The importance of alluvial mining to Victoria can be gauged by the total amount of gold produced from this source since the discovery in 1851, for out of the 66,000,000 oz. that Victoria has produced, some 40,000,000 oz. were alluvial gold, and at the present time of the 800,000 oz. raised annually, 250,000 oz. are alluvial, of which a good deal more than half was from mines operating on the deep leads, properly so called.

As the shallower alluviums get worked out, and quartz mining has to deal with more complicated and difficult problems as depth increases, the importance of the 400 miles of proved deep leads and others which Victoria possesses will become enhanced. Most of the gold found during the first ten years was from shallow placers, the runs of gold were easily found and cheaply worked. These shallow deposits occupy the beds of streamlets that fed the river systems of the Upper Tertiary periods, the deposits of which have been preserved, and form what is now known as "Deep Leads." It is to a short description of these auriferous deposits, their location, draining, and working that this paper is devoted.

**GEOLOGICAL HISTORY AND DISTRIBUTION OF DEEP LEADS OF VICTORIA.**

The Ordovician, or Lower Silurian deposits were during the Devonian Period thrown into immense folds, having a general strike of N. and S. The strata were very much uptilted, and the higher portions were thrown to such a level that the silurian rocks, which form the present "divide" of Victoria, are only the remains of the mountainous plateau which occupied the State. Underlying these folded sedimentary rocks, and forming immense intrusions and dykes, are igneous rocks of varying composition, which must be looked upon as the ultimate source of the Deep Lead gold. During the uplifting of the Ordovician strata and the intrusion of the Granites, Diorites, and other igneous rocks, quartz veins were formed in the various cracks and fissures, which were in a N. and S. strike owing to the E. and W. thrust which produced them, by the meteoric water which permeated the Ordovician rocks above the critical temperature. These waters were (during their circulation) charged with gaseous emanations from the underlying and adjacent highly-heated plutonic rocks,
which are now showing themselves as granite hills in various parts of Victoria. These gaseous emanations being charged with the various minerals, including gold, were taken into solution by the highly-heated waters which collected in the cracks and fissures above mentioned. Whilst rising to the surface these solutions deposited and formed as their power of holding the silica and other minerals in solution lessened (owing to the decrease in its temperature, and other causes) the quartz reefs which were the immediate source of the Deep Lead gold.

This is only mentioned because of the important bearing these plutonic rocks and their chemical composition have on the richness of the Deep Lead systems; much of the gold which they contain was derived probably from reefs which have long since disappeared, leaving only the harder plutonic outcrops, the exact chemical composition of which might give some clue to the probable richness of the neighbouring Leads, which, being covered with some hundreds of feet of Basalt and heavily charged with water, it is impossible to test with any degree of certainty.

The so-called Auriferous zones, which stretch in parallel N. and S. bands across Victoria being, in the opinion of the writer, merely a reflection of the chemical composition of the underlying and outcropping plutonic rocks.

This immense Ordovician plateau, with its quartz veins, at an elevation much greater than the present divide, was intersected by valleys, and was subjected to a rainfall, to Glacial, and to other denuding forces far more powerful than those at present reducing its elevation.

Much of the earlier erosion of this Ordovician plateau was done by Glacial action; there exists evidence to show in the glacial conglomerates of Bacchus Marsh and those which form the beds of the later fluvatile valleys at Charlotte Plains, Moolort, Pitfield, Heathcote, etc., that glacial valleys were formed at much lower level than the later deep lead deposits, and with much steeper sides. These Glacial deposits are of bluish clay, with numerous granitic boulders (up to 3 or 4 feet diameter) and ironstone, quartz, quartzite, and slate striated stones. They are hard to drive in, but as soon as they are exposed to air and water they crumble.

How deep these beds are in some of the lower valleys has never actually been found; but judging by their wide distribution in these valleys, and the ease with which they must have been denuded to their present level, they must have occupied a considerable area and been of considerable thickness; and their auriferous (or otherwise) character might possibly have a say in the richness of the Leads of which they form the bed.

After glacial periods (whilst the Carboniferous beds of Gippsland were being laid down) the surface was subjected to rainfalls evidently much stronger than they are at present, and during
the older Pliocene periods rivers following the general courses of
the present streams and older glacial valleys were formed, and
the country worn down to the level of that period. The soft
slates and sandstones were washed away, and reefs were gradu-
ally disintegrated; their contents filled up the beds of the ancient
rivers; the gold, by numerous concentrations, being transferred to
the bedrock, became distributed through the lower two or
three feet of washdirt and top eighteen inches of bedrock. In
the proximity of reefs the washdirt naturally became richer, and
it is to them, and also to reconcentration of gold-bearing beds at
higher levels, owing to shifting of the stream, that the various
runs of gold are due. As the river altered its course and cor-
roded its bed still further, numerous benches and terraces of
wash, which must contain gold to a certain extent, were formed.
These high washes have been left untouched up to the present in
many of the leads worked.

Owing to alterations in the gradient, and other causes, these
river valleys began to fill up with various strata, described as
“coarse drift,” “clay,” “fine drift,” “gravel,” “decayed wood,”
etc. The clays represent periods of peaceful deposition on
river banks or backwaters, and the thin beds of lignite, the re-
 mains of vegetation with which the old valley was at times
covered. The sequence apparently was “clay,” “decayed wood,”
“drift,” and occurs several times in sections across the leads.

The width of the bed of the stream varies, of course, with
its position in the lead system; the Berry Lead, as far as it has
been worked, goes up to some 700 feet, whilst lower down it in-
creases to widths up to 2,000 or 3,000 feet, which point to rivers
far larger than any now having the same watershed. During
these times the surface was gradually lowered, and many of the
lower reaches of the valleys were beneath the sea level, and were
covered with some 300 to 400 feet of clays and drifts. At the same
time great volcanic activity existed in the upper reaches of these
rivers; in all probability the two geological disturbances were co-
incident, and one the natural sequence of the other. There were
two volcanic flows, the older covering some of the river valleys,
principally in the east of Victoria, and the newer, which was much
larger and far-reaching in its extent and influence. The newer
volcanic lavas were ejected by numerous volcanoes, the stumps
of which are visible throughout Western Victoria, and by in-
numerable vents, and covered up, and effectually preserved the
older Pliocene river deposits from further erosion, with 200 to
300 feet of basalt.

Since these Post Tertiary or Newer Volcanic times denuda-
tion of the basalts and other exposed rocks has gone on, and in
many cases the Ordovician hills have been denuded until they now
form the beds of streams at a lower level than deep lead, which has
been protected by a capping of the harder basalt. This is gener-
ally the state of affairs in the Deep Placers of California. But
the majority, the most important and valuable of the Deep Leads
are some 300 to 500 feet below the general level of the overlying
basalt, or alluviums, and well below the general water-level of the
country, and in this lies the difficulty of alluvial mining in Vic-
toria, as compared with California and other countries, rendering
it unique.

The following are from returns published, giving particulars
of some of the richest Deep Lead mines that have been worked.
These mines are only on tributaries of the main trunk leads, which
are so far untouched:—

**VICTORIAN DEEP LEAD STATISTICS.**

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>Gold Won.</th>
<th>Value</th>
<th>Rate of Royalty</th>
<th>Royalty</th>
<th>Dividends</th>
<th>Capital Called up.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BERRY LEADS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Madame Berry</td>
<td>387,313</td>
<td>£1,588,515</td>
<td>7½ &amp; 9</td>
<td>£128,317</td>
<td>£855,450</td>
<td>£15,975</td>
</tr>
<tr>
<td>Berry Consols</td>
<td>190,799</td>
<td>£791,826</td>
<td>7½</td>
<td>£59,754</td>
<td>£306,000</td>
<td>£76,000</td>
</tr>
<tr>
<td>Madame Berry W</td>
<td>64,140</td>
<td>£266,265</td>
<td>2½</td>
<td>£8,883</td>
<td>£41,987</td>
<td>£9,000</td>
</tr>
<tr>
<td>Lone Hand</td>
<td>126,950</td>
<td>£517,330</td>
<td>7½</td>
<td>£38,799</td>
<td>£244,450</td>
<td>£6,650</td>
</tr>
<tr>
<td>Ristori</td>
<td>104,224</td>
<td>£430,918</td>
<td>7½</td>
<td>£32,153</td>
<td>£199,500</td>
<td>£11,250</td>
</tr>
<tr>
<td>New Australasia</td>
<td>90,203</td>
<td>£374,771</td>
<td>7½</td>
<td>£16,189</td>
<td>£32,800</td>
<td>£4,000</td>
</tr>
<tr>
<td>Lewers Freehold</td>
<td>13,939</td>
<td>£57,703</td>
<td>10</td>
<td>£1,611</td>
<td>£61,000</td>
<td>£75,500</td>
</tr>
<tr>
<td>Berry Consols Extd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total...</strong></td>
<td>1,333,759</td>
<td>5,488,934</td>
<td></td>
<td>379,520</td>
<td>2,260,343</td>
<td>342,850</td>
</tr>
<tr>
<td><strong>CARSIBROOK LEAD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sadowa</td>
<td>51,390</td>
<td>205,565</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Kong Meng</td>
<td>94,300</td>
<td>377,321</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Napier's Freehold</td>
<td>69,680</td>
<td>278,746</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chalk's Freehold</td>
<td>54,093</td>
<td>216,352</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total...</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,952,705</td>
</tr>
<tr>
<td><strong>DUKE LEAD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band of Hope</td>
<td>32,080</td>
<td>128,319</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old Duke, etc.</td>
<td></td>
<td>495,752</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duke...</td>
<td></td>
<td>284,724</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Duke</td>
<td></td>
<td>105,345</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Duke</td>
<td></td>
<td>200,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total...</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,800,000</td>
</tr>
<tr>
<td><strong>CHILTERN &amp; RUTH'G'N</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barrambogie</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiltern Valley</td>
<td>190,000</td>
<td>?760,000</td>
<td></td>
<td></td>
<td>?165,000</td>
<td></td>
</tr>
</tbody>
</table>

The following leads have been proved, and remain to be
worked (E. Lidgney):—

Great Western Valley ... ... 2 miles length
Madame Hopkins, Ararat ... 8
Landsborough ... ... ... 4
Glenpatrick ... ... ... 4
Beaufort, Continuation of ... 18 miles length.
Pitfield Plains ... 5
Rokewood ... 3
Cardigan ... 30
Upper Bet Bet Valley ... 42
Loddon Valley ... 64
Spring Hill Leads ... 20
Malmsbury and Coliban Valley... 50
Plenty River ... 12
Neerim and Moondarra ... 40
Ovens River, below Myrtleford... 10
Rutherglen—proved 20, worked 5 15
Dargo High Plains ... 20

347 miles.

Fig. 1 gives an approximate idea of the deep leads of Victoria, as far as they have been proved by boring operations and geological surface indications.

The Deep Leads of Victoria. Fig. 1.

Location.

The upper portions of the leads, exposed as recent surface alluviums, were contained in a narrow valley with bedrock on either side; the washdirt bottom, being shallow, was easily located and worked.
As sinking became deeper, the workings were troubled by water, and all trace of the leads was obliterated by basaltic flows, so prospecting bores became necessary. Some £400,000 has been spent in Victoria in boring to locate these deep auriferous leads, by the Government and private companies, or both combined. Cost of boring in basalt is from 8s. to 13s. per foot with diamond drills; hand boring in clays and drifts costs about 2s. in shallow ground, to 4s. or 5s. in deeper ground.

**Developmental Work.**

The lead having been defined by boring, a portion of the valley where the side is steep and in a position which is centrally situated as regards to the lead to be worked, is selected for a shaft site, and is bored so as to finally select a site where no drifts are cut in sinking. Should, however, the distance from the lead be greater than 2,000 feet, sinking through the drifts is considered.

Size of shafts is from 22 ft. to 15 ft. long by 7 ft. 6 in. to 5 ft. wide.

Depth of shafts is governed by the level of the lowest part of lead to be worked, as determined by boring, and is dependent on—

- a. Distance and grade of the underlevels. The grade giving the best results is found to be 3 to 8 in. per 100 ft.
- b. Amount of backs, which depends on the length of underlevels and closeness of the boring: usually 15 ft. is allowed for carefully-bored ground, and 30 ft. for little-bored, above the back laths at the lower end of the lead to be worked.

Cost of sinking; labour per foot; 17 x 6 shaft, depending on the quantity of water encountered.—Drifts, perhaps £50; basalt, £2 to £10; clay, £2 to £4; silurian, £1 to £5.

**Size and Extent of Main Under-Levels.**

The practice is to extend the reef-drive to a point near the lead, and to bifurcate it into the up and down branches, tapping the drifts above with bores, for the purpose of drawing off the water and locating the lead. The main underlevels should be continuously extended during the whole of the time of drainage, so that—

- a. The lead may be properly defined for some 700 ft., up and down.
- b. A large area may be drained, and, by having lines of bores some 1,200 ft. apart, the intervening wash will be protected from incoming water, and can be worked.

**Size of Main Levels or Reef Drives.**

Charlotte Plains, etc.—

<table>
<thead>
<tr>
<th></th>
<th>LEG.</th>
<th>CAP.</th>
<th>SPREAD.</th>
<th>TIMBER.</th>
<th>CENTRES.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>8' 6&quot;</td>
<td>4' 6&quot;</td>
<td>8' 6&quot;</td>
<td>10&quot;</td>
<td>4' centres.</td>
</tr>
<tr>
<td>Branch</td>
<td>8'</td>
<td>4&quot;</td>
<td>8&quot;</td>
<td>8&quot;</td>
<td>4' centres.</td>
</tr>
</tbody>
</table>
Rutherglen District—

<table>
<thead>
<tr>
<th>LEG.</th>
<th>CAP.</th>
<th>SPREAD</th>
<th>TIMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>7' 6&quot;</td>
<td>6' 4&quot;</td>
<td>7' 6&quot;</td>
<td>10' 8&quot;</td>
</tr>
</tbody>
</table>

Cost—Labour... 5/- per foot soft picking.

... 20/- per foot blasting ordinary silurian.

Timber... 1/6-2/- per foot.

**Draining Deep Leads.**

This is the great deterring factor and expense to alluvial mining; to equip each shaft means some £60,000, and then several years' pumping, costing some £5,000 to £7,000 a year before the lead could be prospected, or an ounce of gold obtained.

To drain the leads, 3 in. bores are put up from the main lower levels (or short crosscuts off them, provided with sand doors) into the washdirt, and gravels, to draw off the water there contained, until the pressure has been reduced to some few pounds per square inch, i.e., the water-level reduced to nearly that of the bed of the lead; and then, and not till then, is the wash actually risen into, and cut up by wash-drives, and thoroughly drained.

**Putting up Bores.**

Where the country rock is very hard (e.g., hard, compact slates or granites), a hole is directly bored, by jumping-up bits of different kinds, by means of a wooden lever, some 12 feet long, and the tubing, in 5 foot sections, is forced up through it by a screw or hydraulic jack.

Where the ground is soft (e.g., Glacial conglomerate of the Lower Loddon Leads), a 4 in. "telescope" tube is first forced up, and wedged in, after which the 3 in. tubing is put up. This 4 in. tube collects the water, and prevents scouring away of the country rock. In the top end of the tube a steel ring or cutting edge is inserted, reducing the diameter to 1 1/2 in., and the top 3 or 4 feet are perforated by 3 to 3 holes. The lower end of the bore is provided with a stop-valve, so that the flow can be regulated according to the capacity of the pumps.

The natural water-level of the country is about 100 feet below the general level of the surface plains; in the Lower Loddon Valley, about Woodstock, it is only 60 feet from the surface. The average depth to gutter bottom is some 300 to 400 feet, and as reef-drives are some 50 feet lower still, under these conditions the static pressure at the bore in the drive should be something like 300 feet. The highest reading known to the writer is 140 lbs., the depth of shaft being 400 feet. At two other mines, the Charlotte Plains and New Havillah, 350 and 340 feet deep respectively, the pressures were 100 lbs. and 90 lbs.

With these immense pressures, two or three bores would supply over 1,000,000 gallons per day.
The following is a list of pumping operations carried on by the leading alluvial mines pursuing pumping operations solely, as contained in published reports:

<table>
<thead>
<tr>
<th>Mine</th>
<th>Initial Pump Cap.</th>
<th>Initial</th>
<th>Date of Start.</th>
<th>W.L. from Surface.</th>
<th>Depth</th>
<th>Time of Drainage</th>
<th>Pr.</th>
<th>Date</th>
<th>Pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalks 3, No. 2</td>
<td>2,000,000</td>
<td>55(?)</td>
<td>May 1902</td>
<td>180</td>
<td>310</td>
<td>7 mths</td>
<td>22</td>
<td>Apr. '04</td>
<td>2, 26&quot; Cornish Lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>New Havilah</td>
<td>3,000,000</td>
<td>90</td>
<td>May 1902</td>
<td>140</td>
<td>349.3</td>
<td></td>
<td>50</td>
<td>Apr. '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Charlotte Plains</td>
<td>3,000,000</td>
<td>100</td>
<td>May 1903</td>
<td>125</td>
<td>359.2</td>
<td>3 yrs.</td>
<td>61</td>
<td>July '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Junction D.L.</td>
<td>3,000,000</td>
<td>102</td>
<td>May 1903</td>
<td>125</td>
<td>359</td>
<td>3 yrs.</td>
<td>57</td>
<td>July '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Victoria D.L.</td>
<td>2,500,000</td>
<td>102</td>
<td>May 1903</td>
<td>125</td>
<td>359</td>
<td>3 yrs.</td>
<td>57</td>
<td>July '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Loddon Valley, No. 1 and 2</td>
<td>3,000,000</td>
<td>102</td>
<td>May 1903</td>
<td>125</td>
<td>359</td>
<td>3 yrs.</td>
<td>57</td>
<td>July '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Moolorl Gold, No. 2</td>
<td>1,600,000</td>
<td>125</td>
<td>Apr. 1903</td>
<td>125</td>
<td>359</td>
<td>3 yrs.</td>
<td>105</td>
<td>July '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Fields (i.e., Victorian Gold Estates)</td>
<td>1,500,000</td>
<td>125</td>
<td>May 1903</td>
<td>125</td>
<td>359</td>
<td>3 yrs.</td>
<td>105</td>
<td>July '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Southern and Prentice</td>
<td>2,500,000</td>
<td>60</td>
<td>May 1903</td>
<td>125</td>
<td>359</td>
<td>3 yrs.</td>
<td>22</td>
<td>Jan. '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Gt. N. Ext. Cons.</td>
<td>2,500,000</td>
<td>60</td>
<td>May 1903</td>
<td>125</td>
<td>359</td>
<td>3 yrs.</td>
<td>22</td>
<td>Jan. '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
<tr>
<td>Gt. Southern</td>
<td>2,500,000</td>
<td>70</td>
<td>May 1903</td>
<td>125</td>
<td>359</td>
<td>3 yrs.</td>
<td>22</td>
<td>Jan. '04</td>
<td>Cornish lift Beam Eng. Electric driven 3-thw pumps, 12&quot; plungers</td>
</tr>
</tbody>
</table>

THE HYDRAULIC GRADIENT TO THE POINT OF DRAINAGE.

This is the most important question in Deep Lead Drainage, for on its nature depends—

1. Pumping plants necessary to perform the drainage.
2. The time such plants will take to reduce the pressure or water-level sufficiently to allow of working the washdirt.
3. The amount of pumping one company is doing for non-working leaseholders up and down the lead.
4. The disposition of the pumping plants on one particular lease.

POINTS AFFECTING THE HYDRAULIC GRADIENT.

1. Grade of the lead in the immediate vicinity of the point of drainage, and also the natural hydraulic gradient.
2. Quantity of water pumped at one particular point.
3. Proximity of other mines.
4. Nature of the wash and drifts—i.e., their percolative power, and the effect the horizontal layers of pug have on the flow of water.
5. Cross sectional area of the water-bearing drifts.
6. Presence of natural dykes, preventing the flow through the drifts.

THE ARTESIAN OR NATURAL FLOW THROUGH THE LEADS.

As there is a natural hydraulic gradient (taking case of Loddon Lead, from Clunes to Moolorl) of some 20 feet to the mile, and as only a proportion of the rainfall is accounted for by evapo-
ration and river flow, there must necessarily be a natural flow (provided it is not interfered with by basaltic dykes and other obstructions) to the lower basins into which the various lead systems of Victoria and New South Wales discharge.

The natural grades of the Loddon Leads and tributaries is

*The Deep Leads of Victoria. Fig. 2.*

shown in Fig. 2, also the natural hydraulic gradient, which apparently follows the bed of the lead.

In all cases of drainage the quantity of water percolating
through the drifts (up or down) is a function of the hydraulic
gradient, the cross sectional area of the pervious strata of the
leads and tributaries affected, and the percolating power of the
drifts. Hence the steepness of the hydraulic gradient at any
mine depends on the percolating power of the drifts and their
cross sectional area beneath the water-level, or basalt, at any point
in the lead; therefore, the natural assumption is that the gradient
steepens towards the point of drainage, and gets flatter as the
area of drifts and number of tributaries supplying the water get
greater; also the further it is from the point of drainage the less
water is passing, because of the quantity of water that is accounted
for by the lowering of the water-level in the vicinity of the point of
drainage. The curves in Fig. 3 have been plotted to indicate the
probable nature of the gradient, up and down the lead, after the
reduction of pressure has assumed its normal rate—i.e., after the
flow has become longitudinal constant, up and down the lead,
and is not modified by the radial flow to the point of drainage,
which occurs when drainage is first commenced, in which case the
rate of reduction in pressure, or water-level, is very rapid.

When a mine is drained, and only some 700,000 gallons per
day is drawn from each end of the workings, which figure ap-
pears to remain constant after some time, the gradient adjusts
itself so that at any point the product of the cross-sectional area
and gradient, or power of the gradient, is just sufficient to trans-
port the water collecting either from the surface, main lead, or
tributaries, to the point where it is being drawn off.

As there is probably a slight natural flow down the lead, it is
natural to assume that water-level curves are flatter on the down-
stream side of the drainage point.

I. Effect of natural dykes and horizontal layers of pug.

(a) There are several cases recorded of volcanic dykes or
cores, and other disturbances occurring in the leads,
which must necessarily affect the free flow of water—

e.g., "Hydrothermal deposit," at the Spring Hill and

Central Leads mine. On the S. side (up stream) the

workings are perfectly dry, but on the N. side, 800 feet

away, there was a pressure of some 50 to 60 lbs. The

deposits were bored through some 300 feet without

reaching the natural floor.

(b) Regular faults and several volcanic cores and dykes

occur in the Berry and other mines.

II. Horizontal layers of pug.

Represent the still-water deposit on the banks of the

ancient stream, and occupy considerable area of the

section. They serve as natural bottoms to collect the

water, and whilst the lower workings are perfectly

dry, bores and rises have to be put up during ordinary

work, to drain off this suspended water; their effect is

probably purely local, owing to the shifting of the

ancient streams cutting through the layers.

Some data concerning the hydraulic gradients.—In most

mines parts of the workings are dry, whilst there is a high

pressure a few hundred feet away. Drainage by bores has always

to precede the workings; this points to a steep gradient, perhaps

50 to 60 feet to the mile, in the immediate vicinity of the point of

drainage. It is said that whilst Chalk's No. 3 was being un-

watered to the extent of some 140 feet, the water was lowered

some 40 feet at the old Pioneer shaft, now abandoned, five miles

away, giving a total gradient of 20 to 25 feet to the mile. And it

is also said that recently, when the Charlotte Plains Company,

alongside the above shaft, reduced the level some 50 feet, the level

at Chalk’s No. 3 shaft was lowered 15 feet, pointing to very

open drifts and gradual gradient. (These data are unconfirmed.)

The Victorian Gold Estates.—A small tributary lead was dry,

and worked at R.L. 500 feet, at a point about one and a half miles

by lead from where the main lead was tapped, giving water at

R.L. 600 feet, or a grade of 70 feet to the mile. There is, how-

ever, a possibility of watertight deposits damming back the water

in some way, this being a small stream. In this lease also the

water at the No. 2 was at R.L. 680 to 700 (as indicated by the sur-

face bore, which was freely flowing for some time), and at the No.

1 it was at R.L. 550; the distance between the two points is four

miles, and as there is a probable slope towards both points, there

is water at R.L. 700 to 720, three miles from No. 1, giving an

average slope of 53 feet to the mile. There is evidence of vol-

canic disturbance in the course of the lead, which might interfere,

and makes the case abnormal.

The main Loddon Lead at Ascot has water at R.L. 1,300,

and the bed of the gutter at 900 feet. At Clunes, nine miles away,
THE DEEP LEADS OF VICTORIA.

the lead is at R.L. 650, and the water-level, as indicated by the running surface-bore, is at between R.L. 1,000 and 1,100 feet, this gives an hydraulic gradient of 30 feet to the mile; this would mean an artesian flow down the lead, which might account for the continual high-water level at the No. 2, which is acting as a break to the up-country water, causing a reversal of the hydraulic gradient between it and the No. 1, thereby allowing the considerable reduction in water-level there.

Variation in pressure registered at the bore end.—It is noted that, having the pressure-gauge on one bore and opening and shutting another about 20 feet away, that the pressure alters some 1 to 1½ lbs., showing there must be some friction to the flow of water in the immediate vicinity of a bore; and this points to a local decrease in water-level, and steep hydraulic grade only in the immediate vicinity of the point of drainage. By plotting curves (Fig. 4) it is seen that the pressure decreases rapidly for the first few days. At Charlotte Plains it is said the water-level was lowered 9 feet during the first week, and at Chalk's 3 to 10 feet was recorded, whilst latterly the reduction is only 6 to 18 inches per week, the average being 1 foot over the first year.

Variation in the rate of decrease in pressure.—The weekly readings of pressure vary considerably, sometimes decreasing 1 foot 6 inches, and the next week increasing perhaps 6 inches; this fact, and several cases of unexplained water-levels led to the theory that part of the pressure was due to gas generation in the interstices of the gravels beneath the basaltic layer, principally carbonic acid gas, which afterwards causes such trouble in working. That gases are generated is certain, as all the conditions, such as decomposed vegetable matter, are present in the drifts to cause them, but they probably merely occupy the space above the level of the water, and do not exert any pressure on its surface to cause a higher reading than that due to the hydrostatic head of water. Suppose that of a reading of 80 pounds, 20 are due to gas pressure (that is the water must be some 50 feet lower than otherwise), and that the hydraulic gradient must start from this point. The space between it and the basalt must be occupied by gas under pressure enough to force its way to the surface, owing to the large area it must occupy (pockets of gas being impossible, because of the low resistance to the passage of gas through the drifts, and the great difference in specific gravity of gas and water, allowing the water to assume its own hydraulic slope). The apparent variations in the water-level may be explained by variations of the atmospheric pressure which, owing to smallness and quickness, do not penetrate through the overlying basalt, but alter the standard with which the levels are compared. The water pressure being gradually reduced is shown in the curve, Fig. 4.
Disposition of Pumping Plants and Improved Methods of Draining.

The past system was for mining companies to be formed, and operations commenced as soon as the mine some one and a half to two miles above it has drained, or partially drained, the lead so there was no concerted or combined action. Assuming that the hydraulic gradients take somewhat of the curves in Fig. 3, in any extensive lease, the pumping effort should be concentrated, and water drawn off principally from two lines of bores some 2,000 to 3,000 feet apart. This will mean the rapid extension of reef-drives simultaneously with pumping operations to so allow the up and down lead water-gradients to intersect the bottom, and allow of intermediate workings on the wash at the earliest opportunity, without being troubled by the great bulk of accumulated water up and down the lead. Fig. 3 shows the necessity of this. These lines of bores will be afterwards replaced by cross wash drives, and the under levels extended, and further bores put up to prospect and to drain further extensions of the lead. But there is a considerable lapse of time (as shown in previous table) between commencing pumping and actually rising into and working the wash, which cannot be done until the pressure is reduced to some 7 lbs. per square inch in wash. These long periods of dead work are enough to kill any enterprise, and it is only by improved pumping plants of far greater capacity than have been used up to the present, that these lower lead alluvial ventures can be made profitable.
To assist the present and future pumping plants, the writer has devised a system (Fig. 5) which should effect in some mines considerable economy and saving of time; it is to connect all the bores (previously discharging freely) into a large pipe connected to the suction end of the pump, placed at the bottom of the shaft. This actually reduces the lift from the full depth of the shaft, as it is at present, to the difference between that depth and the head represented by the suction chamber pressure, which is the working pressure due to the hydrostatic pressure at the bores, so that at all times the pumps are only raising the water from the water-level (less friction).

The bore and main friction can be calculated, and reduced to an economical minimum, and the head absorbed at the entrance of the water into the bore can be reduced by simply increasing the number of bores. To endeavour to get the ratio between the working and static pressure, a series of experiments on a bore at Chalk's No. 2 shaft were conducted by Mr. Roberts and the writer by providing a bore with a pressure gauge and throttling the opening down by reducing sockets, which would create a back pressure. This would represent the working pressure under the above system; the results show that with a bore discharging twelve gallons per second freely, by throttling it down until it only discharges two gallons per second, 90 per cent. of the static pressure was registered. So that by putting six or seven times as many bores up, some 80 to 85 per cent. could be utilised in helping the pumping.

The resistance to the water entering the bore apparently varies as the square of the velocity—that is, the discharge—and could be decreased by increasing the number of perforations (or using slots) and size of the bores; and in order to dislodge the peb-
bles which cover the perforations, and cause the resistance, a sud-
den reversed discharge could be arranged by connecting the bore
to an air receiver in the drive, into which water could be pumped
until there was a high pressure, then by suddenly opening a stop-
valve, a good reversed dislodging stream could be obtained, and
a good flow insured. It is said that the wash and drifts in the
vicinity of bores is found to be open and free from sand, which is
scoured out during the first few days of their running. Taking
a typical case.—

Shaft, 400ft. deep; static pressure, 130lbs. = 300ft.; work-
ing pressure, 240ft. at bore; friction in pump bends,
etc., 20ft., say; saving in lift, 220ft.; saving in
power, 54 per cent.

This saving would last for some months, reducing, of course,
as the pressure reduced, and the wash was drained, but through-
out draining the average saving should be some 25 per cent., or
with same firewood expenditure and generative machinery as at
present used, 25 per cent, more water could be pumped. Taking
into consideration the fact that the more water pumped
the steeper becomes the hydraulic gradient (which means less
water to be taken out prior to work), consequently the reduction
in time to rising into the wash should be reduced some 30 to 35
per cent., perhaps 50 per cent.

Taking the case of the first twelve months' pumping at Char-
lotte Plains.

Pressure, May, 1902, 100lbs. = 225ft.; pressure, June,
1903, 68lbs. = 153ft.; depth of shaft, 350ft.

Allowing for the nature of the time-pressure curve (Fig. 4),
the average head available would have been some 174 feet,
allowing 20 per cent. for friction, etc.

Available working head, 136 feet.

Saving in power, 40 per cent.

At another mine the pressure has been reduced from 130lbs. to
110 lbs. in two years. The shaft is 400 feet deep, and a surface
bore put down in a slight depression was running a good stream of
water for some time. It is unnecessary to point out the saving
that could have been effected if the bores had been connected up
with the pumps, as suggested.

The only objection that can be raised is that of sand; but
when it is considered that one 2 in. bore discharges water at 40
to 50 feet per sec., and no sand has come down under these con-
ditions, not much danger exists if the scour is reduced to a fifth.
It is reported that not a truck-load of sand has come down
through sixteen bores at the New Havillah during twelve
months' running. It is only natural that the wash and drifts act
as a perfect natural filter, and any cases of bores running sand is
attributable to poking, sudden shutting and opening, and collapse
of the tubing owing to excessive velocity and scour. Further, if they were to run any quantity, they invariably choke themselves in the attempt. Another, and great advantage of adapting this system is, that much smaller pumping engines can be used, and of size equal to the permanent drainage of the mine, and the capacity, whilst the pressure lasts, will be increased in proportion to that pressure. Further, should the pumps stop, the water merely rises to its own level in the hydraulic circuit. The sump can be cleared of water by simply closing the valve A (Fig. 5).

**Future Pumping Plants on Large Leases.**

There should be a pump of large capacity (say 10,000,000 gallons per day at the first low lift, reducing as the pressure reduces), preferably driven by electricity, used exclusively for drainage from bores in conjunction with this system. This pump is to be removed to another mine (lower down the lead) as soon as the pressure is gone, and work on the wash is commenced. A smaller and more efficient pump is then used for drainage; the surplus power being utilised for traction, ventilation, lighting, puddling, and perhaps winding. E.g., a mine with engines and pumps designed to lift some 4,000,000 gallons per day maximum. When the mine is in full working swing, there will be only some 1,500,000 gallons per day capacity required. This would mean the engine working at only one-third power, or for one-third time, which would necessitate large storage capacity. Certainly a triple may be turned into a compound engine, and one of the lifts taken out, but this hardly tends towards efficient work.

If the efficiency of series centrifugal pumps is as good as some figures show, then, undoubtedly, this class of pumps is particularly adapted for drainage, owing to their low first cost, suitability for electric driving, small space required, and ease of removal to another mine when draining the drifts is completed. By working the runners first in parallel, and then in series, there should be no difficulty in pumping water in proportion to the pressure and power available, in conjunction with the above system.

Cost of Pumping.—With well-designed triple-expansion engines, of about 3,000,000 gallons per day capacity, 400 feet lift, cost comes out about 1d. per 1,000 gallons.

**Alluvial Mining in the Chiltern and Rutherglen Districts.**

The wash having been drained, as previously described, and two levels (the main lower drive and one 40 to 60 feet above, on a level with the lead) having been made, mining operations are commenced; these are fully described by Mr. S. B. Hunter in his report of that district, from which the following is extracted:

"From the upper level, or leading wash drive, cross drives, at right angles and at intervals of 200 to 300 feet, are continued on
either side until the high reef or bank of the lead is reached, the dual purpose, of cutting off any remaining water from the ground, through which the leading wash drive is made, and proving the direction of the lead being thereby served."

"As the face workings are extended from the main shaft, a timber and return or upcast air course is driven in solid reef at the same level as the leading wash drive, generally parallel to the lead; this connects with an upcast compartment at the main shaft, or to a timber shaft some thousands of feet away."

This air course is connected at intervals to the wash drives, and provides an escape in case of sudden flooding, and also an easy means of timber transport. "Between the cross drives," above referred to, "and at right angles to them, blocking drives are made at every 46 feet, allowing 20 feet width of ground to each blocking party. About 2 feet of wash and from 12 to 18 inches of reef bottom are usually taken out, the face being worked evenly across the whole width of the lead." The feature of this system is the pushing of the leading wash drive ahead of main underlevel drive, thereby prospecting and proving the direction of the lead with reproductive work, and also avoiding the danger of rising into partially drained ground.

ALLUVIAL MINING IN THE BALLARAT, CRESWICK AND MARYBOROUGH DISTRICTS.

The lead is prospected from the main lower level by means of bores (which also act as drainage bores), drained, and rises and wash drives constructed, and the lead worked. Often an intermediate reef drive, at higher level, to work the lead "up stream," is begun, either from the main shaft or from a balance shaft, which is a "rise" from the main lower level. The wash and blocking drives are extended in somewhat similar way, as at Chiltern, but the main underlevel is always some hundreds of feet ahead of the leading wash drive, and in this is the essential difference between the two systems.

In the larger mines a return air course in solid country is afterwards made, connecting to the upcast air shaft or compartment.

The Ballarat system is said to cost some 2s. per fathom (equal to 6 feet x 6 feet area of gutter) less than the Chiltern system. In the Ballarat district, owing to the thick overlying basalt, the cost of surface boring goes up to £200 to £250 per bore, which prohibits the gutter to be defined accurately enough to allow of any reef drive being extended into the wash, or at any level except at considerable depths beneath the lowest known level of the lead. The surface boring at Chiltern only costs 1s. 6d. to 2s. per foot, so that the exact level of the gutter can be found and no risk taken in the shape of lost level or sudden influx of water and slum. The Chiltern system has certainly the advantage in the matter of timber, as the transference of timber along the lower
levels and up the balance shafts is an extra expense and inconvenience.

Wash Driving Costs, Etc.

Leading Wash Drives—
Costs—Legs, 6ft.; caps, 5ft.; solepieces, 6ft.; 8in. timber, costing 10/- to 15/- per 100 feet; laths, 10/- to 15/- per 100; cost sets and laths, 6/- to 12/- per set of 4ft.= 1/6 to 3/- per foot in place; labour—facemen at 8/4, trucker at 6/-=3/- to 15/- per foot, according as the ground is dry or wet; total, 4/6 to 18/- per foot.
Rate—According to the nature of the ground, from 1ft. 6in. to 3ft. per shift, if face boards are used, to 6ft. per shift in dry ground.

Blocking Drives—
Costs—Legs, 5ft., 4in. to 5in. timber; caps, 4ft.; cost of legs, 5/- to 6/- per 100 feet; caps, 10/- to 15/- per 100 feet. As the ground has been usually drained by the leading wash drives, blocking drives cost from 3/- to 6/- per foot.

Panelling, 3ft. to 2ft. 6in.; blocking, 6ft. to 7ft. deep.
Laths, 10/- to 15/- per 100; legs, 4in. timber, 2ft. 6in. to 3ft. 6in. long; cost, 4/- to 8/- per fathom, according to the nature of the ground; labour, 12/- to 14/- per fathom; total, 16/- to 22/- per fathom.

The Deep Leads of Victoria. Fig. 6.

Fig. 6 is a diagrammatic representation of alluvial working on a large scale.
TRANSPORT OF WASH-DIRT.

The washdirt is hand-trucked from the faces to shoots (generally at the intersection of the main wash and cross drives) leading to the main reef drives below. These shoots act as bins, and fill the main level trucks, which are collected in trains of thirty to sixty trucks, and hauled to the shaft. In the case where balance shafts are used, the washdirt is hand-trucked from the face to the nearest shoot or balance shaft, where it is run on to a cage, the full truck hoists the empty or timber truck to the higher level, the full truck is then hauled to the shaft. With balance shafts there is always two handlings, which limits the size of trucks to about 1-3 ton capacity, and increases the cost of transport.

Cost of Haulage and Trucking.—Hand trucking and shooting in wash drives, the average distance being 200 to 300 feet, with two flat plates, costs 1s. to 1s. 6d. per fathom. No definite price can be set down, as the cost depends on depth of washdirt taken out, state of repair of trucks and road, and distance to the shoot or balance shaft.

Trucking in Main Underlevel:—

1. Hand-trucking.—One trucker can take three to four 1-3 ton trucks down an incline of 6 inches in 100 feet, and the same number of empties up, at rate of two and a half to three miles per hour. Cost, 2s. to 4s. per fathom per half-mile truck.

2. Horse-trucking.—One horse will take from twenty to twenty-five 1-3 ton trucks from the place where the train is made up by truckers at rate of about four miles per hour. Cost, 1s. 6d. to 3s. per fathom half-mile haul.

3. Electric traction.—A 7-h.p. locomotive will take fifty to sixty 1-3 ton trucks at the rate of five to eight miles per hour. Cost, 9d. to 1s. 6d. per fathom half-mile haul.

The following is a comparison between electric and manual trucking at Southern No. 1 G.M. Co., Rutherglen, E. R. Meekison’s report:—

Engine, 9-h.p.; loco., 6-h.p.; cost, £550. Length of haul, 3,200 feet; capacity, 700 trucks per shaft. Working costs—Electric, £19 per week (including lighting); labour, £61 per week (including lighting).

WINDING.

Is at present exclusively done by hand-pushing the trucks (one or two) from the plat on to one-decked cages, which are hauled to the main brace, lowered to the keps, truck pulled off by the brace-men, empties run on; the cage is again lifted, and then lowered. The maximum number of trucks (1-3 ton capacity) that can be
handled per shift is equal to about twenty fathoms of washdirt, plus mullock. Each trip takes about 1½ min. on an average.

Winding Engines.—

1. Single cylinder, loose eccentric engine, 16 in. to 22 in. diameter, 4 ft. to 5 ft. stroke, with drums 8 to 9 ft. diameter.

2. Two cylinders, cranks at right angles, 14 in. to 17 in. diameter, 4 ft. to 4 ft. 6 in. stroke.

Only the newer alluvial mines have the two-cylinder winding engine. Future alluvial mines, on the lower sections of the Victorian Deep Lead systems, must be worked on a far larger scale and in a much different method, as regards extraction of washdirt, than has hitherto been the arbitrary practice with narrow gutters and comparatively inexpensive opening up. Up to the present time one-third to one-half ton capacity trucks (in the majority of mines the former) are exclusively used. The tare or weight of the truck itself is 500 lbs., so that about one-third of the weight trucked and hauled is lost.

The size of trucks has been restricted by the numerous handlings necessary when balance shafts are used, and in all cases at the plat and main brace, further by the system of hauling the trucks to the surface. The size of the shaft restricts the output to some 400 fathoms per week; so that under the present system, no matter how much the mines cost to open up and drain, or what grade the washdirt is, the output is the same. Further, under existing methods one-quarter to one-third of the expense of working the mine is constant; the cost of opening up and drainage (i.e., interest on capital), ordinary pumping and underground supervision, lighting and repairing, nearly all surface expenses, and management, are constant, whether 300 fathoms or 1,200 fathoms are being raised per week. Hence it is essential to increase the number of producers to a maximum, which has up to the present been about twenty parties of two each, which is a limit with the present rate and style of winding and extension of reef drives; and with the wide and probably lower grade leads to be worked in future, increase of output is necessary, especially so where the initial drainage is so heavy an expense. Owing to the small slope of the leads intermediate drives can be done away with. The wash drive trucking can be done with small trucks, and washdirt dumped into shoots, which feed the large lower-level side tipping trucks of some 1 to 1½ tons capacity (this size being common in most Californian drift mines), which can be mechanically hauled to the shaft, where they can be emptied into shoots or bins.

Large self-dumping skips, capable of holding some 3 to 5 tons of washdirt, could be used for lifting it to the surface, whence it could gravitate to the puddling machines. These skips could be made so that they can immediately and almost automatically
be converted into self-dumping water tanks, which could form a stand-by in case of a rush of water or accident to the pumps, thereby saving idle pump power, which has always to be kept as a stand-by. Mulllock and timber could be dealt with in a separate compartment. Reef drives could be extended during the whole period of pumping, and so kept well ahead of wash workings.

Treating the Washdirt.—This is done by puddling, whereby the slums are run off and large gravel separated from the finer gold-bearing wash, which is sluiced. Puddling takes 15 to 20 min. per machine, and costs 9d. to 1s. 6d. per fathom. Four puddling machines, driven by a simple 12 in. to 16 in. diameter by 3 ft. stroke low-pressure engine, is the usual complement of a large alluvial mine. There have been no improvements on the puddling machine for the past thirty years, and such a system, involving so much labour, should be open to many improvements.

Sluicing.—Sluice boxes are either wooden or iron troughs, 15 in. wide, 9 in. deep, laid to a fall of about 1 in 10, and provided with ripples, which can be removed on “clean-up” days. The slums are in some cases run over blankets. It is said that except where the gold is very fine, this just about pays. It is, however, a check on careless puddling. The total cost of working, transporting, and treating washdirt on the scale carried on in the larger alluvial mines is anywhere about £2 to £2 10s. per fathom, of which the timber is 6s. 6d. to 8s. per fathom.

In the preceding paper an endeavour has been made to give a general outline of the operations connected with Deep Alluvial mining, as carried on in Victoria, without any attempt at detail, except in the case of drainage, which is certainly the most important and difficult problem connected with this class of mining, and considerably more attention must be given to it in future, and far larger and improved pumping plants used to overcome the water difficulty, which has kept this class of mining back so long.

For many of the working costs and other figures, the writer is indebted to Mr. D. H. Browne and others connected with the alluvial mining industry.

**Addendum.—(May 4th, 1904).**

The lengths of Deep Leads yet to be worked are given in the following table. Probable minor sinuosities are not included. The portions marked *a* have been proved by boring, etc., and are worthy of attention; of those marked *b* there is not sufficient data to warrant any further statements other than that of the probable lengths:

<table>
<thead>
<tr>
<th>LEADS.</th>
<th>MILES.</th>
</tr>
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<tbody>
<tr>
<td>Berry-Moolort Loddon System</td>
<td>(40 (a) 60 (b))</td>
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**DISCUSSION—DEEP LEADS OF VICTORIA.**

<table>
<thead>
<tr>
<th>System</th>
<th>MILES.</th>
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<tr>
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<td>70 (b)</td>
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<tr>
<td>Stawell System</td>
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<tr>
<td>Langi Logan System</td>
<td>5 (a)</td>
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<tr>
<td>Campaspie System</td>
<td>10 (a)</td>
</tr>
<tr>
<td>Ovens District</td>
<td>20 ? (b)</td>
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<tr>
<td>Chiltern and Rutherglen System</td>
<td>30 (a)</td>
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<tr>
<td>Murray System (Wodonga)</td>
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<tr>
<td>Landsborough Lead</td>
<td>12 (b)</td>
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<tr>
<td>Glenpatrick Lead</td>
<td>5 (b)</td>
</tr>
<tr>
<td>Rokewood Lead</td>
<td>5 (a)</td>
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<tr>
<td>Upper Bet Bet Valley Lead</td>
<td>20 (a)</td>
</tr>
<tr>
<td>Neerim and Moondara</td>
<td>10 (b)</td>
</tr>
<tr>
<td>Dargo High Plains</td>
<td>10 (b)</td>
</tr>
</tbody>
</table>

The drainage of the Great Southern Lead, at Rutherglen, presents the most concerted pumping operations that have been carried out.

In Fig 2 A, A shows a typical cross-section of the lead, and the proportion of permeable water-bearing strata to clays; B gives the general locality plan, showing probable tributaries, and widths of the valleys between the bedrock outcrops, which are hatched; C is a longitudinal section of the Chiltern Southern Lead, showing the present surface and lead bed. The broken lines show the probable positions of the water-levels at the various dates marked (the month is January in each case).

The exact positions of the water-levels are only known at the various shafts. The intermediate levels have been determined by noting the level to which the water rises when pumping operations have temporarily ceased, and the local steepening of the gradient has disappeared.

A short history of the pumping operations is as follows:

Prior to 1894 the Southern Lead below the Chiltern Valley Mine was untouched. The lead had only been worked between miles 9 to 12, and here and there near its source. Up to this time the water did not cause any trouble, owing to the small area of ground to be drained, and small cross-sectional area of the drifts.

In 1894 the Great Southern (21½%) started pumping some 2,000,000 gallons per day, and was not assisted until 1898.

In July, 1897, the pressure at the bores in the Great Southern showed water at 320ft. from the surface. The pumps were
Deep Leads of Victoria.

Fig. 26.

VICTORIAN INSTITUTE OF ENGINEERS.
stopped for repairs, and in 3 days the water rose 150ft. in the shaft, or to 290ft. from the surface. Up to October, 1897, it only rose 18ft., or to 272ft. from the surface. This illustrates the fact that there is only a local depression of the water level at the point of drainage, and that the hydraulic gradient is much steeper there.

In 1898 the Southern and Chiltern Valley United, Southern Consols, and Northern Extended Consols, each pumping some 1,500,000 gallons per day, started, and the water-levels stood as is shown.

At this time two tributary leads, the Northern and Southern No. 1, were being worked; the water-levels in the main lead were as is shown, so there must have been a steep gradient in these tributaries from their junction with the main leads to where they were being worked (where some 400,000 gallons per day were being drawn off); the gradient was perhaps 50ft. to one mile.

In 1899 the Southern and Chiltern Valley United, Southern Consols, and Great Southern (the latter after 7 years' pumping and expenditure of some £80,000), all opened out into wash, and after 12 months' operations only about one-quarter the amount of water pumped previously had to be raised. After pumping till 1900, as no appreciable reduction of water-level was registered, then the Northern Extended Consols stopped, and the water rose to within 220ft. of the surface, giving a gradient of some 50ft. to the mile, towards the Great Southern, which was working the wash 3 or 4 miles away.

In the beginning of 1902 the Southern and Prentice (which had previously pumped for a short time and then stopped), Northern Extended Consols, and later the N. Prentice, were each raising some 2,000,000 gallons per day, and have pumped continuously ever since. The N. Prentice have now several drives in wash, but they are very wet. Roughly speaking the water had cost Rutherglen mines £250,000 and some 7 years of dead work before an ounce of gold was obtained; but there is no doubt that much money, and certainly time, would have been, and will be, saved if larger and better pumping plants were employed.

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