

surveying weather. Another difficulty is the great variation in temperature, which may be as much as 40° to 60° F. in a single day; thirdly, the breaking up of the ice from time to time along every exposed portions of these precipitous coasts; and lastly, the sharp ridges and peaks into which the mountains shape themselves, making it only possible to cross them in a few places. Beyond this it is unnecessary for me to say more at present, the different reports giving each a summary of what each has done and seen in his own department. Neither have I time nor opportunity while engaged in busy organisation for another campaign. I have only to thank one and all, whether of the scientific staff or the ship's company, for their untiring perseverance and energy during the past, and trust with them that our countrymen will have got together such a sum of money as will enable us to carry on the work for another year.

The first-class meteorological and magnetical station at Scotia Bay, Laurie Island, continues during the absence of the *Scotia* at Port Stanley and Buenos Ayres. I have for this purpose left Mr. R. C. Mossman in charge, with five men under him: these are Dr. J. H. H. Pirie, Messrs. Ross, Cuthbertson, Martin, and Wm. Smith. I have also left coal enough for twelve months, and provisions enough for eighteen months. It is not unlikely that, besides the above-mentioned subjects, the party will be able to do some sounding, trapping, and dredging. The *Scotia* must relieve this party, but it is hoped that enough money has already been subscribed to enable her to carry out a full year's programme of work.

NOTE.—Since the receipt of the above narrative at the Antarctic Office, a further communication has been received from Mr. Bruce, in which he states that at Buenos Ayres he got into touch with Dr. Moreno, who presented him to the Vice-President and other officials of the Argentine Republic. In consequence of the cordiality of his reception by these, Mr. Bruce states that the Expedition is practically assured of everything it requires gratis, probably including 200 tons of coal. Mr. Bruce is also arranging to take down four Argentine scientists to continue the meteorological and magnetic station at Scotia Bay, the Argentine Government taking the responsibility of relieving this party.

As has been already announced in the public press, the response to the appeal of the Expedition for further funds has been sufficient to justify the prolongation of the *Scotia's* cruise.

THE INDUSTRIAL DEVELOPMENT OF THE FORTH VALLEY.

By H. M. CADELL of Grange, B.Sc., F.R.S.E.

THROUGHOUT the misty centuries of Scotland's heroic age from those dim and distant days when Antoninus and his legions cast up the long rampart of Graemesdyke to restrain the wild Scots and Picts from plundering the declining Empire of the Caesars, down to the time of Wallace and Bruce's wars with the English and the succeeding stormy centuries of civil feud and faction that fill up the later chapters in our

stirring annals; during that eventful age the Valley of the Forth was the theatre for nearly all the great acts of Scottish history. On the waters of the Firth of Forth also famous victories have been won. In 1489, for example, after a terrible sea fight the Scottish admiral, Sir Andrew Wood of Largo, completely defeated and captured the superior English fleet, commanded by Stephen Bull, in an engagement which began off the Isle of May and ended at the mouth of the Firth of Tay, whither the vessels had drifted during the two days the engagement lasted.¹ In later times Largo again became famous as the birth-place of another bold sailor, whose adventures are familiar to every child where the English tongue is spoken—Robinson Crusoe himself. But a far more useful and important event took place in the Forth Valley in 1802. This was a maritime victory of a different order, but none the less worthy of fame from causing no waste of blood or powder. It was nothing less than the successful trial trip on the Forth and Clyde Canal near Grangemouth of William Symington's little paddle-boat, the *Charlotte Dundas*, the forerunner of modern steam navigation.

Although the Forth Valley extends far to the east of Queensferry, the present paper will deal only with the upper part between the Bridge and Alloa, legally described as the estuary or Firth of Forth proper. Within the limits of this article it is not possible to do more than give a general sketchy outline of a subject that has to do with history and statistics extending over centuries. The writer's object is merely to direct attention to some aspects of a local geographical question that he considers interesting and worthy of public consideration at the present time.

Among the old industries of the Forth Basin, the following may be noticed first:—

Iron-making.—The establishment in 1760 of the Carron Ironworks, on the banks of the Carron near Falkirk, was an event which, though small at first, proved of immense importance to local industrial history in later years. These works, which were granted a royal charter, remained for more than a generation not only the largest and only works of their kind in Scotland, but became after a time the most famous in Europe, and perhaps in the whole world. For many years the guns and shot used so successfully in the naval wars that gave Britain the command of the sea were all made at Carron, and the praise of the "Carronades," as these pieces of ordnance were nicknamed, was in every gunner's mouth a century ago. The sagacious projectors of the Carron works, Dr. John Roebuck, the enterprising scientist, and Mr. William Cadell, the shrewd business man, travelled far before they finally chose a site, which afforded adequate supplies of ironstone for ore, wood for fuel, and water for power. They fixed on a place whose geographical conditions were admirable, halfway between the east and west of Scotland, with vast capabilities for development and transit by land and sea, surrounded

¹ This international compliment was repaid with interest in 1547, when the English admiral came to Blackness, where he took three and burnt seven Scottish ships that had come thither for refuge.

by a mineral field with seams of ironstone and coal of enormous and at that time almost unsuspected value. The Carron works are associated also with James Watt and his first practical steam-engine. Watt had made the acquaintance of Dr. Roebuck, and came from Glasgow to Kinneil House near Bo'ness to work out his invention in peace and quietness with the Doctor's assistance, and it was on one of Dr. Roebuck's coalpits at Bo'ness that Watt's first steam winding-engine was erected in 1768. Although this was a pioneer in its way, it was so well constructed and successful a piece of mechanism that it remained in use for fifty-seven years, and was not dismantled till about 1825.

Coal-mining.—Coal had been mined on the banks of the Forth for several centuries, by the monks before the Reformation and by private proprietors afterwards. Sir George Bruce of Carnock was, in the end of the sixteenth and the beginning of the seventeenth century, the great mining genius of his age. He sank a famous pit on the foreshore near Culross, connected by underground workings with other shafts on the shore, and on one occasion terrified King James VI. by taking his Majesty down the latter and bringing him to daylight by the Moat Pit, which at high tide was completely surrounded by water. Sir George also extended his operations to the south side of the Firth, and manufactured large quantities of salt by evaporating the sea water with coal from his various collieries. The King, Sir George, and his famous Moat Pit all perished in 1625, the destruction of the pit being brought about by a storm of unprecedented violence that washed away the protecting sea wall and flooded the submarine workings, which were never re-opened.

Another mining genius of that district was Archibald Cochrane, ninth Earl of Dundonald, father of the celebrated naval hero known in history as Lord Cochrane. Lord Dundonald, the last of his family who owned Culross estate, mined the coal under it and elsewhere, and spent his energies on various chemical and industrial projects, including the manufacture of coal tar. While distilling the coal for this purpose he noticed that the vapour produced was highly inflammable, and thus accidentally became the discoverer of coal gas, which one of his assistants, Mr. Murdoch, afterwards turned to practical account on a large scale.

Salt-making.—One of the staple industries in those days was the manufacture of salt, and at places where "panwood" or small coal could be got easily, the shore was studded with steaming salt pans and chimneys belching out volumes of black smoke. The industry was a profitable one, and the salters and miners were a peculiar and by no means refined race who lived from generation to generation in a state of semi-serfdom, till finally emancipated by Act of Parliament about 1796. Pieces of the foreshore were enclosed near the pans to form reservoirs or "bucket pots," where the muddy salt water that entered at high tide was allowed to settle before being pumped up or lifted by hand as it was wanted. Such names as Prestonpans, Grangepans, Bonhardpans, and Kennetpans tell of the old salt industry, and at all such places the shore above high water is now composed of a thick bed of pan ashes, while very often the old stone walls in the vicinity may be observed to have a character-

istic cope of the rough slaggy clinker that accumulated in the fires. These in the olden time were merely open hearths without any bars under the glowing coal, and were far from efficient as consumers of fuel. In 1589 Sir George Bruce (then only "George Bruce, burgess of Culross") in consideration of £1000 Scots advanced by him towards procuring the erection of Culross into a royal burgh, received from the town council a monopoly of the salt manufacture within the burgh. He made good use of this privilege, and according to John Taylor, the "Water Poet," who made a journey to Scotland in 1618, Sir George Bruce manufactured ninety or a hundred tons of salt every week, "which doth serve most part of Scotland, some he sends into England and very much into Germany."¹ At one time in the parish of Tulliallan there were thirty-five saltpans in operation, but in the middle of the eighteenth century the number had declined to twenty-one, according to Mr. Beveridge's interesting history.

In 1613 Sir George Bruce was also working the coal on Bonhard estate in Linlithgowshire, about a mile to the south of Bridgeness between Bo'ness and Carriden, and he obtained from Sir John Hamilton of Grange, who owned the land along the shore, a feu-charter to enable adits or water levels to be driven so as to drain the Bonhard mines, which were situated 200 to 300 feet above the sea, and also to provide a site for saltpans and bucket pots along the beach. The salt industry was carried on with vigour for about two centuries in this part of the Forth, but the whole of the Bonhard pans that had been established by Sir George Bruce after 1613 had ceased to exist before 1788, and the very name of the village had been changed to Causewayfoot or Cuffabouts, by which it is now known. The only remaining evidence of the extinct industry is traceable in the banks of pan ashes above the beach and the foundations of the old bucket pots that can still be distinguished along the top of the foreshore at a few places. Salt was still manufactured with considerable profit in the neighbouring village of Grangepans at the beginning of the nineteenth century, but the competition of the Cheshire salt and the abolition of the duty so lowered the price that it was only found possible to continue the manufacture by adding large quantities of rock salt to strengthen the weak sea water. The salt made in these primitive old pans and purified by curious methods, including the use of malodorous blood from the shambles, was excellent in quality, beautifully crystallised, and stronger in taste than the fine table salt that supplanted it. The rough old salters were a skilful race at their own trade, and as the pans were gradually reduced in number, they died out, and in some cases at least nobody could be found capable of manipulating what has become in this district practically a lost art. The last of the saltpans on this side of the Forth came into the writer's possession in 1888, but had to be closed soon afterwards for the reasons just given. Salt is still being made at Charlestown on the north shore, and at Prestonpans and Cockenzie, but with these small exceptions the industry, famous for three

¹ D. Beveridge, *Culross and Tulliallan*, vol. i. p. 160.

centuries on the Firth of Forth, is now a thing of the past, interesting to domestic historians only.

On the north side of the Firth, opposite Bo'ness, coal-mining and salt-making were still important occupations a hundred years ago, and the coast round Torry Bay from Crombie Point to Culross was a fairly busy place.

In the centre of the bay lies Preston Island—an island at high tide only—covered with the picturesque ruins of old saltpans and the buildings erected by Sir Robert Preston of Valleyfield, who spent, it is said, £30,000 in sinking three pits in a fruitless attempt to imitate Sir George Bruce's submarine colliery enterprise in the vicinity two centuries earlier. The pits on Preston Island have sometimes been mistaken for Sir George's famous Moat, but the latter was about a mile to the west, and although its position was still visible and was shown on the old Admiralty Chart surveyed in 1851, it is now almost obliterated, while the Preston Island shafts, which are lined with excellent masonry, are still in excellent preservation.

Torry Bay, with its broad shallow foreshore of mud, is capable of reclamation some day, but the riparian villages of Torryburn, Low Valleyfield, and Culross—clean, picturesque, and sleepy—have now no industries requiring flat ground on the seaward side, and offer little encouragement for the modern utilitarian enterprise that would only spoil their quaint old-world character, a character that is vainly to be sought for among the thriving new towns without a history on the banks of the busy Clyde.

Culross girdles.—Culross, at an earlier date, was famous for its wrought-iron girdles for baking scones and cakes, and for many years enjoyed the monopoly for the supply of these important utensils to the whole of Scotland. The Culross hammermen or girdlesmiths were a craft among the smiths whose history extends over three full centuries from 1549 to 1851, when the ancient corporation drew its last breath. The monopoly the girdlesmiths claimed was declared illegal by the Court of Session in 1725, and the manufacture at Carron of cast-iron plates much cheaper but less durable than the tough old malleable-iron girdles gradually ruined the industry, which indeed was destined to extinction by the decline in the use of girdles of any kind for baking purposes among Scottish housewives. Like spinning-wheels and knocking-stones, they have now become almost unknown to the present generation.¹

Shipbuilding and Whaling.—Another local industry was shipbuilding, which sprang up before the middle of the eighteenth century on the north shore at Kincardine. In 1786 as many as nine vessels were on the stocks at one time, some of which were built for the West Indian trade and the Greenland whale fishery, and others for the coasting trade in connection with the coal and salt works. There were many small shipowners all round the Forth, and indeed up till the middle of the nineteenth century shipowning was one of the most important branches of industry. The old tombstones at Bo'ness, Queensferry, Kincardine, and

¹ Beveridge, *Culross and Tulliallan*, vol. ii. p. 188.

elsewhere testify to the number and wealth of these worthy mariners, who built good houses and left many useful as well as ornamental memorials behind them. Whale-fishing was for long a most lucrative occupation on the Forth, and as the hardy whalers returned from the annual Greenland cruise it was their custom to fire off a gun for every whale they brought in as the ships sailed up past Queensferry and came within earshot of home. Bo'ness in 1787 had eight whaling ships and two "boiling-houses," but latterly for about thirteen years only one vessel, the *Jean*, was left to make her lonely voyage. She too gave up after 1859, but a boiling-house continued in use for some years by Norwegians who brought whales' blubber here to be made into oil. The whales' jaws were often set up on end in the shape of Gothic arches over gates, and the boiling-house, where at certain seasons the blubber was being made into oil, filled the air with fumes whose awful odour still haunts my early childhood's otherwise happy memories.

The shipbuilding on this part of the Forth is now practically confined to a small yard at Grangemouth, from which during 1903 seven vessels were launched with an aggregate tonnage of 7506 tons against four vessels of 5134 tons in 1902. No ships have been built at Kincardine or Bo'ness for about a generation, while the race of local mariners and small shipowners is almost extinct.

Decline of Forth Commerce.—In the beginning of the eighteenth century after the Union, the Firth of Forth with its mines, salt pans, shipbuilding, and shipping trade was the centre of Scottish commercial enterprise. Leith was the first seaport in the country, and it was considered an important step for the Collector of Customs to be promoted from the fishing village of Glasgow to Borrowstounness (or Bo'ness), which then held the third place among the seaport towns of Scotland. The port of Borrowstounness included in 1713 the whole of the estuary from Cramond to Kincardine Ferry, and in 1792 there were 165 vessels on its register.

Had the spirit of enterprise been transmitted to succeeding generations, the Forth Valley, from its admirable geographical position between rich mineral districts, with an excellent outlet for trade with Europe and Scandinavia and admirable sites for towns and harbours, might well have continued the "hub" of the Scottish commercial world. The spirit of local enterprise, however, appears to have declined after the Union, and with the rise of American commerce a great part of the trade drifted away from the Forth Basin to the Clyde, and this drifting went on till after the latter half of the nineteenth century.

In the Forth Basin during the nineteenth century when ironstone was abundant and Spanish ore had not begun to supplant it, large iron-smelting works were in existence at different places. In Fifeshire there were blast furnaces at Devon, Oakley, Lochgelly, and Lumphinans on the north side of the river, and in Linlithgowshire at Causewayend, Kinneil, and Bridgeness, while malleable iron was made at Cramond and Dumfermline. The Carron furnaces, which were the predecessors, are now the sole survivors of the group, and round them a great subsidiary iron-founding industry has grown up which gives employment to the large

and growing population of Falkirk, Camelon, and Larbert. The principal blast furnaces of Scotland have, however, now all fitted into the Clyde basin, and the malleable-iron works and shipbuilding yards with other subsidiary industries have, as a rule, moved away from the Forth, and grown big by the ordinary law of gravitation elsewhere.

Like some other old ports on the Forth, Bo'ness declined visibly after the canal was opened in 1790, and the town remained until the last third of the nineteenth century a sleepy, dingy place with dwindling trade and plenty of grimy old buildings straggling along its narrow and crooked streets, far more picturesque than clean or sanitary, bearing dates from 1564 to 1750 or thereabouts on the doors and window lintels, with the initials of their well-to-do builders in the palmy days of the old port. The tide has, however, for the last twenty-five years ceased to ebb and begun to flow vigorously again, and in the fine new streets and handsome avenues that are being laid out after the manner of a garden city on the high ground there is distinct evidence of a return of the enterprise and prosperity of former days. The population, which fell from 2613 in 1795 to 1790 in 1841, has risen now to over 8000, and is still growing steadily.

Rise of Grangemouth.—The Forth and Clyde Canal, completed in 1790, was originally intended to end here, and a large part of it was actually constructed across the Carse of Kinneil to within a mile of Bo'ness.¹ Some short-sighted people, however, raised frivolous objections, and the agents of the Duke of Hamilton, who owned most of the ground, were not sufficiently alive to the importance of the work, and allowed it to be run to sea on Sir Laurence Dundas's land at the mouth of the Carron five miles farther west. The foresight of Lord Zetland's ancestor was amply rewarded by the birth of the new town of Grangemouth on his estate of Kerse, and the want of it at Bo'ness proved a heavy blow to the prosperity of that district for a whole century to come. Had the canal been brought to Bo'ness, as was intended at first, a much better harbour might have been constructed here than at Grangemouth. The distance out to the deep water is much smaller, and the enormous expenditure on dredging that has been necessary to keep the mouth of the harbour clear of mud at Grangemouth might have been nearly all avoided. A glance at the map will show that Bo'ness is naturally a better place for a harbour than Grangemouth, as the foreshore is here unusually narrow, and vessels can get out into deeper water without any difficulty. This advantage will always hold, no doubt, but the large new docks that are now being made by the Caledonian Railway Company, who own Grangemouth harbour—works which extend from the old docks down to low-water line—will greatly mitigate the natural drawbacks of the site, but only after very heavy expenditure. Larger ships are, however, being brought into use every year, and the main channel outside Grangemouth is none too deep at present when the tide is out, so that, without considerable dredging, the new harbour

¹ The partially completed canal across the Carse of Kinneil to Bo'ness is shown on William Forrest's excellent map of Linlithgowshire, published in 1818.

will always be handicapped in the race for trade with big ships. Grangemouth was founded in 1777 by Sir Laurence Dundas, and erected into a separate port in 1810. It has steadily grown in size, and its population has increased from 2000 in 1851 to 8500 in 1903.

Present State of Industry.—The geographical capabilities of the Forth are as great as ever, and new industries are steadily advancing and replacing those that are dying out. The pitwood trade, for example, in which vast quantities of pine stems of small diameter, principally grown in Scandinavia and Finland, are imported for coal-mining purposes, is now centred in the Forth, chiefly at Bo'ness and South Alloa. The imports of pit-wood in 1903 amounted to 160,000 loads (or tons) at Bo'ness and 100,000 loads at Alloa, while at both ports and at Grangemouth there is a large import trade in sawn timber.

Coal-mining is still active in Fife, Stirlingshire, and at Bo'ness, and although not a business that affects shipping much, the manufacture of mineral oil on the south shore, in Linlithgowshire, is a most important branch of local industry of not more than forty years' growth.

The old port of Alloa is at present the most prosperous of all the towns on the estuary. Its population, now 16,000, has doubled within the last fifteen years. Its former shipbuilding trade has fallen off, but is likely soon to be resumed on a large scale with modern appliances. Alloa yarns, like Alloa ales, have a world-wide reputation, and the woollen mills give employment to over 2000 hands. The adjacent collieries are being greatly extended, and the growing trade both of Alloa and South Alloa in coal, timber, and other merchandise, point to the advantages to be gained by the scheme of river improvement and conservancy advocated in the following pages.

Rosyth Naval Base.—The great Bridge now attracts visitors to the district from every land, and the new Naval Base inside it will in a few years completely revolutionise the quiet old corner of Fife above "the ferry." The importance of such a site for a naval station was pointed out long ago, and it is well that it has at last received the public recognition that is undoubtedly its due. Nobody not an ignoramus, who has taken any trouble to inquire into the merits of the question, can doubt that Government have made a remarkably good bargain for the nation in the terms on which this site has been acquired from the Marquis of Linlithgow. There is on the ground close to the shore an immense bed of excellent sandstone for building, the value of which will appear whenever permanent structural work is started. Overlooking the shore are inexhaustible quarries of whinstone for making roads and pavements, while limestone and coal are extensively mined in the near vicinity. The foreshore, about a quarter of a mile in breadth between high and low water, has for the most part a flat rocky bed on which the heaviest structures can be securely placed without costly foundations, and outside this there exists below low-water level, under a large part of the area, a strong clay foundation for deep dock walls and harbour works.

On the edge of the shore stands the picturesque old keep of Rosyth, which we may hope will be restored to far more than its ancient glory in a few years, and like the neighbouring castle of Blackness, and the more

distant fortress of Stirling, be upheld by the nation of the future among the memorials of a heroic past.

From the beach the shore rises gently upwards in a succession of low terraces, partly wooded and admirably adapted for parade grounds, parks, and healthy building sites with excellent soil for gardens and a warm southern exposure. The ridge of high ground at North Queensferry will give shelter from the cold east winds in spring and serve completely to conceal the new city of Rosyth from the view of any unwelcome visitors outside the Bridge, while on the high wooded rock of Castland Hill the Commander-in-Chief may build a noble mansion overlooking, from a good elevation, the whole of this splendid and historic scene. Through the courtesy of the Proprietors of the *Sphere* I am enabled to give the accompanying bird's-eye view of St. Margaret's Hope and the coast east of Rosyth Castle.

That the Rosyth Naval Base, besides its national value, will have also an important local value in its effect on the industrial development of the Forth Valley there can be little doubt. Subsidiary trades may be expected to spring up in its vicinity all round the shores of the estuary. There is both room and natural inducement for fresh engineering enterprise, and it is impossible to predict what developments may take place here within the next twenty years.

Proposed Ship Canal.—The proposal to make a large ship canal across Scotland was recently again brought forward after the Naval Base was sanctioned, and although the prospects of such a proposition being carried out in the near future are not bright, owing to weighty financial and engineering obstacles and the doubtful commercial utility of such a work, yet from an academic and national point of view the construction of such a waterway from the North Sea to the Atlantic is a work that must commend itself to the approval of every enterprising mind.

Much opposition will no doubt be raised to a canal that might have the effect of carrying the trade between Glasgow and the North of Europe past such ports as Bo'ness and Grangemouth, where many cargoes are now discharged and put on rail for the West of Scotland, and coal from the Western coalfields is loaded and shipped for the outward voyage. These harbours are now owned by railway companies, who it is certain will offer powerful opposition to any canal scheme that may possibly interfere with their traffic.

Two routes are practicable—(1) the direct route, 30 miles long, *via* Grangemouth and the long straight valley of the Carron, Bonny, and Kelvin rivers to Glasgow; and (2) the route *via* Stirling and the Forth Valley to Loch Lomond and the Clyde below Greenock. Each route has its advantages and drawbacks. The direct route is, broadly speaking, the best for trade purposes between Glasgow and the Forth; and the Loch Lomond route, which will not benefit Glasgow, has the advantage of a better water-supply for locks and fewer engineering difficulties in the way of railways and bridges across it. The relative practicability of the routes has not yet been adequately discussed, and it would be rash to take any side until the whole of the facts have been clearly ascertained.

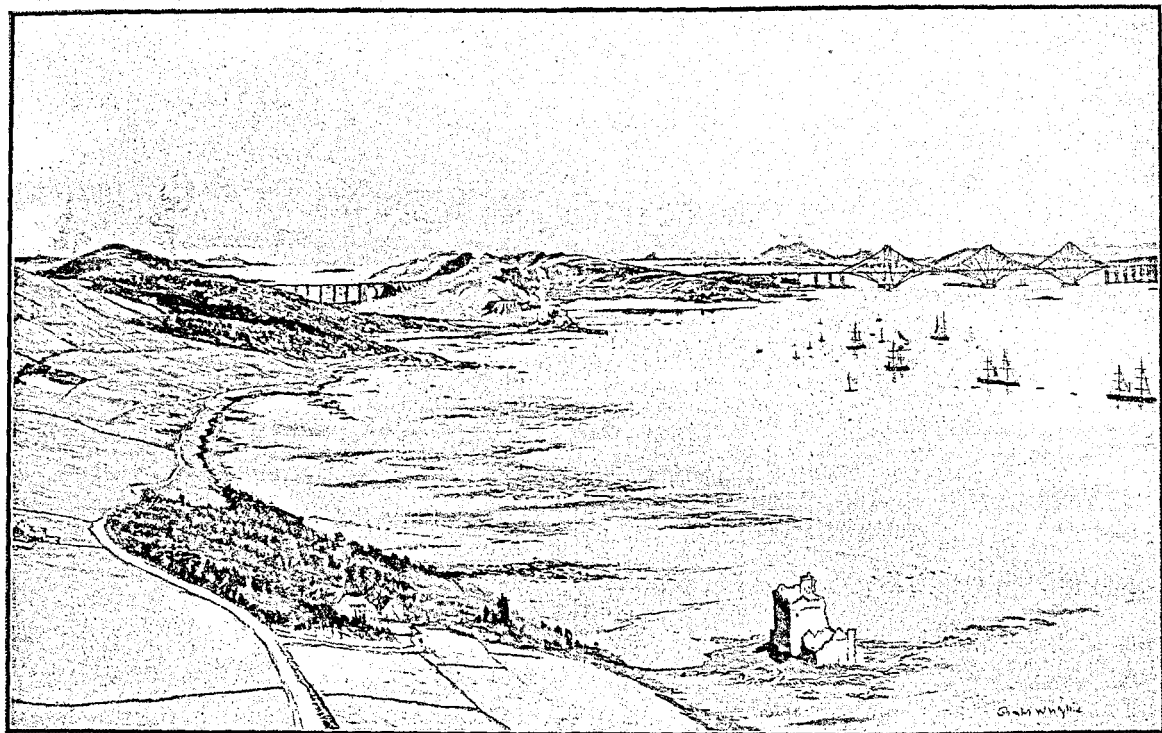
Such a subject, it need scarcely be said, will involve much careful investigation and calculation on the part of thoroughly qualified experts before anything can or should be done towards carrying it into effect as a national undertaking. With a large ship canal for a backdoor, the Naval Base as a strategic asset to the country would of course be enhanced in value. At a pinch the nation's history might conceivably turn on the possibility of being able to bring say half a dozen battleships through from one side of the country to the other within a given short space of time. If we were to lose these ships or an equal number, worth say £6,000,000, for want of the canal, then a canal would be worth this price or far more, taking the other consequences of such a naval disaster into account. But such a contingency is happily rather too remote, in the meantime at least, to bring the question within the scope of practical politics.

Foreshore Reclamation.—Among the many things that may be done to improve the shores, the work of foreshore reclamation deserves special attention. All along the upper part of the Firth of Forth there is a broad zone of flat "slobland" or "sleeches," bare at low tide and covered at the flood for the most part with only a few feet of water. At many places this waste wet land is capable of being reclaimed like Holland and added to the productive area of the country.

It may be useful, perhaps, now to draw attention to this question in its bearing on the geographical evolution of Scotland, a question that naturally appeals to the popular imagination, and one in which the writer, like many others who know the ground, has always taken a deep practical interest.

The acquisition of land from the sea is in itself an attractive subject for riparian proprietors to consider, where their estates are favourably situated and the prospects of a return are not too remote. Reclamations of foreshore are often too costly to repay the outlay on anything like a reasonable scale, especially nowadays when farming, except near large cities, is not sufficiently prosperous to afford large rents for the land thus acquired, even though it be of high agricultural value. But on the shores of the Forth the ground close to the sea may be expected, as I have already indicated, to acquire an improved value for more lucrative industries than agriculture in a few years, so that there is now fresh ground for encouragement in reclamation schemes in the estuary. However, be that as it may, it is always consoling to reflect that although the financial test is the crucial one in the vast majority of such cases, hard cash does not absolutely represent the value of everything, and the man who has spent his substance and energies on what may seem to some the aimless work of snatching land from the sea, must at the end of his days have some satisfaction in reflecting that if he is no richer after all his toil, and has perhaps not left his country much better, he has at least left it a little *larger* than when he first set foot upon its surface.

First Tulliallan Reclamation, 1821.—The first important foreshore reclamation on the Forth, of which there is a reliable record, was begun by Lord Keith, the then proprietor of Tulliallan estate, in 1821, and is described



Bird's-eye View of Rosyth Castle, St. Margaret's Hope, and North Queensferry.

by Mr. William Menzies, Lord Keith's factor, in vol. xii. of the Highland Society's Prize Essays, published in 1839. In this very interesting paper Mr. Menzies gives an account of two reclamations, the first of which was carried out in the bay which existed in 1821 between Kincardine and Kennetpans. An embankment was begun in April of that year which enclosed an area of 152 acres, and had a length of 2020 yards. The spring tides rose to a height of 8 feet over the foreshore along the line of the bank, which was composed at first entirely of mud wheeled with barrows from each side, and subsequently partly of brushwood to strengthen it, and had an average height of $11\frac{1}{2}$ feet. It had afterwards to be faced on the outside with stone, and heightened 3 feet or more, as it subsided considerably during the course of construction. As the work progressed the mud accumulated inside so as to raise the level of the enclosure and render the drainage more easy. For a year after the tide was shut out the saltness of the ground prevented the growth of vegetation, and it was not till 1824 that drainage and agriculture were begun, and an attempt at cultivation was made. In 1827 the first good crop of grass was obtained, and the productiveness progressed till 1830, when the ground was broken up in rotation for oats, barley, potatoes, beans, wheat, and clover grass, which improved yearly as the salt was extracted from the ground, and subsequently yielded almost unequalled returns. The cost of this reclamation was between £6000 and £7000, and the rent was progressive as the land improved in fertility. Dividing this figure by 2020, the length in yards of the embankment, it will be seen that the cost of the latter was under £3, 10s. per lineal yard.

Second Reclamation, 1829.—The next reclamation of importance was carried out on the east side of Kincardine pier by means of an embankment running to near Longannet Point, which enclosed an area of 214 imperial acres. This was begun in the spring of 1829, and progressed slowly so as to allow the mud to silt up inside. The spring-tides rose $11\frac{1}{2}$ feet over the line of the bank at the Longannet end, and 7 feet at the Kincardine end. By the middle of the summer of 1836 the mud had risen over the lower parts of the enclosure to a height of 7 feet 9 inches, and had raised the surface above the high-water level of neap tides. Openings were left to allow the tide to enter and deposit its mud, and at last these were, not without difficulty, closed successively, the sea being finally shut out in the end of February 1838, nine years after the commencement of the work. The whole cost exceeded £12,000, and many difficulties had to be overcome, but the work was greatly aided by the facility for procuring stone, of which about 170,000 tons were used in the embankment. In this case the embankment, which was about 3000 yards long, cost at least £12,000, or £4 per lineal yard on the average. An additional expenditure was, however, caused afterwards by the necessity that arose for pitching the outer face of the sea wall with stone to prevent it being damaged by storms.

The total area reclaimed was 366 acres, and the whole cost of the two operations was about £19,000, or say £52 per acre. At £2 agricultural rent (the value of the carse land at Kinneil for grazing at

present), which is less than an acre of good land was worth half a century ago, a return of nearly 4 per cent. on the outlay is given, which is not high certainly, but more than most good securities yield nowadays.

Reclaimable ground on south side.—The wide expanse of sleeches or slob land between Bo'ness, Grangemouth, and Kincardine Ferry, over 3500 acres in extent, offers a much larger field for enterprise of this sort, and I shall now speak of the various schemes that have been proposed, and of what may still be done towards reclamation of that waste area, the extent of which is sketched on the accompanying map on a scale of 1 inch to a mile.

So far as the writer knows, the first proposal to reclaim the foreshore *ex adverso* of the Duke of Hamilton's Kinneil estate in Linlithgowshire, extending from Bo'ness to the river Avon, was made by a Dutch company with skilled engineers about a century ago. This scheme, it is believed, failed because the Duke would only grant a thirty years' lease to the company instead of a sixty years' lease, which they said was necessary to recoup them for their outlay, before the new land was handed over to his Grace.

Mr. Livingstone Learmonth's Scheme, 1875.—In 1875 another and much larger proposal was made to reclaim the whole of the foreshore between Bo'ness and Kincardine Ferry and take in an area of 3600 acres. The proposer was Mr. Thomas Livingstone Learmonth, the enterprising proprietor of Parkhall estate in the vicinity, who had at his command a large fortune which he meant to devote to this laudable purpose. The plans were prepared by Messrs. Blyth and Cunningham, C.E., and I am indebted to Mr. Westland of that firm for kindly supplying the information about the scheme which my late friend Mr. Livingstone Learmonth, who died 28th November 1903, at the advanced age of eighty-five, was unable, owing to ill-health, to give me when I last spoke to him on the subject. The proposal was defeated in the House of Lords, owing, Mr. Learmonth once told me, principally to the opposition of Lord Dunmore, whose family then were riparian proprietors adjoining a small part of the ground included in the scheme. An embankment at some places 22 feet high was to be run round the foreshore from Bo'ness to Grangemouth along low-water line, and a new cut made for the mouth of the river Avon, with banks at each side to keep the tide at high water off the sleeches. A similar embankment was to be run from the mouth of the Carron at Grangemouth up the frith to Kincardine Ferry, to take in the foreshore opposite the old Tulliallan reclamation. This proposal was estimated to cost £275,000, but could probably be now done at a considerably lower price. At that estimate the land would have cost £76 per acre, which did not include a payment of £10 per acre proposed to be made to the riparian proprietors as compensation for any foreshore rights they might claim. Although agricultural land was much more valuable then than now, these charges were ruinously high and enough to kill the whole project.

Foreshore rights.—In this connection it may be mentioned that the foreshore rights of frontagers are not very clearly defined in general, as the Crown and the proprietors both claim to have rights over the sleeches,

and unless a proprietor or his predecessors have actually bought the *solum* of the foreshore from the Crown, and acquired a special title or have a Crown charter thereto, their actual rights to everything between high- and low-water mark must be considered as more or less shadowy. If the question were ever raised in Court some of the claimants for compensation might find that, although they might have certain rights of access and servitude, they had much smaller proprietary rights to the *solum* of the ground than they supposed, and in demanding considerable payments from others who proposed to reclaim these foreshores, they were asking for something that did not properly belong to them. In such cases it is better for promoters of reclamation to bargain with the riparian proprietors to sell such rights as they might legally claim, and get the Crown to dispose of such rights as it might have, rather than incur the cost of litigation and opposition, and so obtain a perfectly clear title before beginning operations. In this particular case the Duke of Hamilton, or rather Mr. Henry Padwick, his Grace's commissioner at that time, was "morally" a promoter of the scheme, on conditions highly advantageous to himself. Mr. Livingstone Learmonth was to pay him £1 per acre, or £1500, before he began operations, for the right to do so on the part of the foreshore *ex adverso* of the Duke's Kinneil estate. Twelve years were to be allowed for the execution of the work, and at the end of that time the Duke was to have the option of either paying Mr. Learmonth the value of the 1500 acres of land so reclaimed, not on the basis of his expenditure in making the land, but on a valuation made by neutral arbiters, or if (as was most likely) he did not elect to do so, Kinneil estate being then exposed for sale, of giving up his rights to it on receiving £15,000 from Mr. Learmonth, or £10 for every acre the latter had reclaimed. Under this agreement Mr. Learmonth did not stand to gain much in any event, and the Duke, who took none of the risk, not even a share of the promotion expenses of the bill in Parliament, stood to make £15,000 at least for the foreshore rights to which he laid claim. The total amount of compensation money at £10 per acre which the scheme involved was £36,000—far too large a sum to pay to people who would not take any share in the risk, and had only a doubtful claim for compensation after all. It was also far more than such a scheme could bear with any prospect of ultimate financial success. Mr. Learmonth told me that, although vexed at first, he was not sorry in the end that the bill had been rejected since the scheme as estimated would never have repaid him. But at the same time it was undoubtedly a sad loss to the whole district, and a splendid chance missed of carrying out a great public work, the benefit of which, had it been completed, must long ago have become abundantly evident. Mr. Learmonth, nothing daunted, went with his plans to Denmark, where more liberal terms were offered, and spent a sum of about £300,000 that should have gone towards enlarging Scotland in reclaiming some 11,000 acres of a foreign country on the other side of the North Sea, which, however, has unfortunately, after quarter of a century's trial, not yielded him anything like an adequate return for his enterprise.

Compensation to frontagers.—Mr. A. Beazeley, M.Inst. C.E., in his

excellent book on the *Reclamation of Land from Tidal Waters* (1900), devotes a chapter to the legal requirements, and preliminary negotiations with riparian proprietors, the Crown, and others, that must first be settled before the details of any large reclamation scheme are complete. As to the amount of compensation to frontagers for foreshore rights he states at p. 264 that *one-tenth* of the land embanked has been mentioned, but according to Mr. Wiggins (a standard authority half a century ago) this is a larger deduction than almost any intake will allow so as to leave the adventurers a sufficient chance of adequate remuneration for their enterprise. Mr. Wiggins arrives at the conclusion that *one-fifteenth* of the value of the ground reclaimed opposite any estate is a sufficient and fair proportion to allow the frontager as compensation. At this rate the riparian proprietors of the Forth above Bo'ness would be amply compensated by a payment of £3, 10s. per acre, on the assumption that the land when reclaimed is worth £52, 10s. and yields a rent of £2 per acre, or slightly more. Or else, to avoid a direct outlay and a payment on the basis of a more or less problematical valuation, the frontagers might receive *pro rata* a similar proportion of the ground itself when actually reclaimed *ex adverso* of their respective holdings.

Mr. Livingstone Learmonth's scheme was perhaps a little too ambitious, as the sea wall was to be carried out to the line of low water in order to gain as much land as possible, instead of being kept back where the foreshore level was not so low, and the dyke could be made at much less expense.

Forth Conservancy Scheme, 1880.—Another proposal was drawn up in 1880 by Messrs. Thomas Meik and Son, C.E., in 1880 in connection with a bill to constitute a Forth Conservancy. The foreshore to be reclaimed was bounded by an outer embankment that followed a better line between Bo'ness and Grangemouth, and the acreage of foreshore to be enclosed was not quite so large as that in Mr. Learmonth's scheme. I am indebted to Messrs. Meik and Son for information about their scheme, which I understand was to cost about £100,000 less than Mr. Learmonth's. The whole area to be reclaimed was 2925 acres, of which 2030 acres were below and 895 above Grangemouth.

The idea of a Conservancy Board and a scheme of this sort is one to be commended, and should still be carried out in the interests of navigation, but the bill was dropped after the plans had been prepared, as there was a risk of opposition by shipowners and others on whom a small rate would require to be levied to pay interest on the works and redeem the capital outlay.

Unless another empire-building millionaire appears on the scene with a hobby for reclamations, the only chance of taking in this tempting foreshore will probably be under some scheme of river conservancy. To carry out this, the shipping and harbour authorities must be satisfied that it will really benefit the navigation of the estuary, and the unanimous opinion of engineers must be obtained in its favour before the traders will consent to pay even the small dues necessary to finance the work at first. Every year ships of greater draught are being built to replace the smaller vessels and reduce the cost of transport by sea,

requiring the depth of the harbours or the channel outside to be increased accordingly. Above Bridgeness the south side of the low-water channel is less than one fathom deep for a mile and a half from the south shore, and opposite Bo'ness harbour the one-fathom line is half a mile out, so that any operations calculated to deepen the water there would be of much value to the navigation. Again, both Grangemouth and Bo'ness suffer greatly from the mud that accumulates in the mouth of the harbours, and has constantly to be dredged at heavy cost. Now it seems probable that the access to both these ports, as well as to Kincardine and Alloa, might be improved by a well-planned conservancy, that would have the effect (1) of confining the river so as to make it scour out a deeper channel nearer the south side of the low-water channel between Bo'ness and Grangemouth, (2) of removing a great deal of the suspended silt and thus clarifying the water, (3) of reclaiming a large tract of valuable land that may be used partly for agriculture, and partly for commercial purposes.

Suggested New Conservancy.—Such a scheme might prove both feasible and financially attainable, and would combine the improvement of the navigation with the reclamation of the large area of unproductive foreshore in question. The accompanying map explains graphically the general outline of the proposal, and also shows the extent of land already reclaimed at Tulliallan and quite recently at Grangemouth in connection with the new docks as well as the smaller area reclaimed in the Bo'ness district, all of which is profitably used for the new local industries that have sprung up during the last half century. A sea wall 5300 yards in length, running in a straight line from the new low-water frontage of the Grangemouth Dock to Bo'ness, a short distance above low-water line, would define the current on the right bank, and at the same time provide a receptacle for the silt, very much as Messrs. Meik proposed in 1880. This dyke would be continued up the river from Grangemouth to Kincardine Ferry, a distance of 4200 yards further, and a low training wall from Longannet Point to the Hen and Chicken Bank would define the channel on the north side.

These outer embankments, with others necessary for the sides of the Avon and Carron rivers, need not be completed to their full height at once, but might be made in sections in order to allow the tide to have access and raise the level of the intake by sedimentation as the work progressed. Although it is not suggested to reclaim any land on the north side in the meantime, the proposed rubble training wall would cause accretion of mud behind it that might in time raise the foreshore high enough to make it capable of complete reclamation at some future date.

The embankments on the south shore would enclose 2837 acres in three sections:—

- | | | | |
|-----|------------|---------|-------------------------------------|
| (1) | 1318 acres | between | Bo'ness and new cut for River Avon. |
| (2) | 650 | " " | River Avon and Grangemouth. |
| (3) | 869 | " " | Grangemouth and Kincardine Ferry. |

2837 acres.

No. 3 section is quite separate, and might or might not be included in the undertaking, as will be observed by reference to the map.

The practicability of the proposal turns at the cost of the work and the revenue that may be expected to accrue from it. The revenue will depend on the rent and area required, which in the gross is 2837 acres. In order to make provision for the claims of frontagers it might be easier, as already hinted, to give them some of the new land when made, rather than an actual cash payment. According to Mr. Wiggins' scale already referred to, one-fifteenth should be sufficient in equity to meet their possible claims, but in this case if we set 237 acres, or about one-twelfth of the area aside under this head, the nett remaining available area would be 2600 acres. At £2 per acre (the grazing rent on the adjoining carse of Kinneil) the revenue would be £5200, but if say 50 acres were let for trade purposes at £8, or £6 more than this to begin with, much greater returns becoming available afterwards from this source, an additional £300 would accrue, making the whole revenue £5500. At 4 per cent. on twenty-five years' purchase the capital value of the undertaking would thus be £137,500, and the vital question now is, Could the work be done for this figure?

In a recent discussion of the subject at the Royal Scottish Society of Arts, the author gave £100,000 as the probable cost, partly based on estimates that he had arrived at after thirteen years of experimenting on the reclamation of a small area of foreshore belonging to him at Bridgeness.¹ He had the advantage of the valued criticism of several experienced civil engineers, whose opinion was that it would be impossible to complete the scheme for such a small price, and that unless a very considerable revenue could be derived from other sources than agricultural rent, the financial prospects were not encouraging.

The second of the Tulliallan reclamation embankments in 1829 cost £4 per lineal yard, and the first one only £3, 10s. At the higher rate the various embankments of the suggested scheme whose total length comes to 16,400 yards would cost £65,600. Labour was, of course, very much cheaper in those days, but on the other hand there were no railways or labour-saving appliances such as would be employed now. A great deal depends on the facilities for obtaining materials, but at the Bo'ness end there are vast quantities of colliery rubbish that could be cleared away, with advantage to the Kinneil estate, and good quarries for stone to face the outer slope where necessary. To the west of Grangemouth similar sources of material occur, but without actual working estimates it is not possible to speak with absolute certainty as to the whole cost. The cost of making the embankments does not of course represent the total outlay, as roads, drainage, bridges, etc., must be provided before the land is in a condition to produce revenue.

Under a conservancy scheme, by which a small due would be levied on the vessels benefiting by the improved waterway, there would be no difficulty in financing the scheme at once. The registered tonnage of vessels using the harbour of Grangemouth, Kincardine, and Alloa is about 2,500,000 tons, and the actual tonnage is about twice this figure

¹ *Foreshore Reclamation on the Forth.* Trans. Royal Scot. Soc. Arts, 1903, vol. xvi. pp. 13-32.

every year. Conservancy dues of only say 2s. per 100 tons register, or say one-eighth of a penny on the actual tonnage, would produce £2500, the capital value of which is at twenty-five years' purchase £62,500. This sum plus the £137,500 given above happens to make exactly £200,000, which would more than pay the whole outlay.

Benefit in Clarifying Water.—The Firth of Forth above Queensferry is geologically a trough excavated to a depth of at least 600 feet in the rock, the bottom of which is lined with hard boulder clay, covered by plastic clay, on which there is a thick bed of recent mud or fine sandy silt. There is little or no heavy gravel here, only occasional stony beds, and at places in the fairway the silt has been proved by boring to be not less than 120 feet in depth, without a single hard stratum in it. Such superficial banks of gravel as exist are mainly old ballast deposits which vessels up till about thirty-eight years ago were permitted to throw out before they entered the harbours. This can be proved by walking at extreme low tide along the low-water line, when some of the banks are bare and are seen to consist chiefly of flints and pieces of chalk from the south coast of England, and of other stones quite foreign to the country. The Admiralty about 1865 wisely prohibited the continuance of this pernicious custom, and compelled the ships to discharge all their ballast on shore, otherwise the banks would have grown much larger. Above Blackness there is less sand than mud, and above Bo'ness there is almost nothing but mud for the waves to work on. The waves do not "fret" the coast very much at high tide, and the shore line above Queensferry has not been appreciably eaten away for at least half a century, so far at least as I can ascertain or the ordnance maps indicate. In these circumstances any injury to navigation is due to the suspended silt with which the water is heavily loaded in stormy weather. On a rough day I have collected samples of turbid water, and found it to contain 24 to 36 grains of solids per gallon in suspension, equal to from 9 to 13½ ounces of dry sediment in every cubic yard of water. The mud is not derived nearly so much from the river as from the adjacent "sleeches" or "slob lands," a fact that can easily be proved by going out a few hundred feet in a boat in rough weather, when the brown muddy zone fringing the shore is seen to give place to comparatively clear water in the fairway of the channel. Now if this muddy fringe be removed by constructing reclamation banks that will not only prevent the waves lashing the mud-flats, but will help to abstract the suspended matter already in the water, it is clear that the sea will become less turbid, and there will be no reservoir, so to speak, of silt left from which the harbours are replenished with mud, the constant dredging of which lays already such a heavy burden on the navigation of the estuary. Mr. David Stevenson in his well-known book on *Canal and River Engineering* mentions this very circumstance. He says (1st ed. p. 139): "Where a river channel has been thus fixed and confined by walls, it has been ascertained by repeated observation that the tidal water comes up the channel in a comparatively pure state instead of being loaded with particles abraded from the sandbanks and marshes."

The old "kitchen middens" or refuse heaps thrown out on the beach at or before the Roman period at Inveravon, west of Kinneil, contain,

amid beds of black ashes enormous quantities of oyster shells, some of them as large as a plate, from which the natives must have had many an excellent dinner in their time. Oysters of the best class prefer to live in clear water, and are now unknown in the muddy channel of the estuary above Bo'ness. Could the tide be again clarified by the retention of the suspended silt, its bed might once more become the home of thriving oyster-banks, a secondary benefit to be expected from such reclamation works—a benefit that no men of good *taste* could fail to appreciate.

Objection to Reclamations answered.—It has been objected to foreshore reclamations on the Forth that they tend to diminish the capacity of the estuary for admitting the tidal water, which on ebbing is required for the scouring out of the channel. This objection is no doubt valid for some rivers, but it has apparently little if any force in the case of the Forth, because the low-water area is already large in the upper part of the estuary, and the constriction at Queensferry will always cause a swift current to flow outwards and keep the channel below the Bridge clear enough for all practical purposes. So strong is the tide at and above the Bridge that the soft bottom is scoured out at one spot to a depth of no less than 41 fathoms. This deep hole is situated about midway between Bimar Rock and Inchgarvie, and has not diminished in depth since the first Admiralty Chart was made in 1851. It was again sounded when the estuary was surveyed by Captain Osborne Moore, R.N., in 1898, and the fact that it had not changed in depth and become filled up proves that very little heavy sediment, capable of filling up such a depression, is rolled along the bed of the estuary, and although hundreds of acres of tidal water have already been abstracted by reclamation works higher up, the current is still quite strong enough to keep its own channel clear—so strong that there is ample margin to spare, even if all the available land were reclaimed and a corresponding reduction made in the volume of tidal discharge.

To test the validity of this theory in its relation to the Firth of Forth, Captain Williams, R.E., of H.M. Ordnance Survey, has kindly supplied me with the exact extent of the high and low water areas from Queensferry to a point three-quarters of a mile above Kincardine Ferry, where sea and river water join at low tide. From these figures we find that:—

	Acres.
The total area at high tide is	<u>21,094</u>
Of which below low water,	12,578
Above low water on N. side—	
Foreshore,	3230
Saltings,	1
	<u>3231</u>
Above low water on S. side—	
Foreshore,	5160
Saltings,	125
	<u>5285</u>
Total above low water,	<u>8,516</u>
Total as above.	91 004

Now, if we consider the whole area proposed to be reclaimed as 2837 acres, consisting of 1968 acres west of Bo'ness and 869 west of Grangemouth, we arrive at the following result. The foreshore west of Bo'ness is only covered, taking the average of the whole area, by about 6 feet of water at the height of ordinary springs, and as the total rise and fall is about 18 feet the quantity of water is consequently only $\frac{6}{18}$ or $\frac{1}{3}$ of the wetted ground were it covered to the full depth of the tide. Similarly the average depth of water above Grangemouth is only 4 feet, or $\frac{4}{18}$ of the total tide.

Now the survey of the foreshores was made before the recent Grangemouth reclamations were started, so we must include that area (say 260 acres) in the calculation of the total quantity of abstracted tidal water by the actual and proposed reclamations. We thus find:—

$$\frac{1968 + 260}{3} = \text{about } 743$$

$$\frac{4}{9} \text{ of } 869 = \text{ „ } 193$$

Total area abstracted = „ 936 acres of water 18 feet deep.

To arrive at the ratio of this figure to the whole quantity of tidal water entering the estuary, we must take the low-water area over which of course the tide rises to its full height, and add say half the foreshore area, as the average depth of the tide cannot be considered as more than 9 feet over all the foreshores in the estuary, if even it is as much as this at spring tides.

	Acres.
Whole low-water area as above,	12,578
Half of foreshore area, 8516 acres,	4,258
Total acreage covered by 18 feet of tide,	16,836
Total abstracted by reclamations as above,	936

The ratio of the tidal water abstracted by the reclamation of the 3097 acres in question is thus that of 936 to 16,836 = about $\frac{1}{18}$ or $5\frac{1}{2}$ per cent.

These figures will, it may be hoped, supply a sufficient answer to the abstraction objection, as it is not likely 5 or 6 per cent. of a diminution in the flow, and that at spring tides only, will make any appreciable difference in the scouring power of the river farther down. The main difficulty in fact, if difficulty there be to the execution of such a proposal, is not that of the engineer but of the financier, and it seems to the writer that the probable profit and other advantages to be gained are still such as to bring the scheme quite within the range of "practical politics." These advantages may be briefly summed up as:—

- (1) Improvement in the navigation of the channel below Alloa;
- (2) Clarifying of the water, and thus saving dredging of harbours;
- (3) Providing ample space close to low-water line for new wharves and maritime industries, such as shipbuilding in connection perhaps with the adjacent Naval Base;
- (4) Increasing the size of the productive area of Scotland; and
- (5) Improving the salubrity of the district by the drying up of miles of damp mud-flats, from which unhealthy vapour rises in clouds when the sun shines in warm weather.