EARLY ELECTRICAL SYSTEMS IN COLLIERIES:

THE TRAFALGAR COLLIERY IN THE FOREST OF DEAN AND THE BRAIN FAMILY.

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1. The use of electricity for industrial purposes began very slowly during the middle decades of the 19th century. Electric telegraphs, electric bells, electro-plating, electric lighting by means of arc lamps, all began to play their part during the years 1840 - 1885. There was, however, little application of electricity in mining operations during this period. A pioneer in this respect was the Trafalgar Colliery in the Forest of Dean in West Gloucestershire, where electric signalling was introduced in the 1860's, electric blasting and electric lighting in the 1870's, to be followed by the very first application of electric power in underground pumping and ventilation in 1882. This early electrical enterprise was due to three members of the Brain family - a very prominent family in the Forest of Dean, which was itself the scene of so much important industry over many centuries.(1,2)

An important contribution to the historical record of this enterprise has been given by Hart,(2) whose brief account and useful references make a starting-point for any further investigation. The present contribution is intended to fill out and extend the story, to indicate the extent to which the fame of the electrical work at Trafalgar Colliery spread in those early years of electrical engineering, and to describe briefly some associated electrical enterprises outside the colliery.

2. The Brains of the Forest of Dean

Brain is a common name in both the Forest of Dean and the Bristol area. Little is known of two of the three men of that name with whom we are concerned here, in spite of quite extensive searches, but the third of them was knighted, with the consequence that obituaries of him are found in several papers including The Times,(6) and he appears in Who Was Who.(5) We shall therefore first discuss Sir Francis William Thomas Brain. He was born at Hope Mansell, Herefordshire, on 28 October 1855, the son of Cornelius Brain of Ruardean and his wife Anne, who was also a Brain and a relative of her husband. In 1872 he became a pupil of W.Blanch Brain at Trafalgar Colliery, in 1881 he became manager of the colliery and in 1883 was additionally secretary of the Trafalgar Colliery Co.Ltd. In 1889 he became the managing partner of the Electric Blasting Apparatus Co., of Cinderford, to which he had been consulting engineer for many years. In 1891 he was vice-president of the National Association of Colliery Managers. He was later President of the Colliery Owners Association, and was knighted in 1913. He died on 31 October 1921, and for some time before this had been residing at Stoke Bishop, near Bristol. He had married in 1884 and had two daughters. He was apparently a free churchman, for he made some provision in his will for the Congregational Union of Gloucestershire and Herefordshire.(7,8)

The other two Brains associated with the electrical work at Trafalgar Colliery were William Blanch Brain and Carl T.Blanch Brain. In spite of careful searches of the Somerset House indexes and of local newspapers over a very long period (1880 - 1930 in the case of Somerset House), no record of their deaths has been found. Nothing is known of their ages, parentage or lives except for the record of their work which is given in this paper, and the following few facts :-

W.B.Brain: In 1872 was managing owner of Trafalgar Colliery.(9)

C.T.B.Brain: Associated with Trafalgar Colliery and the underground power experiments made there in 1884, connected with Elwell-Parker Co. in 1886 and then living in Wolverhampton.(32)

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3. Electrical Systems at the Trafalgar Colliery

3.1 Electric Signalling

Ravenshaw,[10] lecturing in 1905, stated that electric signalling had been adopted at the Trafalgar Colliery in 1866, "laying cables down the shaft", but as he attributed this innovation to Frank Brain, who was only 11 years old at the time, we cannot be very certain of the reliability of this date. A brief biography[3] of Frank Brain published in 1893 stated that "electric signals have been in use for more than 20 years" at the colliery, which dates the system back to perhaps 1870. No further reference has so far been traced. It is worth pointing out, however, that in 1874 electrical signalling in mines was described as the new system and better than the old mechanical system of bells,[11] thus confirming at least that the Trafalgar system was a pioneer one. A detailed description of another early colliery electrical-signalling system, used at Risca in Monmouthshire in 1874, is given by Bagot.[12]

3.2 Electric blasting and fuse manufacture

To what extent electric blasting was used in its early days at Trafalgar Colliery is not quite clear, but the Electric Blasting Apparatus Company, of Cinderford nearby, was making electric fuses in 1875 for exploding dynamite in shaft-sinking operations; and Frank Brain seems to have been associated with the company from the beginning.[3] There is thus a strong presumption that the new method was used at Trafalgar. It would seem that W.Blanch Brain also had something to do with this development, for he was credited with it in an article published in 1884;[14] indeed he was quite probably the original inventor, for he applied for a patent on electric fuses in 1873.[13] The company's factory was next to Trafalgar Colliery.[2] The main application became blasting at the coal face.

By 1886 the company's electric fuse had been improved and was reported on as "the handiest form we have seen". "It can be supplied at very little greater cost than ordinary firing fuze". [15] It comprised a wooden stick of any desired length carrying two conductors to the detonating cap at one end. The old method of firing them was to connect each fuse in turn to a battery or to an electro-magnetic generator carried by the miner. Frank Brain's patent of 1886[16] provided for a much safer and more convenient system using electric "mains" laid in the shaft and with branches to the coal face. A dynamo machine at the surface provided the necessary firing source, and incandescent heads buried in the explosive charges could be connected in series or in parallel according to the mains system adopted. Thus all charges could be fired simultaneously, and if desired in the interests of safety the firing could be done after all miners had left the mine. The firing switch was a sparkless one, where the contact was made and broken in an insulating liquid.

Frank Brain continued to improve the system. The normal detonating charge was apparently a mixture of "chlorate of potash, sulphide of antimony and phosphide of copper", and in 1893 he patented an improved mixture in which silver and platinum were substituted for the phosphide of copper.[17] The following year he patented an improved mechanical design of the fuse head.[18]

The use of electric fuses was recommended by the Royal Commission on Accidents in Mines (19) in 1886 as a means of improving safety in mines.[20]

In passing, it is perhaps worth mentioning that the possibility of applying electrical blasting to mining had been pointed out as early as 1866,[21] following the successful development of electric torpedoes with remotely-controlled explosions.

3.3 Electric lighting

Arc lighting was a well-established practice for the illumination of large areas such as railway yards, large workshops, public squares, etc. when it was introduced by the Brains in 1878 for the illumination of the Trafalgar Colliery surface works.(22) What made their installation interesting and important was the novel equipment used. W.B.Brain patented in 1878, in the same patent specification,(23) both an improved design of arc lamp and an improved design of dynamo. A report published in 1881 (24) makes it clear that both these improved designs were employed at Trafalgar, although perhaps not from the very beginning.

Difficulties associated with the use of electric arcs for lighting were usually of two kinds :- one due to the burning away of the carbon rods between which the arc was struck, and the other due to the shadows produced by various parts of the carbon-rod holders. Various ingenious mechanisms and arrangements were designed to overcome these, and two comparatively successful lamps were the Brush arc lamp of 1875 (26) and the Jablochkoff electric "candle" of 1877.(27) Both these overcame the first difficulty but not the second. Brain's lamp overcame both. In his patent he describes two basic forms of the lamp, and it is not known for certain which he used at Trafalgar. The one which seems most likely had two horizonal negative carbons, in line, end-on, and with point against point, held together by a cord and pulley device; and one vertical positive carbon striking the arc between its lower point and the junction of the two negative carbons. In its initial position the vertical carbon is in contact with the junction of the two negative carbons, but a special electromagnet and clutch operates as soon as current passes and pulls the positive carbon upwards by a small distance so that a suitable arc is struck. As the carbons burn away, the ends of the rods are maintained in the same position by the cord and pulley device already mentioned, since the holder of the positive carbon is at the other end of the cord. For a simplified schematic diagram of the arrangement see Fig.1. The main component of the light emitted was stated to be that due to the incandescence of the ends of the negative carbons, and this was reflected over the colliery yard or other working area by an adjustable parabolic or other reflector.

As regards Brain's improved dynamo, this increased the efficiency as compared with the general run of designs by ensuring that the conductors were used effectively. It was really an improved Gramme machine, although Brain did not say so. By making the armature coil a flat toroid, as shown in Fig.2, and by a suitable design of the field magnets, he managed to reduce the proportion of the conductor which did not cut the magnetic field. It is possible, however, that this arrangement increased the reluctance of the magnetic circuit, and we have no proof that it was an improved design. It did however show that Brain understood as well as most people of that time the basic principles of electromagnetic machines.

Brain filed a provisional patent specification in 1882 (25) for a new type of dynamo to produce direct current without requiring a commutator. The description appears basically unsound, and this is no doubt why the patent was not completed.

There was, during the 1880's, considerable interest in the lighting of the underground workings of mines by electricity.(28) As far as is known, the Brains did not experiment with this.

3.4 Electric transmission of power; electric winding, pumping and ventilation

Power was required in mines for various purposes, the most important being the winding or haulage of the coal or ore from the working face to the top of the mine shaft, the pumping-out of water, and the provision of ventilation. Much of this power was required underground at a considerable distance from the main surface installations. Methods of providing it which had been developed before 1880 were the use of ropes and chains driven from engines at the surface, compressed air transmitted in pipes, hydraulic devices, and often underground steam engines, especially in metal mines as opposed to collieries. All of these had problems and were expensive to operate.

Other industries too had problems relating to providing power at points remote from the main works. It is therefore perhaps surprising that so little attention was paid in the 1870's and early 1880's to the possibilities of electric transmission of power.

Following some limited development of electric motors of a very crude kind in the 1830's and 1840's (43,44) very little was done about electric motors for several decades. Effort on electrical machines was concentrated on generators, and it was apparently not until 3 June 1873 (45) that it was discovered that a dynamo could also work as a motor if connected to an electrical supply. It was not until the end of 1885 that Marcel Deprez's experiments in transmitting electric power over a distance of 56km in France drew attention generally to the possibilities of electric transmission.(46)

In these circumstances the pioneering work of the Brains at Trafalgar Colliery was remarkable. In his patent of 1878 already referred to,(23) W.B.Brain states that his improved dynamo "may be connected to a battery or other electric source, so as to be applicable as a motor for drilling, rock boring, and other reciprocating or revolving appliances". Following experiments made early in 1881,(29) the Brains had, by December 1882, a working electric power system underground at Trafalgar Colliery with the electricity generated at the surface and transmitted over half-a-mile of cable underground to electrically driven pumping machinery. Some publicity was given to it at the time, (30,31) but it and its later extensions received much notice and commendation from 1886 onwards.(32-42) It was, with little doubt, the first such installation in a mine. But even before this the Brains had made extensive experiments with electric power for winding.(31,35)

The 1882 pumping installation comprised a small electric motor "similar to a Gramme machine" and therefore probably of W.B.Brain's patented design, weighing 264lb and able to give "nearly four horse-power with a suitable current". It drove a double-acting pump with 5 in.x 8 in. cylinder via gearing and belt. The underground machinery was enclosed and kept locked-up, unattended, and controlled entirely from the surface. An electrical monitoring system was provided. The power was transmitted via 1000 yards of stranded cable, 19 strands of wire each 0.072 in. diameter, lead sheathed, mounted on insulators in the underground galleries. The return conductor is believed to have been an ordinary iron rope in the ground; it certainly was so in the extended system of 1887.

This installation gave great satisfaction, and another similar to it was provided in early 1886, also with about half-a-mile of cabling. Continued successful operation led the Brains to decide to replace a larger pumping system using both hydraulic and steam power by an electric plant. This had to deal with the main flow of water into the deep workings of the mine, and had to operate about a mile from the generating plant. It was put into service in May 1887. The motor was supplied by Elwell-Parker of Wolverhampton, with whom C.T.B.Brain had recently become associated. It was about 17 h.p., 650 rev/min, driving a double 9 in.x 10 in.pump

at 25 rev/min. There were 2000 yards of 19/16 copper cable (i.e. 19 strands of 16 gauge wire), with a 4 in. iron rope as return conductor. The cable was not highly insulated itself, and although proving satisfactory in the underground passages where it was hung on insulators, it gave trouble in the wooden pipes in the vertical shaft. Replacing the vertical part by lead-covered cable cured the difficulty.

Careful observations were made of losses in different parts of the system. The steam engine was a secondhand marine engine in poor condition and was reckoned to lose 22% of the steam power. The generator, another Elwell-Parker machine, was reckoned to lose 16%, the cables 11%, the motor 10%, and the pump 6%, leaving the useful work done on the water as 35% of the initial steam power. It was reckoned that in terms of running costs, including labour (which in this case included a man full-time at the underground pumping station), the electric working compared well with other methods, as well as being cheaper and quicker to install.

In addition to the pumping load, both the early installation and the later system had electrically-driven ventilating fans in remote parts of the mine.

It was not until 1891 (47) that an electric haulage system was introduced on a permanent basis at Trafalgar.

3.5 Electric locomotive traction

It was stated in 1889(48) that a locomotive using electric drive powered by storage batteries was designed and made for the Trafalgar Colliery by Mr.A.Reckenzaun in 1886; and that a description and illustration had been published. Unfortunately these cannot be located, and nothing further can at present be said about the locomotive, nor whether it was used at Trafalgar, and if so, whether it was successful.

4. Associated electrical activities

The Brain family were responsible for other electrical work in the neighbourhood, and these activities are briefly described here.

4.1 Lighting of the Severn Bridge, 1879

The magnificent bridge across the Severn estuary built for the Severn and Wye Railway Co. in 1879(1) (and unfortunately so seriously damaged when a ship collided with it in fog in 1959 that it has now been dismantled) was a major engineering project which was helped along by electric light provided by the Brains.

> "Owing to the increased strength of the river with an increase in the height of the tide, the erection of the staging could only be carried on during the neap tides, so that the work was confined to seven or eight days in a month. Mr.W.B.Brain one of the proprietors of the Trafalgar coal mine undertook the provision of the electric light, and by means of a couple of powerful lamps supplied by a gramme machine, the work was continued night and day ....." (49)

The electric light was first used on the bridge on 5 March 1879.(50) The erection of a span of 312 ft weighing over 500 tons in such a difficult estuary in less than 4 months was thought to be a remarkable feat.

It is interesting that a long article in October 1879 describing the bridge and its erection,(51) makes no mention of the Brain contribution, but states that the electric light was provided by the Pyramid Electric Light Company. We proceed to discuss this company.

4.2 The Pyramid Electric Light Company

This company was, as we have just seen, in business by October 1879 since it is mentioned in an article dated the 31st of that month. It was presumably in business before March that year, if it provided the electric light on the Severn Bridge. The fact that the local newspaper said that the light was provided by W.B.Brain suggests very strongly that Brain was the proprietor, or one of the proprietors or directors, of the company. The Forest of Dean thus had one of the earliest electric light companies.

The company opened some new works in Whitecroft, at the southern edge of the Forest, at the beginning of July 1882, and it was stated that it was "the intention of the Company to provide for public and private lighting by electricity". (52) It was not successful, unfortunately, for it was wound up in 1884. (53,54) The liquidators were Messrs.Foster and Brain of Whitecroft. Here we have a Brain in a new capacity !

4.3 Underwater blasting for harbour works

Lydney Harbour was the main port for the export of Forest of Dean coal, and the expansion of the industry necessitated an expansion of the docks in the late 1870's. It was necessary to enlarge and deepen the lower floating basin, and when other methods of blasting the rock under water had failed, the Engineer (Mr.G.B.Keeling) resorted to dynamite, and with advice from W.B.Brain exploded the charges electrically. This was so successful that when in 1884 it became necessary to enlarge the river basin, the same method was used, employing Brain's equipment and fuses.(55)

4.4 Electrical batteries

W.B.Brain held several patents for new kinds of electrical batteries.(56-58) No evidence that these batteries were ever manufactured, or even used locally, has been found.

5. Conclusions

It can be seen that the Forest of Dean was the scene of some important pioneering electrical enterprise, mainly in the 1870's and 1880's, and the Brain family provided the initiative and expertise. The three members of the family directly concerned were, among other things, very able electrical engineers, and showed not only a willingness to enter new fields, but also a sound understanding of electrical principles and of the economic and practical considerations. It should be emphasised that W.B. and F.W.T.Brain, at any rate, were primarily colliery owners or managers, and their interest in electrical engineering was largely directed to the improvement of colliery operation and efficiency.

The references given, including so many important national journals and books and the lectures given to important national and regional societies, indicate the way in which the fame of the Trafalgar electrical enterprise had spread.

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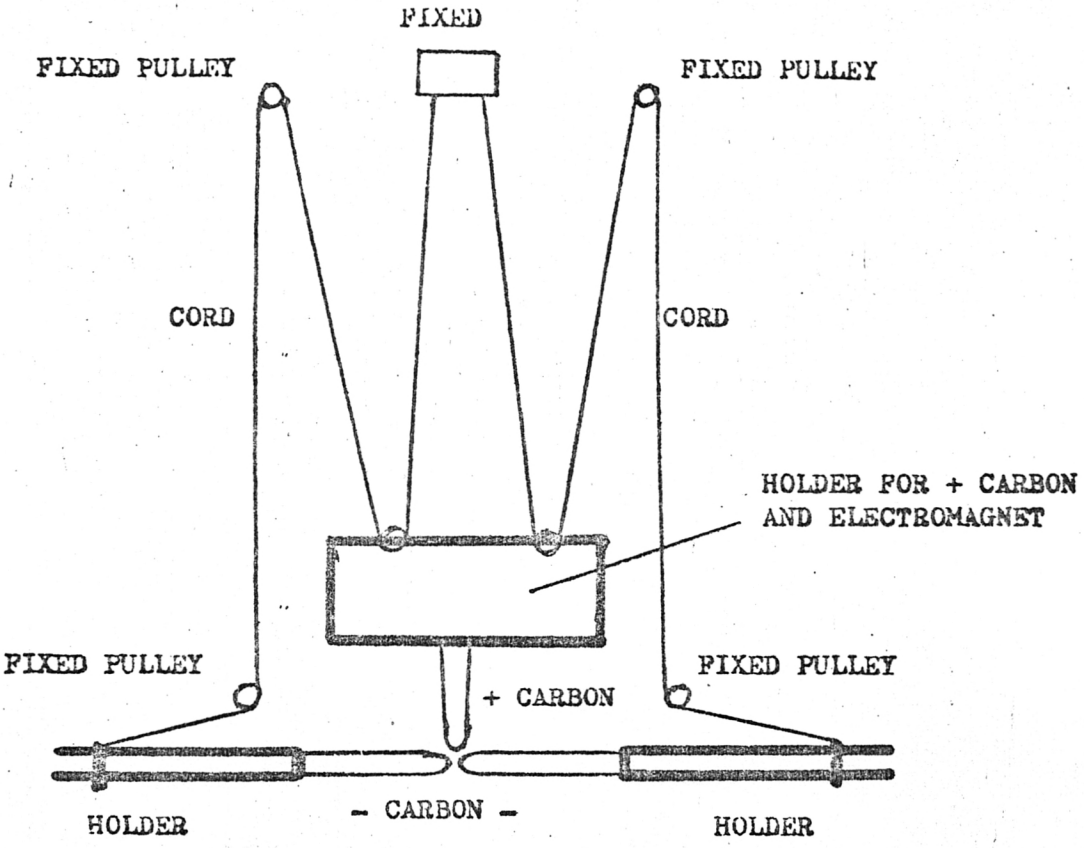

FIG.1 SCHEMATIC DIAGRAM OF BRAIN'S ARC-LIGHT MECHANISM

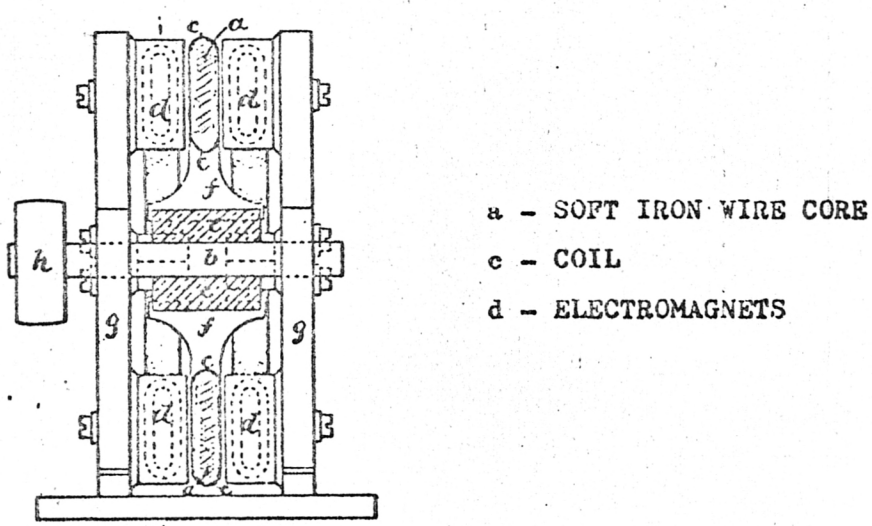

FIG.2 CROSS-SECTION OF BRAIN'S IMPROVED DYNAMO