

Archibald Cochrane, 9th Earl of Dundonald

(1748-1831)

Father of the British Tar Industry
by Paul Luter©

Introduction

Archibald Cochrane, 9th Earl of Dundonald and the father of the British tar industry, was deeply concerned with "Promoting ideas which were useful to his country and to mankind in general". He was a man with a very acute mind able to research and implement his ideas in a very wide field of interests. He was an aristocrat during the Age of Enlightenment who put his education and capital to very good use. Besides being the father of the British tar industry he had a deep interest and understanding of many associated chemical developments and markets. After service in the navy and army he developed extensively the resources of his home estate at Culross which included coal, ironstone, fireclay and salt pans. For many good reasons he also established himself and his industries in the the Shropshire home of the Industrial Revolution. He worked with many of the great chemists, metallurgists and industrialists of the time including Joseph Black, Matthew Boulton, Richard Crawshaw, John Loudon Macadam, William Murdoch, William Reynolds, John Wilkinson and others. He was granted nine patents covering inventions in the fields of coal tar, industrial chemicals and agro-chemicals and wrote many books and pamphlets explaining his discoveries.



This paper by Paul Luter gives a brief account of his life and highlights some of the ways in which he succeeded. It was presented as the 'Annual John Wilkinson Lecture' to the Broseley Local History Society (Incorporating the Wilkinson Society) on 1st March 2006. – Ed.

Background

Archibald Cochrane was born on January 1st 1748 at Culross, Scotland as the son of Major Thomas Cochrane, eighth Earl of Dundonald (1691-1778) and his wife Jean Stuart. Cochrane's parents had been married in Edinburgh on 6th September 1744. Archibald had four brothers John, James, Charles and Basil, (1755-1826) who later became a captain and senior servant in the East India Company. His brother Charles died in action on 18th October 1781 and James (1751-1823) later became vicar of Mansfield. As a youth of fourteen, Archibald then took a post as midshipman on a cruise under Commander Stair Douglas off the coast of Guinea. Whilest serving as acting lieutenant on the ship he had occasion to observe the liability of vessels to be rotted by the sea, which in some cases was so very great, that a few months was sufficient to render them not seaworthy. He then conceived the idea of laying them over with tar extracted from coal. Dundonald experimented upon his return on a decked boat at the port of Nore. The Nore lies between the Hook of Holland and Hamburg, and it was here Archibald first found tar to answer all the purposes required.

In 1764, aged just sixteen, Archibald joined the third Kings Own Regiment of Dragoons as a cornet. He was replaced according to records in 1768. Later, he joined the 104th Regiment where he obtained a Captain's commission. Between 1768-1775, the Earl of Hopetown forwarded Archibald one hundred guineas as an allowance. He finally relinquished his commission in the army in 1778 after

fourteen years of service. On 17th October 1774, Archibald married his first wife Anne Gilchrist at Annesfield, near Hamilton, Lanarkshire. He fathered six children by Anne including his eldest son Thomas. Thomas Cochrane, Archibald's father and the 8th Earl, died on 27th June 1778 at La Macha, Pebleshire, and as the heir to the Culross estate, Archibald succeeded his father as the ninth Earl of Dundonald.

Tar from Coal

In 1780, Dundonald discovered a new, easy method of extracting tar from coal. Many previous trials had been made by the Marquis of Rockingham near Sheffield and by others at Coalbrookdale and at Newcastle under the German Baron van Haak. However, the small quantities made at that time meant that it could not be sold economically for less than twenty-eight shillings per barrel.

(If bituminous coal is heated in a closed retort it softens as the temperature rises and most of it melts, releasing hydrocarbon vapours such as coal gas and coal tar. The proportion of volatiles varies significantly depending where the coal was produced. After the volatiles are released the residue solidifies as coke which may be strong enough to be used in blast furnaces for iron making. Coal tar can be distilled into many fractions to yield a number of useful coal tar crudes, including benzene, toluene, xylene, naphthalene, anthracene, and phenanthrene. These now form the starting point for the synthesis of many products, notably dyes, drugs, explosives, flavourings, perfumes, preservatives, synthetic resins, paints and stains. The residual pitch left from the fractional distillation is used for paving, roofing, waterproofing, and insulation. Much of the benefit of the work of Dundonald must have come from the development of techniques for separating the many products and identifying their end uses and markets. Ed.)

The British Tar Company

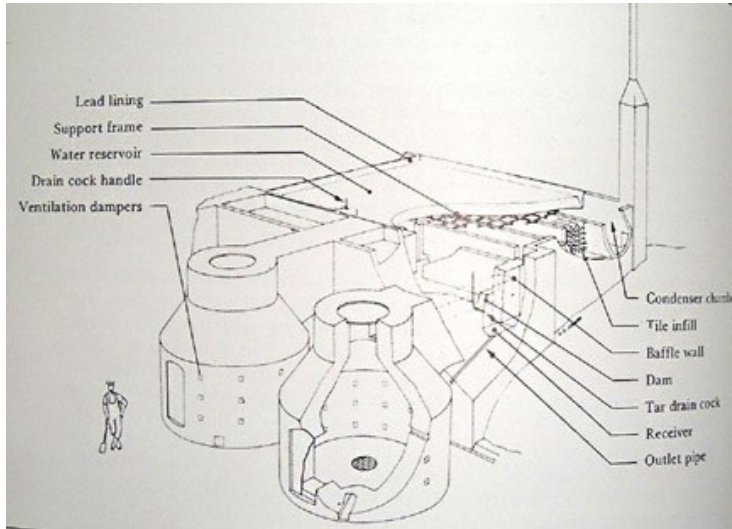
In the summer of 1780, Archibald borrowed £10,000 from his wife the Lady Anne, née Gilchrist, which he promised to pay back with interest. The money was used to start a business called "The British Tar Company" with Dundonald himself, John Clerk (1728-1812) and other partners. Clerk had apparently working on the same idea as Cochrane and on 30th April 1781, he took out a patent No: 1291, for a process "to Distil Bituminous Coal for Obtaining Tar and other Products."

In June 1782, Joseph Black (1728-1799) Professor of Chemistry at Edinburgh University came to Culross to inspect Dundonald's plans for four new tar kilns, which, Dundonald planned to build in the grounds of Culross Abbey. On returning to Edinburgh, Black studied the plans and by 18th January 1783, Black had completed his first consultation on wording of Cochrane's specification. Dundonald's plans were not cheap to build or run as each kiln cost £50 and used 6½ - 7 tons of coal each week, while the waste cinders were sold as coke at Leith Market. The coal tar was recommended for the preservations of nuts, bolts and as a effective preservation of cast and hammered iron from rust including coating the inside of guns in naval yards to stop them from scaling.

In January 1783, The British Tar Company had twenty tar kilns on Dundonald's Culross estate producing a total of fifty-six barrels of tar/wk. The price of tar had gone up from fourteen shillings a barrel in peacetime to twenty-one shillings per barrel in wartime. The British Tar Company was making £58 16s per week from the Culross kilns. Dundonald commented that the tar and varnish was selling as fast as it was produced. It was used on the bottoms and masts of ships and the oil of turpentine was used for painting houses. Dundonald was also selling coked cinders to the Carron Ironworks for melting iron ore. In January 1783, he sent a sample of his new purified alkali to Messrs Hutton and Davy who manufactured sal ammoniac (ammonium chloride, used in dyeing and as a flux for metals, Ed.). By March their tar was selling at twenty-one shillings, a barrel.

However by May 1783, Dundonald confided to Black that there were already disputes going on within the company partnership. Consequently, whilst at Culross, Dundonald was paid a visit at by the company bankers Peter Miller and Captain Moody of Leith.

By mid August 1783, Matthew Boulton made the long journey from his Boulton and Watt Soho Works in Birmingham to Perth to discuss business with Dundonald. Meanwhile prices of tar in Newcastle had reached twenty-six shillings a barrel. Customers wrote to Mr. Edward Park,



Dundonald's Agent to the British Tar Company at Culross. They included Captain John Hall of the ship "The Swan" a tender in Government service who found the coal tar ideal for coating ship bottoms after boiling one hour, the shipbuilders Messrs Marshall and Gray from Kincardine, John Grieve of Grange coal works, and Alexander Morrison, a shipmaster of Aberdare. The British Tar Company products were also sent to Norway and St Petersburg, Russia and used by coppersmiths for the preservation of their iron buckets.

Salt Production

In 1784, Dundonald produced a fifty-two page booklet on the 'Manufacture and Trade of Salt on the Herring Fisheries and on the Coal Trade of Great Britain'. A copy was submitted to the Right Honourable William Pitt, Chancellor of the Exchequer and expressed concern that the two hundred saltpans previously at North and South Shields had diminished to just twenty.

By 1786 Thomas Cochrane, Archibald's brother had erected apparatus on the Culross estate to purify salt on a large scale, heating the pans with coal from the estate. In February 1786, Dundonald wrote to Joseph Black asking him to attend these salt trials, which were to be of national concern because the government was proposing a new law that all salt sold in Great Britain was to be purified before it was to be offered for sale.

Tar Making Monopoly

On 15th March 1785, London newspapers wrote that, the previous day, a motion was announced in the House of Commons for leave to bring in a bill vesting in Archibald, Earl of Dundonald, and his executors, administrators and assignees. The bill was for the sole use of a method of extracting or making tar, pitch, essential oils, volatile alkali, mineral acids, salt and cinders from pit coal throughout his Majesty's dominions for a limited time. The proprietors of coal works nationally were in opposition to such an intended monopoly, saying that if an exclusive right of making coal tar oil and other articles, the produce of pit coal, should be granted by the legislature to any person whatsoever, it would materially effect and injure the owners of coal works and manufacturers where the processes have been going on for some time. Tar oil had already been extracted from pit coal for several years past and used for various purposes, particularly at Liverpool in preventing woodworm on the dock gates and by owners of vessels on the River Severn for preventing decay of trows. In 1785, Archibald published a booklet entitled 'An Account of the Qualities and Uses of Coal Tar'.

Madeley Wood and Jackfield

Soon after the trials, during May-November 1786, Dundonald held discussions with the Coalbrookdale ironmasters, William and Richard Reynolds at Bank House, Ketley in Shropshire. The nature of the discussions may have involved the discovery of tar in large amounts found by William

Reynolds in an underground canal Reynolds was making at Madeley Wood (now the Ironbridge Museum's Tar Tunnel).

Reynolds listened to Dundonald's advice on how to manufacture varnish from the tar emanating from the rocks in the tunnel and later in 1788 Reynolds recommended that the Ironbridge at Madeley Wood be coated with this varnish for protection. By June 1787, with the tar kiln projects at Madeley Wood and the Calcutts both moving forward rapidly, Dundonald found it suitable to move into the house called "The Tuckies" at nearby Jackfield.

In October 1787, Dundonald's plans for tar kilns at Madeley Wood received a temporary setback when William Rathbone refused building permission for the kilns, because of complaints from anglers about the possible pollution to the River Severn and their concern about the effect of noxious fumes upon the local residents. However, it seems that by December, there was a change of heart, as William Reynolds, who had carried out trials on the productivity of Dundonald's coking coal across the river at Benthall Furnaces, had found his trials on the destructive distillation using clod coal successful. Dundonald was anxious over the results of these trials, as he had already asked William Reynolds, if he could set up a tar works at Ketley, so the results of Reynolds experiments at Benthall were pivotal.

Second Wife

In 1787, Dundonald's wife Anne, whom he had been with thirteen years, died, and this put off any business plans Dundonald proposed for several months while Dundonald was in mourning. However, a year later, April 12th 1788, at St Georges Church, Westminster, London, Dundonald re-married to Isabella Raymond, widow of John Mayne.

Dundonald was concerned that further procrastination at Madeley Wood would open the way for new objections on the part of the inhabitants and the watermen. So he proposed a refinement to the process in order to enhance the safety of the works by burning the noxious hepatic inflammable air and getting free of the tar water. He was able to use the tar water for watering the cokes and damping the kilns and as manure for William Reynolds land instead of discharging to the River Severn. Dundonald hoped these adjustments in the process would sway Rathbone and the issue in a positive way. Soon after, in spring 1789, John Loudon Macadam, inventor of the 'Tar Mac' Macadamising system of road making, visited the tar kilns at the Calcutts, Jackfield, near Broseley and expressed his opinions on the process to Dundonald.

(John Loudon McAdam (1756-1836) was the son of James McAdam and Susanna Cochrane, the niece of the 7th Earl of Dundonald. He was sent to America in 1770 after his father died. There he did well in business and was a member of 'The Committee of Correspondence of 51' in Boston with Paul Revere and others. After the War of Independence, much of his property was confiscated and he returned to Scotland. John's association with Admiral Lord Cochrane and the 9th Earl of Dundonald acquired him controlling interest in an iron works and mills that manufactured coal products such as tar for sealing sailing ships. His major business associate was Admiral Keith Stewart. His interest in turnpike maintenance accelerated when he was appointed surveyor to the Bristol Turnpike in 1801. Ed.)

Profit Shortfall

At this time debts were mounting for The British Tar Company and after an investment of £16,000 in the Shropshire works the company had debts totalling £42,000. Other investments had been the procuring of coal, salt and tar in speculations at Culross and in another works in Ayrshire, where £13,000 had been invested and a further £13,000, purchasing back the patents from former partners and an investment in a company called Messrs Chapman and Crawford. Consequently the British Tar Company decided not to invest further money in the erection of works until cashflow improved. Their plan was to induce others to erect works on their own terms. The problem was that their sal-ammoniac

speculations at Culross were in debt and their English tar works were their only profitable factories. In September 1789, Dundonald asked William Reynolds to come into the partnership with the new trading name of "The Mineral Tar Company."

In June 1789, Dundonald wrote of the British Tar Company's position stating that they ran two sets of works in Shropshire at Calcutts in Jackfield, near Broseley, and Madeley Wood and three sets in Staffordshire including those at Lower Colliery, Netherton, Dudley Wood and Tipton. These works were built on property owned by other people and in all five cases, except at Tipton; the leases would last for a short period of twenty-one years.

Dundonald complained about the mode in which the British Tar Company was managed and the investments would not pay back more than four per cent on capital. This would hardly be enough to pay off the initial capital that they borrowed at five per cent in setting up the Shropshire and Staffordshire works. At this time, Dundonald knew the company's expansion was vital, if they were to survive. At Dudley Wood the tar works were proving a great success under the sub-management of William Pitt of Pendeford. The following year in August 1790, Richard Crawshay wrote of his approval of a new scheme of Dundonald's in attempting to rid the ironmasters of what was described as "the carbonaceous principle" or rust caused by exposing iron to vital air. Dundonald recommended the addition of salt to quell the problem and sent Crawshay a copy of his new manuscript on iron. Benthall and Ketley

The results of Reynolds experiments on the clod coal at kilns in Benthall, Broseley, proved that the production of tar from coal was a viable commercial proposition. To Dundonald's satisfaction in October 1789, William Reynolds authorized the building of tar kilns and distilleries close to his Ketley works. While the building of kilns was in progress at Ketley, Dundonald approached Reynolds regarding the dire financial situation of The British Tar Company. Reynolds shrewdly decided to bear no part of the company's debts or expenses the company had already incurred. However he promised Dundonald, he would invest in the Ketley estate, when he received commercial gain from the cokes produced from Dundonald's process. Dundonald himself would have to manage with profits arising from the chemically extracted tar, varnish and oils from the process. The weather turned adverse for The British Tar Company in Scotland, as they could not produce any salt at all because of the heavy rains of 1790-91. However, between Christmas 1790-1791, Dundonald made a profit of three thousand, three hundred and eighty-five guineas (£423/10/-) from mining coal from Culross and in supplying the extensive Carron Iron Works at nearby Falkirk, Scotland.

Potato Bread

In February 1791, Dundonald produced a booklet consisting of three letters, which was entitled, "The letters of Earl of Dundonald on making bread from potatoes." William Creech printed the booklet in Edinburgh. In it he published details of his experiments and describes how the process had been long used by the West Indians in the preparation of Cassado flour (tapioca). This powdered potato could be taken as a broth for sick sailors on long voyages and could be made from sweet potato in warmer climates. The mixture could also be used as liquor for cows in wintertime and in the production of potash. Dundonald near Culross Abbey trialed the process during the first months of 1791 and a Mr. Findlay, a baker from Edinburgh, who baked the bread and sent out specimens to Dundonald's acquaintances.

By March 1791, Dundonald had published his pamphlet on feeding the starving populace by making good bread by a mixture of starch and potato powder being added to flour.

The combination of other interests and the dire situation within The British Tar Company had grown so oppressive, that Dundonald wished to give up the remaining fourteen years of his tar patent. He felt

troubled that he had spent ten years of his life and yet, had never received a penny from The British Tar Company, while others within the company had profited greatly. In 1791 the price of tar had increased to a high level and by March 1791, the company was being managed by George Glenny, banker and gambler, Lord Kinnaird and Admiral Keith Stewart, who according to Dundonald, was a man who, " had a heart without a head." By December 1791, several influential manufacturers, including William Reynolds were using Dundonald's coked coal in their blast furnaces to great saving and effect. But there was no profit in this for Dundonald, who expressed himself to be better off as "a disinterested promoter." Records show that at this time Dundonald had an estate in Stourbridge at this time where an eleven-foot vein of clay was uncovered.

More Tar Works

After 1792, the Horsehay and Coalbrookdale Ironworks were using the Dundonald varnishes and later the Shropshire Canal Company used them to preserve tub boats. By 1792, Dundonald and his partners had three successful tar works situated at the Bradley ironworks and at Tipton and Dudley Wood. The ironmasters at all three ironworks nearby furnished the tar works with raw coal and receive cokes in return. According to an article published by the Chemistry committee of the Royal Society of Arts and Manufacturers in 1791, out of one the hundred tons of coal employed in making tar each day at John Wilkinson's works at Bradley, eighty tons would "fly away" in smoke. Dundonald introduced aftercooling of the smoke to condense out and recover tar products with a good improvement to process economy.

By 1793, Dundonald was one of the first pit owners in Britain to stop the employment of women and children underground. On October 4th 1794, he took out a patent No. 2015 for "Preparing and Obtaining Vitriol of Argil (aluminium sulphate) and other Salts, Saline and other Substances."

Culross Estate

In 1793, Dundonald published a booklet, printed in Edinburgh, entitled, "Description of the Estate of Culross, particularly the mineral and coal property including an account of coal workings at Culross since 1572 and a description of the coalfield on the Firth of Forth." The booklet offers a fascinating glimpse into the estate that Dundonald inherited and which was soon to be sold that year. Dundonald



describes that the estate was made up of three main sections. A nine-hundred acre estate, which included Culross Abbey, a further eight hundred acres of forest, first planted in 1751, and ten thousand acres of coal territory. Dundonald's coal territory contained twenty-seven seams of coal from two to nine feet thick. By 1793, seven of these seams were still unworked. These seams contained "Smithy coals and rich, cakey, dry Splents, well adapted for the manufacture of pig and bar iron and entirely free of sulphur."

Originally the Culross estate had been acquired by Sir George Bruce of Carnock, Dundonald's great, great grandfather by the female line. The coal and saltworks there formerly belonged to the Abbots of Culross and Sir George purchased the land from Colville, Commendator of Culross in 1575. Sir George was the younger son of Bruce of Blairhall and brother to Edward Bruce, Lord Kinloss. Sir George erected machinery consisting of the Egyptian Wheel called a "chain and bucket" to drain the coal. However, in March 1625 most of the Salt pans and coal pits along the coast of Fife were drowned by storms. Between 1597-1625, during a twenty-eight year period, Bruce had dug more than

a mile under the sea. In discussing Bruce's work, Dundonald quotes from a booklet entitled "The penniless pilgrimage of John Taylor into Scotland," first printed in 1618, and reprinted in 1625. Dundonald tells us rather amusingly, that if the Gunpowder plotters had known of these tunnels, they would of used the design in London to blow up the King's barge upon the Thames.

The water from the mines was conveyed to a well, where there was a horse mill with three horses and a great chain of iron going down many fathoms with thirty-six buckets fastened to the chain. A similar idea was used in 1726 by John Curve and is included in Reynolds' sketchbook. The salt works made ninety to one hundred tons of salt weekly and some was sent to England, Germany and parts of Scotland. Three quarters of all Scottish salt was from Firth of Forth production. At this time the Rock Salt in Cheshire had not yet been discovered and in 1673 a great duty on French Salt was brought in order to improve the English salt trade. There were forty-four salt pans on Dundonald's land using one hundred and seventy-five pick men.

He also mentions that during 1621-22, large quantities of coal were sent to London from Culross. However, the Scots army stationed at Newcastle interrupted the trade of the river. Finally, in 1676, all mining ceased on the Culross estate and the mines became redundant for a period of ninety-eight years. Dundonald finally re-opened the mines there and at Valleyfield in 1774. By 1793, the price of coals had advanced twenty-five per cent.

A feature of the Culross estate was the forest, first planted during 1751 and used to cut wagon way rails, sleepers and pit timber. Dundonald had ten acres cut down annually and each tree made three shillings. The sawmills there made a profit of £1,300 annually. Large quantities of wood from Culross went for wagon rails at collieries in Tyne and Wear and in Shropshire.

Bands of ironstone were also numerous on the estate, suitable, partly for forge work and partly for melting iron. There were fourteen strata of ballstone (ironstone) lying eight feet thick and Blue Clunch (a fireclay) at two shillings and sixpence per ton. There were several sites within sixty yards of the high water mark, which Dundonald felt would be good sites for furnaces in which Dundonald proposed using ironstone as a flux instead of limestone. On the estate Dundonald also describes the "inexhaustible veins of indurate fine clay measuring eleven feet thick, which he describes, as " equal in quality to that of Stourbridge". The seam was rendered level free to the height of forty perpendicular fathoms by a mine from the high water mark.

There were two fire engines on the estate, one with a 40" cylinder, the other 50" cylinder. Other mineral riches on the estate included coal to the west of Queeensferry and slate, which gave one-seventh of its weight in green vitriol and alum. Although Dundonald did not wish to part with Culross Abbey in 1793, the property was in need of great repair. He was forced to sell the mines for four thousand guineas, a sum of twenty thousand guineas below their true value. He had just begun to build a proper quay and harbour for shipping coal from the estate. In his sale of the Abbey, Dundonald had reserved the power to re-purchase the property within ten years on repayment of the original price plus a five per cent interest.

(The Royal Burgh of Culross in the Kingdom of Fife is on the north side of the River Forth and now looks across to the oil refineries at Grangemouth. It sits between the huge Longannet power station to the west and the derelict Low Valleyfield colliery and the disused salt pans of Preston Island to the east. Fortunately, it has been in the care of the National Trust for Scotland since the 1930s and includes many 16th century buildings including the Palace of 1597. On the hillside above the village are the remains of Dundonald's Culross Abbey. It must be well worth a visit. - Ed)

Some Problems

The sale of the Abbey at this time was hindered by Dundonald's unfortunate connection during 1783 with Mr. William Chapman and the late Mr. Liddell of Newcastle. Adverse reports about Dundonald were circulated by coal proprietors within the Firth and circulated by Scottish colliery managers. Dundonald challenged coal owners to validate their remarks. Indeed during April 1792 several gentlemen and coal masters came to visit to inspect Culross collieries and gave a good report. Dundonald had long been willing to dispose of his tar patent to the government or to coal and ironmasters in Britain on being re-imbursed money he had expended. But, he wanted a House of Commons enquiry into the state of the manufacture of Coal tar in Britain and the reasons why (by 1793) that, shipbuilders would not make use of Coal Tar, even after the fullest evidence of its resisting attacks on sea worm. (Complete cladding with copper of the underwater hull of a ship had been first used on HMS Alarm in 1761 to prevent attack of the wooden hull by the Teredo worm in tropical waters. The copper was also found to reduce biofouling of the hull very significantly which gave ships a great advantage of speed when compared with those dragging round a vast growth of marine weed. By 1793 the navy was cladding all ships with copper rather than tar – Ed)



Culross Palace today

During 1793, Dundonald expressed his delight at what he described as, "The erection of the properly planned and constructed tar works in Shropshire and Staffordshire which he had superintended. However, adverse remarks materially hindered his progress and by 1793 little remained of the fortune from his maternal, great grandfather, Sir George Bruce, and only the castle remained. Dundonald felt caught in a void between Traders and Peers. Traders said, " You are a Peer", whereas Peers said, "You are a trader-we have nothing to do with you." Dundonald was also criticised in an anonymous letter published under the signature of one "Millbank" in July 1792. Dundonald described the letter as the "abusive Epistle of Millbank." Sadly a copy found its way to the Lord Advocate of Scotland, which did not help Dundonald's plight. Consequently, Dundonald separated himself from Scottish peers, intending to dispose of his property and retire with the debris of his fortune. Dundonald had two sons, grandsons of the Gallant Captain Gilchrist of Southampton. Dundonald was ready to accept a rank in the navy or army if war came, he having left the navy previously because of domestic concerns. By 1793, no coal was being mined on Dundonald's estate or on the Firth of Forth, and four-fifths of coal coming into Scotland was coming from Newcastle and Sunderland. Dundonald noted this coal was "rubbish" in comparison with Culross coal. Dundonald criticized the Scottish colliery system and he launched verbal attacks on the masters methods wanting to put a stop to "the barbarous and ultimately expensive methods of converting colliers wives and daughters into beasts of burden and causing them to carry coals to the pit bottom or the bank on their backs."

He advised better use of steam engines and recommended the adoption of the "Long Wall" coal mining system, as in Shropshire. He also condemned the methods of the Scottish colliery owners in retailing beer and whiskey to the colliers and expressed concern over the cheapness of coal bought by the large ironworks, who were eating up huge amounts of stock and which was causing problems. He was able to show that each furnace was using 9,000 tons of coal annually and calculated that, as each miner turned out eight tons per week each, that it would take many colliers to serve the five furnaces. The calculations were designed to show the drain on labour from the ironworks and Dundonald suggested, "Ironmasters should recruit for themselves."

New Partners

In 1794, John, William and Gorge Losh became new partners in the British Tar Company. Soon after, the British Tar Company opened a new chemical and tar making complex at Bells Close, Walker upon Tyne, near Newcastle. It was here that in an effort to turn business affairs around that Dundonald also brought in Captain John Dumaresque and Dundonald's brother John. During 1795, Dundonald carried out experiments in William Reynolds laboratory at Bank House, Ketley. As a result he succeeded in producing a baked mixture of dried potato and starch, which had been developed and would feed the poor in times of need. The project needed support from the government and Richard Reynolds wrote to the Board of Agriculture encouraging the promotion of this project. Dundonald was concerned that with the increasing population that lower classes of people were better fed at a cheaper rate and William Reynolds planted large amounts of potatoes at Wallimoor Wood, Wombridge to support this ideology.

On February 28th 1795, Dundonald took out a third patent No: 2039 for "Preparing Saline Bodies as Manure" and soon after on March 11th 1795 he added another patent No. 2043 for "Obtaining Mineral of Fossil, Alkali or Soda from Neutral Salts and Supplying to Various Purposes". In March 1795, Dundonald, with the use of coal tar now completely out of favour, and with the help of Mr. Vancouver, Dundonald released a booklet entitled, "A treatise showing the intimate connection between Agriculture and Chemistry" addressed to cultivators of soil and proprietors of Fens and Mosses in Great Britain and Ireland and proprietors of the West Indian estates. The booklet shows us Dundonald's intimate understanding of the chemistry of soil.

In it he encourages farmers to deepen their understanding of chemistry, particularly in the action of manures upon the land and the methods of preparing manures and thus getting more from the soil. Dundonald stated he had learned much from the discoveries of Priestley, Cavendish, Bergmann and Kirwan and had also understood much from the earlier work of Dr Francis Home on saline bodies (1756) and also Sir John Pringle's essay on antiseptics. He encouraged the analysis of cattle urine and of dung heaps and the use of ashes, lime and chalk upon the ground as manures. The booklet also discussed ways of improving hemp as Dundonald felt that if hemp was cultivated on a more extensive scale in England, the oil from the seed could be well applied to the manufacture of soap, which was then made of tallow. This in turn would cut the huge amounts of hemp then being imported at cost from Russia.

By April 1795, Dundonald's fourteen-year patent for producing tar from pit coal was ending and other works proprietors had begun to build kilns for their own tar projects. On June 29th 1796, the diarist, Charles Hackett visited The British Tar Company's, Walker on Tyne works, situated four miles northwest of Newcastle. He observed the men, "separating sal-ammoniac from sea salt, and the production of white lead." Later, William Losh brought drawings of the Leblanc soda manufacturing process back from a visit to Paris and the company attempted to apply this new technology at the works. On visiting Shropshire the same year, Hatchett, observed the kilns erected by Dundonald for the distilling of pit coal at the Calcutt's near Broseley.

Hatchett commented that, "by this process the bituminous part of coal (lost when making coke) is conveyed through long winding chimneys and after being condensed is received in a recipient." Other sources agree that it was at the Calcutts that Dundonald erected a number (up to twenty) of large ovens termed stew-coal ovens with a view to extracting oil or tar and thus cheapening coke for making iron. " For each hundredweight of coal, Dundonald was able to obtain four pounds of tar and volatile oils and some varnishes adapted for japanning purposes. Indeed as early as 1788, Dundonald had "Cypress Congreve" varnish in production at Wrockwardine Wood, now in Telford, Shropshire. The process consisted in conveying the liberated gases from these ovens by means of flues into a capacious funnel or a chamber built out of bricks and supported on arches. Here large amounts of water for the cooling and condensing of these gases was brought in by means of numerous leaden ducts or channels. The condensed products were then carried by iron pipes into receptacles and then pumped into a boiler to undergo further refining. On April 5th 1796, Richard Crawshay received a copy of Dundonald's new booklet on chemistry. Dundonald had been very much influenced by the chemical ideas of a Swedish chemist named Torbern Bergman, so much so, that by 1799 he described Bergman's work as "his bible and prayer book" on the subject.

On August 16th 1797, Dundonald took out his fifth patent No: 2189 for "Making White Lead" and this was followed on January 25th 1798, with a sixth patent for "Preparing Neutral Salts and applying those to other neutral salts." By 1798, John Losh and Dundonald had leased a pit near the Walker on Tyne works, where the naturally occurring brine springs were used to make alkali.

Sibling Problems

Dundonald found himself in a strange predicament at this time when John and Basil Cochrane, his brothers tried to saddle him with all their debts. By 1799, they gained possession of £23,000 acquired from the fortune of Archibald's marriage.

The brothers also extorted three patent controls from Dundonald and this action completely split the family's devotion to one another. It again seems that Dundonald was being forced out of the company and being starved of income from it, as George Glenny, the British Tar Company's agent as a government contractor, lived a very wealthy lifestyle from his great house in Southampton Buildings. By 1799, Dundonald had built further tar kilns at Ketley and we know that each barrel of tar produced at Ketley contained thirty-two gallons. A further refrigerator and condensing vessel was also built there according to Dundonald's specification. By September 1799, after Dundonald had separated himself from the financial entanglement with his brothers, William Reynolds requested an agreement with Dundonald personally for the carriage of tar along his canals at Ketley and Wombridge.

However Basil, Dundonald's brother brought in George Glenny, a attorney to fight for the British Tar Company's rights in this matter. By December 1799, after ten years in business with The British Tar Company, Dundonald was £45,000 in debt mainly due to losses in personal fortune and through mineral prospecting in Scotland. His trade problems were further exacerbated by levies on alkali and alkali salts. Dundonald began to recommend to some ironmasters that they adulterate alkali and soda in order to avoid taxation.

Financial Problems

Dundonald noted that only Mr Aubone Surtees, a wealthy banker from Newcastle upon Tyne, was only one who seemed to be exempt from this levy. By the end 1799, a loan of £10,000 from Lady Dundonald had not been repaid and the company was only paying thirty pounds per annum for the Calcutts tar kilns at Broseley. By 1800, the Losh brothers had excluded Dundonald from any management consultations and subsequently he was no longer informed of the worsening financial state of The British Tar Company. From this time onward, Dundonald, scared of long-standing creditors catching up with him, progressively lead the life of a perpetual fugitive. He often was

staying incognito at lowly inns while seeking small loans from his wealthy friends in industry. By this time, he was also suffering from a profound, if largely justified, persecution complex, his health was fading and during November 1799, he visited Dr Thomas Beddoes at Bristol Hot Wells to get some medical help. It was whilst he was in Bristol that Beddoes gave Dundonald a copy of his new publication, which he had prepared, which contained an account of all of Dundonald's chemical discoveries and discussions. At this time Dundonald was residing at the house of Mr. Oliver at number 22, Bell Yard, Caney's Street, Lincoln Inn, London.

Coalport Developments

During December 1799, William Reynolds had proposed a plan for a Dundonald type chemical works to be situated at Coalport. The works was to make soap, dyes and paint, using the natural gradient of the land, which suited the chemical processes proposed. At this time Dundonald tried to persuade Reynolds to allow him to direct the alkali works at Wombridge in place of the young chemist, John Biddle, whose failure Dundonald egotistically prophesied. Interestingly, Reynolds still regarded Dundonald's initial proposals for the large integrated site at Coalport with favour. Consequently, in May 1800, Reynolds was making plans for these Coalport proposals to be checked by experts in London.

In December 1799, Alexander Brodie took over the kilns at The Calcutts from Dundonald and was marketing tar at nine pence per barrel. Consequently an income of nearly £700 from oils, resins and varnish paints was reached. At this time, Lady Isabel Dundonald (nee Raymond) began to be swindled by George Glenny. Dundonald distaste for Glenny can be seen in his letters where he describes him as "a scoundrel" and wanted a proper legal enquiry to be made as to his conduct. Meanwhile the partners in the British Tar Company including Dundonald's brothers John and Basil had been declared bankrupt.

In January 1800, with Dundonald now unable to sustain the house, William Reynolds moved into The Tuckies. It was there, that Dundonald visited Reynolds to show him his new patents for preparing glauber salts, alum, alkaline salts and white lead, but unfortunately Reynolds was away in South Wales. By February 1800, Dundonald himself had become quite ill and he left his sick children in London in order, once again to get cures from Beddoes in Bristol. At this time, Dundonald had also persuaded his son William to give up thoughts of going into the army and instead, the steady and reliable William would join him to assist the fortunes of The British Tar Company. In March 1800, William Reynolds fell quite ill and was becoming progressively weaker. Dundonald urged him to take great care, but by November, Reynolds was so ill that all plans regarding the chemical works at Coalport were shelved.

Trials in Birmingham

By autumn 1800, Dundonald himself had become almost paranoid about misrepresentations as to his conduct and character. His attitude to business in Shropshire changed dramatically, so much so, that he directed any trials on Shropshire tar to be conducted in Birmingham by John Biddle. Dundonald received a favourable report from Biddle about his glauber salts process and consequently asked Reynolds if he could make alkali under his own patents alongside Reynolds present soap works at Wombridge. Dundonald was again forced to move home in an attempt to shake off creditors and moved from lodging at the mail stage at the The Dog Inn, Birmingham and his old quarters at the nearby Castle Inn, where letters were directed to him, undercover, through the landlord.

On July 21st 1801, Dundonald took out another patent No. 2529 for "Preparing a Substitute for Gum, Senegal and other Gums." A month later, Dundonald produced a paper entitled, " Directions by Lord Dundonald for Extracting Gum from Lichen or Tree Moss". The booklet printed shows he had made experiments in which gum fit for use in calico printing was produced. The process was one whereby the lichen, which was abundant in Sweden, Norway and Northern America, was initially uprooted in

winter, and kept in storehouses to dry. the lichen trees were then stripped of their outer skin by boiling and then the skins were cooled on a brick floor for twelve hours. The lichen was then put into a copper boiler with some wine, soda ashes and volatile alkali and boiled for up to five hours. The resulting gummy liquor was withdrawn and filtered. The residue was used for a tallow making process. The gum produced proved to be useful in making ink, stiffening silks and staining paper.

Dundonald was still actively involved with some works and in 1802 the British Tar Company were still producing coal oil at Ketley. On June 28th 1803, Dundonald took out a patent No. 2719 for "Treating Hemp or Flax to Aid the Heckles" (a heckle is a comb for flax or hemp – Ed.). On May 3rd 1804 the Royal Society of Arts and Manufacturers Committee of Colonies and Trade received a letter from Dundonald about the tests he had carried out on Canadian hemp.

In 1804, the Swedish researcher, Erik V. Svedenstierna, visited tar kilns at The Calcutts on the slope of the hill close to the River Severn. He observed that:

“Twenty ovens have been built in order to collect Dundonald 's invention. The ovens were arch shaped and built with bricks and have inside and outside, the appearance of a hayrick or beehive seven to eight feet in height and diameter. On the side of the oven is an opening, through which the pit coal is introduced, and on the floor is a square hole with strong and closely-spaced grate bars, under which there is a space for ashes and which is connected with an opening in an outer wall. In the oven dome itself there is another opening into which is fitted a cast iron pipe several inches in diameter, which then enters a brick built water reservoir. When the oven has been filled, it is heated at the ash-hole, and as soon as the coal is burning sufficiently the large opening is walled up. The smoke then passes through the pipe in the roof and is condensed in the water reservoir. A quantity of hydrogen gas or combustible air (coal gas) develops during condensation and is led away from the reservoir through another pipe. The tar is drawn off from the reservoir into a large tank where it is left so that impurities are deposited and most of the water separated. The tar is at this stage is still unsuitable for most uses and must therefore undergo a kind of distillation and as a result of this distillation and being mixed with a little water changes into strong viscous oil, which is similar to our pitch oil. This oil is used to paint certain parts of buildings, and, mixed with lamp-black, to touch up fences and suchlike.”

During April 1805, William Murdoch was conducting experiments on burning the gas from coal. It was during one of these experiments that Murdoch was reminded that, "currents of gas" escaping from many of Dundonald's tar ovens, had been quite frequently fired creating vast amounts of heat and light.

Finale

On March 14th 1812, Dundonald took out his final patent No. 3547 for "Preparing and Manufacturing Alkaline Salts from Vegetables." Five years later on September 18th 1817, Isabel Dundonald, Archibald's second wife died and just over a year later in April 1819, Dundonald married for the third time at Fulham, Middlesex to Anne Maria Plowden the daughter of Francis Plowden. Anne Maria was, as one researcher described her, 'an estimable woman, unspotted in character of a high, untitled family'. With her small pension, which she obtained through the benevolence of the crown, she brought a gleam of light to the dark decline of Dundonald's life. However, in September 1822, she died in childbirth, leaving the child in his care and from that time, onward Dundonald was abandoned into poverty, after just three years of marriage.

After Anne Maria's death, Dundonald seems to have been resident at Eppleton, Houghton le Spring in Northumberland but in 1824 he left England for France, where little is known of his life course. He died in poverty, seven years later, on July 1st 1831 at the age of eighty-three, in a house in the Rue Vaugirand, Paris. John Randall in describing the work of Dundonald in the Broseley area of

Shropshire tells us that on his death Dundonald left legacies to a total of £15,000 to his thirteen surviving nieces and nephews.

Appendices

Notes on Coal Tar

In 1780, Dundonald discovered a new and easy method of extracting tar from coal. Dundonald describes how many previous trials were made by the Marquis of Rockingham near Sheffield and by various persons at Coalbrookdale and at Newcastle, under a German aristocrat, Baron van Haak. However, the trifling quantities made meant coal tar was not commercially sold for profit for fewer than twenty-eight shillings per barrel. Dundonald recommended coal tar for the preservations of nuts, bolts and as a effective preservation of cast and hammered iron from rust including coating the inside of guns in naval yards to stop them from scaling.

The pamphlet includes copy of a letter addressed to Mr Edward Park, Agent to the British Tar Company at Culross from captain John Hall of the ship "The Swan" a tender in Government service. Captain Hall bought coal tar from Culross in January 1783, and then boiled it for one hour and then coated the "The Swan's" bottom. Other letters included in the pamphlet include those from Thomas Know, a Merchant from a sloop named "Margaret", the shipbuilders Messrs Marshall and Gray from Kincardine and their brig "Elizabeth and from John Grieve of Grange coal works, and Alexander Morrison, shipmaster of Aberdare. The booklet tells us other tar products were being sent to Norway and St Petersburg, Russia and used by Coppersmith for the preservation of their iron buckets.

* Coal Tar was blacker than common tar and dipping a stone in tested its consistency. Coal varnish was made of resin dissolved in essential oil of coal and could be mixed with colours to make varnish products. Others products made from the process are Cinders, Lamp Black, concrete volatile alkali called "Spirit of Hartshorn"(Ammonium carbonate, formerly made from the antlers of the Hart deer.), Sal Ammoniac (Aluminium sulphate) , Glauber Salts (Hydrated sodium potassium sulphate) and Barilla (impure sodium carbonate forerly extracted from soap wort) or Fossil alkali (sodium carbonate). The Coal Tar could be used on Ships Bottoms, Floodgates, Jetties, Palisades, Pail and Rails, Wagon Wheels, Shingle roofs in West Indies, Anchors, Guns, Shot, Shells, Fire engine cylinders, Buckets, Spades.

Account of the qualities and uses of coal tar and coal varnish with certificates from shipmasters and others. Printed by T & G.Wilkie in St Pauls Churchyard 1785. See Reference National Library of Scotland Shelfmark 5.911 (23) Dated 1785

In March 1795, Dundonald, with the use of coal tar completely out of favour, and with the help of Mr Vancouver, released a booklet entitled, "A treatise showing the intimate connection between Agriculture and Chemistry addressed to cultivators of soil and proprietors of Fens and Mosses in Great Britain and Ireland and proprietors of the West Indian estates. The book shows us Dundonald's intimate understanding of the chemistry of soil. He encourages farmers to deepen their understanding of chemistry particularly in the action of manures upon the land and the methods of preparing manures and thus getting more from the soil. Dundonald stated he had learned much from the discoveries of Priestley, Cavendish, Bergmann and Kirwan and had also understood much from the work in 1756 carried our Dr Francis Home on saline bodies and Sir John Pringles essay on antiseptics. He encouraged the analysis of cattle urine and dung heaps and the use of ashes, lime and chalk upon the ground.

The booklet discussed ways of improving hemp and stated that if hemp was cultivated on a more extensive scale in England, the oil from the seed could be applied to the manufacture of soap, which was then made of tallow. This would cut the huge amounts of hemp then imported from Russia.

See Reference National Library of Scotland Shelfmark Mc.3 (9,622-9,624)

Edinburgh University Library. Reference EUL, Gen 874/IV/ 58-67, 5 & 6

Notes on Lord Dundonald's Tar Manufactory

Notes made sometime between Joseph Black's visit to Culross in Summer 1782 and his letter to Andrew Stuart of 25th January 1783.

Collection of Facts [f 60,681]

The coal is 3s 6d per ton- the cinders of which do as much business in the salt pans as the coal. Four kilns 14.5 ton 2.5 times per week. 15 tons give 8 barrels unboiled / 6 barrels of boiled tar worth 26/- per barrel at Newcastle.

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In time of peace the barrel was worth 14s. One ton of coal yielded 4 cwt of water, which being distilled with lime gave 40lb weight of [Sp] ini spirit, which is very pungent to smell. It is also very pure and free from oil, but a great deal of lime was used, which made a paste or plaster when with water. About 1/20th of the unboiled tar can be made into volatile oils and varnishes. Oil of turpentine in peace time is between £3 and £4 sterling the Ct

In closed vessels Lord Dundonald's coal gave 1/10th of tar. At Newcastle they work with sixteen cylinders about 25" in diameter and distil a chaldron per week. They made good cinders and get five barrels of tar per week. Their fuel for heating the cylinders is refuse matter.

The expense of the furnaces was £50 each. Four Kilns cost £200 per annum. Two men cost £36 per annum. Two charges per week of coal being 1,508 tons at 3/6d equalled a cost of £263 18s. Repairs to the kilns cost £10 per annum and 603 barrels at 4s each cost £120. Totalling outgoings of £439/18s. Their income from sales from the kilns was from 603 barrels of tar at 25s each which totalled £753 15s and £226 4s from the sale of cinders which brought a total income of £979 19s. Other estimates showing tar and cinders at other prices estimated income at either £859 7s or £648 7s depending on prices of tar and cinders.

Calculated from the income of £979/15/-, the following calculations appeared. Four kilns worked off per week 28 tons of coal in two charges of 14 tons each. 20 kilns therefore would give 5times as much or 140 tons. Two tons of coal would give 1 barrel of tar and 140 tons of coal would give 70 barrels at tar. One hundred and one barrels of tar give eighty-one of boiled tar, therefore seventy barrels would give fifty-six barrels of boiled tar. These are calculations for 20 kilns.

A calculation for thirty kilns shows that 30 kilns worked off 210 tons of coal per week. (each kiln seven tons a week). Therefore 210 tons of coal would produce 105 barrels of tar. Therefore 105 barrels of tar would produce 84 barrels of boiled tar.

Estimates per week

Profit per week estimates in time of war equal £45/13/6d, which when multiplied by the 48 weeks the supposed number of workable weeks in a year equals a profit per annum of £2,192 8s. In peace time a profit per week was £26/5/6d which when multiplied by 48 working weeks gives a yearly profit of £1,261/4/-. Black comments that Dundonald's figures are different than his own due to fact that Dundonald estimates one barrel of tar from 1.75 tons of coal and not Blacks 1 barrel for 2 tons of

coal. Black estimated 81 barrels of boiled tar from 101 of tar. One hundred and forty tons of coal will give 70 barrels of raw tar or 56 of boiled tar.

Debt and Credit Calculations

Outlay per Week

Twenty kilns cost £1,200, the weekly interest on these is £1/3/1d. Repairs of Dundonald cost £3/15/- weekly. One hundred and forty tons of Chow Coals at 3/6d per ton cost £24/10/- weekly. Cost of workmen for charging and drawing the ovens at 8d per ton of coal weekly equals £4/13/4d. Sixty-four barrels at 3/- each cost £9/12/-. Seven cwt and 16lb of resin to make varnish at 24/- per cwt cost £52/5/5d.

Weekly Income

Sixty-four barrels of boiled tar at 21/- per barrel equals £67/4/-. One hundred and forty measures of cinders at 1/6d each equals £10/10/-. One hundred and fifty-five gallons of varnish made of volatile oil and resin at 3/- per gallon equals £23/5/-. This totals income per week at £100/19/- in time of war. However in time of peace the incoming changed to sixty-four barrels of tar at only 14/- equalling £44/16/-. Cinder sold at 14/- for a total of £10/10/- and varnish brought in £23/5/-. Totalling £78/11/- income.

Profits per Annum Calculations [5,6]

Four kilns cost £200 per annum and the interest on them equalled £10. Repairs equalled £10. Two men equalled £36. Coal at two charges per week 1,508 tons at 3/6d equalled £263/18/-. Six hundred and three barrels at 2/6d each equalled £75/7/6d totalling £395/5/6d.

Credit equals 603 barrels of tar at 25/- each = £753/15/- and Cinders at 3/- from each ton of coal = £226/4/-; totalling £979/19/-. Therefore Profit would = £585/14/6d. Or 603 barrels of tar at 21/- = £633/3/- and Cinders at 3/- from each ton of coal = £226/4/- = Total of £859/7/-. Profit would equal £464/2/6d, another alternative calculation involving peace time of 603 barrels at 14/- and cinders = £648/7/- and a profit of £253/1/6d.

Dr Roebuck stated that from exact experiments that his coals distil in close vessels give one with another only about 1/60th of unboiled tar and Lord Dundonald allows that the produce of Tar with open furnaces is little more than half of the produce in closed vessels as 12 to 22.5.

The unboiled tar of 1,508 tons of coal is 800 barrels, 40 barrels of which are volatile oils. Suppose each barrel contained 2cwt at 40s per cwt, the barrel was worth £4 each sterling and the forty barrels £160/-/. Also 1,508 tons of coal will yield 60,320 lb: of rectified spirit in which if its weight be a quarter of above. It will produce 15,080 lb reckoned at £754. The volatile alkali be 1/6th the quantity = £502/10/-;

Or 1/7th the quantity £430/10/-, or 1/8th = £377/-/.

Lord Dundonald's Tar Profits of thirty kilns

Weekly Expenses

Thirty kilns cost £1,800 the weekly interest of which is £1/14/7½; Repairs per week = £5/12/6; 210 tons of Chow Coals at 3/6d per ton = £36/15/-; To Workmen at 8d per ton of coal = £7; Purchase of 84 barrels for tar at 3s per barrel = £12/12/- and 9 and 3/8ths cwt of Resin at 24/- for Varnish = £11/5/-. Totalling £74/19/1½.

Produced Weekly

84 barrel boiled tar at 16/- per barrel = £67/4/-; 210 measures of Cinders at 1/6d per measure = £15/15/-; 201 gallons of varnish at 3/- per gallon = £30/3/-; Weekly Profit £113/2/- x 48 weeks = £1,831/4/-. If the tar sells at 14/- the weekly profit will be annually (x 48 weeks) = £1,428; if at 12/- profit will equal £1,028/16/-, and at 10/-, £621/12/-.

Second Collection of Facts

Building a kiln costs £50 each. The Quantity of cinders obtained is about 11% per ton of coal. These cinders do much work in the boiling of salt as the ton of coals would do. Four kilns will hold 14 tons of coal at one charge and they can easily be charged and discharged two or 2.5 times per week. Dundonald says twice.

Fifteen tons of coal yields 8 barrels of boiled tar. These barrels sell at 21s per barrel at Culross and 26/- per barrel at Newcastle. The present price of common tar is 27/- per barrel and in time of peace 14/-. The barrels are made of wood from Lord Dundonald's own plantation. About 1/20th of the unboiled tar can be made into volatile oils and then into varnishes by addition of Resin. Oil of turpentine in time of peace makes £3 to £4 sterling. The expense of building one kiln of furnace with the whole apparatus belonging to it including its proportion of the still in which the tar is boiled amounts to £50 sterling. At Newcastle they have one work going with 16 cylinders about 2 feet in diameter. They made good cinders and get 5 barrels of tar per week. The fuel for heating the cylinders is a bad coal or coal of little value. Mr John Clerk says his coal gives 1/20th that of the Candle Coal yet gave a quantity of oils far exceeding other coals.

Sir John Dalrymple extracted the following information from the Newcastle partners:- 2½ tons of coal costs there 10/- and made one barrel of tar which sells for 21/-. Four kilns require 4 men. Two and half pints of good volatile oil can be got from each barrel of unboiled tar. Resin makes an excellent varnish for the upperworks of ships. Varnish is 1 pint of unrectified oil mixed with 4 pints of resin and is bought for ships at 3/- per gallon. (4 English gallons ≡ 9 Scots pints).