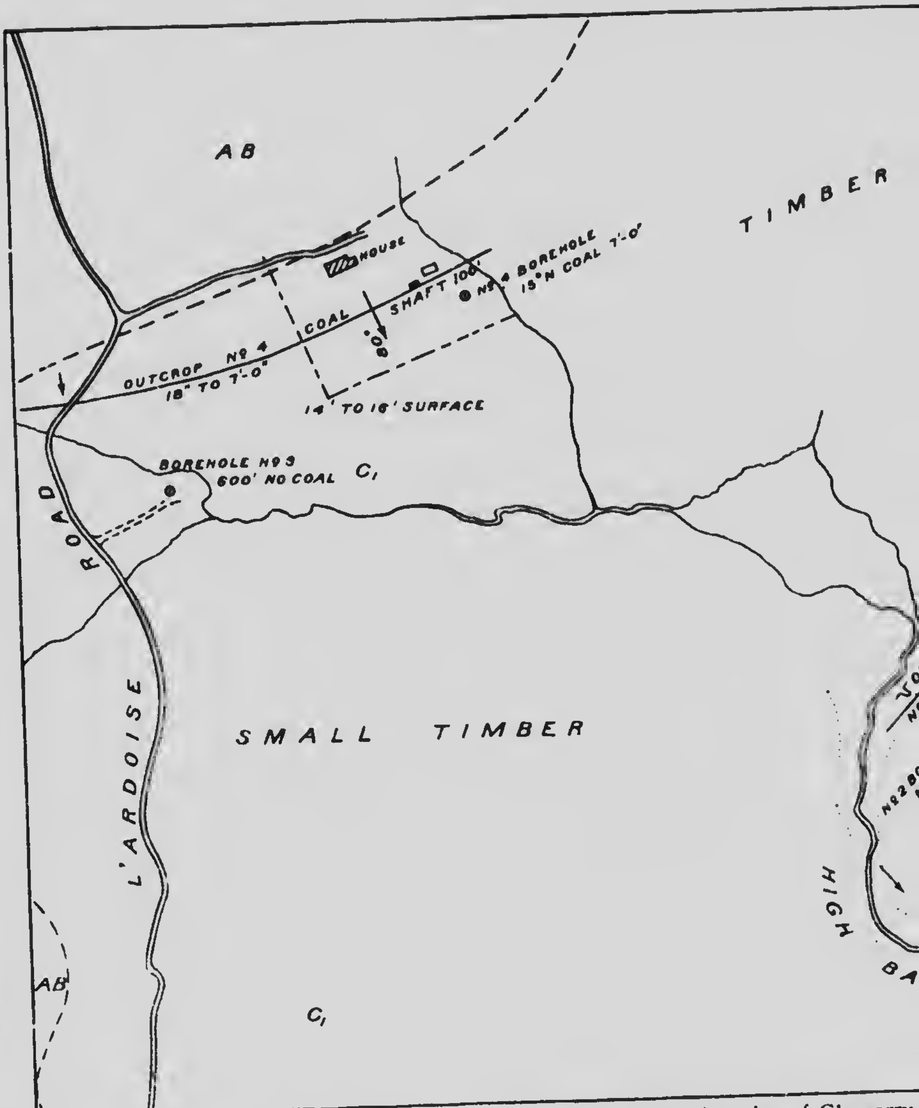


Fig 4. Enlargement of portion of Glengarry
one mile, approximately: showing advan
map, Fig. 3.)
AB = Pre-Cambrian.
C_1 = Coal Measures.

Glengarry district, to a scale of 6 inches to
ving advantages of larger scale. (See 1 inch

Inverness.—

This coal-field is generally represented as having four seams: varying from 3 feet upwards. There are apparently two coals, each 3 feet thick. The Government drills of 1913, show a somewhat different record, for in Drillhole No. 2, two seams of coal were found: the first 13 inches, and the second 39 inches. The other bores, put down at the same time, showed coal of 2′–8″; 2′–2″; and 1′–1″. It is assumed that these seams belong to a lower group where a seam, 2′–6″, is currently reported as existing.

Chimney Corner.—

The coal-field in this district, is in the nature of a mystery of years ago. The only section available is many years old, and shows three thin-coals: one, 18 inches, and the two lower seams, each 3 feet thick.

Port Hood.—

The most reliable records of the coal seams in the Port Hood district are derived from the drilling done in this field during the years 1907 and 1908. From the drill records plotted, it appears that the thick coals of the area were not touched, so that the coals found are evidently exclusive of those known and considered as the main seams. There is a remarkable array of thin seams ranging from 1′–2″ to 3 feet, in all seventeen seams, giving an aggregate of about 32 feet of coal. Without accurate sections, and the exact positions of the boreholes, on a large scale plan, it is impossible to tell how many of these coals have been passed through twice; but making a guess it may be correct to assume that, the 2′–8″ coal in bore No. 6, is the same as the one of similar thickness in No. 1, also the same thickness as that in No. 4, and that recorded as 3-foot coal, in No. 2. To take the 2′–6″ coal in No. 2 as corresponding to the 2–′8″ in No. 4, would probably be placing too great a depth of strata below this seam containing workable, but thin-coals. Elsewhere it is stated that Port Hood contains one coal of 6 to 7 feet, and another thin one of 20 inches. There is a material difference in this case between old records and more modern drilling; hence the question is forced upon us, will or will not there be as great a difference in other fields, if the records are re-examined in the light of present knowledge—where any has been acquired.

Mabou.—

From one source it is stated that there are only two coal seams in this area; while at the same time there is a graphic section in existence which shows four thick coals. Mr. Fletcher's researches disclosed at least two thin-coals, approximately 18 inches thick, on Coal Mine point and on Finlay point, respectively, and it is very probable that there are others.

PICTOU COUNTY.

The Pictou coal-field is generally looked upon as the "star" area in eastern Canada, with regard to thick seams of coal, and naturally from the standpoint of tonnage output, the thin-coals are viewed as of relatively less importance than in any other district. The graphic section shown on page 121 is taken from the Mining Record of March 22, 1916, and includes the recent discoveries of Mr. Notebaert in that field. There is, as will be seen, one or two thin-coals, but they are intermixed with thick coals, meaning thereby, coals that are so above the average thickness that the workability of such thin-coals is almost out of reason.

CUMBERLAND COUNTY.

Springhill.—

According to the section published in the government report on the Mining and Metallurgical Industries of Canada, 1907-8, p. 560, this area contains—after the first three thick coals—a lower series of thin-coals, actually showing, in all, ten seams over one foot thick. The thickness of the strata between many of these seams is very little, and the task of operating them in the future is going to be something of a problem.

Joggins Area.—

This area is the "star" area of thin-coals in Nova Scotia, just as the New Glasgow field is the "star" area of the thick coals. Geological records show that there is some connexion between this area and the Springhill district; and it is possible that some of the lower coals shown in the Springhill section are the counterpart of those known in the Joggins area. As usual, however, there is very little known about the seams and their relationship to each other, beyond a few local results added to information that has come down from surmises made years ago.

Saltsprings.—

A most interesting graphic section is that given by Dr. Gilpin, and taken from a hitherto unpublished notebook (1880), which shows seven seams of coal ranging from 1′-6″ to 3′-4″ separated by thicknesses of strata 200 to 300 feet. Memoir No. 59 of the Geological Survey, mentions two coals: one foot, and 2½ feet, respectively.

Other Districts.—

There are many coal-bearing districts in eastern Canada, of which but little is known. Hearsay reports of coal make up the major part of the available knowledge. On Debbert river there is a seam which is given as 3 feet thick, shown in Drillhole No. 5 of the Government drill records of 1906, as 6′-9″. No. 4 hole of same year, and same district, shows two seams: the top 7′-3″, and the other 4′-10″.

On Merigomish island, in Pictou county, there is an occurrence of an 18-inch coal. North of Truro, coal outcrops at several places: Kempton, and some other areas; but the information regarding thickness, and extent, consists mainly of rumours. Some development work has been done at various points in this neighbourhood, but it has been lost, or remains in some private possession, and probably will never be available to the Province.

NEW BRUNSWICK.

This Province is the home of thin-coal mining in eastern Canada, and so far as known the 151 million tons available are contained in seams averaging 30 inches or less. The best developed and most valuable area is that of Grand Lake, where the seam ranges from 20 to 33 inches. In the Beersville area the thickness is less, averaging about 15 inches, and in Dunsinane about the same.

In Memoir 59, (G.S.C.) on page 57, dealing with the Beersville area, New Brunswick, the thickness is given as from 18 inches to 10 inches.

In the present working mine the thickness is 16 inches, and in places goes as low as 13½ inches. The average over the field will in all probability be about 15 inches. The dip is gradual, generally to northeast, and beginning at the depth of 20 feet at Coal Branch, increases going down the Coal Branch river to 100 feet at Beersville. Below Beersville a fault cuts across the river at least 100 feet down-throw northwards. On the downward side the coal has been located. The bed has been opened up along the river from Coal Branch to Beersville, and there is interesting evidence that a stream was in existence at the time the bed of coal was formed. Old outcrop workings—which are numerous— have cut into old river beds, almost on the same level as the existing river.

Two miles west of Coal Branch, and three miles west of Harcourt, the underlying Lower Carboniferous rocks crop out in the Salmon river and its branches. The westward limit of the area is, therefore, roughly about, and parallel to, the line of the Intercolonial railway. Eastward it certainly goes beyond Beersville, how far, is only conjecture. Even taking these limits as known, and allowing for probable line of crop northwestwards, there is a possible 20 square miles, and probably much more. This would yield 24,000,000 tons as against the 13,000,000 estimated in the Memoir.

In addition, there are a number of other coal-bearing districts which have been known for years, but despite that fact, the information about thickness and possibilities is probably less now than it was the day they were first discovered.

PARTICULAR[illegible] [illegible]CTIONS OF GOVERNMENT BOREHOLES, 1902–15.

The plot[illegible][1] put down from Government drills in the years 1902–1915, include every borehole which indicated coal in the drill records. They seem to show that in the exploration of later years—which is manifestly more exact in its recording of the knowledge acquired—that the number of thin seams either discovered or rediscovered by these drills, is considerably greater than the number of thick coals so found. It is, of course, certain that some of the boreholes passed through the same seam twice or three times in the same district, but this occurred in both thick and thin sections, hence a comparison of the totals of the number of seams found, if not actually correct, can, quite conceivably, be relatively so. During these years, 46 coal seams under 3′–6″ have been drilled through, as against 25 beds over this thickness. This gives 65 per cent of thin-coals found during the time the Government drills have been in operation. It is known that the position of some of these drillholes has been lost, which is regrettable, since an accurate knowledge of the location is useful in determining the relation of the thick and the thin-coals found in juxtaposition: a subject that is bound to gain in importance, and be the cause of much conjecture as the years roll by.

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[1] See the 32 diagrammatic sections at end of bulletin.

Tonnage in Thin Seams.

District.	Aggregate thickness.	Area sq. miles.	Tonnage.	Total tonnage.
Nova Scotia				
Cape Breton				
Point Aconi..........		16 (land)	204,800,000	
Sydney Mines........	13′–0″	52 (sea)	665,600,000	870,400,000
Victoria............				
Lingan.............	14′–0″	5 (land)	67 200,000	
		45 (sea)	[illegible]9,200 000	806,400,000
Glace Bay..........	11′–0″	10 (land)	105,600 000	
		47 (sea)	496,320,000	601,920,000
Port Morien.........	6′–0″	6 (land)	35,560 000	
		24 (sea)	138,240,000	173,800,000
New Campbellton....	3′–0″	1½ (land)	4,320,000	4,320,000
Mira Bay...........	10′–0″	20 (total)		192,000,000
Glengarry..........				28,000,000
River Inhabitants....	....	....	....	1,000,000
Port Hood..........	11′–0″	5 (total)	....	52,800,000
Mabou............	6′–0″	4 "	....	23,040,000
Inverness..........	6′–0″	8 "	....	46,080,000
Chimney Corner......	7′–0″	6 "	....	40,320,000
Mainland				
New Glasgow........	8′–0″	10 "	....	76,800,000
Saltsprings..........	10′–0″	7 "	....	60,200,000
Springhill...........	18′–0″	9 "	....	155,520,000
Joggins.............	6′–0″	44 "	....	253,440,000
				3,386,040,000
New Brunswick				
Grand lake..........	22″	112 (total)	....	138,000,000
Dunsinane..........	18″	4 "	....	5,760,000
Beersville...........	15″	20 "	....	24,000,000
				167,760,000

Comparative Tonnage.

	Tonnage.
Total for thick and thin-coals over the same area (metric tons) ...	7,079,968,000
Total for thin-coals over the same area (metric tons).............	3,553,800,000

Comparison of thicknesses in Cape Breton.

	Thin. (Aggregate)	Thick. (Aggregate).
Boularderie and Sydney Mines..........................	13	23
Victoria and Lingan..................................	14	32
Glace Bay..	11	31
Port Morien...	9	20
	Average.....	25

NOTE.—To get the correct average thickness, tonnage should be taken into account; but 25 feet is sufficient for present purposes.

MINING THIN-COALS.

The winning of thin-coal seams is a class of mining which in the nature of things, must be growing of considerable interest in the older coal-fields, and to the older established companies. As the thicker and more attractive seams approach exhaustion, the question arises as to whether the thinner seams are to be considered as capable of being profitably operated; whether the coal company is to cease business; and whether the coal-field is to be abandoned. A decision on either course of action is, to the surrounding community, a momentous one; and bearing this in mind, there is much to be said for the policy of "carry on." Very little is known about thin-coal mining possibilities, consequently, some remarks on this subject, based on actual operation in 15-inch, 18-inch, and 20-inch coals, may be of value, and of interest. But, there is this to be remembered, experience in mining one thin-coal is no criterion of success in mining another; experience, however, can greatly add to judgment based on technical knowledge.

PRINCIPAL FACTORS TO BE CONSIDERED.

In thin-coal mining the features that dominate success are (1) the efficient handling of the extraneous rock overlying the seam; (2) the quantity removed; and (3) its final disposal. The winning of thin seams necessitates some of the rock roof being taken down in the workings, in order that a convenient working height may be obtained. The quantity that has to be handled seemingly depends on:—

(a) The thickness of the coal.
(b) The nature of the roof.
(c) The arrangement of the mine.
(d) The method of operation.

Rock handling, while usually shown in general cost sheets as a separate figure in the face cost figures (i.e. so much per ton for "Brushing"), also appears as an incidental charge in the cost per ton deduced from all the other cost items: owing to the fact that there is less "payable material" (coal), in every ton of material handled, hauled, or hoisted.

OVERCOMING THE ROCK FACTOR.

The efficiency of haulage, pumping, hoisting, and other mine operations, are at a maximum in thick seams, consequently, no extraordinary or unusual methods can be looked for, or expected to be put in operation as aids to thin-coal mining, in order to overcome the rock cost. Since useless rock is dislodged and accumulated in mining, and once dislodged, there is no means of destroying it in the mine, the logical place to effect the needed saving in expense is at the place of its production, namely, the coal face. Two means of effecting this economy present themselves:—

(1) Direct methods.—Any mining system or appliance that can be used to reduce the quantity of rock dislodged.

(2) Indirect methods.—Faster extraction, and concentration of output, whereby a greater tonnage is placed against all costs except actual mining.

Increased coal extraction may become, under some conditions, a direct method of reducing the quantity of rock mined, since there are roofs which will make less waste material in the course of mining, if the advance of the face is accelerated. Generally, however, the great advantage from quicker coal production at the face comes from a speeding up process of the whole mine organization: more coal handled through a relatively shorter distance, at a greater speed. The fact that quicker extraction of the seam sometimes means profitable operation is verified in those cases of thin-coal mines where the introduction of improved machinery and methods has not resulted in a less cost per ton at the face, over the older methods displaced, but which, nevertheless, prove machine mining to be a success, solely because the organization created to handle the machine-cut and machine-handled coal has been so perfected as to give a substantial reduction in all other mining costs; thus offsetting the increase due to decrease in thickness. Organization is, therefore, a very important matter where machine mining is in operation.

Machine mining as applied to the extraction of thin-coals is the outcome of the struggle to overcome the handling of excess rock; and no other economic alternative is available. Mechanical coal cutters are examples of a means to do this by indirect meth[illegible] increased tonnage; while conveyers are a means to the same end [illegible]t methods: less rock made. Loaders, when they become practical [illegible]s, will be in the same category as cutters.

METHODS OF OPERATION.

A discussion on mining methods, as practised daily in the winning of thicker coals, would, ordinarily, involve a consideration of the relative merits of "Longwall" and "Pillar" extraction—long a subject of much dispute; but inasmuch as it is thin-coal mining that is under consideration, this chapter will be confined to a discussion [illegible]ys and means as specially applicable to such seams.

Hand mining methods are rapidly being displaced by machine mining operations; and where the question of the successful mining of a thin-coal is under consideration, the possibilities of machine mining should be given first and undivided attention. There are, of course, exceptions to the almost universal success of machine methods: conditions where hand mining is preferable. These are mainly:—

(a) Where operation is limited by other factors, and to such an extent that the increased capital charges involved through the introduction of machine mining methods cannot be offset by a sufficiently large gross reduction in cost. This case is intensified in those small mines, so situated that outside motive power cannot be bought, and where its local provision would necessarily involve a large addition to capital.

(b) Where the roof conditions, and character of the strata, are so inherently weak that they will not stand the greater roof stresses demanded in longwall working.

A roof that can be described as "mealy" is generally unsuitable, and extremely troublesome in machine workings. The cost of excavating a machine, buried nightly, within perhaps, a short stretch of a few yards at one particular point, runs away with any advantage there may be from machine installation. In extreme cases, the laying out of cutter walls might also become doubtful where timber was scarce and costly, and where none was recoverable in the workings. Water troubles may cause a normally good roof to become unsuitable for machine longwall mining.

(c) Where the mine is situated in such an isolated region that skilled and steady labour is very difficult to obtain, and to retain, a series of "stops and starts," operation and suspension—occurring through machine hands leaving unexpectedly, operations thus coming to a periodic standstill until the deserters are replaced by other men—might militate severely against machine mining.

In those cases where conversion t machine work means a change to entirely new and untried methods, and in face of a passive or maybe active labour opposition, the expense of trying to educate the men to the new ways may completely discount the benefits of the suggested change.

The introduction of machine mining was the first step towards bringing the potential value of the thin-coals up to their present economic value. It is not many years since a 24-inch seam was considered the lowest workable thickness; now, machine mining takes out seams down to 12 inches. The coal cutter was the first phase in this successful innovation and the one that is, as yet, the most developed. While, to-day, machine methods are applicable to all systems, and the various modifications thereof, it is in thin-coals—at least in the longwall method—that the greatest field of application will be found, because :—

(a) With thin-coals, machine mining must come to mean in the future, not only undercutting by mechanical appliances, but, in addition, the entire series of operations necessary to the getting of the coal by power. This is the logical development of applied power to offset the increase in wages and other costs brought about through mining thin-coals. And that being so, the longwall system is the one that offers the greatest tonnage within the smallest area, and consequently provides the maximum of continuous work with the minimum of lost time. Conditions under which machines can be kept going steadily for eight hours getting coal are preferable to conditions where the work in each place is a series of separate operations occurring intermittently during the day.

(b) With thin-coals, under any system whereby the machine changes from place to place, the amount of coal obtained or work done in each place becomes very small, since the seam is low and consequently the proportion of time spent to the tonnage cut, in changing from position to position, automatically rises. While this fact is not so evident nor so serious in mining the thicker coals, it becomes very pronounced in the case of the smaller seams.

(c) Concentration of work is also an additional feature of longwall working, whereby the problem of handling and attending to machines and to their outputs, is simplified and manipulated at a decreased cost rate.

While longwall mining seems the natural path along which thin-coal operations will develop, the sum total of other considerations may be, and frequently is, adverse to the introduction of this method. The adverse factors of greatest importance are:—

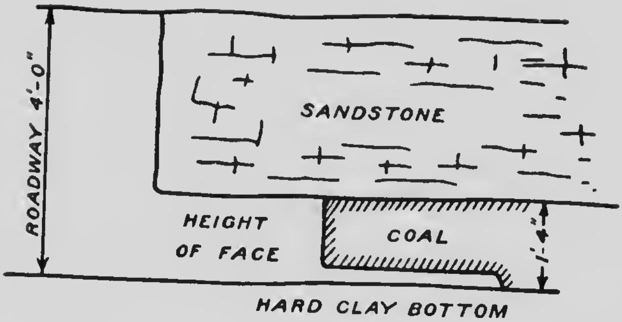
(1) Roof troubles.

(2) Inexperienced labour.

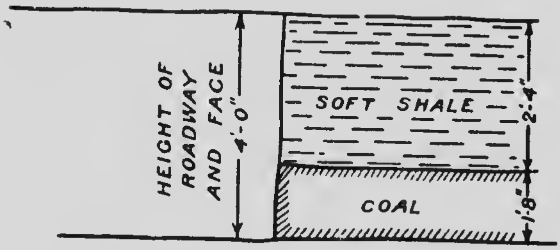
This roof question has a recurring frequency that emphasizes its importance in determining not only the method but also the manner of working It is worth remembering, however, that this question can be viewed from another standpoint: which is exemplified in saying that it is, perhaps, not the condition of the roof that makes the operation successful or otherwise, but the method of mining. Practice has proved this to be so; some cases where a coal worked by longwall hand mining had barely successful results, when turned into machine sections were complete failures, because the quantity of rock then handled became too great. Changing the direction of the advance of the face through 90 degrees, produced fairly satisfactory results, since the rock taken down was much less. These attempts were all made under the same roof; the only changes introduced were differences in the method of mining. It was the method of working in this case, therefore, that determined the behaviour of the roof.

The study of the different forms of roof, and their relation to the various modifications of machine or hand, "Longwall," or "Pillar and stall" methods of working, is a wide subject, and no two cases seem alike. Four hypothetical cases can be mentioned:—

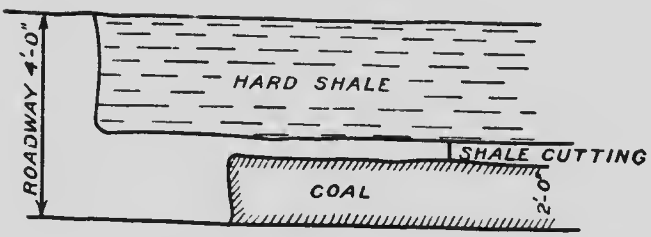
(1) A roof with heavy pressure and "short break"—meaning thereby, a superimposed rock which is continually exerting a heavy pressure through another rock immediately over the coal and which latter rock has, of itself, little adhesion—is inimical to longwall



Thin-coal section under normally good conditions.



Thin-coal section under normally bad conditions.



Thin-coal section under average conditions.

Fig. 5.

working, since the quantity of waste rock dislodged is far greater than any reduction of operation cost could overcome. The immediate overhead rock being of very fine character, runs, on disturbance, like "meal." Such a roof may cause a seam to be unworkable under any conditions; but is particularly adverse to machine mining, since even vibration may cause a break. The "cleats," "cracks," or "breaks," in this rock, are so well developed, and equalized in three directions, (extra well-defined stratification and two sets of cleats close together at right angles) that only a continuous solid support would hold it up.

(2) As the distance between the "cleats" or "breaks" increases, and one set becomes more developed in one direction than another, the roof acquires more stability, and cohesive power to stand strain in one direction. In such cases, an alteration of direction of working would cause a distinct difference in the behaviour of the roof. A pillar section, going in either direction, might be very successful, owing to the natural solid supports in the form of pillars being correctly placed. This case still supposes the existence of heavy pressure, but with the immediate coal roof steadily gaining a strength of its own.

(3) The case of the roof with the "short break," but without heavy pressure above, as in case (2), provided the immediate roof is not too broken, is largely favourable to machine longwall; for the stone produced can be used for building purposes, packs, and pack walls, while the pressure is neither so great, nor so sudden, as to disturb the stone walls before they take the weight. There are conditions here, also, where the working again determines the roof conditions. For example, a roof under which a face is advancing at the rate of only 18 inches per day, hand mining may prove difficult to hold, owing to the pressure getting time to weigh on the artificial supports and perhaps getting out of control; but if a machine is installed, which advances the face from 4 to 6 feet per day, the rate of progress is trebled, and the pressure has somewhat less time to exert its troublesome and costly influence before a new exposure of roof is made, under which the miner works in greater safety.

(4) Machine longwall is most successful where the roof has great adhesive power, and little immediate direct pressure, but it is also conceivable that adhesion might be so great as to produce no packing stone, and be a cause of additional trouble through excessive falls and bumps: subsidences that take place when the long stretch of unsupported roof and unbroken strata behind the coal face becomes too great to be sustained by artificial means, and which, in falling, crushes through roads right up to the line of the workings.

Between these four cases there are innumerable variations of all sorts and conditions, hence it frequently happens that roof possibilities can only be judged, and final success arrived at, by a process of trial and elimination.

Machine mining helps to attain better control of the roofs, as witness the conditions in any old hand mined longwall working, set out without any regard to roof conditions. Naturally, through various troubles, certain places fall behind others: some pillars are built solid, timber is left standing in the waste. From all these causes trouble arises. One miner says his coal is hard, and therefore, demands extra rates; another fills nothing but small coal; falls are numerous, and seem to occur regularly at one or two points; more timbering is wanted at each roadhead. At other points, the pavement has to be lifted. In other words, due to the over-riding weight of the strata above, lines of force are produced which run any way, and local pressures come into existence at certain points, whose position is determinable by the relationship between the line of the coal face, the distance apart of the roads, and the areas open, supported, and unsupported. The man in charge of such a section usually blames the roof and in this contention is quite correct; but he should go behind this statement, and realize that it is his method of working that caused the roof to act in such a manner.

The introduction of machine walls and conveyer operations, demands straight lines in the coal face, and that the necessary supports be placed at stated intervals, running both ways. Regularity becomes the fashion, with the result that equal pressure lines—unknown under former conditions—develop parallel to, or at right angles to, the line of the coal and can be taken advantage of in operation. The cohesive strength that is in the roof becomes a help instead of a hindrance: safety is increased; for if you know what a roof will do, you can, within limits, make your preparations accordingly. No two roofs are alike: in weight exerted, in the type and direction of break or in the swing of the loosened strata; but once regularity of working is established, they may be expected to exert their several powers in the same way.

Inexperienced labour, in machine or hand, longwall mining, is, in certain cases, so great a drawback, that it is often a reason for the non-adoption, or condemnation, of longwall methods. In communities and districts where one class of mining has been in vogue for years, and where the facilities for spreading knowledge of modern mining work are poor, there is usually bred a race of workers who are more or less passively, and sometimes actively, opposed to the introduction of new methods. Insular industrial circles are all, more or less, afflicted by the antediluvian doctrine, "What was my father's way is good enough for me;" and where this is the case in mining, the introduction of machinery, or any alteration of system will involve not only consideration of the whole question of the organization of the work, but also the steady propagation of information on the subject. In the capacity of the workers to appreciate this technical knowledge, and on their willingness to learn it, lies a great deal of the future success of machine, and longwall methods. There are mining districts where, for this cause, it takes dozens of years before a new idea can be grafted onto the native mind. Previous to that psychological moment, it was banned as a "foreign" notion. Conditions such as these require infinite patience, much tact, and a steady educational effort, before the results desired are attained.

MACHINE MINING.

The miner of thin-coals being constrained to offset cost, in some way, endeavours to do so as near to the seat of trouble as possible, namely, in and at the coal face itself; and with practical experience of hand methods at the maximum efficiency in the mining of thick seams, he must of necessity inquire into, and adopt, some way of extracting the thin-coals, so that he will get better results per ton, per man, than can be achieved by actual man-power. The only alternative is machine operation, hence, machine mining has come into general practice, and is, under average conditions, essential to success in thin-coal mining. By machine work, however, is meant not merely the accomplishment of just one portion of the work, but the question of the application of power to the whole operation of getting the coal: from the commencement of the undercutting, to the placing of the coal into the mine cars. To adopt an appliance is to accomplish only a part of the work, it is a task half done: a method that can never give the best results until the remaining parts are also worked on a similar basis. The half that is done by machine is always waiting on the half that is done by hand, and is retarded by it, involving a consequent lowering of efficiency, and an inevitable increase in cost.

The predominant factors in thin-coal mining success are (1) less rock dislodged; (2) increased tonnage; and (3), increased concentration of effort, by the same working force. The last of these essentials can only mean rapid face advance, and in attaining that the regular cycle of face operation should be continuous: the one following the other without rest, irrespective of hours worked. But, inasmuch as labour imposes conditions relative to the number of lawful hours a man may work, the successful application of the economic law of continous operation has to be carried out under a proper arrangement of cutting hours, over a definite length of face, in a certain loading time, and limited repair hours: in a word, involves systematic organization and design. Speed in mining is only possible in its entirety by having all the major operations of the face done by machine, and until operators realize the fact that, the adoption of one type of machine is only a partial relief from their necessities, the thin-coals problem will still remain only half solved, and can only be approached with caution, and be viewed with apprehension, because certain useful knowledge is wanting. Lack of knowledge breeds fear and hesitation, and both these are elements of failure. What is wanted is, a bolder policy; and the citizens of a country where the thin-coal question has become acute, have a right to expect it from those in possession of coal lands, and who possess capital to prosecute the necessary experimental work. With the subject of thin-coals facing them and a closer union between the operator and the manufacturers, there is no reason why the machine problems of the thin-coal mine should not be satisfactorily and successfully solved.

It is true to-day that some of the types of machines for thin-coal work are only in their infancy: imperfectly designed, and crudely made; but the fact that this is so, is somewhat due to lack of demand, and more so through the inability of the coal operator to state clearly what is wanted. A great and successful advance in machine methods has taken place in recent years, and it is certain that there will be a greater one in the near future. Past experience has shown, that once the demand for special labour-saving machinery is established, by the realization and concrete expression of the requirements for this or any other class of mining, the machine needed has always been forthcoming.

In thin, as in thick coal mining, four major operations are involved in the process of extracting the coal: (1) undercutting the seam; (2) breaking down the coal; (3) loading away; and (4) attending to the support of the face and roads. Undercutting—the hardest part of the miner's work—was the first to be done by machine, with results now well known, as shown in the utilization of undercutting machines in ever increasing numbers. The breaking down of the coal is the oldest part of the work carried out by a power agent, namely, explosives; but this has, to some extent, been directly influenced by the introduction of the cutter.

In older longwall systems, when the tonnage of coal obtained from the seam was relatively smaller, few roads were required to take away the coal. In the newer machine-mined sections, however, where more coal is obtained per day, it was found that additional roads were needed in order to ensure that the day's cut of coal was certain to be loaded away, to make room for the next machine-cut, at night. This, in turn, meant more fallen stone work for every road in the section, and in addition there was a faster and a greater shovelling of the coal to the roadhead. To overcome these conditions, the face conveyer was invented, which reduced the rock handling in the roadhead, by the simple expedient of eliminating all roads except one or two, such as the main hauling road, and a ventilation road. Further, it provided the miner with an appliance immediately at his back, into which he loaded his coal, thus also eliminating the turning over and shovelling of the coal along the face, which is not only an arduous task in the cramped quarters, but an operation that took up half the miner's time, and added to the breakage produced.

The loading of the coal into the conveyer is the last operation still being done by hand. To get machines to accomplish this work—which should be the case—there is yet to come into existence the low, underground, coal loader: a travelling machine like the coal cutter, which will pass up the face after the web of coal has been broken down, and will load it into the conveyer at its side.

Machine mining has, generally, the following economic advantages:—

(a) A much increased output from a given area.

(b) The undercutting cost is less, by the large increase of output per man.

(c) Owing to better and advantageous control of the roof the cost of timbering and explosives are both reduced.

(d) Better coal is produced: less slack being cut by the machine than by hand mining.

(e) There is greater safety at the face.

The most important point is, the recognition by management and men alike, of the changed conditions introduced in the mine: such as piece work division of the labour; "tuning up" needed with the increased output; and the regularity of service. The foregoing as well as the following remarks apply equally well to conveying and loading operations.

Laying out Workings.—

Under the longwall machine method, there are three ways of extracting the coal, each of which has its own advantages:—

(1) Longwall advancing—the more common way—is practised mainly because it produces an immediate return on capital invested: does not demand as large an expenditure on plant and material before the nature of the field is determined, and before all the capital is spent; and is, moreover, the easiest way to explore a district or area where the exploitation of other coals is dependent on the information gathered from the working of the first.

(2) Longwall retreating—the system advocated generally, because the outlet roads are maintained in the solid coal, instead of being maintained in disturbed strata; the system considered as specially suitable in the case of weak roofs. With thin-coals—where the cost of holding these roads is much increased owing to stone having to be taken down, together with less return from coal mined—this method is not so attractive as in thicker beds.

Working on a return system also involves the outlay of a very large amount of capital, in development work. Frequently, the claim is made of much cheap eration by this system, but this in a large measure is accounted for by charging development work in the one case to capital, and in the other against the cost per ton.

(3) Panel working of longwall—a compromise between the other two methods—has the advantages or disadvantages of both, according as other conditions cause the proposals to weigh one way or the other.

The details which go towards the planning of a mine, are, in either system, about as varied as the conditions under which they are applied; but as far as thin-coals are in question, the most potent factor in laying out the workings is the extra cost entailed in development work, which is partly due to work in stone and partly in coal; the troublesome maintenance of roads in waste under certain types of roofs; and the proper relationship of development work to mining coal, keeping in mind the relatively small tonnage obtainable from each panel or any other subdivision of a workable area.

Undercutting Machines.—

Seeing that conditions are such that longwall systems are most suitable for thin-coals, it follows that the selection of machines capable of giving success, is of some interest.

Three types of machine are in common use, and are available, namely, the Chain, the Bar, and the Disc. Of these, the "Chain" is the most cosmopolitan. Established practice and usage is commonly the reason why a certain type is a favourite in any particular country and district; but beyond a few outstanding advantages in any one type, allowing for adaptability to certain special conditions, there is no reason why any design should not be almost equally successful. The outstanding features that cause disagreement in selection of types are the trouble said to arise from the disc machines when operating in coals that part readily, and where deep undercutting is indulged in, owing to the coal falling down and jamming the cutter, and the inability of the cutter to cut into its own work. Advocates of the other types also mention the noise made by this machine, as a trouble and danger that should eliminate it from the market. On the other hand, advocates of the disc type point to the early troubles of the chain machine, mainly the want of power; to the frequent weakness of the bar in cutting a tough coal; to the fact that those machines in a soft coal make much dust—a danger in face work where gas exists—which is certainly an unsaleable product; and to the trouble of manipulating the cutter in thin-coals at the end of the day's run. Taking, however, an average coal suitable for machine mining, the success of the venture does not depend so much on the choice of the machine installed, as on certain other conditions that are matters of actual operation: all dependent on the use of a machine of tried capacity. It is only in exceptional cases, where some special advantage which one machine possesses over another, that choice is made of a particularly suitable appliance.

The first general requisite in a machine for working in thin-coal is adequate power in a minimum of space. A machine that is deficient in power is a source of continual trouble; it "balks" and jams continually, wherever a tougher piece of work than the ordinary is encountered, and, as a result, its actual cutting time becomes so limited that either the length of the face cut in the night has to be shortened, or the cutting shift has always to work overtime. In the early days of machine mining want of power was a frequent source of trouble, and sometimes of actual failure. It often happened that machine men descended at six o'clock in the evening and did not reach the surface again until ten in the morning. Hence, time and labour were heavier ends in the balance of costs, than power.

Height of Machine.—Height is an equally important factor. With the thin-coals it is sometimes difficult, for mechanical reasons, to get the cutter that will "crawl" along between the roof and pavement, sufficiently low. Generally, a machine should be selected which has inches to spare, since not a few coals are subject to slight fluctuations in thickness; and where this occurs, in cutting, it necessitates breaking and taking down the roof to pass the machine. Wheels versus flats or skids, are elements in height, with the preference for skids; not only because of the few inches gained, but because they eliminate the trouble due to the use of a track along the face, and the problem of staying a machine tightly up to its work—especially when working in a tough coal.

Conveyers.—

The selection of a conveyer is governed more by actual mining conditions than is a coal cutter. Such features in the arrangement of the section as inclination of the coal seams, undulation or otherwise of the strata, have a considerable bearing on the success or failure of a conveyer; and these are questions quite apart from the tonnage to be handled. Conveyers of all types can generally be found of sufficient size to deal with all the tonnage made, hence it is these other questions that must decide the character of the appliance to be employed.

Search for reliable conveyers is not confined entirely to one type, since, conveyer operations being now well developed in the oldest coal-fields, there is a choice of three systems, each of which has its advantages, and disadvantages. These may be classified as follows:—

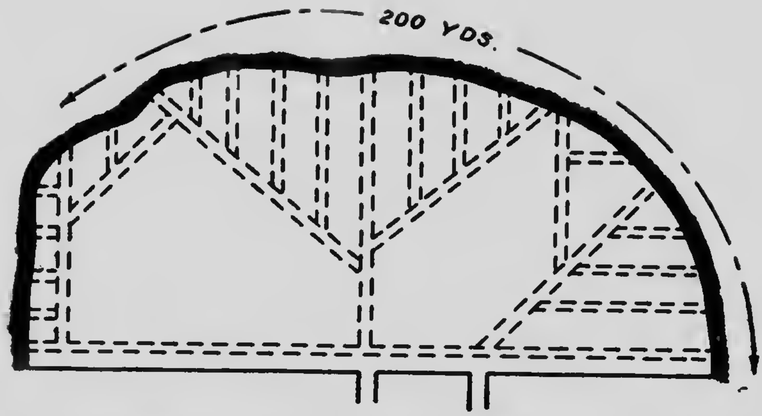
(A) Those that are developments of haulage systems.
(B) „ „ „ „ „ shaking screen system.
(C) „ „ „ „ „ conveyer or chain belt system.

Further, there is a choice of at least three machines; each accomplishing the work under system (A); two under (B); and two under (C); and it is quite possible that there are others. With regard to the question of manufacture, machines under system A are usually the product of the blacksmith shop; (B) has developed from European continental practice—where it is largely used; while (C) the last—in several forms—is now being put on the market in the United States and other countries.

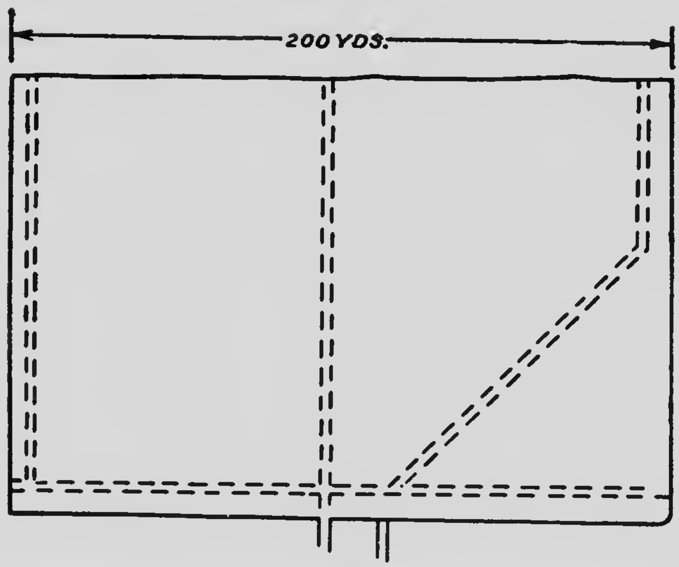
In considering the use of any conveyer, however, it is well to remember that success is not merely a question of selecting a suitable machine—far from it. A clear recognition of the facts that good organization and regularity of operation are essential, has as much to do with reducing costs as the purchase of a suitable machine.

It is not easy to classify the conditions which render any particular conveyer most suitable. Briefly, the main limiting features of each type are:—

(A) Being low, it is suitable for very thin seams, say two feet and under; requires to be operated in sections with a centre main road; it is not so applicable to sections working across the dip, since this means hauling up the hill: requires a special man on the engine: is intermittent in its delivery, and consequently its operation requires to be well synchronized with the arrival of the cars at the face, otherwise, either the men on one side are idle, waiting their turn to load,



(a) Semi-circular machine face showing number of roads required to take away the coal.



(b) Same section as above, after straightening up, and arranging for conveyer.

Fig. 6.

or a half loaded trip results. It is suitable for seams with an undulating pavement, and will operate across a faulted face without trouble, except the need of additional power. Is very easy to shift; will deliver props, etc., from the main road to the men at the face; requires a bridge across the road, and props to hold deflecting knives, which must all be moved with the conveyer.

(B) Being an average 9 inches from pavement, is suitable for very thin seams, is very suitable for inclined seams; but is troublesome on a pavement with rolls or hollows; is not so easy to shift as system (A); being continuous in operation the loader at the cars can attend to the engine, saving one man's wages. Cannot be reversed, and so will not deliver supplies to the men; requires very little power, is ideal for air drives, and awkward for electrical drives unless a moveable electrical air compressor be used; delivery is continuous, and so loading cars is independent of men loading conveyer; requires no bridge across the loading road—which is, consequently, clear, can be made to take any stone in on one side of the conveyer, and discharge it on the opposite side, at any intermediary point between the top and bottom of the conveyer; requires no tension arrangement.

(C) Is continuous in operation: is not suitable for very thin seams, owing to its height; can be reversed, and will deliver timber to the men; requires no bridge across the road; is ideal for electrical drives, but awkward for air; will operate in a section with two roads; needs a tension arrangement at top of section; is awkward on a rolling floor, but is more flexible than (B) in this respect.

Conveyer operation provides the following advantages:—

(a) Concentration of the machine output at a point where proper preparations can be made to meet it.

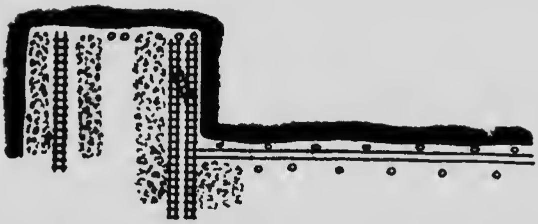
(b) Only one or two roads are needed in each section; which represents, in many cases, a big saving in cost of building packs, getting down the roof, and repairing, say, ten roads as against two.

(c) Disappearance of lines of roof weakness due to road bushing, with consequent continuation of the policy of roof control—first introduced with the conveying machine.

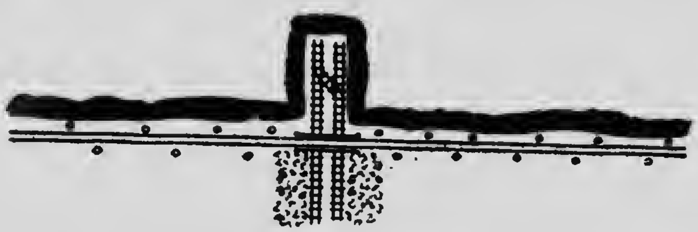
(d) Steady, systematic, timbering, giving greater safety.

(e) Increased output per man, due to greater ease in loading, with consequent reduction of costs.

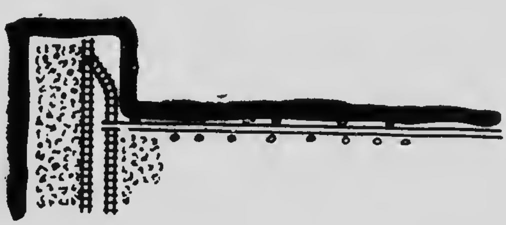
An advantage sometimes claimed is, the larger proportion of round coal brought out from the face; but this is doubtful; while the alleged disadvantage, often stated, that more dust is produced in the faces, does not seem to be borne out in practice.



Double roads—common where inclination is over 6%. Bottom road takes the weight and acts as safety valve device.



One centre road—two conveyers, or intermittent type serving both sides of section.



Single end main road for flat and gentle inclinations.

Fig. 7. Three main roadhead arrangements in conveyer sections.

In operation, a conveyer follows much on the lines of machine wall. The face must be straight, and, with certain types, without undulations. When machine and conveyer are both in use, regular propping is required, since space is needed, first for the machine, and then for the conveyer.

The main haulage road, to be adequate for its purpose, must be double width, to allow of a double track, and should be kept about 50 feet in advance of the usual face line. This provides a space in which to manipulate the large number of boxes required for loading. Inasmuch as these boxes have to be placed under the conveyer head, the pavement of the seam is lifted to a depth sufficient to allow of this. As a rule this pavement is lifted every third night—while the machine is cutting. In order to avoid having to keep a road in advance of the usual face line, a second short conveyer—always of the continuous type—has sometimes been used. The face conveyer discharges at right [illegible]s into the road conveyer, which, in turn, raises the coal a sufficient he[illegible] to [illegible]ch the boxes. An ingenious turntable has been operated with this s[illegible]nveyer, rotating the tubs from one road to the other, in front of the discharging end. It has the advantage of causing no cessation of loading when shifting and putting in a fresh trip of boxes. With the road conveyer a double road is required just the same, one line being occupied by the conveyer and the other by the empty boxes, and any extra height required is obtained by taking down the roof. The necessity of having a good system at the loading end will be manifest when it is considered that 400 boxes or more may have to be dealt with there, in one day.

In seams with any inclination, a second bottom road, parallel to the loading road, is good practice. This is due to the tendency of the roof weight to slide down hill, hence this second road, placed below the loading road, acts as a safety valve, into which roof pressure can exhaust itself without causing excessive crush on the working level.

Shifting the conveyer is an operation usually carried out at night while the cutter is running. Six men on the average is sufficient, depending on the length and type of conveyer, and one or two conveyers may be shifted each night. Sometimes this work is performed on contract.

As with the cutting machines, so with the conveyers, success in working depends on the recognition of the principle that the workings must be arranged to suit the conveyer, and not *vice versa;* and the system adopted plays a large part in operation. It would be poor policy to concentrate 200 tons at the roadhead, and then have no effective means of taking the quantity to the shaft. The same remark applies to timbering and loading. Using machines and conveyers, the operation of the roof being steady and continuous, it is possible to set the necessary timber at regular intervals and in line. This practice facilitates both the operation and shifting of the machines. Where there is much timbering required, this is best done by special men who should be attached to the squad detailed to shift the conveyer. In working, all the coal cut must be removed straightway, to make room for the next machine run; and should any loaders not turn out, others must be found to take their place.

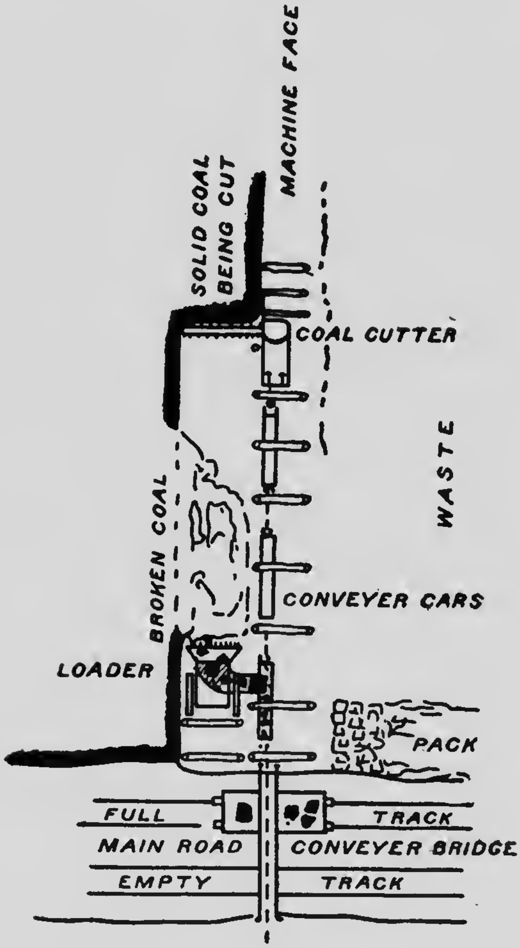


Fig. 8. The ideal thin-coal operation.

Loaders.—

So far, the type of machine which—for the purposes of this report will be called the underground loader for thin-coal longwall mining—is to-day unknown; but it cannot be denied that as the general mining of thin-coals extends, the need for the introduction of such loaders will become better a,ppreciated: and it will be recognized that their sphere of work is as important, in their own particular part of face operation, as that of a coal cutter or conveyer, in theirs. Each, in fact, is the logical counterpart of the other.

To show clearly the use of the loader, it is interesting to follow a ton of coal from the face outwards. Formerly, the coal was undercut by hand; broken-down by hand; shovelled up or down the face to the roadhead by hand; loaded into the mine cars by hand; the cars shoved to a collection point by hand; and from thence, by mule, to the haulage way. It will be seen that there are here four major operations at the face, conducted by man power. With the introduction of machines, certain of these operations were greatly accelerated. The undercutting was first done by machine; and the coal broken down easier—partly due to the use of the machine. Lifting the coal is still done by hand, along the face, but the coal is loaded into the mine cars by the conveyer, and the mine cars are picked up by the haulage direct from the end of the conveyer. Here then, two operations previously done by hand are now done by machine, with an admitted increase in efficiency, on average operations, together with a considerable decrease in cost.

The result is attained through the co-ordination of effort to obtain more coal per man employed, by providing the man with appliances whereby with the same expenditure of energy and labour previously used in handling the smaller amount by hand, a greater tonnage is produced daily; but there still remains one major part of the work which is hand done in thin-coals, and that is, the loading of the coals into the conveyer. It is in filling this gap, in doing this work more economically, that the field for the mechanical loader exists. With its introduction and successful use, another step towards increased efficiency and economy in thin-coal mining will have been taken; then, the modern era of completely machine-mined thin-coals may be said to have begun. An underground loader will naturally work best, like most other mechanical appliances, when and where there is a continuous work period ahead of it, and such a condition is presented in the machine-cut longwall face, more than in any other type of coal mining in thin seams. In the longwall face a continuous web of coal—50 to 500 tons—is, say, ready waiting to be lifted from the pavement into the conveyer. To effect this, a regular succession of varied operations takes place within a short period, hence operating under any other system in a thin-coal, the time spent in moving a loader from place to place would be greater than the time spent in useful work.

A loader has, of course, to be designed to suit the conditions under which it has to operate, and due to those conditions this design will have to be a radical alteration from any known loader at present being used in underground mining. Some of the necessary requirements of the longwall loader, suitable for thin-coal seams, can be stated:—

(1) In general appearance the loader will require to follow the lines of the longwall coal cutter: that is, with outside dimensions approximating 10 feet long, 3 feet wide, and 16 inches high. Experience in coal cutters has demonstrated that these are about the limits

of size; and makers of loaders might as well benefit from previous practice instead of beginning experimentation afresh.

(2) The loader will require to be self-propelling; but in a different fashion to the coal cutter, which, usually, hauls itself along with a rope: the best possible means will probably be the chain tread. The loader has to "eat up" its work as it goes forward, and it requires to travel at the same rate as the coal cutter, in order that the face can be properly cleaned up within a reasonable time.

(3) The loading mechanism must be at the front, since the machine has to tackle what is practically a ridge of coal of small height and width, but of considerable length; and it has to travel in the path it clears for itself.

(4) The loading mechanism must be capable of dealing with the lumps and dust at the same time.

(5) The height the material has to be lifted, and the distance it has to be dumped, are both matters of inches.

(6) Whatever may be the actual amount of power required to do the work, sufficient surplus is a necessity, so that "speeding up" may be indulged in—in the event of lost time occurring; and also, that the loading of stone as well as coal may be done.

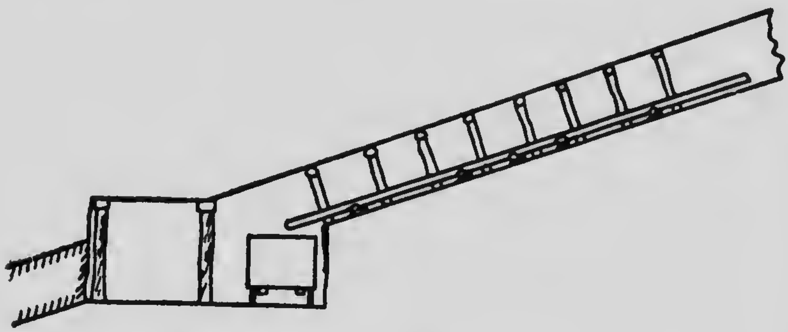
In the thin-coal longwall face, space is at a premium, and is limited in two ways, height and width, consequently, a loader has to be as low as the cutter in running. Generally, to be successful, a loader needs, therefore, to have sufficient propelling power of its own to give it at least the same progress as the wall cutter, namely, 15 to 20 inches per minute, approximately; but about double this speed would be better practice, since this would allow for any loss of time due to breakdown, and also give the machine an opportunity to exercise the reciprocating motion essential in giving the "thrust" in shovelling. Neither skids nor wheels appear very suitable to a loader; with wheels, two tracks will often be needed; while with skids progress must be in one direction, and the machine cannot back to take a special thrust forward. At best, a loader has to travel over a rough floor, hence the best possible arrangement to suit all conditions would probably be a design using either a "caterpillar," or endless chain tread. Loading for longwall purposes must be sideways to the passage of the machine, therefore, it is necessary that the machines be built as low as the regulation height for coal cutters has come to be. The thrust forward of the shovel is an important point: this should be as great as possible, consequently an engine which provides a large margin of power is much to be preferred. The actual shovelling principle is a matter of choice, dictated by the limiting space, and can doubtless be either intermittent or continuous, but another provision is imperative, namely, that its loading arrangement be such that it will raise the coal just enough to tip it over the lip of the conveyer, in order to avoid the jamming of large lumps between the roof and the machines. The second limiting factor is the width. First comes the solid coal, then the broken coal, and then the line of the conveyer. A loader therefore has to start at the end of the face, either from top or bottom; and load the coal sideways into the conveyer, while travelling forward in its own path. There is no room for any other method of operation.

A machine wall may produce from 150 to 300 tons of coal lying in one straight line, so that loading becomes a continuous operation. Considering that filling by hand gives about 6 tons per man, per hour, under coal cutter conditions, whereas the loader could average 20 to 40 tons per hour, the whole face can easily be cleaned up by the one machine and two men, instead of 30 to 50 men. Not only this, but a loading machine cleans up as it goes, from one end to the other, consequently, the coal cutter can immediately follow up the loader. By this means the rate of progress, in any one section, would be very nearly doubled, likewise the output. It ought to be quite possible to obtain 500 tons per day from a 100 yard face; and this should be produced by the machine, with a squad of 50 men, bringing the tonnage up to about 10 tons per man. Given an allowance for interest and depreciation on the combinations of machines used, the cost of production cannot be otherwise than low. Further, the system has the great advantage of concentration of output, and would help to solve a pressing labour problem.

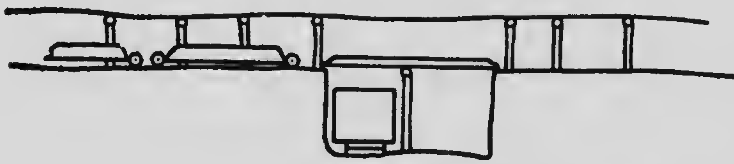
ORGANIZATION.

Organization in thin-coal mining means concentrating attention on a considerable number of factors that are quite apart from questions relating to the efficiency of the various machine types. It is one thing to choose successfully the best type of appliance, it is another to get it properly running in the mine, and in addition, to get the maximum return therefrom.

Formerly, when hand mining in longwall faces was the only practice, and operations possibly appeared more leisurely, they nevertheless were performed in accordance with the standard of speed then set up, namely, the amount of coal turned out per man per day at the face. The management of those days knew that if there were so many men at the face producing coal, there would be required so many other men on haulage; so many on repairs; so many on timbering; and so many performing other duties. The introduction of machines has set up a new and faster standard, hence, if thin-coal mining is to be a success, all work, from the face outwards, has to conform to this increased speed of production. This means, that the mere installation of machines to mine the coal is not simply a question of starting the machine to work, but it also involves a study of handling methods, from the face to the cars. Contrasted with hand mining methods, there is from a modern machine face, three to four times the amount of coal coming "out" by the same roads, to be handled by the same or improved appliances; and conversely, three or four times more supplies requiring to be taken "in" against the increased outward traffic, and to be used without interfering with the work, or causing loss of time. All this demands well planned organization.



(a) Level and dip working with swinging conveyer.



(b) Conveyer cars and road bridge on centre arranged section.

Fig. 9.

To attain the best possible results, it is of primary importance that all calculations and arrangement should be based on the performance of the weakest link in the system, and that the weakest link must be an actual part of the machine mining at the face. All machine mining means continuous production at higher pressure, hence it is useless to spend time, thought, and trouble in an endeavour to create perfect operation at the face, if there is some point along the haulage ways where, as the coal goes outwards, the output becomes restricted through inability to handle the cars, or for some other reason. In some mines—shortly after twelve in the day—there is such a spot, where it is common practice to find, daily, all the available underground labour concentrated in a vain endeavour to push the output through by sheer man power. The process resembles trying to rush a flock of sheep from one field into another through a narrow gateway only capable of passing one animal at a time: the consequence being, that there is an immediate jam.

Where, however, the work is based on the weakest link—whether it be the cutter, or the conveyer, or the loader—the other operations are then in a position to be tuned to proper co-ordination. A cutter has not, usually, a great deal of time to spare, therefore, a stoppage from outside causes, such as the previous day's coal not being loaded away, certainly means the loss of that night's cutting shift, and the next day's coal, which means a considerable increase i cost. A few such occurrences each month will soon smother all the profit there may be in the mining of the coal. Smooth, steady operation has to be maintained. A cutter making good time cannot afford to wait for a timber supply; but a good timber supply can afford to wait on a mishap to the cutter, with less loss in the operations generally.

Time Schedule.--

A time schedule properly thought out, and arranged on a liberal basis is a considerable help. In the first place, it impresses on all concerned the necessity of having every part of the operations finished on time, as against the condition of affairs whereby a timber supply dawdles in during the morning, when loading has commenced, and time cannot be spared to do the timbering work; and in the second place, it helps to fix responsibility. A successful machine section is built up on a series of separate, but independent efforts; hence, where there is constant grumbling, and repeated blaming of some other part of the work for delays, or where men have to be taken from other work to chase car supplies, or to do special track work, such a section can only be transformed into proper working order, by adopting a system of time allowance for each part of the work, and insisting that the particular operation be commenced and finished within a specified number of hours. Of course, the time allowed must be liberal. There are many cases of delay that are incidental to the work: stoppages which are not caused by any want of thought on the part of workmen or management: such as a power failure; a piece of extra bad roof; or a band of "sulphur balls" in the cutter path. Allowance has to be made for these possibilities. But such matters as no machine oil, no timber, or no mine cars, should not be passed over lightly. A bonus system is sometimes a considerable help toward keeping schedule time; but requires to be very carefully worked out, and keenly watched when in operation.

Preparation of the Workings.—

As the conditions which prevail under hand mining are, in the majority of cases, quite unsuited to machine work, the workings must be properly prepared before commencing. Everything possible to expedite this should be done, since, with machines, a certain amount of work has to be performed within a definite time. The men must be well placed, and know exactly what is required of them. The roads should be short, and well graded, as about three times the tonnage has to be handled without fail under the new conditions. If regularity is not maintained, a loss of a night's cut is the usual penalty, and a succession of such defaults will soon make the machine a costly innovation. Supplies should be carefully attended to, and not stinted in any way—especially at the beginning. They should be stored at certain central spots, but always under the official eye, and a list kept of what is needed, and how often. All this data, carefully prepared, means a saving in the future.

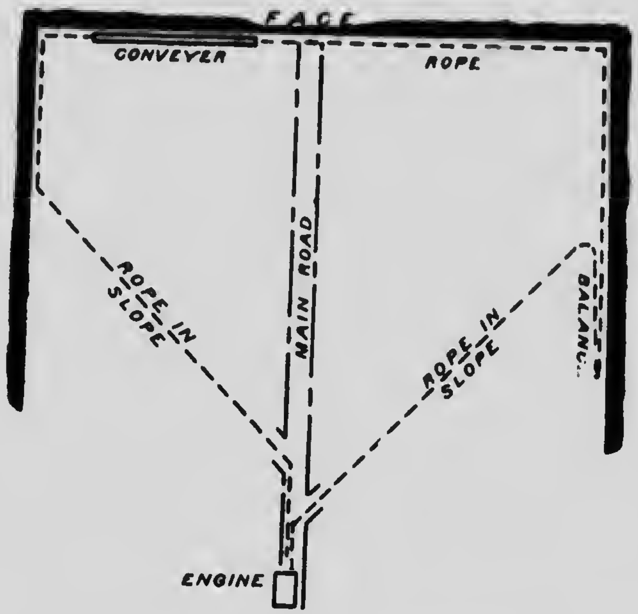


Fig. 10. Rope arrangement, with intermittent conveyer.

Opening out Machine Walls.—

Opening out machine walls, if done by hand, is slow and tedious work; but in modern practice the machine itself is frequently used in carrying a short machine wall to the dip, or across the inclination in any direction. In a face to the dip, one end of the wall should be in advance of the other, so that any water made will gravitate to one point in the workings. By making the machine operate with a deep cut in these short opening out walls, the coal is easily broken down, and a considerable tonnage results. In a level seam, where cutting can take place practically in any way—as far as inclination is concerned, any machine face is a development to another; while in panel work, working out the panels automatically lays out the wall.

Working Operations.—

The usual practice is to undercut at night, the coal being filled during the day. Machines can cut two ways: back and forward each alternate night, over a certain length of face, or only in one direction, the machine being run at the end of the shift, from one end of the section to the other.

This latter operation causes a waste of time, and is an awkward and costly method, and is seldom applied, except in mining thick seams, where it takes more than one shift to clear away the coal. In some collieries, where conditions are good, as many as five cutters follow each other in regular succession over one long face.

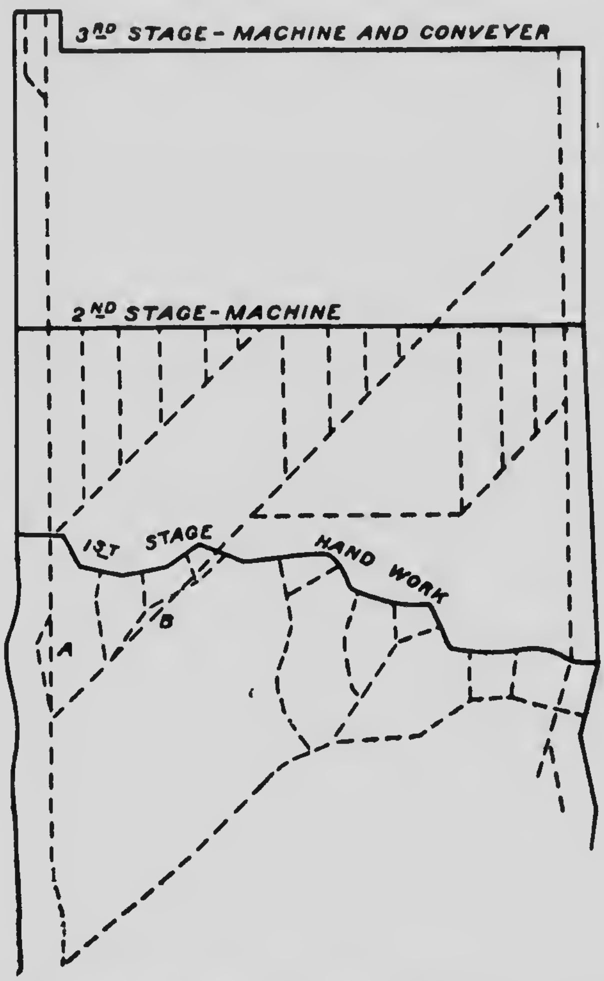


Fig. 11. Three successive stages in the longwall development of a thin-coal coal 28 inches. (Roads made straight at points A and B.)

Loading, and conveyer work, is done by the day shift, and after the coal is cleared away should come the timber and repair shifts. At night, the conveyer is shifted forward, or run into the section again.

Working the Machine.—

The operating of any cutter should be under the care of intelligent and steady workmen. In the past, there has probably been no type of machine subjected to harder usage. The machine-operator should be able to make slight repairs, and keep the cutter in good running order. Their shift should start at least an hour before cutting commences, in order that all details be well overhauled. When the machine is running the operator's duties are to guide and control its movements. The man behind attends to the power connexion, the cleaning out of the small coal, and the setting up of the pro[illegible] Generally speaking, it pays to provide special timber men, whose [illegible] of timbering the machine run, in advance of the machine, and [illegible] should commence at least four hours before coal cutting operations [illegible] Where the work of the coal face is divided like this into piece work [illegible] become more expert at the portion of the task assigned to them [illegible] the general efficiency rises, all of which tends to the success of [illegible]

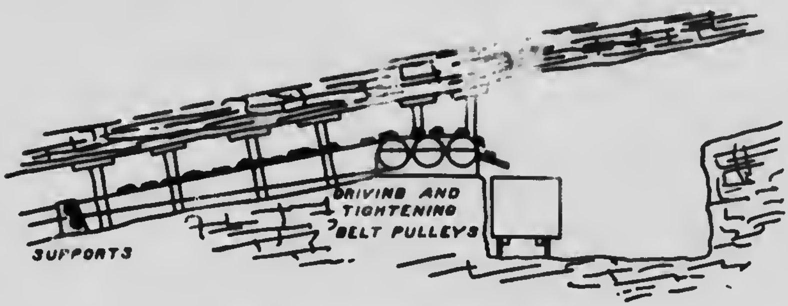


Fig. 12. Belt conveyer coming uphill.

Regular progress reports should be made by the machineman, day by day; stating the time lost, and giving reasons for the delays. These reports form a valuable means of comparison and control.

Holing.—

As a rule, holing is done in the bottom of the seam, for the same reason that the miner undercuts there, namely, taking advantage of the roof weight. Holing in any dirt band that may underlie the coal is not always advisable, as it sometimes leads to trouble in filling, and except in very thin seams—where height is a consideration—holing is best done in the coal. Certain conditions, such as a band of bad coal, or a soft clay higher up in the seam, may cause holing to be done there; but care should be taken that the portion below the holing has a good parting from the floor, otherwise trouble will result in lifting this pavement coal. Holing in the coal, in thin seams, cuts down the proportion of marketable product considerably. If there is a dirt band under the coal that can be cut by the cutter, it is a saving to do it there.

Depth of Undercut.—

The depth of undercut is a matter of experience and opinion, and is mainly governed by the best depth at which the coal will break easily, yet not too readily, so as to avoid any breakage of the coal at top of the machine.

Height.—

The question of height is of great importance when mining thin seams. Where the thickness of the seam gets down to 18 and 20-inch sections, every inch in height counts. By using skids or flats, a few inches is gained over wheels. With thin sections the cutting ought to be kept at the pavement, since any coal left has to be afterwards lifted, in order to maintain the height, thus causing extra work. In using coal cutters in thin seams, provision should be made for any likely decrease in section. Cutting under the coal also gives a few inches. Where thin-coals have to be cut above the coal, the conditions are, usually a seam that lifts easily from the pavement, and a shale band immediately above the coal, which cannot be held up, but has to come down in the course of operation.

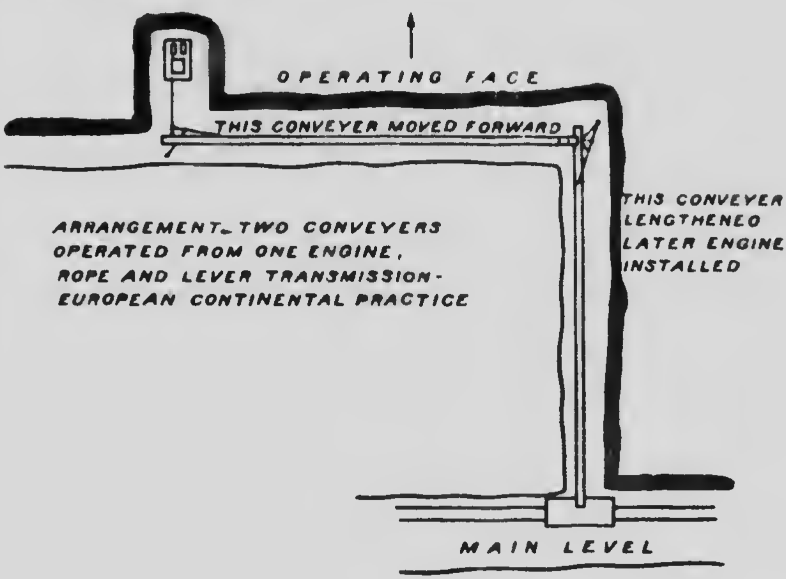


Fig. 13.

Operating.—

In getting ready to start cutting, the coal face from end to end should be as straight as possible. Usually, however, a longwall face gradually assumes an almost semi-circular form, and where the outlet road of the section is in the centre, this form suits just as well, although it is apt to cause falls in the roads, owing to the tendency of the lines of roof pressure to converge. A straight line face permits of the weight being more evenly distributed, and brings down the coal in a regular manner. There are seams where the pressure can be regulated so as to allow the coal to fall, without blasting, a few yards behind the machine. Timbering should also be regular, each prop being a measured distance from the coal, and from the next in line.

With conveyers, a straight line face is a necessity, just as much as a straight road is to a haulage system. In commencing loading, a plentiful supply of cars means a "non-stop run."

Direction of Working Face.—

The direction of the working face is mainly determined either by the inclination, or by the cleat of the coal—where extra well developed. In the majority of cases, however, undercutting by machine is independent of the advantage of cleats, owing to the use made of the roof weight. Usually, a machine is run on the dip and rise, but it sometimes happens that at right angles to this—if not too steep, or any angle between the two—the coal may break out easier in large blocks, and so reduce the small coal to a minimum. Where holing is done over the coal, the cleat of the coal has a very great bearing on the lifting of the coal. Cleats well developed, and parallel to the line of the coal, will allow lifting in about a half to a quarter less time than cleats at right angles to the face.

Loading the Coal.—

Steady men should be employed to work as loaders, and provision should be made to always have a reserve of men upon which to draw. Loading should commence either in the roadhead, or at specified distances apart, by a breaking in shot, and after that work continues filling out each way. The space allotted to the pair of men, should only be what they can reasonably handle; and in the seams of 30 inches, 15 yards is enough—the thicker the seam, the shorter apart the distance of the roads. The economic success of a machine section depends not so much on the length cut, as on the regularity of cutting, hence the importance of stripping. But with a conveyer loading, it does not take so long a time, consequently, either the length of the face can be increased or a deeper undercut made, thus getting more coal.

The Length of the Face.—

The amount of coal to be stripped off chiefly determines the length of the wall, together with the time that can be given to doing it. Where a machine cuts the coal every night, the length must be such, that there can be no doubt about the coal being cleaned away, rapidly, in the following dayshift. What is sometimes called, back, or after strapping, is to be avoided, and sometimes too long a wall leads to waste: much coal being thrown out of the way, to allow the machine to proceed on its next cut.

Inclination.—

The amount of inclination of a seam has, so far, proved no disadvantage to the coal cutter, and machines are at work in seams dipping as high as 40 degrees. Under these conditions, working to the dip and rise of the seam is a necessity, while the machine, instead of having a haulage rope on the down run, will require a brake rope in its place. If working across the inclination is attempted, the machine either has to be well propped up to its work—which is not an easy matter—or, if cutting down, it is apt to bury itself in the cut. Inclination presents no difficulties in the way of a conveyer; instead it simplifies a power-driven contrivance into a series of plates or troughs.

Timbering the Run.—

The timbering of the run depends on the nature of the roof, slips and strength of the coal. About four to five feet is needed for the passage of the machine; and in the next line, two feet for the conveyer. A line of props outside this is sometimes not sufficient to hold the roof; in that case will be needed either a row of props in the path of the machine—which are withdrawn and reset as the cutter passes —or else a set of straps will be required.

The timbering of the whole section, is, generally, a matter that only experience, in each case, can determine. Conveyer working does not make a large quantity of stone for waste packing in average seams, and consequently, pack walls at intervals along the face are necessary. These may be either of stone—brought down on purpose, or of timber, or of both combined. Some roofs will stand on props alone, for the time required, and then fall in regular breaks like the coal from undercutting. Where this can be done, it is a very satisfactory practice. Timbering work should be undertaken by special men employed for that purpose. They should commence work before the machine starts, and should keep ahead as it advances. Timber, cut to the size and shape desired, should always be kept plentifully in the section.

Shifting the Conveyer.—

Shifting the conveyer is a nightly operation, undertaken every night, following the wake of the machine. As most conveyer machines are built on the sectional plan, the conveyer is shifted, part by part, behind the cutter, ready for next day's loading, and in the path that the machine has travelled. There are conveyers which are withdrawn from the section each night, and these are not reinstated until the cutting machine has finished its cut.

Haulage Arrangements.—

Haulage systems should be placed right at the loading head of the conveyer, and should be adequate to take care of the increased number of cars that must be handled. A double roadway is required at the conveyer head, and there should be ample space to allow for the shifting of cars from the empty road to the filling road, together with space allowance for storage of an extra trip.

COSTS AND DATA.

Costs will always form an interesting part of the problem of working thin-coals; but the cost data gathered apply only to particular operations —since no two cases can ever be alike. Therefore, the figures and data given herein can not be used for the purpose of comparison, but can only be taken as examples of what can be done, and as showing the advantages to be gained from practical methods of mining thin-coals under the conditions described where enterprise and efficient management go hand in hand. The figures are taken from various sources: some from personal experience; some furnished by mining friends; and others from published data in numerous technical books and trade journals; but all have been collected together as bearing on the mining of thin-coal seams, and as being the common heritage of an engineering business, which must of necessity keep itself abreast of the changes demanded by continually altering conditions.

General Data for a reasonably good example of Thin-Coal Work.

Thickness of seam	20 inches.
Roof	Hard shale.
Pavement	Stone.
Water	None.
Dip and rise	1%.
Sections	Working across dip.
System of operation	Longwall with conveyer and machines.
Coal areas	Held under lease.
Royalties	9c per ton.
Duration of lease	30 years, with yearly tenancy; conditional on whether mining operations are properly conducted, or not. Judgment of this in arbitrators' hands.
Area	1 square mile.
Total tonnage	1,600,000 tons.
Allowances, for bad coal and other losses	15%.
Workable tonnage	1,376,000 tons.
Minimum yearly tonnage	50,000 tons.
Output	200 tons per day.
Life of area	27 years.

Underground Data:—

Number of shafts	Two.
Depth of shafts	100 feet.
Distance to line of face	600 feet.
Number of sections	Three.
Length of sections	300 feet.
Tonnage per section	71 tons.
Undercut	Longwall machine.
Type of machine	"Chain."
Time	At night.
Loading	By conveyer.
Type of conveyer	Continuous chain.
Length of undercut per night	200 feet.
Depth of undercut	3 "

Number of men in mine at night:—

Machine	6
Timbering	6
Shifting, conveyer and face repairs	8
Repairmen	3
Shaftmen	1
Surface	1
Overseeing	1
	26

Number of men in mine by day:—

Management	2
Office	2
Loading	44
Tramming	6
Hoisting	2
Surface	2
	58

Total number by day	58
Total number by night	26
Percentage of men in mine at night	31%
Percentage of men in mine by day	69%
Tons per loader	4·5
Tons per man employed underground	2·6
Tons per man employed at mine	2·4
Annual tonnage per man underground	1115
Annual tonnage per man employed	650
Length of conveyer	300 feet.

Number of men on conveyer................1 attending, 14 loading.
Loading.................................Into cars at foot of section.
Section kept in advance of longwall face.....50 feet.
Width of road at conveyer head............12 "
Depth of pavement lifted at roadhead.......3 feet 9 inches.
Height of cars...........................3 feet from rail.
Capacity of cars.........................15 cwts.
Tramming system.........................Locomotive.
Weight of engine........................$3\frac{1}{2}$ tons.
Cars per trip............................12
Tons coal per trip......................... 9
Speed.................................. 5 miles per hour.
Time taken round trip, to shaft............30 minutes allowed.
No. of miles per day......................16 miles.
Ton miles per day........................3,200
Time hoisting.......................... 4 minutes.
Cars per wind........................... 2
Total weight per wind.................... 2 tons.

Cost Data:—

	Per ton.	Percentage	
		Underground	Total.
	$		
Cost of undercutting	0.12	10·8	7·4
" loading	0.56	50·9	34·5
" conveying	0.07	6·3	4·3
" timbering and repairing	0.15	13·5	9·2
" shifting conveyer	0.06	5·4	3·7
" tramming	0.08	7·2	5·0
" overseeing	0.02	1·8	1·2
" supplies	0.05	4·5	3·1
Total underground cost	1.11	....	...
Cost of hoisting	0.03	....	2·4
" surface work	0.04	....	2·5
" management and office	0.11	....	...
" supplies	0.05	2·3	3·1
" royalty	0.09	....	5·5
Depreciation on surface plant at 10%	0.03	....	2·4
Depreciation on underground plant at 20%	0.08	....	5·0
Insurance	0.02	....	1·2
Interest on capital	0.06	....	3·7

Percentage underground cost of total cost.............................. 67·8%
" surface cost, of total cost.............................. 14·2%
" overhead charges, of total cost.............................. 17·2%
Average wage of loaders.............................. $2.52
" " per man underground.............................. 2.70

Capital Data:—

	Total.	%
Boiler plant	$2,735	7·0
Power plant	6,250	15·5
Hoisting	2,512	6·5
Surface equipment	1,500	4·0
Shaft sinking and development	2.110	5·5
Coal cutter and equipment	6,210	15·5
Conveyer and equipment	4,560	11·0
Cars and track equipment	6,352	16·0
Locomotives and equipment	3,980	10·0
General stores and sundries	2,501	6·5
Wages for 5½ months	1,100	3·00
Land purchased	260	0·75
	$40.070	

	Per cent.
Percentages capital: power plant	22·5
" " total surface plant	39·5
" " face machinery	26·5
" " total underground	61·0
Nominal capital	$50,000
Capital per ton of annual output	$1 per ton.
" " coal in ground	3c "

Profit Data:—

Capital	$50,000
Average price received for coal	1.80
Cost per ton of coal	1.62
Profit per ton of coal	0.18
Income per year	9,000
Percentage return on capital invested	18%

Cost of Three Separate Machine Walls, in the same Mine.

20-inch coal, longwall machine, no conveyer.

	No. 1.		No. 2.		No. 3.	
	cts.	%	cts.	%	cts.	%
Cutting	15	15·1	18	21·4	18	20·9
Cleaning after machine	2	2·02	2	2·5	4	4·6
Stripping face and loading	56	56·5	42	50·0	46	53·50
Handling rock	26	26·3	22	26·2	18	20·90
	99		84		86	
Tons per day from section	53		50		30	

Four months successive working in one Section.

	cts.	cts.	cts.	cts.	%
Cutting	8	10	11	9	4·2
Stripping face	61	61	61	61	28·9
Handling rock	26	21	30	22	10·4
Labour, surface	36	30	31	26	12·3
„ below	24	20	26	22	10·4
„ extra	10	10	10	11	5·2
Timber	10	12	11	10	4·7
Repairs	16	17	15	16	7·4
Management	6	6	6	6	
Royalties	14	14	14	14	6·6
Sundries	14	16	14	14	6·6
	$2.25	$2.17	$2.29	$2.11	96·5

Tonnage from section	40	37	32	39
Thickness of coal	18"	18"	18"	18"

Price received per ton of coal = $2.25, average.

Little profit in this operation. There is much rock to handle, and the mine is badly arranged, as shown by the high above and below ground labour charges. Face conditions were good.

Comparative Cost of Hand versus Machine Coal cutting.

(Results of data kept at mine installing cutters.)

Conditions.	Hand cutting.	Machine cutting.
Thickness...........18 Tonnage............200 Additional capital expended in installing cutters............$11,000 Power—compressed air. Fuel for coal cutting, machinery, half consumption. Mining conditions good.	Cost per ton,......$1.12	Cost per ton machine, 0.76 Extra stone handling incurred............0.04 Compressor attendance.............. 0.02 Smith for general repairs.............. 0·01 Stores, coal cutters.... 0·04 Fuel, 1,596 tons, six month at $1.08...... 0.08 Interest, 6 months at 5% on $11,000..... 0.01 Depreciation at 7½% . 0.015 $0.975

Balance in favour of machine cutting = 14½ cents per ton.

Face cost: Figures attained in 30" Coal.

	By hand.	By machine.	By hand, and machine.
	cts.	cts.	cts.
Cutting		14 — 16% } 61	14 — 20% } 70
Stripping and loading	70 — 70%	40 — 45% }	35 — 50% }
Rock handling	12 — 12%	14 — 16%	6 — 8%
Timbering	8 — 8%	10 — 11%	6 — 8%
Sundries	10 — 10%	10 — 11%	4 — 6%
Shifting conveyer	....	....	6 — 8%
	100	88	71

Costs in some thin-coal sections.

	1	2	3	4	5	6
Output per day....	50	100	180	120	100	50
Length of wall....	—	—	250 yds.	—	—	—
Thickness........	19″	36″	24″	36″	29″	18″
System...........	Longwall.	Longwall.	Longwall.	Longwall.	Longwall.	Longwall.
Method..........	Hand.	Machine.	Machine.	Machine.	Machine and conveyer.	Machine and conveyer.
Costs:—						
Mining...........	1.24	0.68	0.53	0.41	0.48	0.51
Rock handling....	0.31	0.24	0.12	0.10	0.05	0.10
Labour surface...	0.29	0.14	0.07	0.09	0.04	0.06
„ below...	0.20	0.14	0.10	0.09	0.05	0.05
Tramming........	0.05	—	0.06	0.08	0.05	0.05
Power production.	0.10	—	—	—	—	—
Timber,	0.07	0.06	0.06	0.02}	0.06}	0.05
Rep'rs and supplies	0.05	0.02	0.05	0.04}		0.05
Management......	0.10	0.12	0.10	0.08	0.04	0.06
Royalties.........	0.08	0.10	0.10	0.07}		
Sundries..........	0.18	0.20	0.09	0.03}	0.18}	0.16
	$2.67	$1.70	$1.28	$1.01	$0.95	$1.04

No. 1.—Isolated region; unsettled labour; living costs high; good roof.
No. 2.—Medium to fair conditions; high labour charges; poor lay-out.
No. 3.—Rock heavy; other conditions good.
No. 4.—Mine laid out for work; conditions good.
No. 5.— „ „ „ „ „
No. 6.— „ „ „ „ „

Comparison of men in machine wall only, and machine wall and conveyer sections.

(Labour and cutting force—excluding loaders).

Conditions.	Machine wall.	Machine and conveyer.
Coal–33″		
Length of face 600 feet.	8 timbermen.	8 timbermen.
Number of machines—2	6 machinemen.	6 machinemen.
Grade, 5% against cutter	2 stowing cuttings.	2 stowing cuttings.
	10 labourers.	6 labourers.
Timber: props and half-round cap.	30 stonemen.	6 stonemen.
Distance, every 4 feet each way.	2 firemen.	2 firemen.
Tonnage, 300 per day	1 overman.	1 overman.
Number of roads = 18.		2 conveyer attendants.
Tons per road with machine only 16·6	—	—
Tons per road with conveyer—300 on one road, two additional roads for ventilation.	59 —	33 —
Roads after bushing, 10 feet bottom, 7 feet wide, 6 feet high.		
Main road conveyer method; 12 feet wide, 3 feet lifted pavement.		
Reduction in labour—44%.		

Theoretical labour reductions that might be expected through introduction of a Loader.

Conditions.	Machine wall only.		Machine and conveyer.	Machine, conveyer, and loader.
Same as table above.	Labour	59	33	38
	Loaders	58	52	6
		117	85	44

Timber in Machine Walls.

Conditions.	Tonnage (10 days)	Timber (10 days)	Valued at each.	Total
			cts.	$
Same as previous table.	3,600·12	Props, 3 ft. × 3 ins–4,908	2·8	141.36
		" 3¼ ft. × 3 ins– 808	3·1	25.50
Roof poor, machine sometimes buried.		" 5½ ft. × 5 ins–1,668	8·5	141.96
(3 nights in one week).		" 7 ft. × 5 ins– 92	16·3	15.00
		Booms, 12 ft. × 6 ins– 12	9·3	11.18
		Ties 5 ins × 2 ins– 120	4·8	5.76
		Lids, — 4,500	0·4	19.80
				360.76
		Cost per ton, 10c.		

Time sheet of machine operations taken at a colliery, two months after installation.

Conditions.	Started.	Stopped.	Length of stop.	Reasons.
Thickness = 24″	Arrived face 7 p.m.		80	Getting machine ready.
Roof—moderate with bad patches.	8.10	8.15	6	Shifting stone.
	8.21	8.30	7	Setting timber.
	8.37	9.00	25	Shifting cable.
Distance cut = 300 feet.	9.25	9.40	40	Waiting for timber.
Speed cutting = 20″ per minute.	10.20	10.31	31	No power.
	11.01	11.26	30	Waiting for cutter bits.
	11.56	12.00	15	Shifting cable.
Depth undercut = 3′–0″.	12.15	12.45	15	Changing cutters.
	1.00	1.30	20	No power.
Length of cutting shift = 12 hrs.	2.00	2.10	10	Bad roof.
	3 10	3.20	60	"
	3.25	3.35	5	"
	3.40	3.50	5	Waiting for timber.
	3.55	4.00	9	Shifting cable.
	4·09	4·30	6	Waiting for timber.
	4 36	5.00	25	No power.
	5.25	6.50	10	Disconnecting cable, and attending to machine.
	Left face 7 a.m.			

Analysis.

		Percentage.
Actual cutting time	5 hrs. 19 mins.	43
Total time stopped	6 " 41 "	56
Time stopped for work in connexion with machine	1 hr. 14 "	10
Time stopped for natural causes in face	18 "	—
Time stopped waiting for supplies, and want of power	2 hrs. 17 "	19

These reports and their analyses form the greatest possible argument for efficient organization.

Time sheet of conveyer working; taken from actual operations. Continuous Conveyer.

Conditions.	Started.	Stopped.	Length of stop.	Reasons.
			minutes	
Thickness — 25"	7.00	7.15	....	....
	7.30	8.05	15	No cars.
Roof—good.	8.30	8.40	25	Chain rising on small coal.
	9.10	9.22	30	No cars.
Length of conveyer—270 feet	9.30	10.06	8	No coal.
	10.15	10.31	9	"
Tonnage, daily—80.	10.45	11.00	14	Trouble with motor.
	11.31	12.10	31	Chain rising on small coal.
Capacity—20 tons per hour.	12.35	1.15	25	No coal.
	1.32	2.00	17	No cars.
	2.30	2.43	30	No coal.
	3.00	3.15	17	"
	3.20	3.35	5	"
	3.50	4.00	15	"
	Coal all cut		241 mins. = 4 hrs. 1 min.	

			Percentage;
Analysis.— Total time actual running =	4 hrs.	59 minutes.	55
" standing =	4 "	01 "	45
Time standing, due to conveyer troubles,		70 "	13
" " " want of cars,		62 "	12
" " " " coal,		127 "	24

Per cent idle time for coal, points to mechanical loading.
" " " cars, points to better organization.

Table of some Coal-Cutter Performances in Thin-Coals.

Number.	1	2	3	4	5	6
Thickness of coal	39"	18"	19"	16"	24"	22"
Thickness of dirt	nil	3	nil	nil	—	—
Inclination of seam	5°	nil	nil	nil	1°	5°
Condition of roof	good	good	Fair, but troublesome.	fair	good	poor
Position of undercutting	Pavement.	Pavement.	Pavement.	Bottom.	Bottom.	Bottom.
Nature of undercutting	Coal.	Coal and clay.	Hard coal.	Coal.	Coal.	Clay.
Length of walls (feet)	600	450	420	420	300	660
Distance between roadways (feet)	45	45	45	45	48	51
Number of fillers, per place	4	2	2	2	2–3	2
Coal per filler (tons)	4–6	2½	..	..	3.75	4½
Time cutting (hours)	8	10	11	12	9	8
Time stripping	8	8	8	8	8	8
Depth of undercut	3'–6"	3'–0"	3'–6"	3'–0"	4'–0"	3'–0"
Speed cutting	12"	23"	16"	13"	18"	15
Cut per shift	200	450	420	420	300	330
Output per shift	100	51	50	48	82	55
Face advanced per month	50 feet	76 feet	..	..	86 feet	65 feet
Output per man	4.60	2.50	2.50	2.40	3.75	2.75
Previous output	3.25	..	..	..	1.80	....

Table of some conveyer performances.

Number:—	1	2	3	4	5	6
Thickness of coal	25″	24″	21″	18″	36″	27″
Inclination	nil	nil	10°	1°	2°	nil
Conditions of roof	Good	Fair	Good	Fair	Trouble-some	Good undulating floor
Length of conveyer	300 feet	240 feet	400 feet	300 feet	300 feet	300 feet
Tonnage per day	85	50	60	50	100	60
No. of loaders	16	12	20	16	25	16
No. of attendants	2	2	2	1	2	2
Time running (actual)	5 hrs.	. .	. .	5 hrs.	10 hrs.	7 hrs.
Capacity of machine per day	200	200	20 tons per hr.	. .	30 tons per hr.	....
Operation of section	Machine	Hand	Mach.	Mach.	Mach.	Hand
Output per man	5.00	4.1	3.00	3.00	4.00	3.7
Type of conveyer	Continuous.	Intermittent.	Shaking	Continuous.	Shaking	Intermittent.
Men shifting conveyer	4	3	3	4	3	3

Table of data on roller trough conveyers.

(After European Continental practice.)

Length of Conveyer:—	35M	65M	100M	130M	180M	230M
(a) With direct drive and grades 0–12°						
(b) With tension drive in headways, slopes 0–12°	35	75	100	150	200	250
(c) Lever transmission slopes 0–8°	35	65	100	150	200	250
Slopes 18°–22°	30	50	80	120	180	230
Minimum length for motor operation	5	8	12	20	32	45
Air pressure	60 lbs.	60 lbs.	60 lbs.	60 lbs.	60 lbs.	60 lbs.
Air consumption (60 strokes p.m. 180 m.m. stroke)	200 litre	340	470	620	775	950
Horse power of motor	6·5	9	12	16	20	25
Weight of motor	190 kg.	205	260	310	395	495
Diameter of hose	28m.m.	28	32	35	35	38
Diameter of pipe	40	50	50	60	60	65

For inclinations up to 5° the girders of the roller trough are not set with the slope, for greater inclination they are set horizontal, and for inclination over 12° they are set against the slope.

Comparative cost of actual and estimated Hand and Machine Mining. Eastern Canadian Conditions: based on operation figures of a 16-inch coal wall producing 50 tons per day.

Hand mining pillar and stall.		Machine mining longwall method. 100 yds. face per day.		
	Per ton.	Per day.	Per ton.	
Undercutting	$1.46	$5.50	11¾c	11c
Stonework		2 men at $3.50 and $2.50		
Taking down fall and loading development		$20.00		
	.11	10 men at $2.00	40c	60c
Timbering and shifting conveyer		$8.00	16c	16c
Gathering locomotive, Bottomer, Handling, Bankmen		4 men at $2.00	12c	12c
		$6.00		
	.34	1 man at $3.00 and 2 men at $1.50		
		1 man at $1.75	3.5	3.5
Bankmen	.14	$3.00	6c	6c
Hoistmen		(2 men at $1.50 and $2.00)	4c	4c
Mine foreman		1 man $5.00	10c	10c
Firemen, engineer, etc.		(1 man at $3.00, 1 at $2.00)	12c	12c
		$6.00		
		(3 men at $2.00)	14c	14c
		$7.00		
Gen. sup't. and office	.22	(Sup't. $5.00 Off. $2.00)	2c	2c
		$1.00		
Depreciation		2½%		
Repairs	.01	$5.00		
		(10c per ton)	10c	10c
Timber	.12	(15c per ton)		
		$7.50	14c	14c
	$2.40			$1.74

The assumption is made that the conditions will be no worse for longwall machine than they are for pillar and stall.

General data of a Belt Conveyer Mine.

Thickness .... 24 inches.
Length of conveyer face .... 160 yards.
Belt conveyers, two .... 80 yards length each.
Delivery .... To central gate road.
Motor drive .... 8-horse-power.
Number of loaders filling in each face 5
Face yield .... 105 tons.
Average tonnage, per man .... 10, per shift.
Belt speed .... 90 feet per minute.
Class of belt .... Canvas.

Four belts renewed in one year. Tonnage carried by each:—

No. 1.	295 cuts.	39,978 tons carried at	1·24c per ton.	
" 2.	202 "	21,210 " " "	1·80c	"
" 3.	217 "	22,785 " " "	1·62c	"
" 4.	223 "	23,415 " " "	1·74c	"

Hand-mining costs in thin-coal working.

Locomotive Haulage. **Coal 18-inch.** **Mining costs only.**

Chiefly given as showing the decrease in cost due to increase in tonnage distributed over the same operating force.

Longwall.—					
Tons per day	9	18	30	50	100
Mining	·83	·83	·83	·83	·183
Stonework	·33	·33	·33	·33	·33
Loading	·33	·33	·33	·33	·33
Development					
Haulage		·17	·14	·11	·07
Weighing and handling	·34	·17	·05	·05	·03
Hoisting	·14	·07	·013	·026	·013
Timber	·29	27	·27	·27	·27
Sundries	·01	·01	·01	·01	·01
Management	23	·16	·133	·08	·04
	$2·49	$2·34	$2·136	$2·016	$1·923
Pillar and single stall.—					
Tons per day	9	18	30	50	100
Mining, Stonework, Loading	1·46	1·46	1·46	[illegible]	1·46
Development	·11	·11	·11	·11	[illegible]
Haulage		·17	·14	·11	·07
Weighing and handling	·34	·17	05	·03	·03
Hoisting	·14	·07	043	·026	·01
Timber	·12	·10	·10	·10	·10
Sundries	·01	·01	·01	·01	·01
Management	·22	·16	·133	·03	·04
	$2·40	$2·25	$2·041	$1·926	$1·833

Cost data of a Chain Conveyer Face.

Seam—30 inches.
Inclination—2%
Roof—fair.
Power—compressed air.
Machine-cut coal.
Length of face—250 feet.
Undercut—4½ feet.
Conveyer—chain.

No. of men.	Description.	Duties.	Cost per ton.	
1	Cutter man	Drives coal cutter	$ 1.96	$2.46
2	Cleaners out	Cleans cuttings out of coal, and casts them back	2.98	3.78
1	Timberman	Sets timber after machine, etc	1.48	1.90
1	Shotfirer	Drills holes in cut coal, and charges them	1.28	1.84
6	Coal fillers	Fill coal away cut by machine	10.82	13.80
1	Deputy	Charge in dayshift timbering and keeping work away	1 92	2.41
1	Supervisor	Charge in nightshift, moving conveyer, drawing timber and stoneman	2.34	3.22
2	Conveyer-head	Attending to filling of tubs and braking the conveyer	1.76	2 24
7	Stonemen	Working canches in main and tail gates and putting in packs	7.82	9.98
4	Conveyer-shifters	Move timber, and shift conveyer to face	4 56	5.82
3	Timber-drawers	Set timber and draw back timber	4.78	6.10
6	Hewers	Driving main and tail gates and making stables	9.48	
1	Putter	Putting coals from hewers	.60	
1	Mechanic		2.12	2.70
Depreciation			$ 2.36	$ 3.00
Cost into driver's set			$56.26	$59.28

Performance of three Disc Cutters under difficult Conditions.

No. 1 Cutting in a very hard fireclay, cuts on an average, 112 yards per shift. Depth of undercut 3′–5″. Actual cutting time, 4 hours and 23 minutes. Height of coal, 18 inches. Saving effected, 10c per ton.

No. 2 Cutting in coal 180 yards per shift. Undercut 3′–6″. Time, actual cutting, 4 hours and 46 minutes. Height of seam 21 inches. Saving effected, 20c per ton.

No. 3 Cutting in hard fireclay in a low seam 15 to 18 inches. 632 yards in six consecutive shifts. Total cutting time, 26 hours. Undercut 3′–6″. This seam was not workable profitably without the machine.

Approximate Costs of Cutter and Conveyer for Thin-Coal.

Prices of plant are frequently misleading, and more ornamental than useful, but in order that a general idea of the cost of conveyer and cutter may be obtained the statement below has been worked out, based on estimates received during 1912, when the cost of materials was about normal.

Coal cutters—16 to 20 inches in height.

	H.P.	Price per H.P.
Bar cutter	12	$125 approx.
Disc cutter	20	$100 "
Chain cutter	20	$ 90 "

Conveyers.

	Length.	Price per yard.
Chain	100 yds.	$15.00
Belt	100 "	$ 9.00
Shaking	100 "	$ 6.00

DESCRIPTION OF THIN-COAL OPERATIONS.

An endeavour will now be made to give a short description of some actual operations in thin-coal mining, in the belief that such examples are even more interesting than the elucidation of general principles, and, probably, easier to understand and follow. An account of actual conditions, illustrative of the various conditions under which thin-coals are being mined, and of the still greater variety of methods by which success was achieved, or failure resulted, is always of practical value.

Example No. 1.—

In the Dortmund district of Germany, as well as in the French and Belgian coal-fields, the oscillating conveyer has been very successful, and effectively developed. In 1912, 22 belt conveyers were in use, in eight pits. The flaxen or hempen belts—from 20 to 23½ inches in breadth, are carried on rollers, spaced from two to three yards apart. With a monthly output of 1,000 tons, they are found to last for about eight months. When used for other materials, they last from four to six months only. The cost of the belt conveying apparatus, including engine, for a stretch of about 110 yards in length, is given at about $875. The working costs vary considerably with the condition of the different cases: in two cases given, they were about 7 cents per ton. In fourteen pits they were discarded again. Their advantage is shown principally in the undulating seams. Oscillating conveyers are being used in increasing numbers; 630 of them were in use in the Dortmund district in 1912. The conveyers are in lengths of about three to six yards, and of various sections, trapezium shapes being now the most usual. The breadths are, in general, about 12 to 18 inches at bottom, and 16 to 24 inches over the top edges, and their heights vary from 2 to 6 inches. They comprise swinging conveyers hung from above, or from side trestles, and conveyers set on rollers. Longitudinal oscillation is kept up by motors. The free suspension conveyers cost about $3 to $3.25 per yard on the market; and about $1.56 per yard when made in the colliery. The side-trestle conveyers cost about $438 to $658 per 100 yards of length. The roller conveyers are the latest, and most satisfactory. They are arranged for downhill, level ground, and slightly uphill work, the roller paths being, in the last case, inclined against the hill. The arrangement and cost of the respective conveyers differ considerably, one from the other.

The output of the oscillating conveyer is very considerable. With an inclination of 10 to 20 degrees, one ton of coal is delivered in 45 seconds, one conveyer delivering 600 tons in a double shift. In some of the workings in the pits of the Dortmund district, the general output is five tons per man, per shift. The total cost of working with oscillating conveyers—including repairs and subsidiary expenses—is given as from 2·4c to 2·6c per ton of coal mined. The accompanying saving of wages is estimated at from 6·8c to 12c per ton. The total savings per ton on the whole of the mining operations is estimated at from 16c to 25c per ton.

By far the most interesting feature of this description of the work in foreign fields, consists in the type of conveyer almost universally utilized in thin coal-mining conditions. In one district alone, over 89,000 feet were in operation. Where there is such a length of feet in use in generally thinnish coals, there is something to be said for the method and the appliance. In a few instances there is machine mining, in addition, but not in the majority of mines.

Example No. 2.—

A Belgian seam at a depth of 1,102 feet, about 21 inches thick, dipping about 25 degrees, and having a good roof and floor, was regarded as unworkable; but owing to the bar coal cutter, it now gives a better return per ton than others where the conditions are considered more favourable. With from two to two and one half hours actual work, the machine, supplied with 500-volt continuous current, makes a cut 177 feet long, and 39½ inches deep—equal to 36 tons of coal mined daily. This is with a bar of a length corresponding to the actual cut. It is intended, however, to employ a second machine, of the same type, but with a cutter bar of a quarter greater length, which will, it is calculated, produce 45 tons daily.

Without its cutter bar, the machine—sliding directly on the floor—occupies a space measuring 8½ feet in length, by 39½ inches in width, and 16 inches in height. The working place comprises three forward stalls, 59 feet long, served by a single, self-acting incline; and the three stalls constitute a single working face of the above named length. The roads are cut in the floor of the seam; and stowing follows up at a distance of two cuts from the face. In the second cut, plates are laid on the floor to facilitate the bringing away of the coal. The complete working of the stall is performed in three shifts; the machine-cut being reserved for that of the afternoon, employing the machinemen, a second hand, a timberer, and a labourer.

As the machine is hauled forward at the rate of about 16 inches per minute, the cutter bar—revolving at 350 revolutions per minute, and making at the same time, twenty-three one inch horizontal reciprocations per minute in the direction of its centre-line—effects its cut of the above named depth, 6 inches wide in front and 4 inches at the back; the props being loosened by the impact of the machine, are taken out one after another. The machinemen's mate takes out with a scoop part of the débris made by the cutter, and draws up the cable as it is unwound by the labourer.

The ensuing shift—which can begin work before the cutting shift has finished—consists of four road-rippers and stowers, with a labourer, who is only engaged for two hours in removing the coal thrown out by the machine, and in laying the plates in the cut. It is the next morning's shift (comprising seven getters, two loaders, and three pushers or haulers) that brings down the undercut mass. After the groove is freed from what small coal remains—which is easily done with the Belgian pick—the coal, already borne down a little on the cut, is taken out, producing from 55 to 60 per cent of large, against 30 per cent only by hand work; the yield of the getter being more than four tons per shift.

To the number of hands already mentioned in the three shifts, must be added the smith, engaged for half a day in making or setting up the picks and end-cutter of the machine. The expense of electric current, machine picks and cutters, wear of cable, additional timbering, lubrication, and five years sinking fund, comes to 25c per ton. The method of long stalls adopted—which favours the ventilation—appears to be compatible with water-carried stowing, and also, in the case of insufficient dip, with mechanical conveyance of the coal.

This is machine coal cutting under rather extraordinary conditions, but it serves to illustrate the adaptability of the method. There are only a few mines in which some part of machine mining, properly introduced, will not effect a saving.

Example No. 3.—

The lower Drumgray seam in the Lanarkshire field, Scotland, is, in some mines, operated by means of a conveyer. The coal is 30 inches thick, and the conveyer in use is what is known there as the Blackett chain conveyer. The inclination is 16% in favour of the machine, and the faces advance across the dip. Each conveyer is a hundred yards long, and delivers into a main haulage road 50 feet in advance of the line of the conveyer face. Below this main haulage road, a second road is maintained, which branches off the main level, and which acts as the road into which the roof pressure breaks, and so saves the main level from the cost of considerable repair work. This lower level is cut off every 150 feet by another slope or downset. These are the only two main roads in the three hundred feet of face; ventilation being conducted by openings made through the waste packs into the level of the conveyer face above. The conveyer itself is built in pans, 6 feet long × 18 inches wide at the top, × 15 inches high from pavement, the chain—of link belt pattern—running down the pans, and returning underneath. A tightening arrangement is provided at the top of the conveyer, so that the chain can be kept taut, otherwise it is apt to rise on the top of the small coal.

In the main road the pavement is lifted to allow cars to pass underneath the conveyer, and a double track is installed; an empty and a full road. Under-cutting is done by hand, no coal cutting machines being used; while the operation on the complete face is let on contract to one miner, who provides his own labour. Since installing the conveyer the face has advanced from a rate of 160 to 260 feet per month, and the tonnage per man employed—has risen from 3·6 to 6·2.

Example No. 4.—

This example is taken from Canadian practice, in New Brunswick; and here credit must be given to Mr. C. W. Dean, of Beersville, for a very remarkable achievement, namely, the successful mining of possibly the thinnest coal seam ever worked in Canada: 16 to 13½ inches; pointing the way to consistent mining progress under better conditions. And it should be noted that this was accomplished after a number of engineers and managers from the United States and elsewhere, and representatives of companies capitalized in the millions, had discredited the field, and negatived the possibility of ultimate success.

The seam is, as stated above, very thin, and the immediate roof bad. Sixteen to twenty inches of "fall" or shale accompanies the taking down of the coal, and has to be trammed to the surface. The grade is 1%, with little water, while the mine is self-draining, and has natural ventilaton. The method of working is pillar and single stall. The distance from the mouth of the mine to the face is approximately 600 feet, and to this extent Mr. Dean is, unfortunately, limited to a belt of coal near the outcrop, since after that, the cost of hand-tramming becomes too great. This, however, is a haulage problem allied to capital, and is in no way related to any inherent natural obstacle in the coal or the coal-field itself.

The following figures are taken from the books, hence, are not estimates, but actual costs, realized over a considerable length of time. The first group covers the operation at the mine's best period, namely, immediately after the preliminary development, and when the tramming cost was yet low—the places not being too far advanced.

Period: October 1912 to June 1913.

Average profit per ton: 51·3c.

During the months of December, January, and February, the output was practically nil, and had to be hauled to the railway cars at an extra rate of 13·4c per ton.

Period: June 1913 to July 1914.

Average profit per ton: 28·8c.,

or 14·3% on the cost of re-arranging the plant, and developing a new plan of operation, tramming in the first level having compelled a change.

Throughout this period the coal was trucked to the railway cars—a distance of one-half mile. The cost figures were high, owing to not being able to haul during January, February, and March—when the railway line was closed down—and having to feed the horses during these months.

Very few operators in Canada can show like results, and yet this was done, backed by no capital, only by Mr. Dean's individual enterprise and management.

Example No. 5.—

In the Joggins field, another interesting example of thin-coal operation is being carried through successfully, at Minudie, by Mr. John S. Barton. The attractive feature to the inquiring mining engineer is not the method of working, but the character of the seams themselves, and the dip of the field at which they are worked. Four sections show the thinness of the coal and the splits of the seams, by bands of dirty coal and clay. No. 1 Victoria seam shows two bands of coal, 13 and 14 inches, respectively, separated by 12 inches of hard clay. Above the top coal there is 18 inches of inferior coal and clay to be taken down before the roof proper is reached. In all there is in the seam 30 inches of foreign material, and 27 inches of coal. The other seams, while not quite so intermixed, are, nevertheless, of the same character. There are few mines that can show such a number of what might fairly be called, and, in other fields would be called, "unworkable coals" in actual operation; and fewer companies where such coals are profitably operated.

This is essentially a case where the mining conditions as they exist to-day, designed for the thick coal operator, press hard on the thin-coal mine. Such seams as the above are thin, exist at a high inclination, and contain intermixed bands of clay, all conditions that are inimical to the best of mining work. Such conditions deserve better consideration than they now receive, and the men and the companies that contend with them deserve encouragement, and help, if need be, from the country or from the coal industry, as a whole. They are pioneers in a class of mining that will increase as the years go by, and their experience is going to be invaluable to future operators.

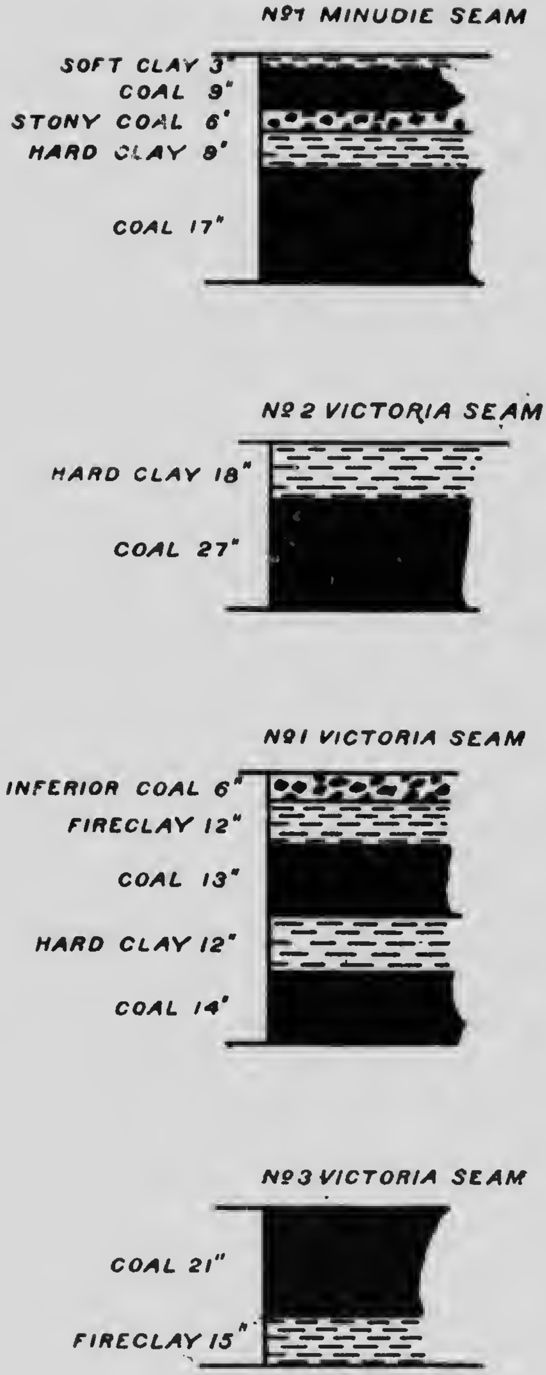

Nº 1 MINUDIE SEAM
SOFT CLAY 3"
COAL 9"
STONY COAL 6"
HARD CLAY 8"
COAL 17"
Nº 2 VICTORIA SEAM
HARD CLAY 18"
COAL 27"
Nº 1 VICTORIA SEAM
INFERIOR COAL 6"
FIRECLAY 12"
COAL 13"
HARD CLAY 12"
COAL 14"
Nº 3 VICTORIA SEAM
COAL 21"
FIRECLAY 15"

Fig. 14.

THE DESTRUCTION OF THIN-COALS.

Thin-coals are being lost to the provinces every year. The natural demand for the cheapest and the best coal, found in the thick seams which afford the greatest profit on the invested capital, cannot help but cause a steady wastage of thinner beds, whose claims to present attention are not so apparent. Sections and areas are abandoned, because it is claimed the mine does not pay, quite forgetful of the fact that, probably, actual coal extraction is profitable, but not on the capital tied up in the mine. A heavy profit is needed on an output of 200 tons a day, in order to make a return on $1,000,000. There is, in not a few cases, a distinction with a difference between a mine failing to pay, and the coal seam failing to pay.

Loss and destruction takes place through:—

(1) Operation of an underlying thick coal.

(2) Operation of an overlying thick coal.

(3) Operation of seams close together, but only working one part thereof.

(4) Extraction of thick coal only, in land areas which might provide a passage to thin-coal areas of an overlying seam.

When operation of a coal seam commences, there is equilibrium between the roof and the pavement. There is potential pressure, but it cannot become active. Immediately extraction begins, this equilibrium is disturbed, and movement of the strata commences. Based on mining

Fig. 15. Diagram illustrating the wave-like effect produced by subsidence, as distinct from the step-like effect of faulting. Wherever each layer about a seam has great adherence this wave-like change occurs.

experience, efforts are made to counteract this initial movement, and to bring the strata to rest in a secondary, or artificially induced state of equilibrium. The use of timber and other supports, and the adoption of suitable methods of mining, are the means to this end. But years of experience have shown that movement of the strata, once begun, cannot be arbitrarily arrested; it is only temporarily stopped, and within certain limits, brought under control. In seams where the movement gets beyond the provision made for its guidance, the coal is considered unworkable from roof trouble.

Where there is a leasehold system of coal operation, carrying with it responsibility for surface damages, the subject of roof trouble has been carefully studied; and it is largely from experiment and observation in such coal-fields, that our present knowledge has been obtained. But it has to be remembered that surface subsidence represents results at the extreme end of a line of fracture; the point where, naturally, the least change will be apparent. The nearer to the scene of the disturbing operation, the greater must be the displacement of the overlying strata; moreover, the rate at which the amount of displacement decreases upwards is not regular, but depends on the condition of the intervening strata. Consequently, there can be cases of underground operation where little depression is ever noticed on the surface but where the maximum damage may be done to the overlying coals.

This is conceivably the case when it is considered that the gradual extension of the break towards the surface is a "filling in" process, each rock or stratum occupying the position of the one below; and since rock breakage varies not only according to the type of rock but also in relation to the character of the fracture, the amount of space decreases rapidly, or slowly, as these factors operate. One or two examples, showing the actual measured results, will make the general principles clearer.

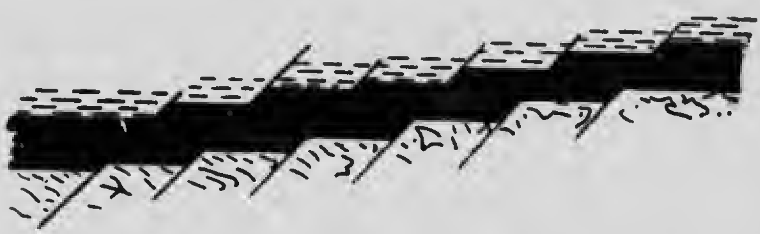


Fig. 16. Exaggerated effect on strata which is blocky: indicating successive advances of the face, and showing fault-like results. Most destructive shattering of roof and coal.

Some extremely interesting and pertinent results have been given in a paper by Karl Balling, somewhat freely translated as below:—

In a brown coal mine in Northwestern Bohemia, the pillars supporting a surface railway waste much coal. Where the depth from the surface to the roof of the seam is 984 feet, the pillars must be at least 380 feet wide, and 475 feet, if the depth be 1,246 feet. With the present system of working by short stalls, 17 cubic feet, or 0·549 ton of brown coal are removed per square foot of mine area (5·2 cubic metres or 6 tons per sq. metre) Thus, the quantity wasted per mile of railway on both sides of the line, , in round numbers, 2,200,000 tons (5,280 feet × 2 × 0·549 ton × 380 feet) to 2,700,000 tons.

Successful attempts have been made to rob the coal in the pillars below the light railways serving two of the collieries; and observations have shown that under certain conditions, coal in pillars under passenger railway lines, can also be safely removed. The coal was taken out in 1898–1899, and the subsidence of the ground has since been carefully noted, and its extent determined twice a year. Along the track of the railways, the subsidence takes place gradually, with no sudden changes of level. The mean during a month is 4½ inches or 0·15 inch (3·8 millimetres) per day. From July 1900 to March 1902 no subsidence was observed over a part of the line. Along a distance of about 1,080 feet the subsidence in 2¾ years varied from 11 to 2 per cent of the total subsidence observed over a distance of 3,280 feet, (1 kilometre) from 1897 to 1903.

In the Wilhelm colliery, the robbing of the pillars ended in 1899, and the last observations were made in 1903. The thickness of the strata above the roof is 1,266 feet. The quantity of coal removed varied from 18·2 to 18·5 cubic feet per square foot of mine area. Observations were made along the railway line at points 164 feet apart. In December, 1897, the distance of the working-face from the railway-line varied from 223 to 49 feet. Subsidence caused by shrinkage of the ground was now first noted. From December, 1897, to September, 1898, the rate of subsidence at seven points gave an average of 3·6 feet. From this date the subsidence was due to the removal of coal directly under the line. From September, 1898, to April, 1903, the greatest subsidence at any one point was 3·9 feet, and this in the writer's opinion should be taken as the mean. Of this, the greater part, 3 feet, subsided during the first two years. In many short stall workings, when the intermediate pillars can no longer support the weight of the roof, they give way, the rock falls up to the diluvial strata and a hollow is formed at the surface. The more rapidly the coal is got out the less is this danger, because the area of broken fragments increases more rapidly than the cubic capacity of the space from which the coal has been removed.

Assuming, as in this mine, that the rock above the roof is 1,246 feet thick; the diluvial strata, 19·68 feet; the angle of repose of the broken fragments, 86 degrees; the coefficient of increase, 3½ per cent.; and that the floor of the working is rectangular, and the length of the shorter side, upon which the maximum pressure of the rock falls, 372·28 feet; 18·37 cubic feet of coal being removed per square foot of mine-area. All the coal in the pillars having been wrought, there will be a large space into which the broken fragments will fall, in conformity with their original angle of repose. The rock may fall up to the diluvial strata, if the shorter side, S. of the rectangular floor is approximately equal $4h_2$ cot B (h_2, being the thickness of the rock up to the diluvial strata), and if the cubic capacity of the space from which the coal has been removed on the side S_2, is greater than $0{\cdot}7854 \times (S_2)^3 \times VC + \cot B$; VC being coefficient of increase of the falling fragments. The writer works out the formulae numerically, and proves that with these values the falling in of the rock may reach to the diluvial strata. There will then be 10,350 cubic feet of space left, which will be filled by the diluvium falling in, and a hollow will be formed at the surface, the depth and circumference of which will depend on the gradient and coefficient of increase, and the cubic capacity and consistency of the surrounding rock. As a rule these hollows are slowly formed.

The above values of the angle of repose and the coefficient of increase apply for thicknesses of the rock above the roof varying from 684 to 1,246 feet. If no hollows are formed the ratio between the coal won per square foot of mine area and the thickness of rock may be reduced.

Instead of 18·368 cubic feet there may be (18·37—[10·350 ÷ S_2], or 10·350 cubic feet +138,613 square feet) or 18·29 cubic feet or a ratio of 1 to 68. This gives 9–61 cubic feet with a thickness of 656 feet of rock, and 19·25 cubic feet with a thickness of 1·312 feet. The total thickness of the seam of coal being 65·6 feet, to remove 18·368 cubic feet per square foot, or 28 per cent, is not sufficient. With a relatively greater thickness of the upper strata, the ground cannot break up if the coal is more rapidly wrought, and if no pillars are left between the short stalls; it is these pillars alone which cause the ground to fall up to the surface. If all the coal be removed, the height of a working should not be too great. Taking the rock at 1,069 feet, the height of the first level 9·8 feet, and the coefficient of increase, at 3½ per cent, the fallen fragments will reach to a height of 281 feet. The pressure of the rock will then act upon the roof, and the coefficient of increase will fall 2·7 per cent. When all the coal has been removed the fragments will reach to the intact rock. As the area from which the coal has been removed is enlarged, the pressure will increase, the fragments will fill up the hollows, and their gradient will become smaller until their resistance is as great as the pressure exacted on them. When the next short stall working, below the floor of the first level, is begun, the broken fragments will fall lower, and a space of 7·6 feet will be left between them and the intact rock; 216·8 feet of rock will now break up, and the thickness of the remaining rock will be 571 feet. After removing the coal from these two levels, the ground will subside 5·1 feet. If a third lower 3 feet level is worked, the falling of the rock will extend 105 feet further upwards; the thickness remaining intact will be 466 feet; and the total subsidence will be 8 feet.[1]

This represents conditions during the removal of a very thick coal, in successive layers, on the pillar method. The most interesting result

[1] Karl Balling. Osterreichische Zeitschritte Fur Berg-und Hüttenwesen. 1903, Vol. LI.

is in the showing that the question of amount of subsidence is a calculable quantity, and not, as is commonly thought, a mere guess. With proper attention, and taking steps to get the needed information, the rates of subsidence of the strata concerned, and the amount and the position of its greatest action, can be determined in each field, and in each particular mine.

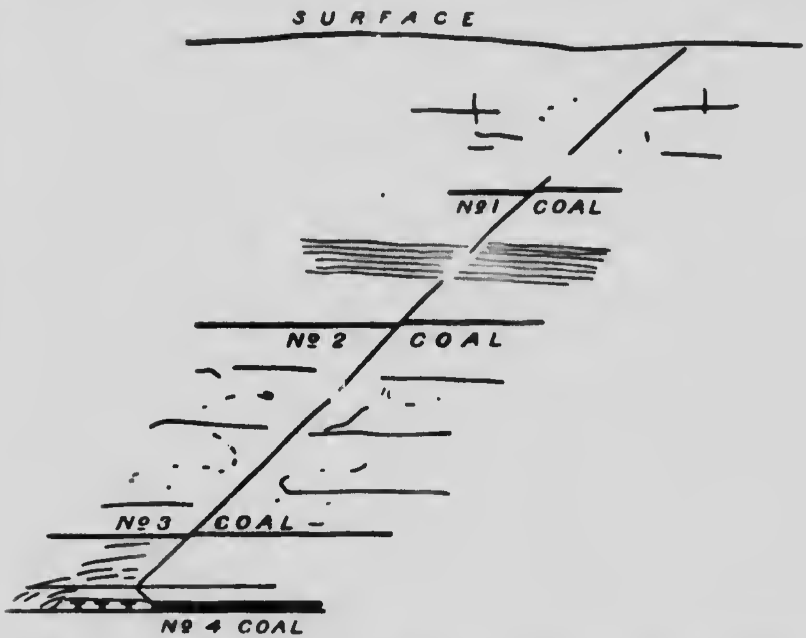


Fig. 17. Section illustrating the common features of subsidence at any one position of the advance of the face: showing direction of "draw", and shift of strata. No. 3 Coal will be the most affected.

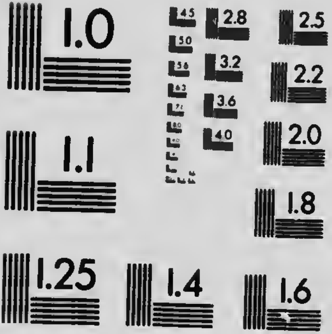
The maximum disturbance is given, approximately, as three feet at the surface, from operation at a depth of 1,000 feet. Any intervening seams of what might be called thin-coal, 36 inches and under, must therefore have in the course of time changed their position completely.

Another interesting and specific instance of the effects of subsidence is that detailed by Mr. Tylden Wright,[1] in reference to the extraction of the coal under Newstead Abbey, Nottinghamshire, England. The seam mined was three feet in thickness and 1,120 feet from the surface. Observations extended over a period of seven years. When the advancing face was 270 feet from the abbey, and 9 months before any portion of the coal was excavated below the building, it began to move and fall at the rate of ⅛ inch per month. As the face advanced the depression increased to 1½ inch per month, and at one time one end of the abbey was 10 inches

[1] Minutes and Proceedings of the Institution of Civil Engineers 1898, Vol. C, XXXV, p. 145.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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lower than the other. But so steady was the subsidence induced by the complete and regular extraction of all the coal in the three foot seam, that not a stone in the ancient carved windows (800 years old) with all their exquisite tracery, dropped out. The total subsidence was finally measured as 23 inches.

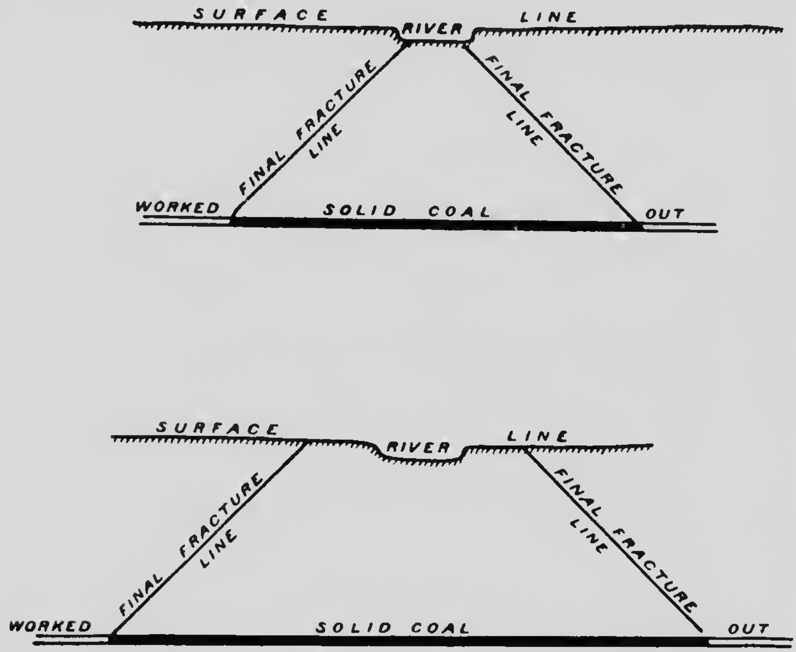


Fig. 18. Good and bad practice in the protection of a river bridge, railway line, or important building. Normal strata—horizontal. (Complete coal extraction in worked out areas.)

Here then is an example in longwall mining, whereby a 36-inch coal produced a subsidence of just under two feet—two-thirds of the original thickness—on the surface 1,120 feet above; and yet no damage was done to the building. From this case, it can be concluded, that if all the overlying coals (if any) possessed as great a composite adherence between roof coal and pavement, as that which existed between the stone layers of the abbey, those coals would be intact and workable.

A third example, based upon personal experience, at Hamilton Palace Colliery, Bothwell, Scotland, can be outlined:—

Working..............................Under a river 150 feet wide.
Thickness of coal......................6 feet.
Overlying coals........................None.
Underlying coals.......................Two: 3 feet, and 3′–6″ thick, respectively.

Operation..............................Complete extraction.
Depth..................................350 feet.
Surface strata.........................Clay and sand 40 feet.
Overlying rock.........................Usual Carboniferous strata.
Method of working......................Pillar and room.
1st extraction.........................Pillar 60 ft. × 40 ft. rooms, not over 14 feet.
2nd extraction.........................Complete.
Direction..............................45° to first advance.
Subsidence.............................Two to three feet.
Damage from water......................None.
Reason.................................The surface clay being more or less fluid filled the cracks in the strata, thus acting as a tarpaulin, keeping the water from flowing into the workings.

The question of subsidence is, naturally, of greatest interest in the mining of thin-coals, where there are sections containing a number of successive seams, overlying at various depths. It may be observed, in passing, that with undersea coals, the interest lies in the question of possible flooding, and of the danger point somewhere near the shore, where the clay covering on the sea floor is at its thinnest, and where it is more or less porous, through admixture with solid blocks broken from the cliffs.

Movements of strata brought about by the coal extraction take place in an upward direction, influenced by the nature of the strata, the method of working, and the inclination. The rate and amount of disturbance are influenced by the method of working, the thickness of the seam, and the nature of the strata. For example, a coal seam worked on the longwall method, produces a disturbance that is constant in a direction parallel to and somewhere in front of the working face, and there is only one break of the overlying rock. In pillar and room methods, however, there are commonly two slips: the first coming when the pillars are formed (dependent on the size of pillar left), and the second when the pillars are extracted. This double movement is far more destructive than a single steady subsidence. Years may intervene between the two disturbances, but the ultimate danger remains the same. With pillar and room workings, there can be conditions under which any primary disturbance may not affect a seam above. The opposite extreme to this, is, where an overlying coal comes within the scope of the first "draw" induced, due to formation of the pillars, when such an overlying strata is naturally subjected to two subsidences, entirely at variance in direction and amount. Consequently, cross "slips" result, and the final effect cannot help causing the possibility of much greater loss. Wherever the extraction of pillars is being carried out, the tendency is towards the destruction of coals above, in an ever widening circle upwards, and there is a simultaneous "draw" towards a common centre. Pillar sections may be operated as a series of separate workings some distance apart, and this again may introduce cross "draw," which is very undesirable. Extraction of pillars, in small areas, is apt to produce nothing more or less than "pipes" of disturbance extending outwards as they rise, and these in turn, hollows on the surface. Such phenomena bring about an unworkable condition in overlying coals, since there is then formed a series of alternate areas of undisturbed coal followed and surrounded by altered stretches. The effect is, the making of workable pillars in the upper coal whose position

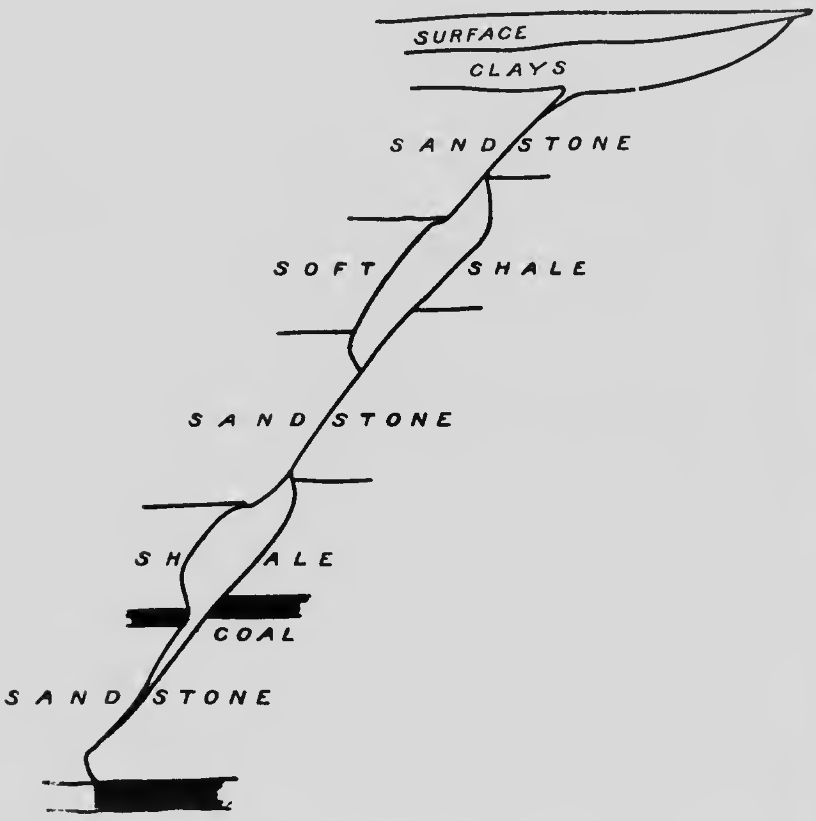


Fig. 19. The last break is the production of an artificial fault; and where this fault passes through strata of varied composition, water circulation produces hollows and cavities. Operation of these second or upper seams may break to these openings and hence to the surface.

cannot be afterwards determined. This precludes the possibility of the economic mining of the seams of thin-coals, in their entirety; although it is known with certainty that parts of the seam could be extracted. If the areas of good coal are larger in proportion than the areas of broken coal, and the seam generally accessible, the larger patches are worth searching for. In the older coal-fields, inland, there are always a large number of small collieries mining at a profit old pillars and small areas of coal, which on old plans made by other miners were shown to have been abandoned.

This serves as an illustration of the difference between undersea and land areas. In land areas, those abandoned coals can afterward be recovered or at least the attempt to do so can be made; but in the undersea areas, or deep-seated fields, all such operations are, owing to the danger of the breaking through of overhead waters, obviously precluded.

A thin-coal between two leaves of strata possessed of great bending moment might escape without any change in either the roof or pavement of the seam, although the stratification of the coal itself would be destroyed. In other cases the movement is irregular and jerky, and the seams above become broken, taking the form of irregular steps, producing, in fact, a series of miniature faults, but with the coal roof and pavement intact between each artificial fault plane.

Outcrop coal is generally the first to be worked, and trouble can be caused to future operators from "creep"; although if destruction takes place through this cause, the coal seam affected has to be relatively nearer than where subsidence above is due to operation. "Creep" is a slow movement of the strata, brought about by the action of roof pressure on supports that are too small for the weight being experienced. Gaining momentum very gradually, its final effects are similar to subsidence due to extraction; except that the settlement of the strata is quieter, and takes place over almost double the number of years. "Creep" is more or less characteristic of pillar workings, where the demand for cheap coal at the commencement of operations has been readily complied with. In compliance with the cry of the directors for "tonnage," the management has "robbed" part of the pillars in the mine. This slow movement is an insidious trouble maker, and once started is almost impossible to control. It is infectious. A section may be considered perfectly strong enough to stand until the extraction of pillars takes place, but "creep" may appear from another section through one small range of pillars and thus pass through the whole mine.

To the future operator the most formidable result brought about by "creep" is the destruction of parts of the seams through which future operation of the area may take place. The line of outcrop coal may, in this way, have been so mutilated, that it becomes impossible to again enter the area, without extra cost of driving through broken ground, and maintaining roads therein. "Creep" may also be the cause of the dislocation of seams above and below it, in the same manner as that produced by total extraction from other operations.

OPERATION OF AN OVERLYING COAL.

Loss of thin-coals can also be caused by the taking out of a thick coal above them. This comes about through the "waste" or waste rock of the thick coal being too close to the actual roof of the underlying coal to allow

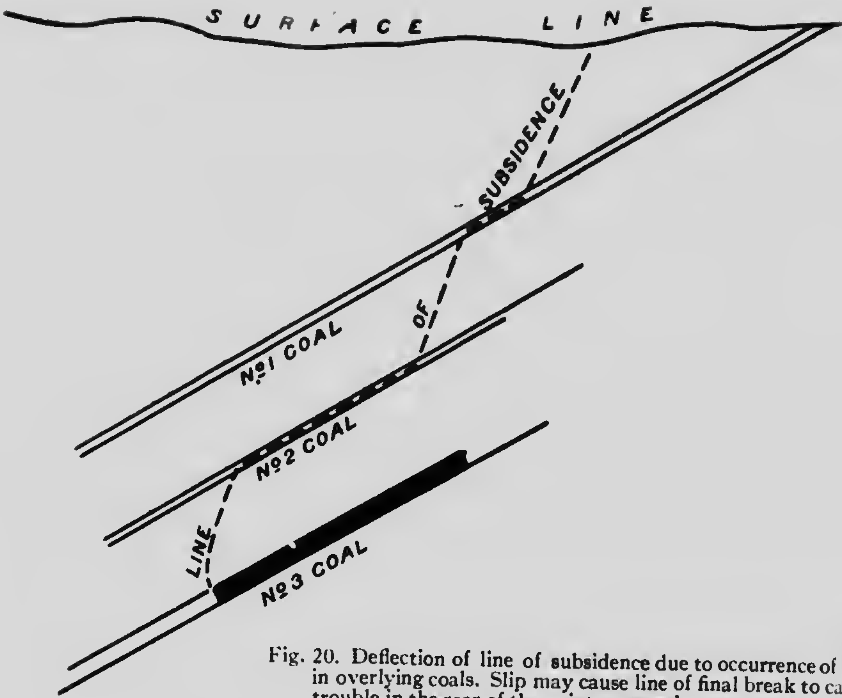


Fig. 20. Deflection of line of subsidence due to occurrence of slip in overlying coals. Slip may cause line of final break to cause trouble in the rear of the point expected.

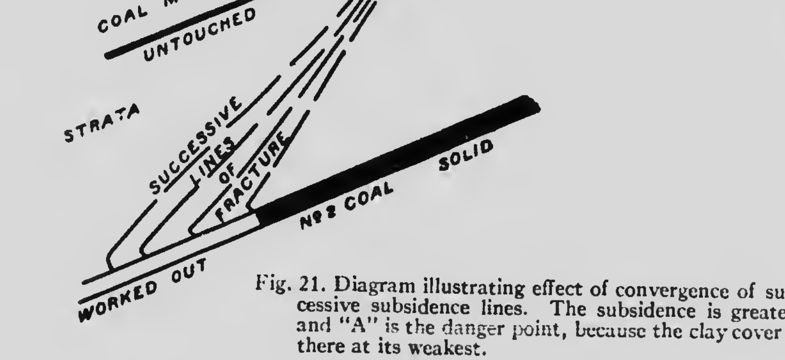


Fig. 21. Diagram illustrating effect of convergence of successive subsidence lines. The subsidence is greater, and "A" is the danger point, because the clay cover is there at its weakest.

of it having a cover of sufficient strength and workability. To cause such an effect the coal seams must lie, relatively, close together. The trouble actually encountered commonly takes the form of roof breakage right up to and through the position of the seam above. Where the intervening strata is of great strength, so strong that operating the coal causes no break in the roads, the underlying seam can be worked without trouble, but extraction without causing roof breakage in roads into the upper working is unusual. As the strength of the small thickness of intervening strata increases, so the chance of successful operation of the lower coals improves.

HIGHLY INCLINED SEAMS.

Coal seams that are tilted, and highly inclined, behave, under the influence of subsidence, very differently from what is generally observed to be the case with the flatter coals. Subsidence is frequently accompanied by the phenomenon of slip, the coal being the natural line of least resistance. A very ragged line of break is thus formed, which frequently cuts across from coal to coal abruptly, often at right angles, and for long distances travels in the coal itself. Breaks caused by the travelling forward of the underlying coal face, instead of forming a successive regular wave of subsidence at the surface, may, with inclined coals, concentrate at or near one position, producing a break that is more open and abrupt in its appearance. The next succeeding break may not show for several hundred feet, but will be as abrupt as the first one produced.

The amount of the movement has always a tendency to increase, not due to the continuous extraction of the coal, but due to the slip and settlement of one section of the strata over another. Where operation of an overlying coal is undertaken under those conditions, difficulty arises, not necessarily because of broken roof and coal, but because of a series of slides, whereby the whole block of strata will sometimes suddenly shift its position.

The line of subsidence in pitching coals always flattens, getting nearer to, and almost parallel to, the dip of strata, as that dip increases. This throws the surface effects a long distance in advance of the actual face, a fact that has to be taken into account when estimating on the distance beyond which there will be no movement produced.

SEAMS CLOSE TOGETHER.

Where there are two coals close together, it is obvious that the thin coal is the one left unworked. Such seams are, and frequently can be worked at the same time, on some system of co-operation; perhaps one slightly in advance of the other, using the same roads. Knowing that there are many feasible methods of doing this, in favourable cases, where there is seemingly an attempt to avoid this question of operating two coals, involving the consequent sacrifice of a thinner coal, the operators should be asked to show cause why they should not be required to mine both coals by some method of joint extraction. No particular remedial methods can be suggested for cases of this kind, as there are no two places where the conditions

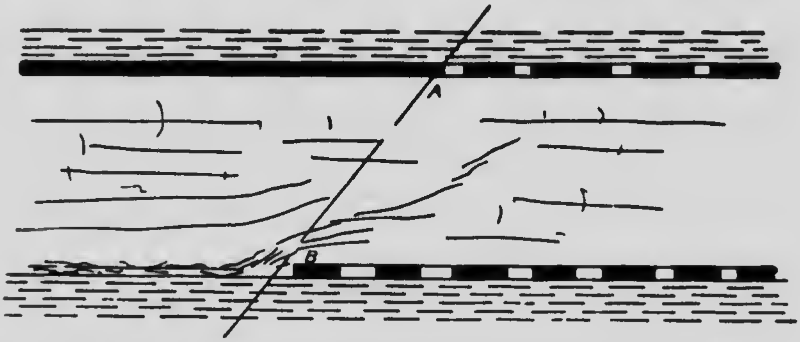


Fig. 22. Diagram showing simultaneous operation of two coals, 70 feet apart. Lower seam retreating, drawing pillars; top seam advancing, forming pillars to A: after this point, in longwall.

are alike. Thickness of strata is the principal factor, for, above a certain thickness, the coals have to be considered as two separate seams, and not the split of one.

GENERAL CONCLUSIONS.

There are exceptions to every rule. Where seams have been destroyed, or supposedly destroyed in the operation of other coals, it has still been found possible, after the lapse of a number of years, to reopen beds. This has commonly been done in the case of, say, a coal which by reason of its quality is of special value, and has elsewhere become exhausted. Success in such a case depends on facts that only actual operation will disclose, and which cannot under the circumstances be predicted.

In any working of this nature, some curious effects are noticed. There may be a perfectly straight and regular face for a considerable distance; then, suddenly, the coal in front of the miner will fall away abruptly, leaving a space between the coal and roof, into which props can be inserted for a long distance ahead. Weird cavities that lead down to unfilled levels in the lower coal, if close at hand, are frequent; and where falls of roof have been heavy, the old timber that was used to crown that cavity stands upright against the upper coal. In some cases the pavement is not broken, but the coal will take a sudden dive downhill, or shoot uphill, and thus form an artificially produced anticline and syncline, before getting back to normal, ready for some other vagary. Any attempt at undercutting often brings the coal away from the face in slabs that fall heavily on the machine, and of a size and shape difficult to break into lumps that can be readily handled. The most frequent condition encountered is a tremendous amount of slack, and a large percentage of small rock. This latter material runs in the roads, and fills them up over rail level, like a snowstorm forming drifts in a cutting. Where an overlying coal has been completely taken out, the waste of the original coal is sometimes so homogeneous as to appear

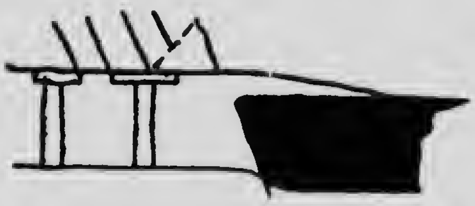


Fig. 23. An effect in an upper seam caused by operating a lower coal.

to the eye more or less solid; and it is only when a pick is used on the tough mass that it breaks and shows signs of being made up of both large and small fragments. The old timber chocks and ties interlacing in the crushed rock help to bind it together. This is a result of induced pressure.

Pending the collection of data particularly applicable to the conditions in Nova Scotia, some of the more interesting inferences, deduced from experience elsewhere, supplemented by suggestions connected therewith, are here tabulated:—

1. In the extraction of underlying coals, the worst result in its effect on the upper beds is to render them unworkable, because of the breakage of the coal seam, and the formation of a roof that is unreliable, and sometimes positively dangerous.

2. Where the abovementioned conditions are likely to become serious disadvantages to future operation, there does not seem to be any valid reason—if it can be avoided by any change in methods—why a future artificial increase in the cost of mining should be created through mining systems at present in use.

3. The collection of data relating to questions of this nature should be commenced at once.

4. The amount of subsidence produced is variable, depending on various natural factors differing in each district.

5. Subsidence appears to take place in advance of the underlying face, and is roughly parallel to the direction of advance.

6. The least disturbance of overlying strata is caused by steady extraction; for example, under the longwall methods.

7. The greatest disturbance is caused by piecemeal operation, of which the worst example is in the case of small pillars, followed by their later complete removal.

8. Disturbance to an overlying coal, caused by the first coal worked below it, would be much less than that caused by the second.

9. The inclination of the break tends to become parallel to the coal, as the dip increases.

10. There can be conditions where the subsidence in overlying strata can be greater than the subsidence produced by working the coal: namely, when an overlying strata is waterlogged, or consists of a running sandbed.

11. In cases where the possibility of any destruction exists, and the companies holding the areas refuse to consider working under a changed system when requested, the right to mine that seam should be rescinded, and consideration given to a plan for re-leasing to another operator, under conditions which are protective to both. The plan of having several independent concerns operating different seams of coal above and below each other in the same leasehold, is in daily and successful operation in a number of coal districts, where the coal mining laws are much more strict and exacting than in eastern Canada.

12. Under certain circumstances this principle of multiple leases could be carried further, as in cases where a thin-coal existed at or near the thicker coal at present being worked, when certain definite areas could be leased, or sublet to a group of workmen who would provide either all or part of the small capital required, and who would sell to the larger company f.o.b. roadhead: thus creating a mine within a mine, under carefully defined conditions.

SOME ECONOMIC CONSIDERATIONS.

A conservation policy which advocates the operation of a certain proportion of thin-coals before the thicker ones become exhausted, is almost in direct contradiction to the ideas promulgated on this subject in other countries. There, the conservator usually says to the operator, "See to it that you work your coal lands in such a fashion that destruction of the thinner seams is avoided, so that they may be kept intact, and rendered available in future years." Here, in the eastern provinces, conservation, in addition to the above, should say, in part, "Work some of the thin-coals first in such proportion as is economically possible, in order that the life of the thick coals may be prolonged, since from this latter source comes the class of fuel on which continued prosperity depends." In eastern Canada to ask for the immediate operation of part of the thin-coals, means not only to utilize the thin seams themselves during the time when their extraction would yield the greatest return to the provinces; but, it is also a means to the preservation of coals of more value than the thin-coals, which are within a measureable distance of exhaustion.

The justification for such a policy rests upon the statements outlined below:—

1. The future rise of costs is, in the eastern Canadian coal-fields, quite outside the control of any operating company, or Government.

2. The selling price of coal is dominated and fixed, and will be maintained at its present level by influences outside these Provinces.

3. As the years pass, a day will inevitably be reached when it will become impossible to mine coal and sell it at a profit in any outside market.

4. Therefore, provided that the eastern provinces expand as they have in the past—which means increased general prosperity—the period during which the coal resources can be utilized to the best possible advantage, that is, to yield the greatest return, will inevitably be limited.

5. The amount of coal left unmined after the maximum tonnage exhaustion stage has been reached, will be of considerably less value to the provinces generally. This does not necessarily imply that it will not pay to mine coal for the inside market; but it does indicate a long period of depression, and subsequent readjustment to a lower scale of living conditions.

6. If it were possible to put farther away into the future the day when the cost of mining will rise to the selling price in the outside markets, then, so much more of the coal resources could be operated to provide the highest return to eastern Canada.

7. To some extent this will be accomplished by more economical methods of working in the future, but it can also be materially assisted

by some reorganization of administrative and mining conditions: a partial solution that entails the least alteration to existing methods is through the operation of some of the thinner or more difficult coals in conjunction with the present easier worked beds, so as to conserve, to some extent, the better seams.

8. Bearing in mind the fact that it is possible to operate 12-inch coals profitably under existing economical conditions, and also that the proportion of thin to thick coals is, in tonnage, very low now, any required readjustment involves no manipulation that could not be successfully evolved, and inaugurated at the present time.

9. Seeing therefore, that as time passes the relative cost of mining thick coals and thin-coals will become more equal, it follows that re-adjustments, in the future, will be more difficult than in the past.

THE REASONS FOR RISING COSTS.

After studying the geological character and distribution of all the Nova Scotian coal-fields, it will readily be perceived, that there is now not one single area of any considerable size—with one exception, namely, Point Aconi—which is a virgin field. While, therefore, eastern Canada has not by any means very seriously depleted her coal resources, the Maritime Provinces have, nevertheless, come within a measureable distance of exhausting the available land area on which new collieries can be developed and maintained in the production of fuels of equal quality, and at the present rate of productive capacity. Unlike other countries, it is out of the power of operators in eastern Canada to take up the plant of existing mines and move the same to "fresh fields and pastures new," leaving the deep coals and the undersea coals to be worked at a later date, when time has created a better adjustment of costs between the provinces and outside rivals. The same old mines and the same old slopes—with comparatively few additions—will have to do duty, as extraction openings, for areas that lie beneath the sea.

The geological conditions very fortunately allow of a natural division of the coal districts into four groups. These divisions are:—

Class 1. Districts that largely embrace undersea areas.
" 2. Districts that contain coals lying highly inclined.
" 3. Areas that provide a combination of conditions, as in Nos. 1 and 2.
" 4. Areas that contain thin-coals.

Class 1 includes the Sydney coal-field.
" 2 includes the Pictou field, Springhill, and part of the Joggins areas.
" 3 includes Inverness, Mabou, Port Hood, and part of the Joggins areas.
" 4 includes the New Brunswick field mainly.

Leaving aside the New Brunswick areas, where at present the output is negligible (but which contain the greatest known deposits of thin-coals), the mines in each of the other classes disposed of their outputs in 1914, approximately, as follows:—

	Internal.	*External.*
Class 1.................	66%	95½%
" 2.................	29%	3½%
" 3.................	6%	1 %

It will be perceived that the output from collieries in District 1 almost entirely supplied the outside market. The seams operated in the mines of this group are the easiest worked at the present time, and so situated, that it is their economic operation that holds the outside market to Nova Scotia. It is possible to go further and say that the collieries in Districts 2 and 3 are in such a position geographically, so placed geologically, and so hampered by financial considerations, that eastern Canada could not depend on them alone to retain the American and the St. Lawrence coal markets. On the other hand, collieries in groups 2 and 3 are better situated in the majority of cases to handle the internal trade, hence, to some extent, a natural balance has been created: enough, at any rate, to point the way to the possibility of greater development along this line.

PROBLEM OF DIMINISHING RETURNS CONSIDERED.

Distance.—

Any factor that will inevitably diminish private returns, and decrease public revenues, should receive serious attention. It is a natural law in all deep land and undersea mining, that the distance between the coal face and the opening to the mine is constantly increasing. As a consequence, production is constantly decreasing, due to the time lost in travelling from the mine opening to the scene of operations. This increasing distance factor will not only reduce the amount of production, but will naturally increase the cost of pumping, ventilation, haulage, overseeing, and general management.

Labour.—

Then there is the labour question involved. With a distance of, say, two miles from the mine entrance to the scene of work at the coal face, it is reasonable to assume that even with the best underground transportation facilities, at least half an hour will be lost from the working day. It is inconceivable that labour will accept less per day for the privilege of spending an hour or so less in the mine; on the contrary, labour will expect to continue getting the same wages, although giving less actual work in return. Consequently, an increase in mining cost in proportion to the time lost, may be certainly expected. The best way to offset this inevitable loss in time is, to increase speed and output by the introduction of labour saving machinery. Similar steady rises in cost, in other lands, have been checkmated in this way.

It is computed that the loss of an hour in time would bring the mining cost up to $2.05 per ton—an increase of 30 cents per ton. That this figure is approximately correct is evidenced by the British estimate, that the cost of introducing the eight-hour day there, meant an increase of 1/- (one shilling) per ton = 25 cents. It is interesting to note that Mr. Finlay's 90% rule[1]—which is based on a bituminous eight-hour working day in the United States—would give $2 per ton as the average gross cost in eastern Canada.

Seeing, therefore, the inevitable influence of the distance factor, as affecting—in a constantly ascending scale—the cost of mining, and taking into consideration the probable demand for an eight-hour day, in the near future—for it is unlikely that Canada will escape inclusion in the world-wide movement—it is manifest that in any discussion affecting the future of the coal industry of eastern Canada, especially with regard to the export trade, the question of diminishing production, with corresponding increase

[1] Cost of Mining, by J. R. Finlay.

in the cost of mining, will have to be taken into account, and the sooner the question is faced, and adequate provision made to meet these crises, the better. Unless something radical is done to checkmate the two negative factors of "distance," and the impending "eight-hour day," the result will be serious; probably leading to the shutting out of Nova Scotia coal from the St. Lawrence trade.

NECESSITY OF INCREASING OUTPUT.

Seeing that the natural tendency is towards a decrease in the production of coal, the necessity of inventing and fostering artificial means of increasing the output is manifest, in order to meet enlarging home trade, and at the same time to hold the foreign market. Hitherto, there has been a steady increase in production, and in all probability this upward movement will continue in the future, based on the economic law of supply and demand, the increasing demand being caused by the general average development and expansion of the country generally. One factor, however, will finally cause this upward growth to cease, and that is, the want of land area on which to open up new collieries. Attention has already been drawn to the fact that the only untouched area of any size is Point Aconi. Here only, is there scope for the establishment of mines of such magnitude and design, as to allow of them catering profitably to the outside market. It is true there are one or two other areas available, but none of these are capable of holding more than one large colliery. Based roughly, on a feasible, divisional arrangement of the remainder of the Sydney field, there does not seem to be room for more than six to eight additional openings. It is probable that these, in the course of time, would develop to an annual output of two million tons, which in turn would lead to a possible total of ten to twelve million tons, that is, provided no collieries in the older fields closed down entirely, and that the natural decrease of the older mines of the various areas is offset by an increase from the newer. Beyond this point, there is no reason to anticipate further development, and even at that, it is probably an outside figure, although it has to be recognized that the tendency is always towards growth.

DURATION OF THE COAL RESOURCES.

Consideration of the duration of the coal resources of eastern Canada is from one standpoint only, viz., the coal available for the outside market. An empirical estimate is all that is possible. For example, it can be argued that 100 years will probably be the limit to getting out coal for the outside market, since within that time all the adverse factors: distance from openings, wages increase, and financial burdens, will have become operative to such an extent that they will render profitable operation prohibitive. This would limit the available tonnage suitable for those markets overseas to one thousand million tons of the best coals.

Any method of arriving at the required results by computation, would involve a long and intricate calculation, which again would be based on some data not yet definitely ascertained. To some extent, this data can be reasonably assumed. Perhaps the subject can be treated along the following lines.

The total land area available is given in Geological Survey Memoir No. 59, as 92·66 square miles. Taking into account the length of the field, this would give, for one average seam, 2 miles from outcrop to water edge. If an additional mile is added thereto—making 3 miles in all—it seems likely, as far as present indications show, that this is about the limit of profitable operations. That is, if the whole output was being extracted from this distance, the costs thus deduced (or their equivalent by other conditions) would be so much over the general average, as to cause future development to cease. Further, the limit of thickness for that distance of three miles cannot be reasonably expected as less than four feet.

In the abovementioned Geological Survey Memoir, the total tonnage in the land area is given as 1,022,496,000 tons, which includes all coal over one foot in thickness, and is calculated on an average aggregate of 33 feet. Assuming that there is only 25 feet of coal of sufficient thickness workable to that distance, this would give a total in the land area of 775,000,000 tons. The sea area, to the three mile limit, provides 4,064,357,000 tons, which also includes all coals over one foot in thickness. For one mile, this would yield, approximately, 1,355,000,000 tons, also for an average aggregate of 33 feet, which again, at 25 feet, would allow a tonnage of 1,000,000,000: giving a grand total of 1,775,000,000 tons. At the ten million rate of extraction, this equals a duration of 170 years.

These figures, however, are merely illustrative. The important point is, that the amount of coal available for these outside markets, instead of being inexhaustible, as supposed, is within a measurable distance of coming to an end. Only something like one-ninth to one-fifth, i.e., to 2,000,000,000 out of 9,718,000,000 tons, of the total coal supplies is going to be used for the greatest benefit of the Maritime Provinces.

The question arises, therefore, by what method of readjustment and reorganization of the present coal industry and mining system, is it possible to utilize, to the greatest advantage, the coals which are suitable for export to the outside markets; and at the same time, cater to the inside market by using other sources of supply?

THE COAL MINING SYSTEM.

With a view to making the inquiry as to the character and ***modus operandi*** of the existing mining system of practical value, it is purposed to confine consideration, almost exclusively, to New Brunswick; since in that Province, coal mining is practically limited to the working of thin-coals; thick seams being conspicuous by their absence.

The following facts about the New Brunswick coal industry are presented, in order that the situation may be better understood:—

Total tonnage available	151,000,000
Present yearly output, (1912–1913)	51,000
Total imported tonnage (1913)	646,600
Tonnage imported over the I.C.R. from Nova Scotia, to points within New Brunswick (last figures available, 1911)	295,275

From the above figures, the following additional information can be deduced:—

Output per capita	0·16 tons.
Consumption per capita	1·8 "
Percentage of coal mined within the Province	8%
Percentage brought into Province	92%
Percentage brought into Province by rail routes	42%
Provincial income from coal mined in the Province, per capita ($104,000)	30c.
Provincial income from coal mined outside the Province	nil (Wages paid to sales staff employed in Province, and partial cost carriage—which goes to Government railways.)
Provincial income lost from coal mined outside the Province per capita ($1,293,200)	$3.60
Income per capita in Nova Scotia on same basis	$31.00

A comparative study of freight rates shows that they are all against Nova Scotia coal coming westward by rail. Assuming that a considerable quantity of the railway-imported coal is required for the use of the Government lines, the cost of hauling this tonnage can be charged at the rate of ½c per ton mile; and if sold to an outside consumer, rated at certainly not less than ½c per ton mile. The greatest centres of consumption in the Province are, according to the lists published: Moncton, Newcastle, and Campbellton.

The following table shows the freight costs for these three places:—

	Moncton.		Newcastle.		Campbellton.	
Rate	¼c	½c	¼c	½c	¼c	½c
North Sydney	83	1.66	1.02	2.04	1.29	2.58
Sydney	86	1.62	1.08	2.12	1.32	2.64
Stellarton	41	0.82	0.61	1.22	0.87	1.74
Springhill	16	0.32	0.36	0.76	0.62	1.24
Maccan	12	0.24	0.31	0.62	0.58	1.16

Perhaps there are natural drawbacks in the New Brunswick field: drawbacks, which, it is claimed, are insurmountable objections to greater development, and these must first be disposed of. These might be (1) the quality of the coal; (2) the cost of getting the coal, and (3) reaching the market.

COMPARISON OF QUALITY OF COALS.

In order to compare quality, a table based on the average of a number of Nova Scotia and New Brunswick coals, was plotted. The lines of general average, cross-drawn, indicate that the New Brunswick seams are as good as the average of Nova Scotia seams; and are not, in any case, so greatly adverse as to account for the preferable purchase of Nova Scotia coal to the extent that is now being done, commonly attributed to the production of a home coal of poor quality.

COST OF MINING.

Recollecting that the seams are thin, the natural tendency is to blame the want of success, generally, on the small thickness of the coal seams; but in this particular case, the miner can prove a fair "alibi."

In 1907 (date of the last collective figures obtainable), the average cost of mining in New Brunswick, in coals 25-30 inches thick, was given as $1.65 per ton. The average cost in Nova Scotia for approximately the same period, and on the same basis, was $1.54 per ton, which is only some 11c lower. As an offset to this advantage, however, there is the additional cost of water freight which can be placed at 35c, and of rail freight—an average 25c per ton.

Even allowing for differences in tonnage, better organization, a[nd] a number of other items, that vary one way or another, there would still appear to be sufficient margin in favour of New Brunswick to justify greater output and greater development.

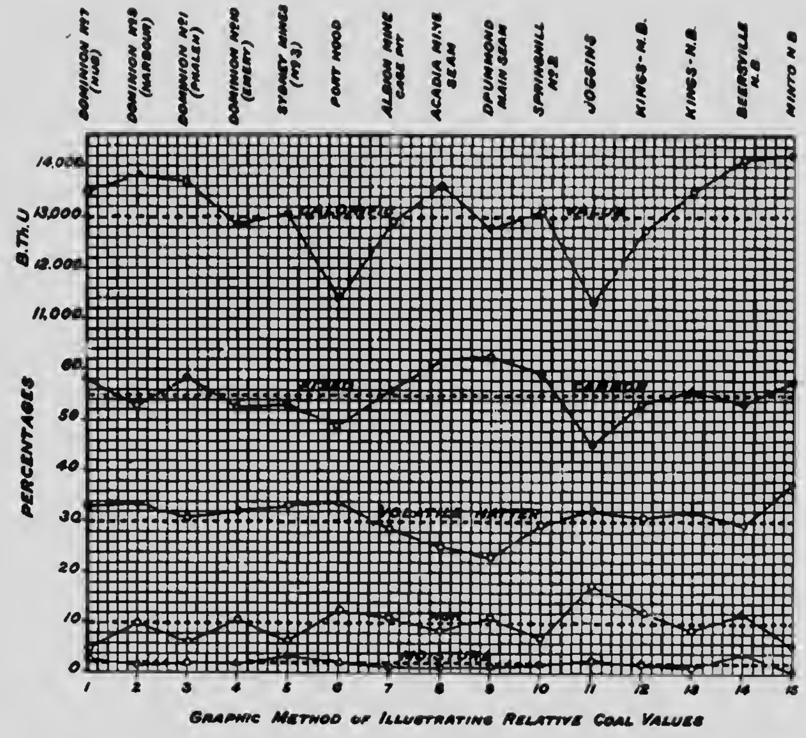


Fig. 24. Nos. 1—13 inclusive, from "An Investigation of the Coals of Canada" Dr. J. B. Porter.
No. 14, by MacFarlane and Boyd, Mining Engineers, Glasgow, Scotland.
No. 15. From New Brunswick Mines Report, 1915.

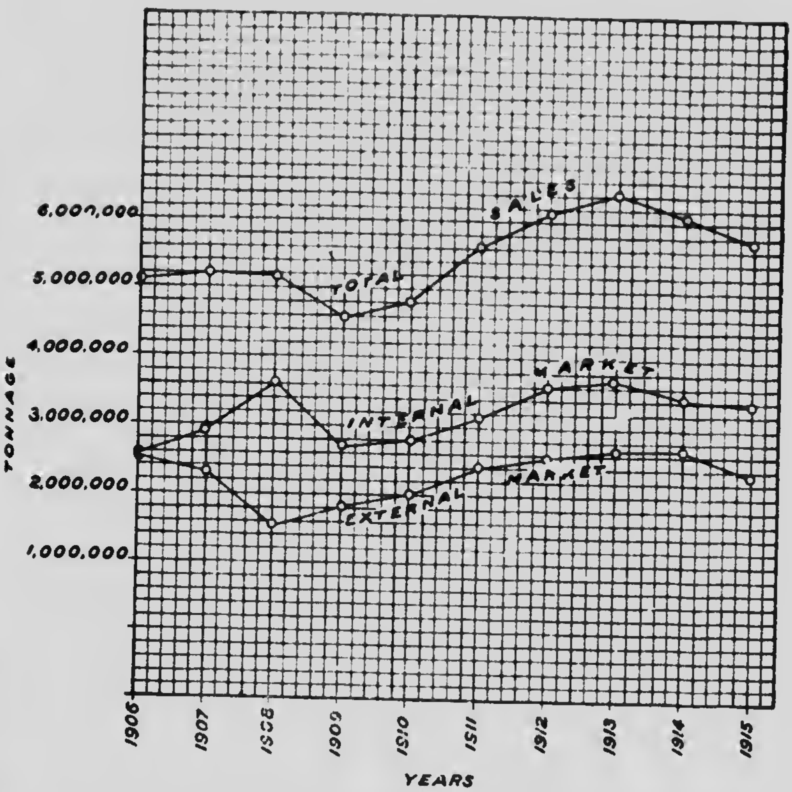


Fig. 25. Sale of Nova Scotia coal: relationship of external to internal market.

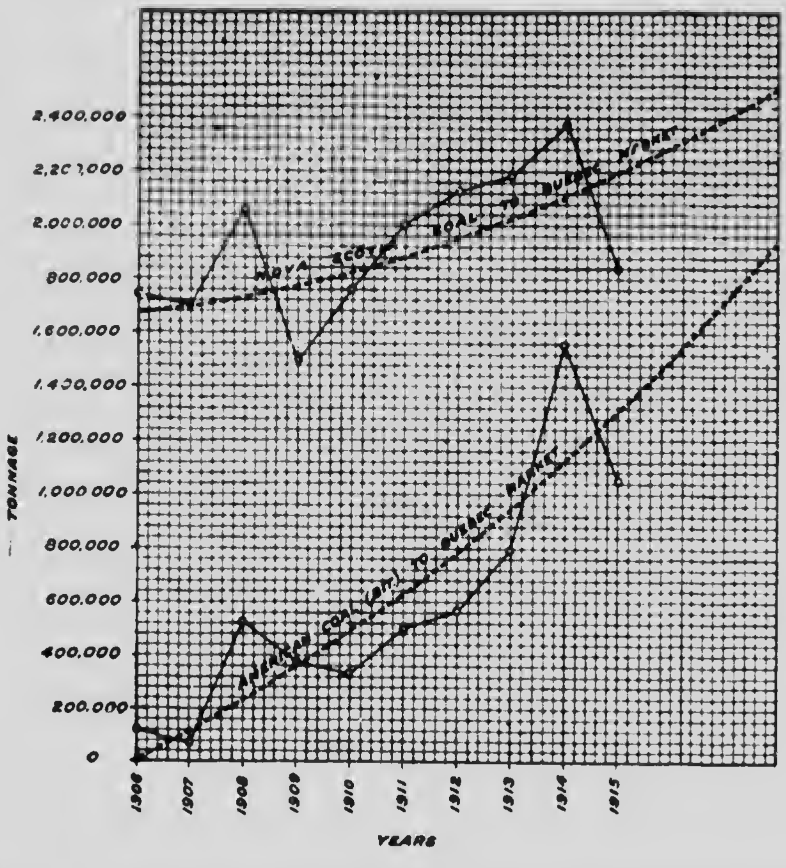


Fig. 26. Coal imports to the Quebec market: note how the American coal line is growing toward the Nova Scotia line.

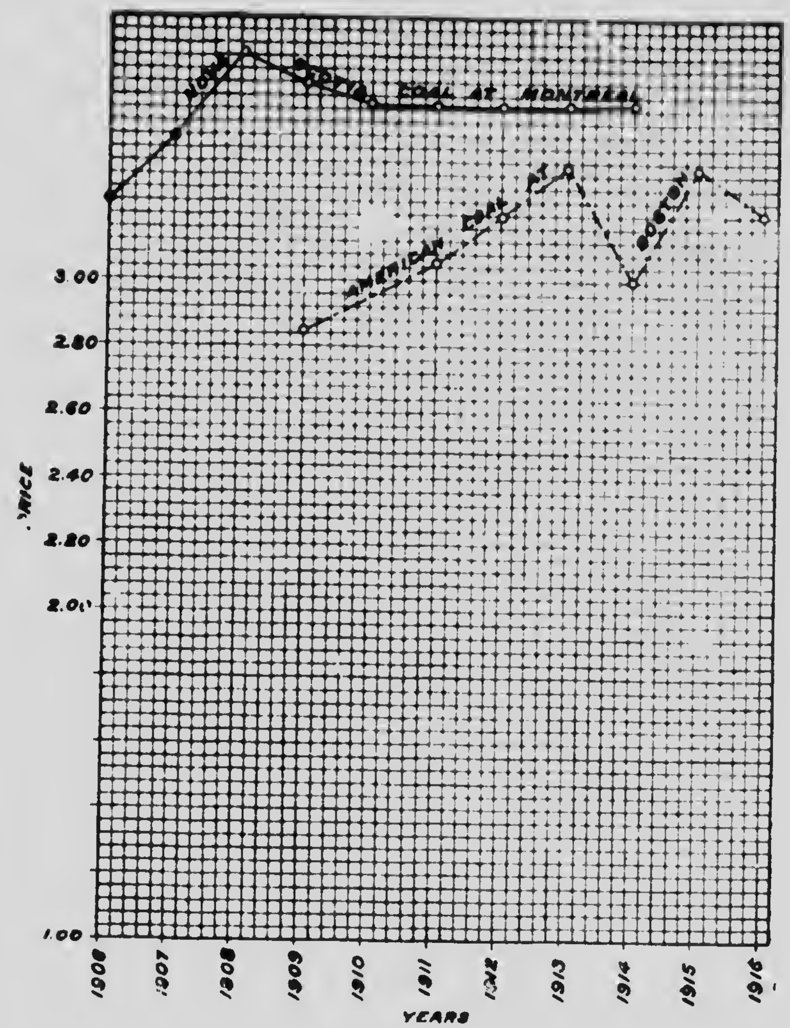


Fig. 27. Coal prices.

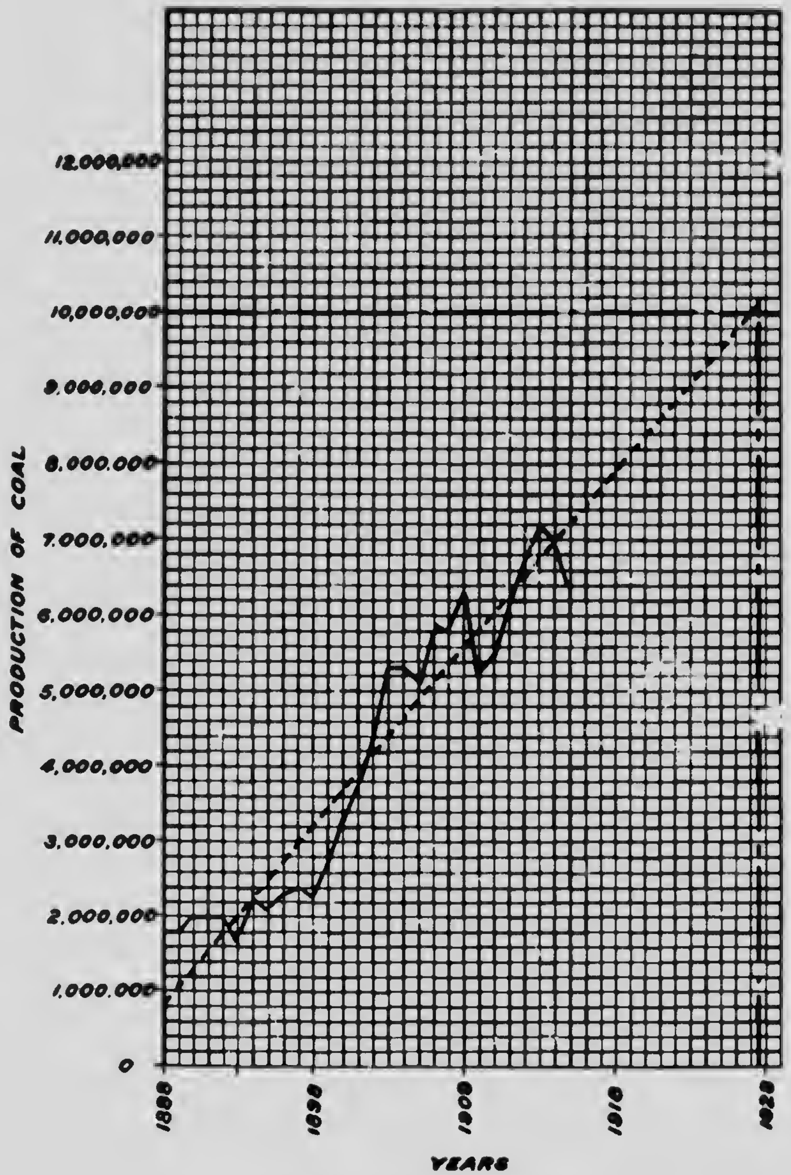


Fig. 28. Nova Scotia outputs.

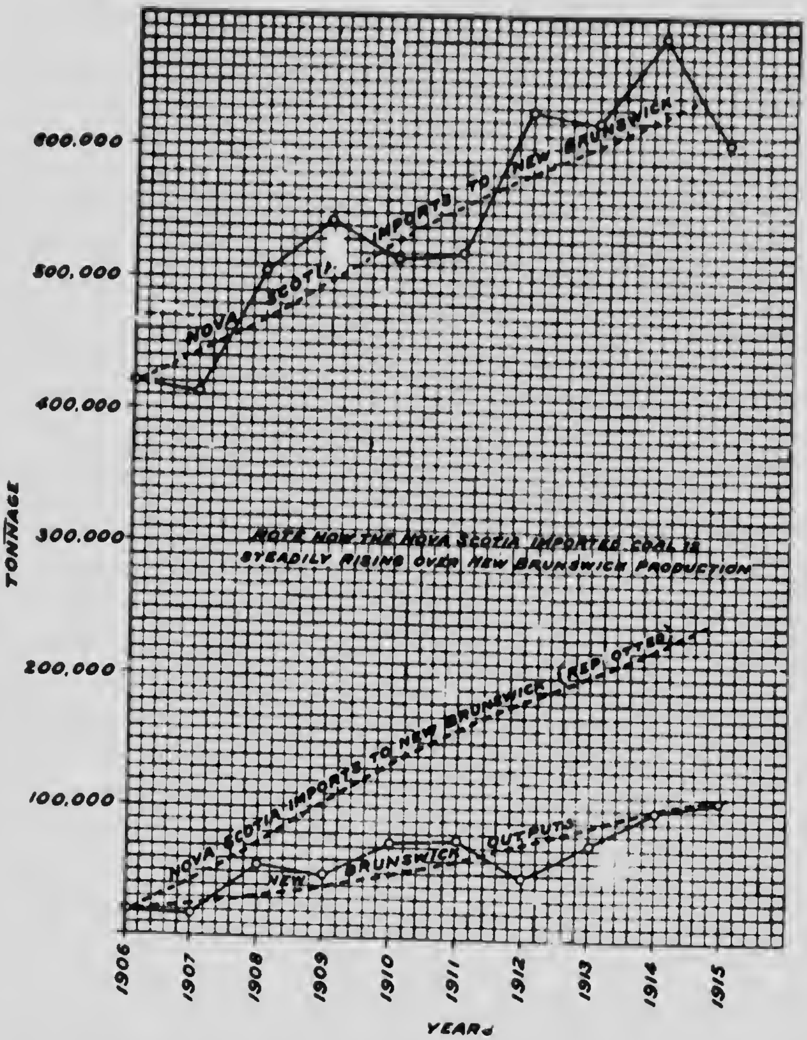


Fig. 29. Importation of Nova Scotia coal to New Brunswick, compared with New Brunswick output.

ADMINISTRATION.

In any discussion of the thin-coals problem, the question of the general relationship of the coal mining industry to the existing administrative system is of paramount importance. In approaching this subject the aim will be to consider (1) the attitude of the administration; (2) the character of the administrative system; and (3) to fix responsibility for the present and future development of the coal industry.

When carrying out any inquiry of this kind, it is always an advantage to take into consideration what has been done by others operating under like conditions and circumstances. And in this respect we are fortunate in having a notable example in the case of Belgium; in which country, many thin-coal mines are operated under very difficult conditions. The mining laws of Belgium may be taken as a pertinent object lesson; and it will repay us to glance at the provisions made, since they are of an eminently practical character.

BELGIAN MINING LAWS.

The following extract is taken from the Ann. Mines Belgique, 1911, Vol. xvi.:—

Applications for Concessions: The new law (modifying and completing those of 1810 and 1837) on mines, open workings, and quarries states that applications for a concession must be made to the authority (Deputation Permanent) of the Province in which the mine is situated, and, if it extends over more than one, that in which the extent is greatest, copies being lodged in the others. The petition must be accompanied by four copies of a plan drawn to a scale of 1: 10,000 (which must be checked by the Mine Inspector and certified by the "Deputation"), showing adjacent concessions. The application, when registered, will be open to general inspection.

Within 30 days of registration the application will, at the applicant's own cost, be posted up and also advertised in the "Moniteur" and at least one local paper. During another 30 days counter applications will be admitted, and determined upon by the Minister of Industry and Labour, on the advice of the Conseil des Mines. Opposition to the counter applications will be admitted up to 60 days from the publication being registered and notified to the Governor of the Province; but advertising counter applications is only required so far as they may relate to lands not included in the original application.

Within a further period of 60 days at latest if everything is satisfactory, the "Permanent Deputation" will emit its opinion, which will be sent with all the documents to the Minister; and a definite decision, approved by the Mines Council, will then be embodied in the Royal Decree.

The extent of the Royalty as fixed by the Act of Concession is defined by vertical planes of indefinite depth, passing through points marked on the ground according to a method approved by the Ministers, but, when circumstances require, the limits may be other than vertical planes, and their depth determined. *Obligation may be imposed on the concessionaire to join in co-operative measures for economically working, sending off products, etc.*

Renunciation: Subject to Royal authorization every mine concessionaire may renounce his concession, or part thereof, on finding that it contains no workable deposit, or that the deposit is no longer commercially workable, the procedure being similar to that for obtaining a concession. Third parties interested have the right to lodge opposition, while proof that creditors have been notified must be appended to the application. No renunciation can be granted without a favourable report by the Conseil des Mines; and a Royal Decree will determine the conditions, fixing, if opportune, the delay (that may be extended by decree) during which the concessionaire must execute all works required by the regulations and clear himself from obligations connected with the concession. On the expiration of this period, the petitioner will send to the Provincial Authority a certificate that the mine is clear of all claim upon it, which body will within 60 days and after consulting the Mine Inspector, certify accomplishment of the imposed conditions. Third parties have the right to appeal. While exonerating the concessionaire from the various charges on a mine, renunciation does not free him from the obligation to compensate surface damage.

Transference: *Under the present law no mine can be wholly or partly sold, ceded, divided or let on lease without Government authorization;* and this must be obtained previously except in the case of public adjudication of the mine, whether voluntary or enforced. The acquirers or inheritors of a mine must obtain Government ratification in due form, within six months, on pain of nullity; and opposition, to be valid, must be entered within a week at the Ministry of Industry and Labour.

Forfeiture: *Saving legitimate impediment every concessionaire must begin working at the latest five years* after the Act of Concession is promulgated. The work must be pursued regularly until the mine is brought into effective working, and must not be interrupted without a legitimate cause. Forfeiture is incurred, six months after the concessee has been duly notified by the Ministry of Industry and Labour, if he has (1) not satisfied the above conditions; (2) ceased working for five years without reasonable excuse, or has not, after notice, resumed working and continued it for five years; or, (3) if without cause proved legitimate and owing to action of the concessionaire working has been restricted or suspended so as to compromise public safety, or deprive consumers of their necessary supplies. When forfeiture is admitted by a judgment, or a decree having the force of law, the concession will be revoked by a Royal Decree which brings matters back to their state before the concession existed; and the mine can only be again brought into working by virtue of another Act of Concession. *A new concessionaire may take possession of the shafts and generally all the underground workings without giving compensation;* but he can only take the surface works in return for an indemnity fixed by experts, but never exceeding the amount actually expended. The exconcessionaire is held responsible for all damage caused by his working; and he must keep up the mine until a fresh concession is granted, there being efficient provision for neglect on his part in this respect.

The more noteworthy features have been printed in italics, and may be summarized as follows:—

1. TRANSFERENCE.—No mine or mining area can be leased, sold, sublet, or ceded, without Government authorization.
2. FORFEITURE.—Five years is allowed for commencement of operation; thereafter, provision is made for the comp! te return to the Government, of the mine, or area.
3. CO-OPERATIVE PRINCIPLES.—There is a compulsory obligation placed upon the operator to comply with any co-operative measures for working and sending off the products.

Suggested Legislative Provisions.—

Based upon the specific instance of Belgium, and a study of the legislative enactments of other coal producing countries, together with an intimate knowledge of existing conditions in the Maritime Provinces, the writer would suggest the following provisions, as being essential to the administrative control of the coal industry of eastern Canada: especially in view of the imperative need of conserving and developing the neglected thin-coal resources.

(1) The administrative system should make a clear cut distinction between thick and thin-coal mining.

(2) Effective control of the methods of mining; and absolute control over capitalization and speculation in the purchase of coal lands, no matter whether held actively or passively.

(3) Equitable provision for rendering financial help to practical operators intent upon the development of the thin-coal fields: a system which is already admitted in principle in existing precedents.

(4) Well balanced, mining labour policy, as an essential factor in industrial expansion, based upon an intimate study of the sociological problems relating thereto.

(5) Co-operation between operators and shippers, for the grading of the coals; regulation of selling price; cost of clearing; and marketing of product.

(6) Establishment of an educational policy, having as its objective the impartation and spread of useable knowledge of the practical technics of coal mining, and of existing mining conditions in eastern Canada.

Readjustment of Royalties.

The greatest divergence between thick, and thin-coals administrative practice is upon the royalty question. Provided the principle is conceded that the provinces should make the best of the thin-coal seams, both in present and in future operations; and that encouragement is given to their development and operation, a very reasonable complaint is based on existing royalty figures. It is, obviously, unfair to charge the same rate on a two-foot seam as on a six-foot seam: namely, 12 or 10c per ton. This is placing an unjust premium on the operation of the thick coals; when it is remembered that half this small sum may represent, in the cost of mining thin-coals, all the difference between profit and loss.

The mining cost of the thin seam must rise, and the proportion of overhead charge, represented by the royalty, is too heavy in relation to the mining cost.

It is, of course, a very difficult question to decide on what is best and most suitable, and on a generally equitable basis of readjustment. The suggestion is constantly being made that royalties should be based on a graduated scale, proportionate to the coal mined. Mining practice and administration, in those countries where the mineral rights belong to the land, have acceded, through custom and practice, to this method of assessing the royalties. While, however, thickness is the main and deciding factor, quite a number of other considerations are frequently taken into account. In Britain, where the coal belongs to the surface landlord, royalties are matters of adjustment between engineers of either party to the leases of the areas, and some strange anomalies sometimes appear. Thus, on one and the same seam, being operated from two points close together, the royalty may range from 8 to 16 cents. Other conditions besides thickness dominated the situation: conditions based on previously gathered mining knowledge of the leasehold. Should a field be heavily faulted, and consequently be heavy to work, the royalty offered may be much less than that imposed on the same coal in an adjoining colliery, where mining is much easier. The same alleviation might be given where heavy water troubles exist; and generally, to unexpected underground difficulties. Under this system, the price , aid the owner of the land for the right to mine coal thereon, ranges all the way from 25 cents down to 4 cents per ton.

Under some leases another form of royalty is demanded, called a "way leave". This is paid to the owner of a mineral area, on coal being brought underground from an outside lease, but through the land owned by the first landlord. The price charged is seldom over two cents per ton. The institution of the "way leave" royalty arose from the assumption that where any coal was to be won by means of passages driven through the first owner's areas, the second owner was indebted to the first for means whereby his coal was mined and sold; and, in some respects, because the first owner desired compensation for having his surface premises depreciated in value by the sinking of shafts; erection of colliery buildings, and accumulation of heaps of waste rock produced; all appurtenances used to gain, or, part of the operation of gaining, the second man's coal.

The prevailing method of adjusting royalties on underground conditions generally, implies that every coal should become, separately, the subject of negotiation between the operator and the Government. While this might still be carried out in special cases, it yet, to a considerable extent, leaves the subject open to personal influence, and consequently, possible injustice, and worse inequalities. The administrative scheme that would, perhaps, most acceptably cover the question of royalty on all operations, would be a system based on two factors: (1) the thickness of the seam, and (2) the class of fuel produced or mined.

Screening run-of-mine coal results in two classes of fuel being marketed: screened coal, and slack coal. Screened coal sells for a higher price than run-of-mine, while slack coal sells for less.

It is to the interest of all concerned to further the production of round coal, as against the production of slack. On the other hand, it has to be remembered that, there are seams, in the working of which, no method of operation could reduce the production of slack coal; and slack coal is usually a very difficult class of fuel to dispose of. It is reasonable to suppose, that a seam which is soft, and makes slack, is as much entitled to assistance, and in the same manner, as the thin-coal; but not, perhaps, to the same extent.

Assuming a proportional re-arrangement on some of the lines suggested, it would bring reduction, based on thickness: reducing a 36-inch seam to 6 cents, and an 18-inch seam to about 3 cents. The result generally, would be as follows:—

	Base. 12½c	Base. 10c
Six-foot seam	12½	10
Five-foot seam	10	9
Four-foot seam	8	7½
Three-foot seam	6¼	5
Two-foot seam	5	4
Eighteen-inch seam	3	2½

Next would come the consideration of the respective claims of slack, run-of-mine, and screened coals. In a thick seam, the fact that slack coal is made in the mining, is not as serious a factor against profitable mining, as it would be in the case of a thin-coal.

As there appear to be no available data giving average percentages of slack coal, and round coal, nor the prices paid for same in the provinces, it is only a guess to say, that it is at least reasonable, that screened coal could stand 2c per ton more, and slack take 2c less. Further, assuming for the sake of argument, that the present royalty is maintained on run-of-mine coal, for six-foot coal, this would result somewhat as follows:—

	Base 12½c.		
	Screened.	Run-of-mine.	Slack.
Below six-foot coal	14½	12½	10½
„ five-foot coal	11¾	10	8¾
„ four-foot coal	9¾	8	6¾
„ three-foot coal	7¼	6¼	6¾
„ two-foot coal	5¾	5	4¼
„ eighteen-inch coal	3½	3	2½
	Base 10c.		
	Screened.	Run-of-mine.	Slack.
Below six-foot coal	12	10	8
„ five-foot coal	11¼	9	7¾
„ four-foot coal	9	7½	6
„ three-foot coal	6	5	4
„ two-foot coal	4¾	4	3¼
„ eighteen-inch coal	3	2½	2

Which gives, approximately:—

Thick coals.—

Screened.............................. 70%

Slack.................................. 30%

Thin-coals.—

Screened.............................. 55%

Slack.................................. 45%

While the above percentage may be about correct for the thick coals, it seems high for the thin seams.

ADMINISTRATIVE CONTROL.

There is no room for speculation in thin-coal mining. The ancient device of a man coming in and leasing ground for a small sum, and subsequently turning it over, for an exorbitant price, to a large company, has no place in this industry. Such a proceeding—based on greed on the one hand, and speculative risk on the other —would only increase the financial burden of the final operating company, and render it almost impossible to mine the coal at a profit.

Before any company is permitted to lease coal areas, the ratio of mining cost to capital, and tonnage to profit, should be carefully taken into account; and where the estimates and evidence submitted by the prospective lessees is unsatisfactory, the leasehold should be refused. This is the only way in which the coal resources can be conserved.

The Belgian law[1] gets over this trouble by insisting that no property is to be transferred without the consent of the government. This law gives the administration power to veto any transaction, which, in the judgment of its experts, is of the speculative order. Moreover, the five year limit laid down in the same law is manifestly a wise provision, and much better than a system which requires that an annual amount of development be done.

CO-OPERATIVE MARKETING.

Having shown that thin-coal seams are workable, and having suggested certain technical and administrative conditions, which I conceive to be essential to success, there is yet another provision that requires attention, because it is just as essential to general success as actual mining, namely, the marketing of the coal. Wherever there are small mines, and many of them, there is either a *destructive competition*, on the one hand—in which case the operators, generally, are losers—or, *monopoly* on the other hand, in which case the general public are the losers, with consequent instability in the matter of sales and prices. The Belgians solved this problem by legislatively insisting on the adoption of co-operation.

Co-operative coal marketing is a tried system in various parts of the world, and, as a rule, comes into existence as a result of over-production. The suggested introduction of co-operation before production takes place, is a means of solving the difficult problems of avoiding unnecessary wastage in catering to special markets; it means relatively cheaper goods; more powerful organization; better sales; limitation of production to equality with the demand; and fair allocation of the market: all based on efficient production. The most notable example of co-operative selling is the Westphalian Syndicate. This consists of an aggregation of 70–75 collieries, marketing jointly 50,000,000 tons annually, through a selling organization which has only a nominal working capital, and holds no property. It has existed thirty years. Each company is represented on the board by one

[1]See p. 92.

representative, presided over by the General Manager of the Syndicate. Twice yearly, the tonnage is allotted to each mine, which allows making economical arrangements for working some time ahead. Any concern falling short of the allotted supply pays damages for the shortage to the Syndicate. Loss from poor coal is charged to the responsible colliery; but loss through inability to market is borne by the Syndicate. Contracts are made for five year periods, which provides operators with a steady income, and enables them to finance ahead. Each company pays a commission on sales.

Still another means to the same end is presented by the Transvaal Coal Association, constructed on somewhat different lines:—

No. of collieries...............	18.
Tonnage.....................	5,000,000.
Market......................	Internal and overseas.
Collieries in association........	Range from 18,000 to 250,000 tons per month.
Distance from internal market..	Varies from 80 to 120 miles from mines.
Distance from shipping port....	247 miles.
Operations at shipping point....	Resulted in providing shipping facilities, and raised overseas output from practically nil to over 1,000,000 tons annually.
Developing mines.............	Paid a flat rate for run-of-mine coal, irrespective of position.
Operating mines..............	Paid rate on screened coal, and slack, at mine: based on calorific value.
Association..................	Does all the selling on 2c per ton, and generally represents the trade.
	Balance over operation returned as dividends or used as capital to further sale of coal.
Form........................	On basis of joint stock company, each coal mining company on joining same purchasing the amount of stock allotted to it on capacity of mine.
Market......................	Allocated on three year basis, on capacity of mine.
Contracts....................	Made by association on yearly basis. Association collects all money and assumes all debts. Coal Companies Bill Association.

These two cases are admirable illustrations of the successful existence and benefits of co-operation. They are both unforgettable examples of the proverb, "Union is strength." The advantages are obvious, in face of competition from without.

Co-operation, however, is not necessarily confined to the sale of coal. Since it is possible that the seams of New Brunswick may be sent to market in a dirty condition—where a thin seam is in operation under a shale roof, or, a roof from which "fall" is taken down in mining—there is always a possibility that the coal sold will be mixed with rock. This does not represent a condition which cannot, by the application of proper and well understood means, be eliminated. The remedy is, proper cleaning plants. If necessary, co-operative screening plants can be adopted; and as with that problem, so it is with others.

And lastly, there is still the idea, several times advocated, and gradually coming forward as a possible solution for thin-coal fields where the general operations are limited to a number of small scattered mines, and that is, the establishment of a joint by-product plant. It is a proposal that, needless to say, will require to be very thoroughly investigated; but it is a possible means of future progress.

GENERAL SUMMARY.

In concluding this general survey of the thin-coal resources, and existing condition of the coal industry, of eastern Canada, the writer conceives that a brief recapitulation of the main facts, and the more important deductions made, will contribute to a clearer grasp of the whole subject.

Conclusions.—

1. The coal industry of eastern Canada is in its best production period, but is yet in a relatively weak position commercially: beset with outside competition; internal rising costs; and operated by over-capitalized and over-valued concerns, whose earning capacity approximates 3 to 4%.

2. The amount of coal that will enable Nova Scotia to retain the outside market, under present conditions, is not unlimited. If all the adverse conditions become operative, a limit is set at about 100 years.

3. The coal-fields have a high value to the provinces only as long as the maximum output is maintained. Thereafter, their value will decrease; hence the extension of the period of maximum value is most desirable.

4. In order to retain the external market, powerful corporations are needed, capable of the policy of placing large amounts to reserve; since development of the deep and the undersea areas will depend on that reserve almost entirely. A monopolistic condition is more conducive to continued operation than any other.

5. It is possible that if the financial arrangement of the Nova Scotia mining companies were reorganized—if a present loss could be agreed to for the sake of the future, the whole of the existing markets could be held against outside competition for many additional years.

6. Where properly operated, and properly financed under reasonably favourable conditions, 12-inch seams of coal can be worked economically in eastern Canada to-day.

7. Wherever possible, thin-coals in Nova Scotia—in addition to their preservation—should be simultaneously operated, in order to help to limit the continued exploitation of the thicker coals. A greater proportion of the annual output might be mined from thinner coals.

8. It should be legislatively insisted upon, that wherever a thin-coal exists, advantage be taken in existing mine openings to work it.

9. The problem of the thin-coals in New Brunswick is as much a necessary part of present operation as is future preservation; but for different reasons. Development should take place along modern lines of co-operative expansion, accompanied by administrative reorganization so designed that the province, from within itself, may

have inherent powers of progression, without dependence on chance outside assistance.

10. The substitution of tonnage of thin-coals, for tonnage of thick coals, cannot, and never will be a panacea for the troubles of the situation; but it is a possible source of partial relief, and a means to an end that cannot be overlooked wherever the issue at stake is the benefit of the province, and not the immediate profit of the operator.

11. The development of thin-coals generally requires a more co-operative form of organization. The margin between mining cost and selling cost is less in thin-coal mining; it will not stand the capital and administrative charges that seem inevitably to go hand in hand with monopolistic operations.

12. Coal mining speculation should be prohibited. The arrangements of the finances of any mining company ought to be under control, and the perpetrators punished, where the regulations are violated, just as improper mining methods are not tolerated. Apart from the safety question, the ultimate results in both cases of bad workmanship and illicit finance, are loss of capital, waste of coal and consequent loss of credit to the country.

13. The lack of co-operation has led to considerable provincial and interprovincial competition, which should, as far as possible, be avoided, and even eliminated, in the face of a still greater growing struggle, namely, international competition.

14. The whole subject of the thin-coals is one of great importance; and demands immediate consideration because the continued life of the provinces is largely dependent thereon. The greatest need is education and knowledge. The spread of accurate, useable knowledge with regard to the real condition of the coal industry in the Maritime Provinces, is a pressing need at the present time. And, with increased knowledge should come a movement for systematic technical education, so that the coal resources of eastern Canada may be utilized to still greater advantage, both economically and financially, thus contributing to the prosperity and progress of the country.

APPENDIX.

GEOLOGICAL SECTIONS OF GOVERNMENT BOREHOLES. 1902-15.

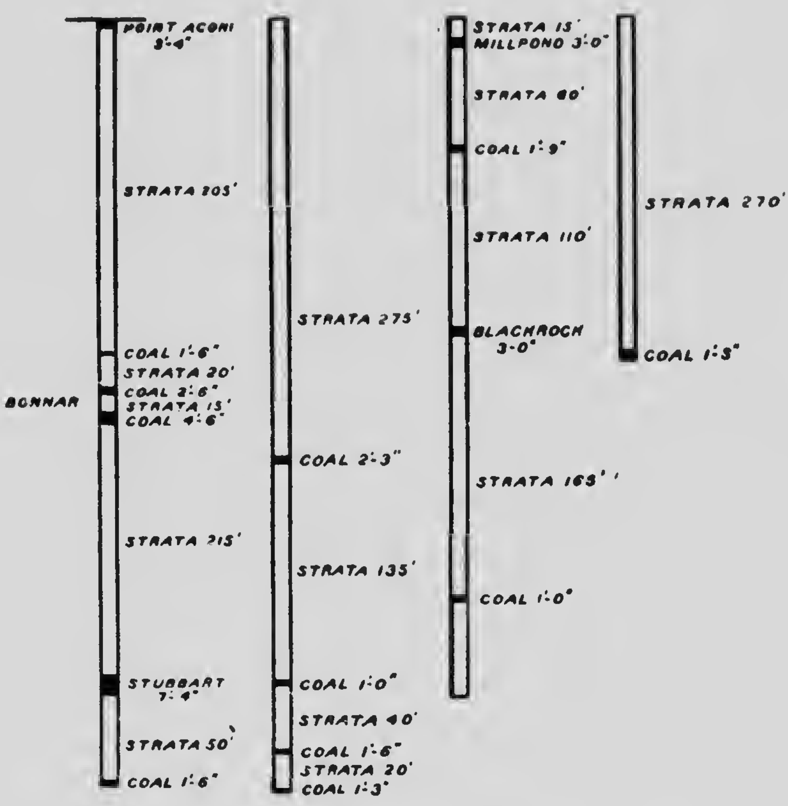


Fig. 30. Geological Survey Sections. Boularderie, Cape Breton, N.S.

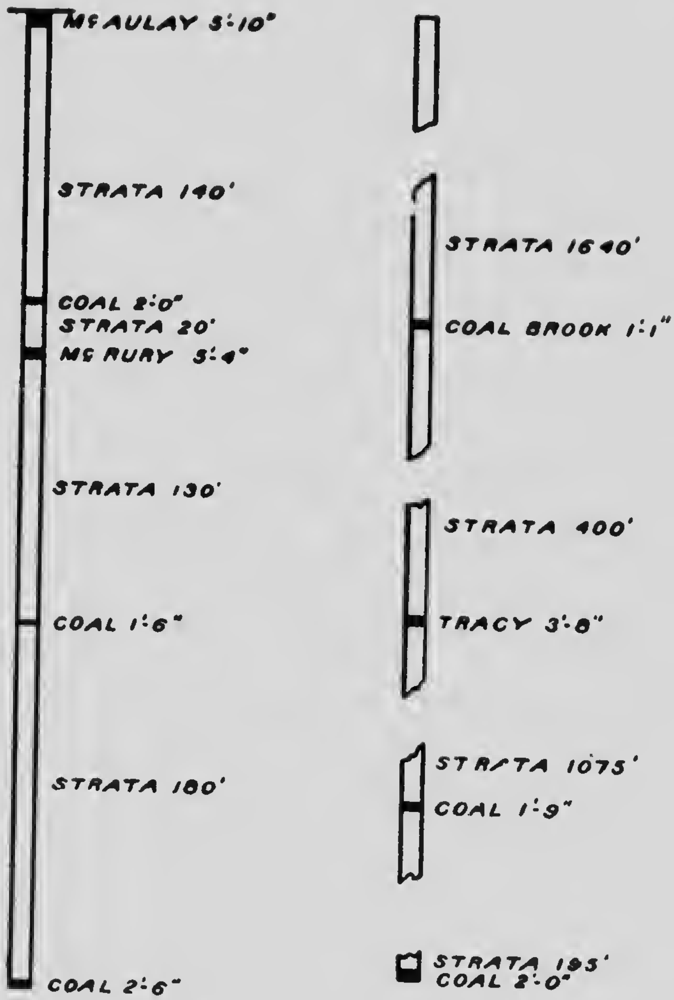


Fig. 31. Geological Survey sections, West Side Mira, Cape Breton county, N.S.

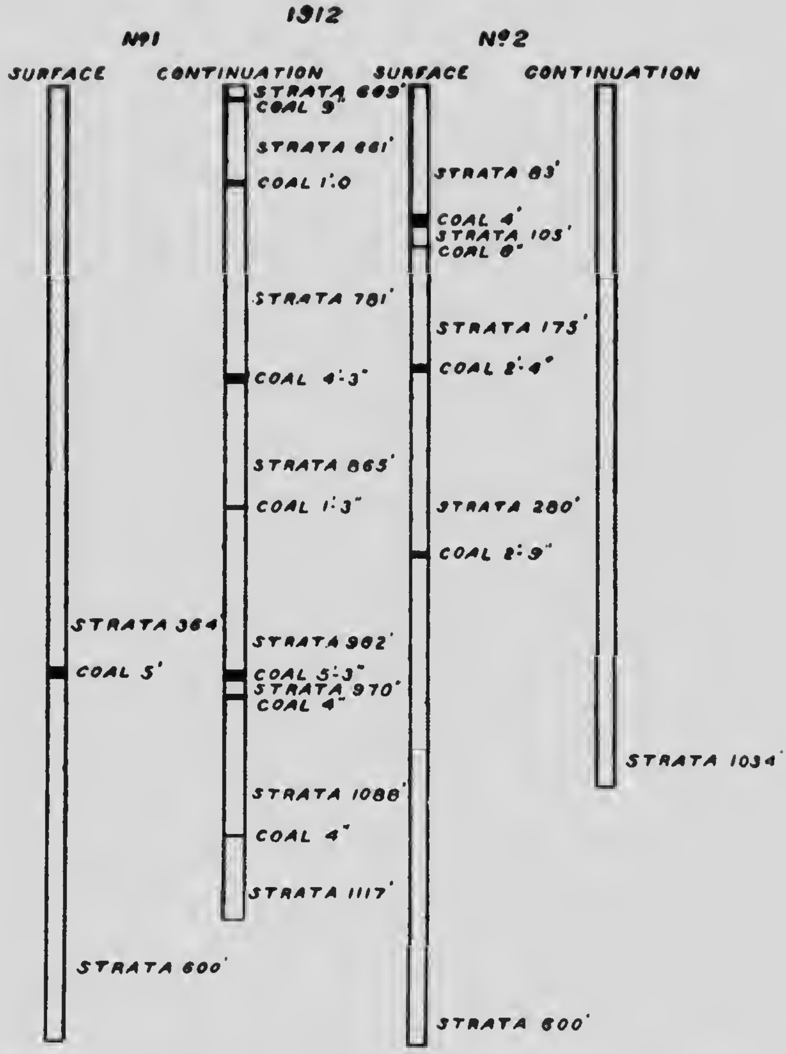


Fig. 32. Government Drill, No. 5, near No. 6 Mine. Sydney Mines, Cape Breton county, N.S.

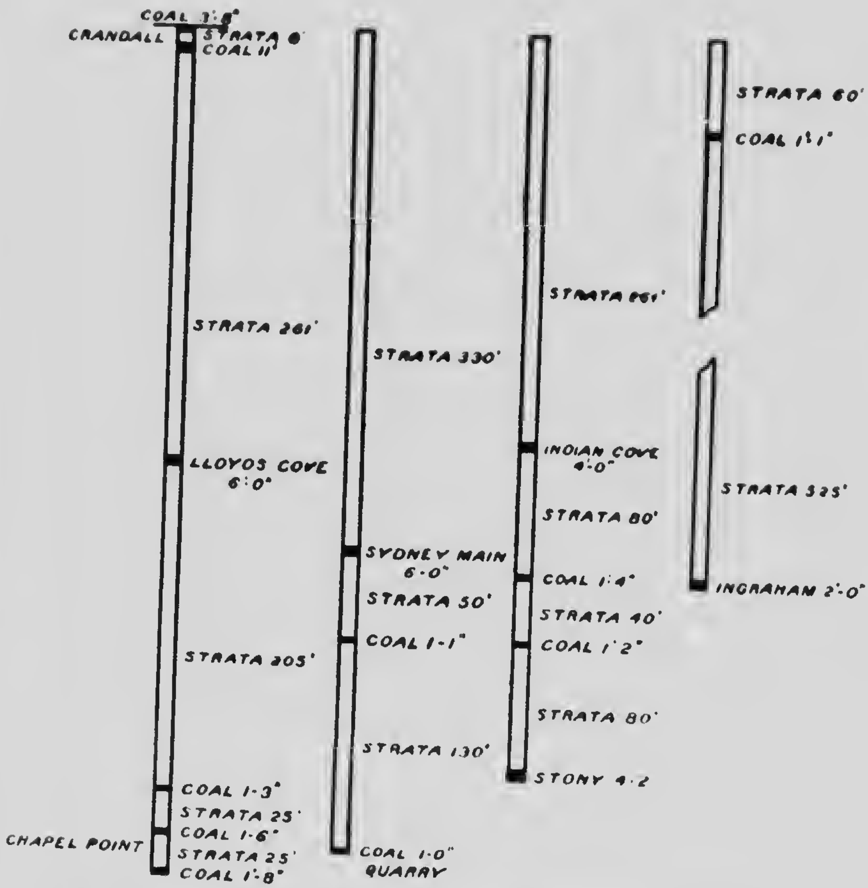


Fig. 33. Geological Survey sections. Sydney Mines, Cape Breton county, N.S.

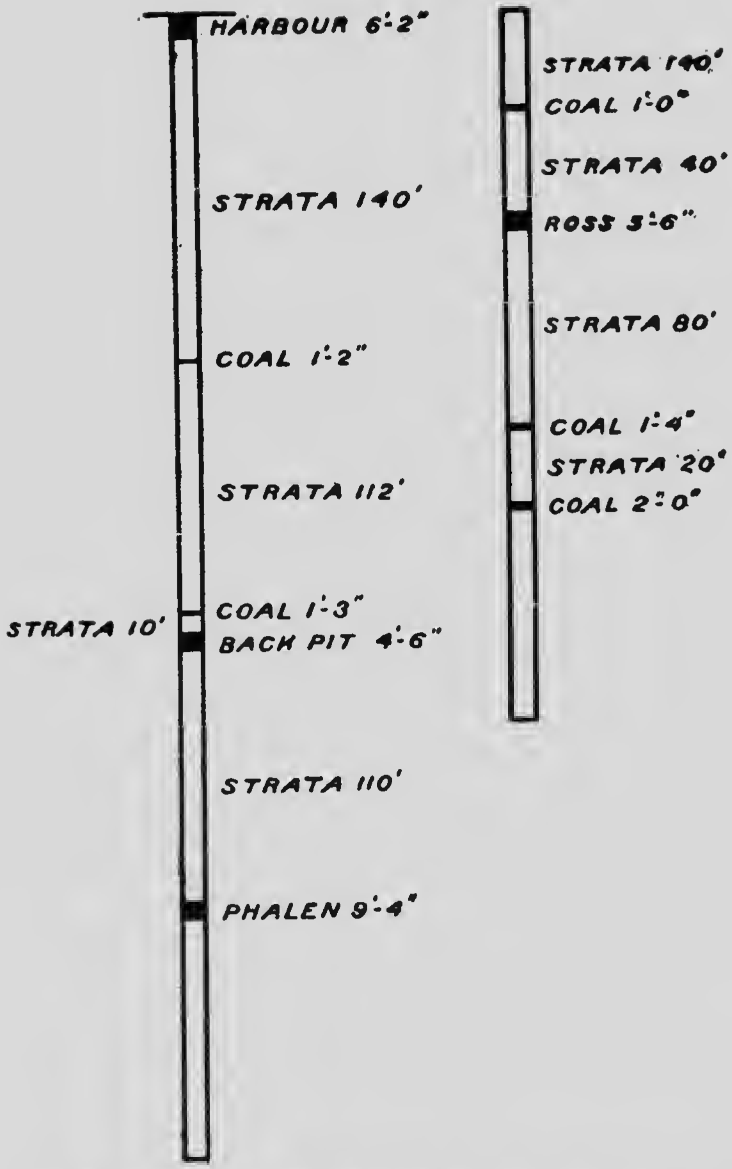


Fig. 34. Geological Survey sections, Glace Bay, Cape Breton county, N.S.

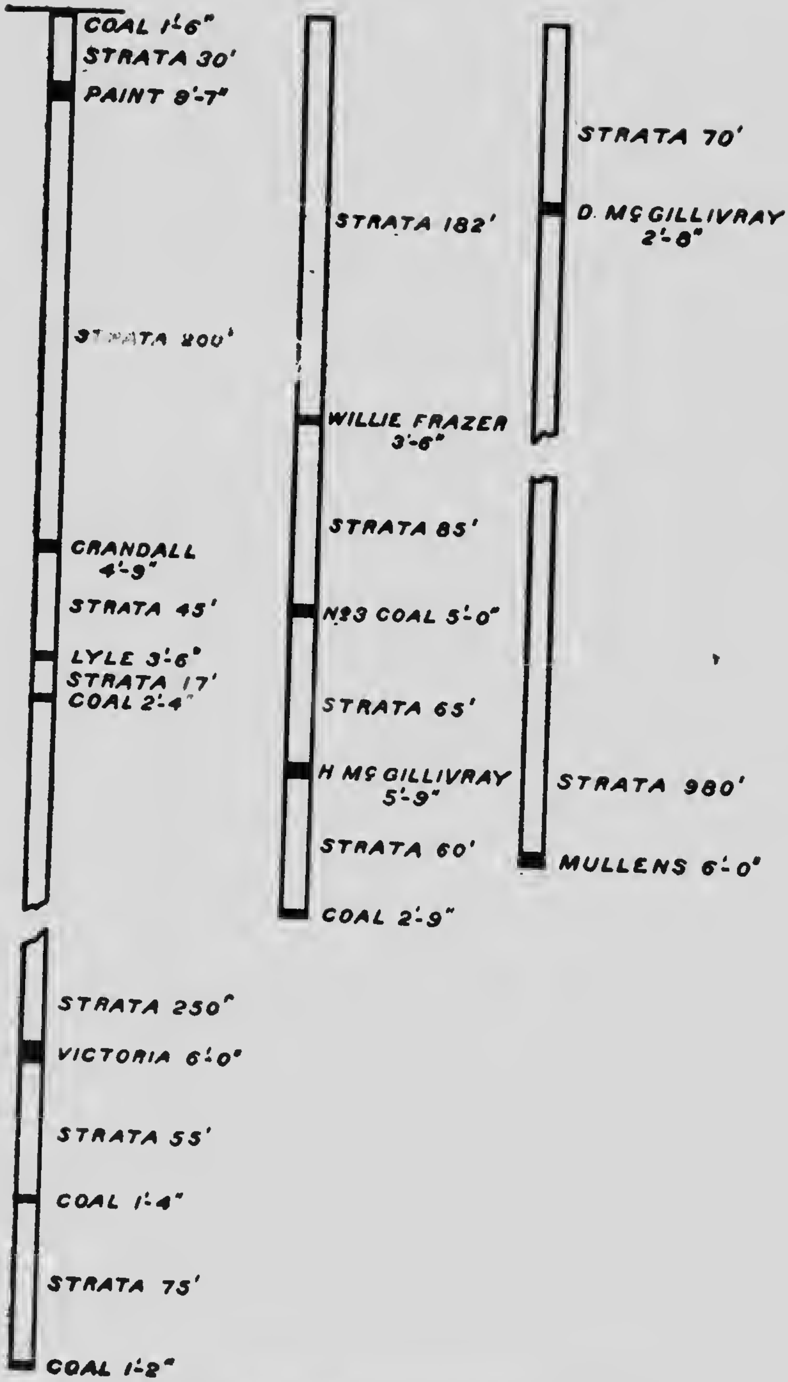


Fig. 35. Geological Survey sections, Victoria, Cape Breton county, N.S.

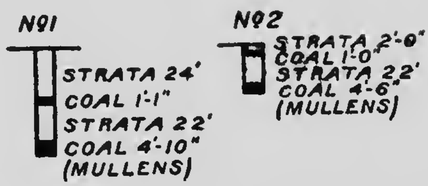


Fig. 36. Government Drill, No. 3, (1902) Lingan Basin, Cape Breton county, N.S.

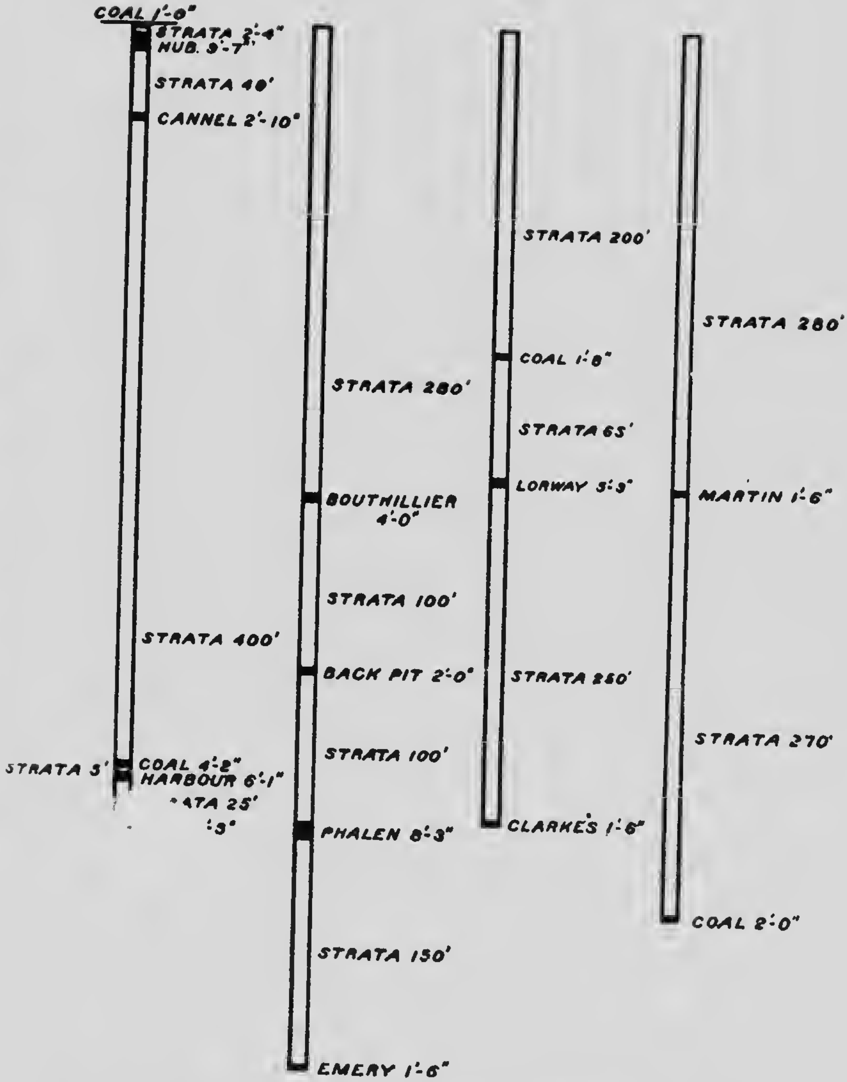


Fig. 37. Geological Survey sections. Bridgeport, Cape Breton county, N.S.

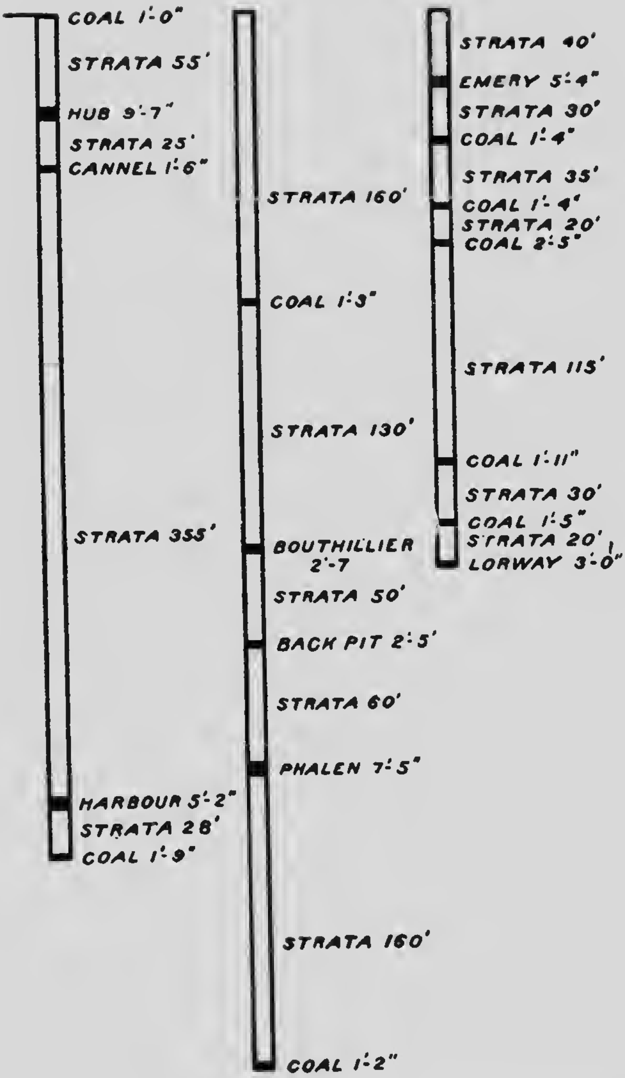


Fig. 38. Geological Survey sections. Table Head, Cape Breton county, N.S.

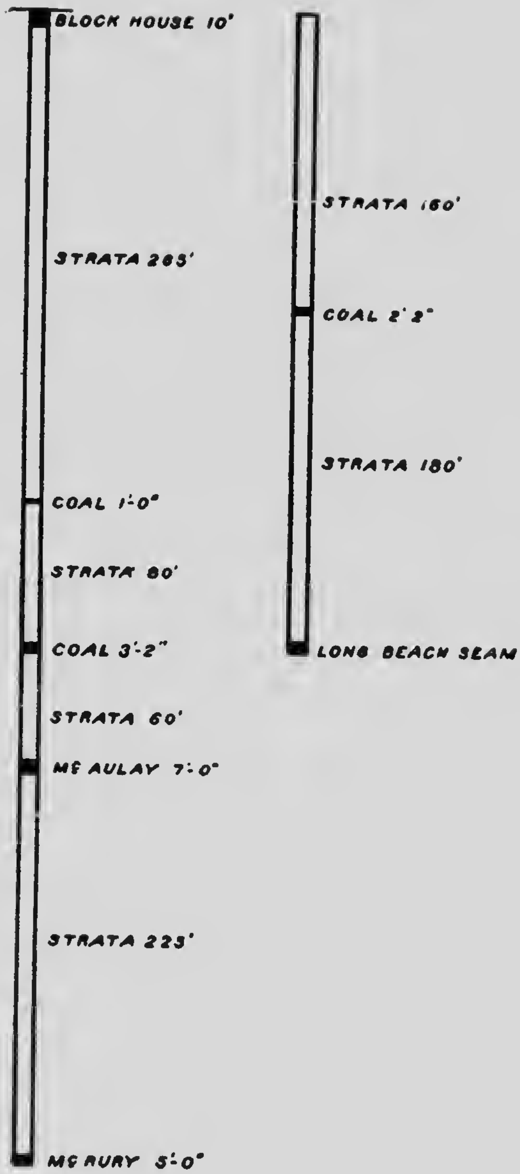


Fig. 39. Geologica' Survey sections. Millbrook, Cape Breton county, N.S.

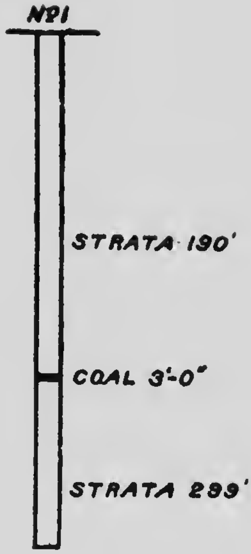


Fig. 40. Government Drill, No. 2, (1910). Glengarry district, Cape Breton county, N.S.

Fig. 41. Government Drill, No. 2. Hole No. 1, 1902. River Inhabitants, Cape Breton county, N.S.

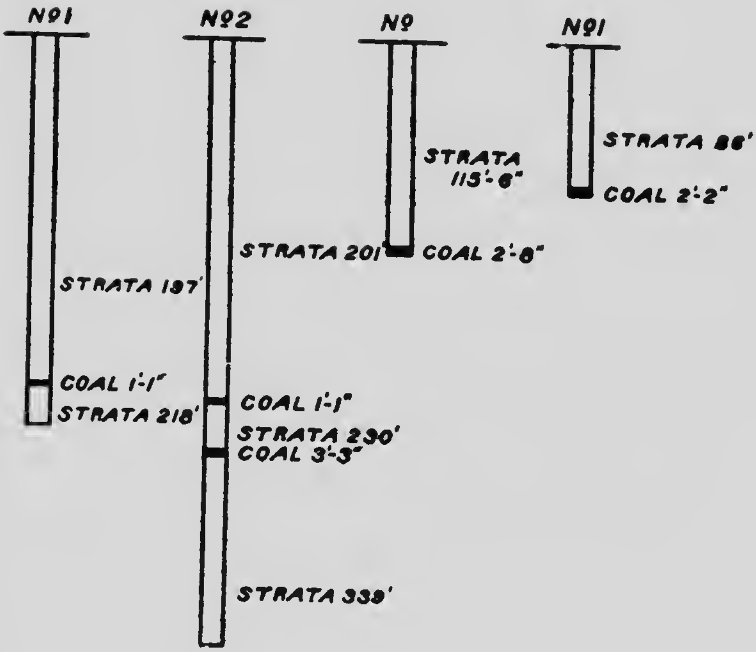


Fig. 42. Government Drills, Nos. 5, 2, and 7, (1913). Inverness area- Inverness county, N.S.

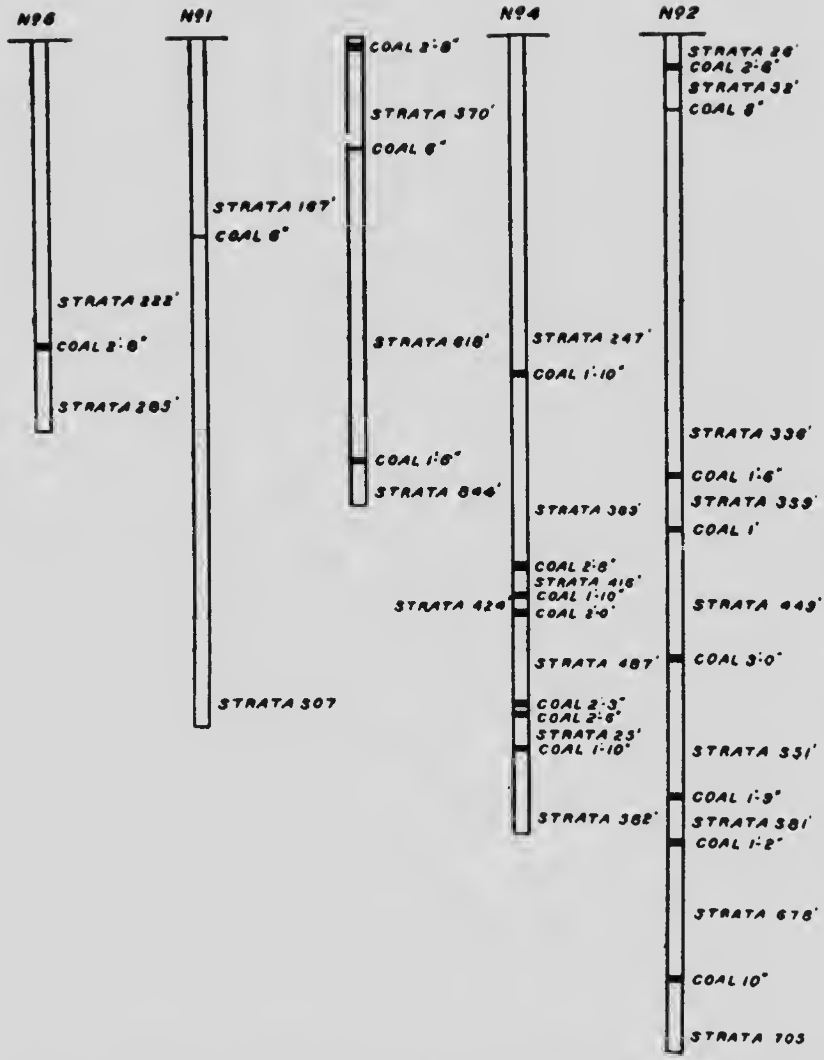


Fig. 43. Government Drill, Nos. 1 and 7, (1903). Port Hood, Cape Breton county, N.S.

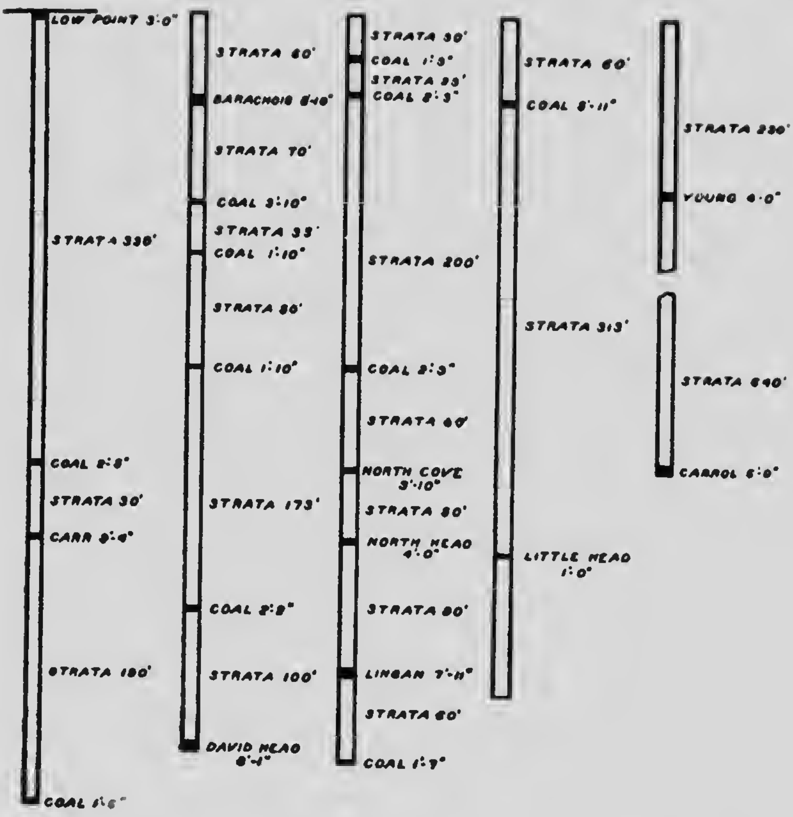


Fig. 44. Geological Survey sections. Low point, Cape Breton county, N.S.

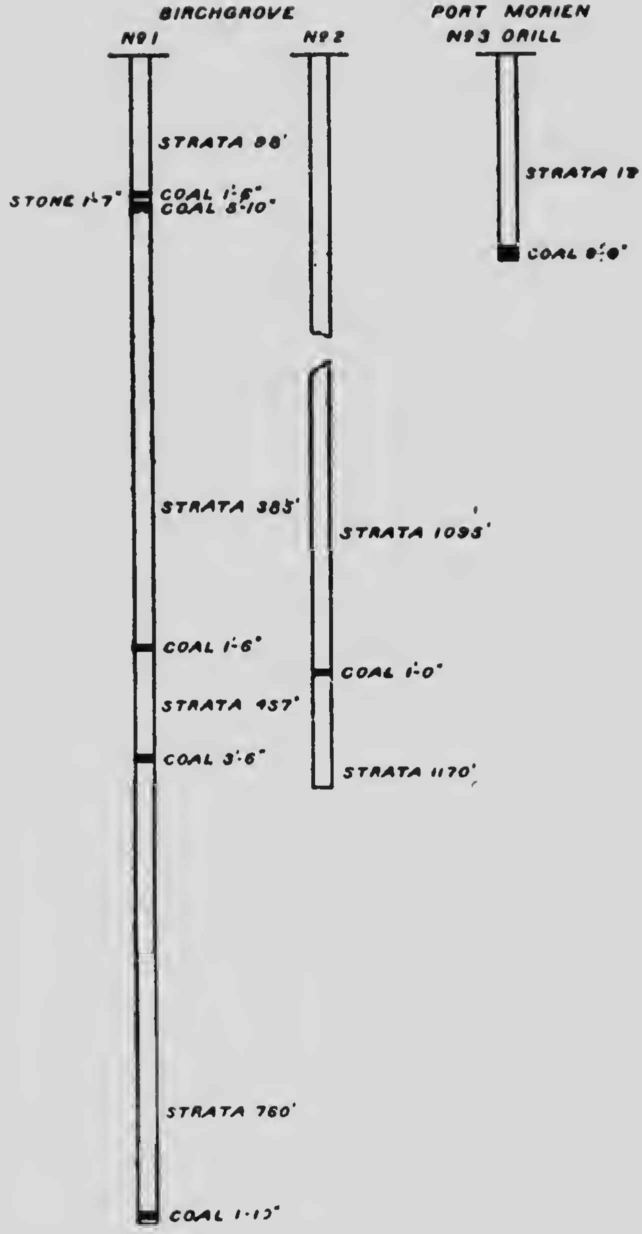


Fig. 45. Government Drills, Nos. 1, 2, and 3. D. I. S. Co. (1908). Birch Grove and Port Morien, Cape Breton county, N.S.

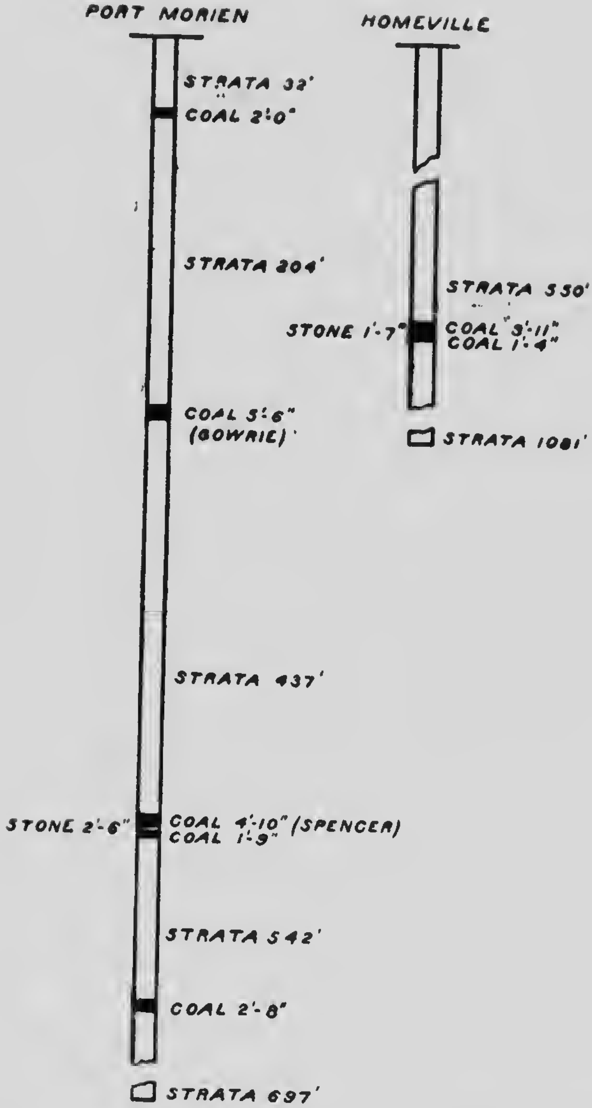


Fig. 46. Government Drill, No. 6 (1905), No. 5, (1907). Port Morien, Homeville, Cape Breton county, N.S.

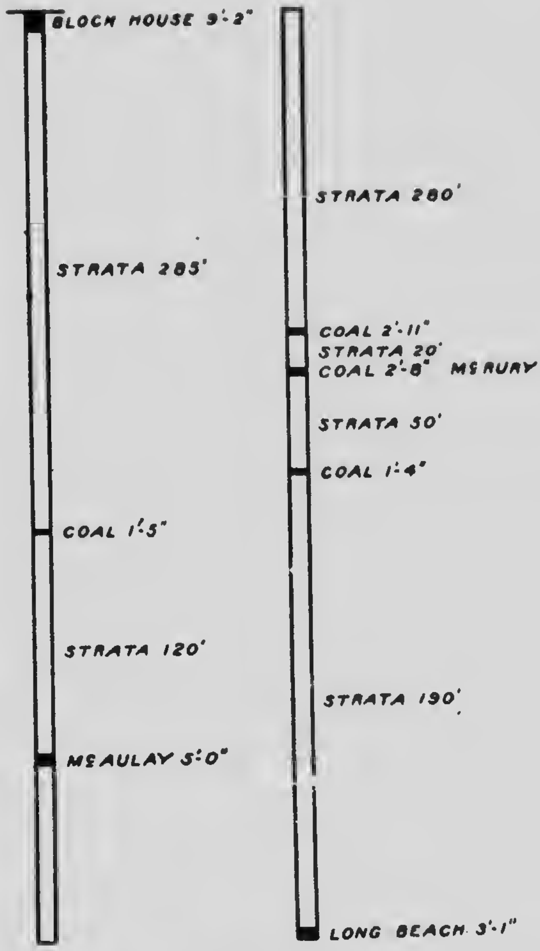


Fig. 47. Geological Survey sections, Blackbrook, Cape Bretc county, N.S.

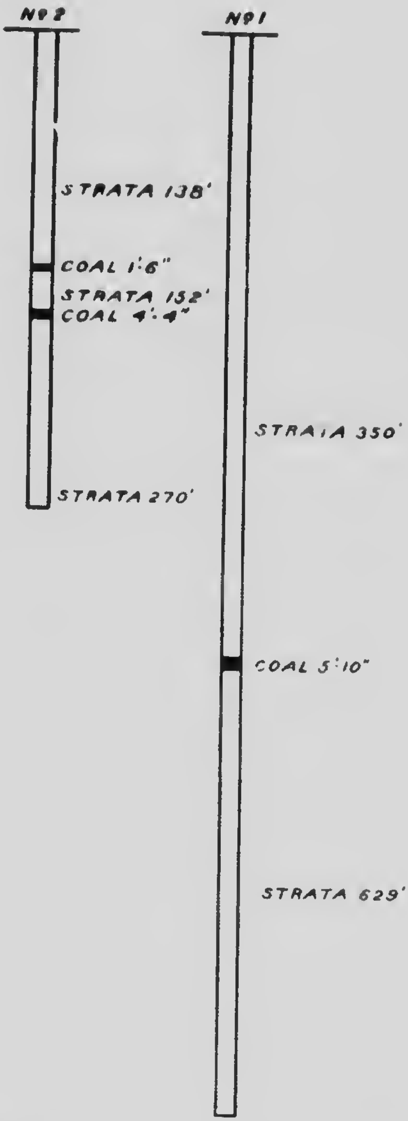


Fig. 48. Government Drill, No. 1, D.I.S. Co., 1907. Gardiner Mines, Cape Breton county, N.S.

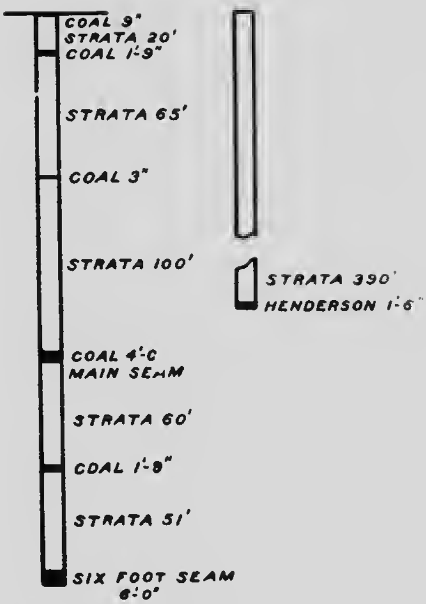


Fig. 49. Geological Survey sections. New Campbellton, Cape Breton, N.S.

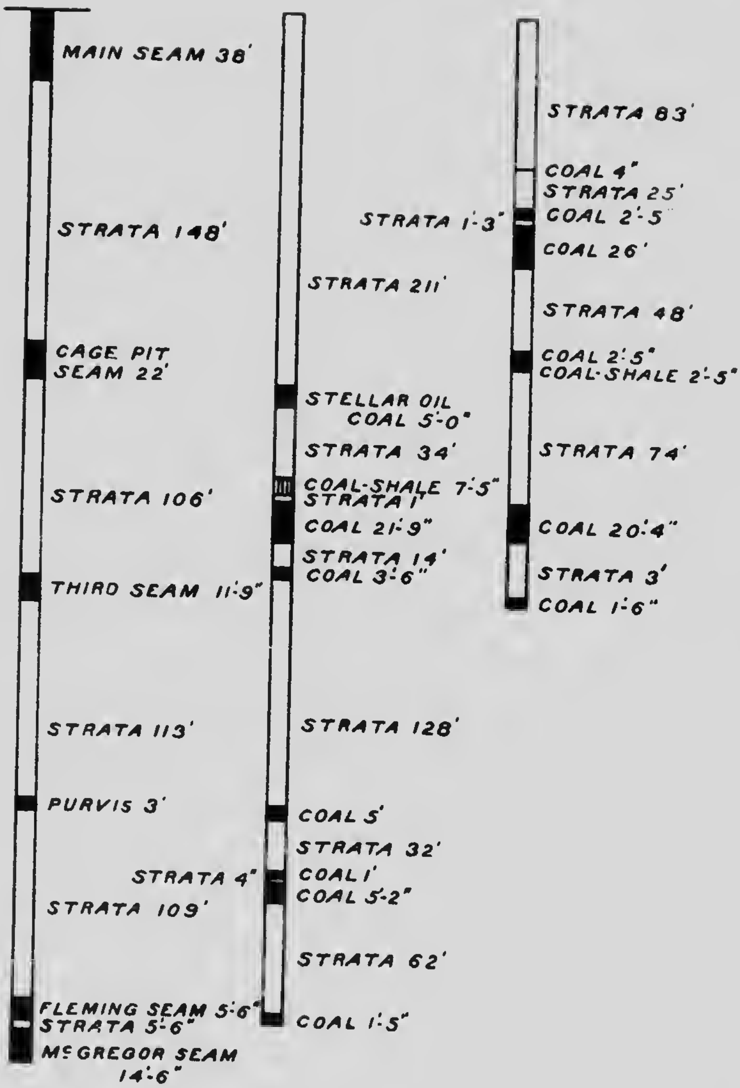


Fig. 50. New Glasgow Field, Pictou county, N.S. (From section published in "Mining Record." By courtesy of Mr. Notebaert of Acadia Coal Co., Ltd.)

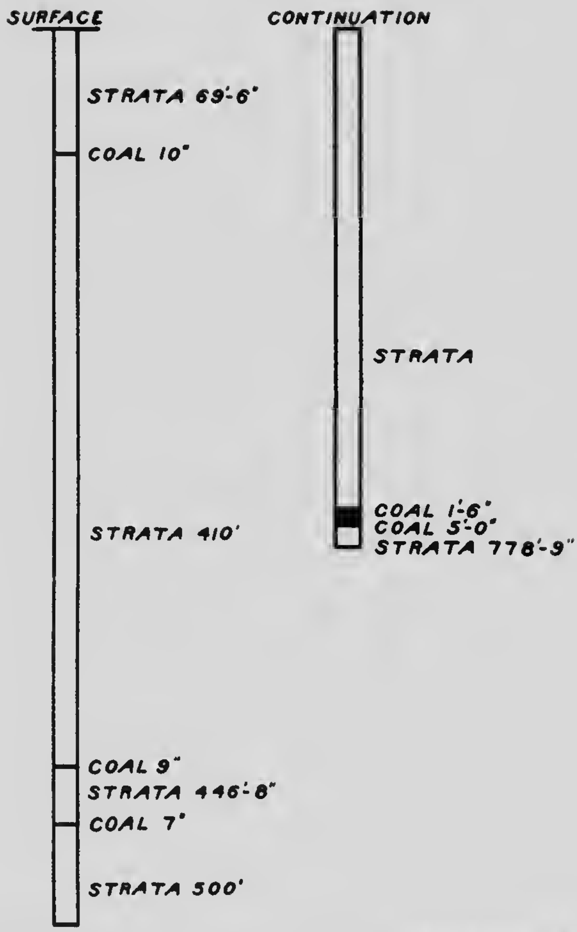


Fig. 51. Government Drill, No. 1, Hole No. 1, (1915). Acadia areas, Vale district, Pictou county, N.S.

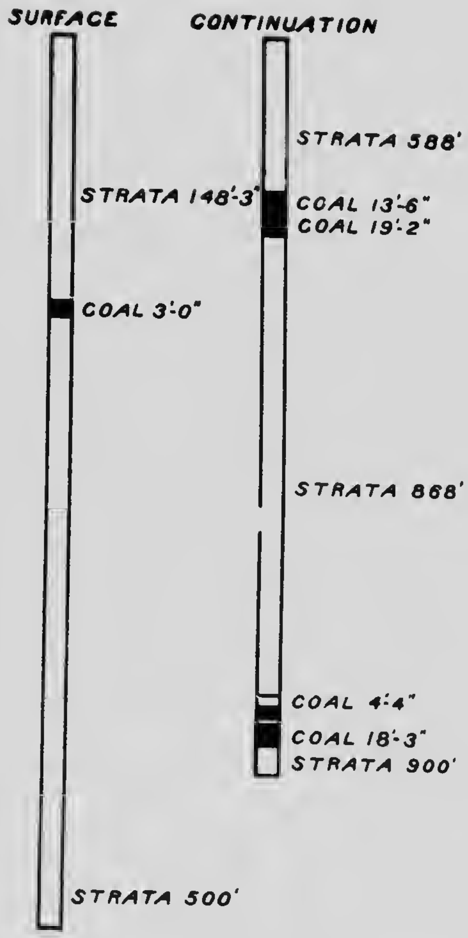


Fig. 52. Government Drill, No. 1, Hole No. 8, (1913). Acadia areas, Stellarton district, Pictou county, N.S.

Fig. 53. Government Drill, No. 2, in No. 4 Seam, (1907). Westville, Pictou county, N.S.

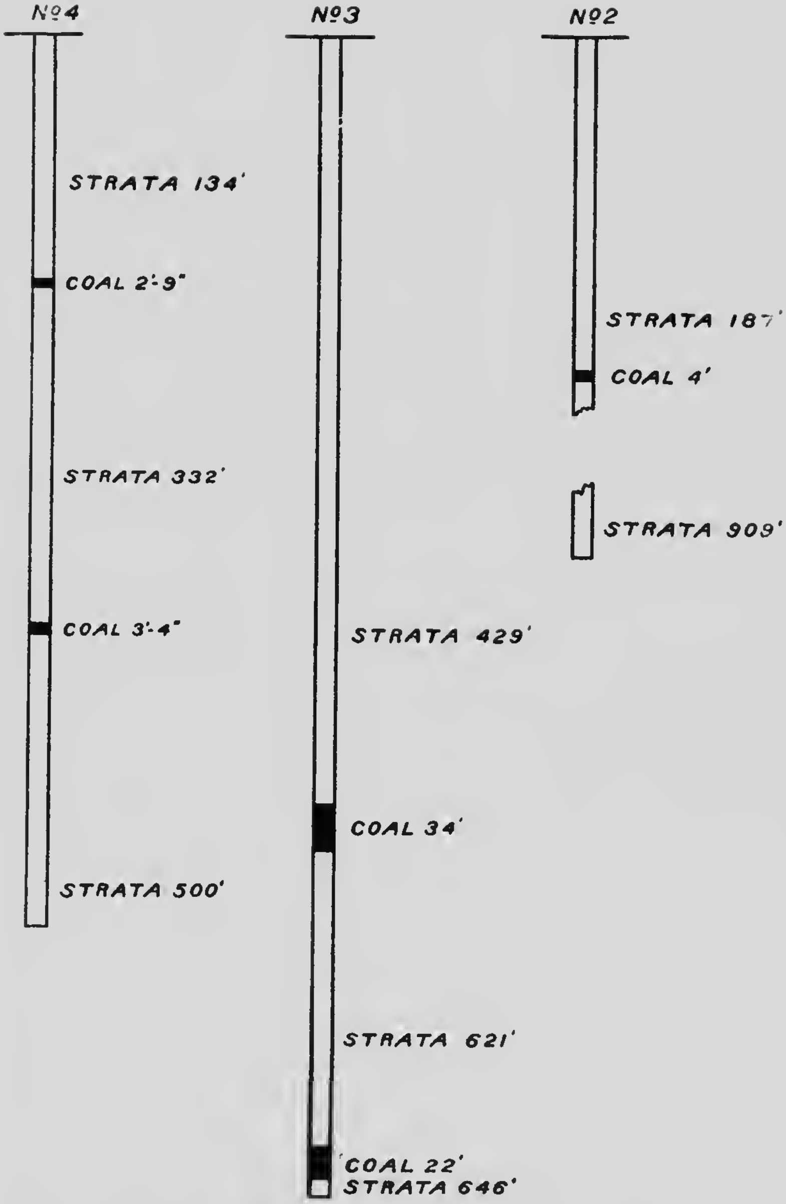


Fig. 54. Government Drill, No. 2, (1908). New Glasgow, Pictou county, N.S.

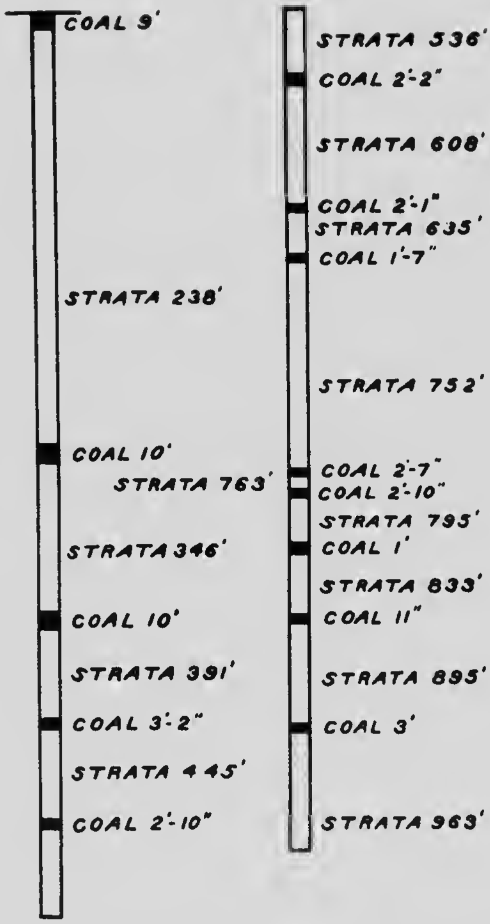


Fig. 55. Geological Survey sections. Springhill, Cumberland county, N.S.

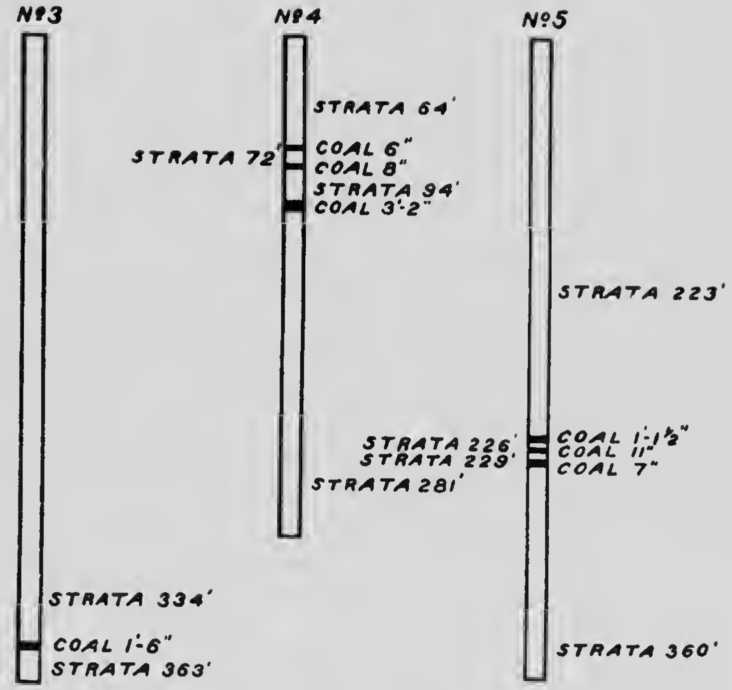


Fig. 56. Government Drill, No. 3, (1910). Joggins district, Cumberland county, N.S.

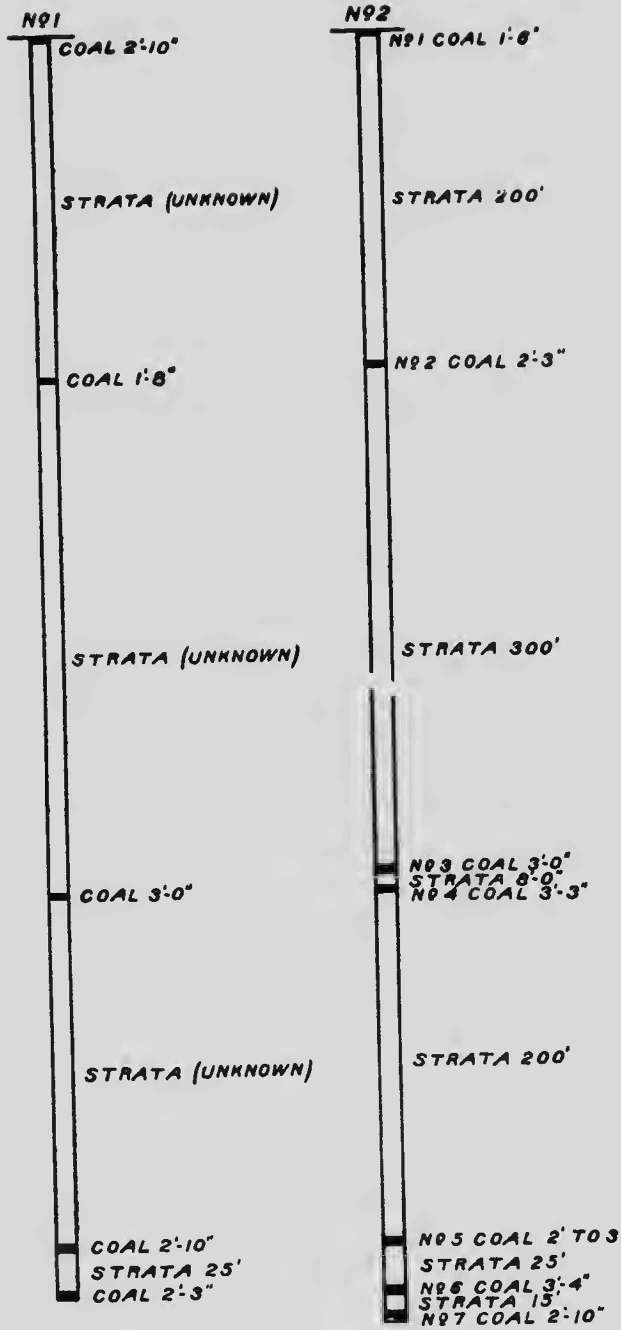


Fig. 57. Salt Springs district, Cumberland county, N.S. (From Notebook of Dr. Gilpin, Jr., 1880.) It is presumed that No. 2 is a correction of No. 1.

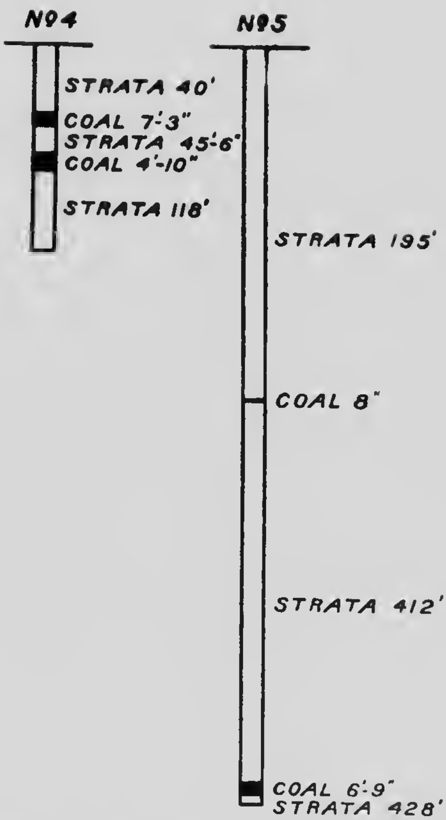
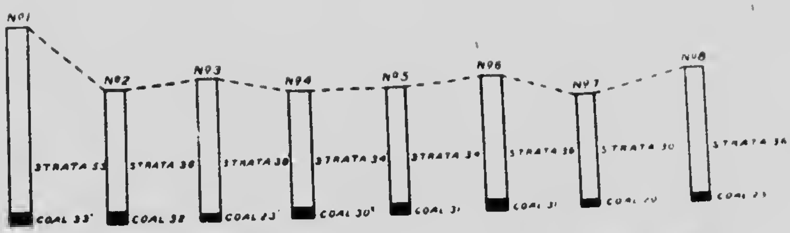


Fig. 58. Government Drill, No. 2 (1906). Debbert, Colchester county, N.S.



No. 1. Barnes mine.
" 2. Kings "
" 3. Tweedie "
" 4. Cokely "

No. 5. O'Leary mine.
" 6. Welton "
" 7. Kelly "
" 8. Gibbons "

Fig. 59. Grand Lake district, New Brunswick.

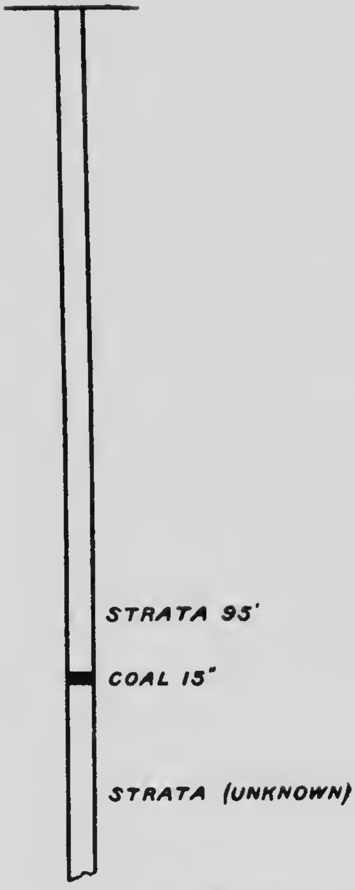


Fig. 60. Section: Coal Branch river, Beersville district, N.B.

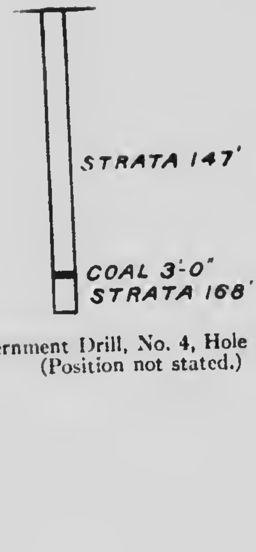


Fig. 61. Government Drill, No. 4, Hole No. 1, (1905).
(Position not stated.)

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1917

Base map from plates, Dept. of the Interior.

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HAANL   PH D. DIRECTOR

1917

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