From Plants and Miners Hats to Magnetic Exploders: Gutta percha in the service of miners

By ANNE BOTH

What has a plant to do with mining? How could lives be saved and costs reduced using a plant product? I first became aware of this material many years ago when using a splint made of the widely known gutta percha. The plant is a tropical tree which has been exploited for commercial purposes for more than a century. The sap of this tropical tree was ripe for exploitation after its introduction to the West and the investigation of its properties found them to be such that the plant would lend itself to a great variety of products both useful and decorative. This paper examines that product of this plant which not only helped drive the industrial revolution and innovative manufacturing but also contributed to safety and cost saving in mines world wide.

The plant and its introduction to the United Kingdom

Although the tropical *Palaquium oblongifolia* or *Isonandra gutta*, one of about 120 species of the genus *Sapotacaea,* was first introduced to England in the seventeenth century by John Tradescant the Elder, it was seen only as a curiosity. William Curteen, an English merchant and shipowner trading in both the East Indies and West Indies had collected the plant for Tradescant from Amboyna (present day Ambon). In 1656 the sample was put into The Ark or Musaeum Tradescantianum at South Lambeth, where, named as 'mazer' wood, it was one of the many curiosities on exhibition to the public.[1]

It was not until the mid nineteenth century that a second example was brought to England and this time it was presented to the Royal Society of Arts. Its donor was Dr José D'Almeida, a Portuguese working in the Far East. D'Almeida was thanked for his gift but no action was taken to investigate the plant and it was put aside. Later in the same year (1843), another example was submitted to the Royal Society, the donor being Dr William Montgomerie, Senior Surgeon of the Straits Settlements (present day Malaysia).[2] Dr Montgomerie had observed the Malay use of a variety of articles made from the sap of the Tuban Guttah tree (*palaquium*) and reasoned that as rubber articles (such as were used in the practice of his profession) were apt to perish in the tropics, they would prove more durable if made of gutta percha (Tuban Guttah sap). He submitted to the Bengal Medical Board examples of some bougies [thin, flexible probes][3] made of gutta percha and suggested that medical items such as bougies, catheters, splints and syringes if made of gutta percha would be superior to those made of rubber.

Mr Whishaw, a member of the Royal Society of Arts, experimented with the new plant material to test its properties, producing some lathe banding and piping, while Michael Faraday suggested that the insulating property could be utilised to cover electric cabling. In a letter to the *Philosophical Magazine* of March 1848 he commented

that being tough and flexible as well as soft when hot, it would be a better material than shellac if used for insulation.[4] Werner von Siemens constructed a machine that could insulate cable with gutta percha, preparing the way for long distance communication. Thus began the link with industry, and in turn, mining.

The plant

A description of the gutta percha plant appeared in the first number of a new journal, *Journal of the Indian Archipelago and Eastern Asia* which was published in Singapore in 1847. When he published information on the plant in the *Journal of Botany* in 1848, botanist William Hooker named it *Isonandra gutta.* He was at that time the director of the Botanical Gardens at Kew.[5] Also known as *palaquium gutta* the tree thrives in tropical climates and has many varieties, which provide the differing grades of gutta percha.

The plant from which gutta percha is obtained is a large tree from 20 to 30 metres in height with a diameter up to one metre. The leaves are dark green with a reddish-brown undersurface and the flowers are whitish in colour and somewhat insignificant in appearance. The sap it produces was at first obtained by cutting down and ring barking the tree to catch the sap as it oozed out[6] but when commercial exploitation began this method led to a decimation of the forests where the trees grew.[7] By the 1880s plantations were developed and the sap obtained in much the same way as adopted in the rubber tree plantations (Fig. l).

Figure: 1: *Palaquium Oblongifolia or Isonandra Gutta*

Source: William Rhind, *A History of The Vegetable Kingdom,* Blackie & Son, London, 1855.

The exploitation of this plant during the nineteenth century that has continued into the twenty-first century occurs not only in the Malay Peninsula but also throughout

Borneo, the Phillipines and in Suriname, French Guiana and Guyana (Fig. 2). However, the sap collected from Central and South America is of a somewhat inferior quality compared with that from the East. After collection, the raw gutta percha was almost all channelled through Singapore by Chinese traders who had the monopoly of its early trade.[8]

Figures: 2a & 2b: *Maps showing areas of distribution of commercial gutta*

Source: B.M. Willett, *Phillips New World Atlas,* 1999.

The properties of gutta percha

The various properties of gutta percha made it ideal for the manufacture of a wide range of products, as evidenced by the numerous catalogues quickly produced by the many newly formed companies in the United Kingdom (UK) and the United States (US). The composition and chemical structure is almost identical to that of india rubber but a different molecular shape gives gutta percha its unique properties. Chemically, gutta percha is a polyterpene natural polymer of isoprene (poly-trans-isoprene, whereas natural rubber is poly-cis-isoprene), which can be described as having a non planar zig

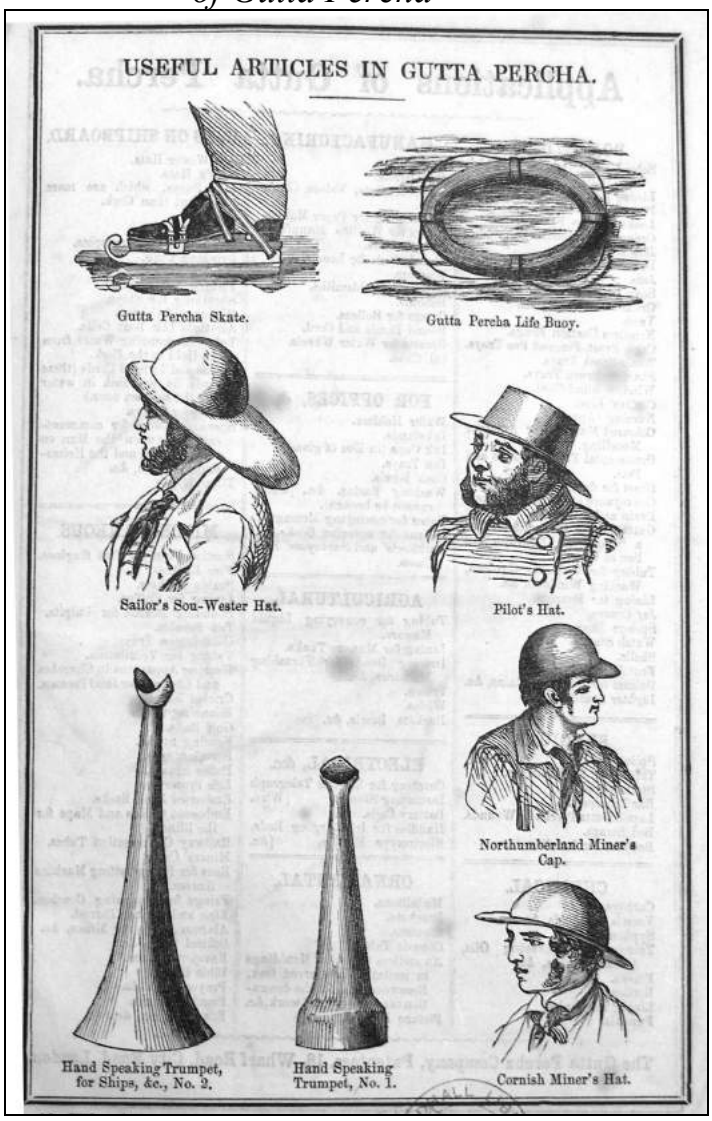
zag chain form. The percentage composition of the purest gutta percha is carbon 86.36 per cent, hydrogen 12.15 per cent, the remainder a small amount of oxygen.[9] Commercial gutta is generally described as of three grades, ranging in colour from a dirty white to reddish brown or blackish gray. It is non-porous, may be easily joined and is waterproof, salt and alkali resistant, but when exposed to some acids it becomes brittle. The odour is described as being neither strong nor unpleasant but at times is also described as smelling of tanbark or old cheese. If the smell is too strong the gutta can be treated with carbonate of soda or chloride of lime. Being light makes it easy to handle and as a poor conductor of electricity it is a good insulator and assists sound conduction. It can be moulded to any shape due to its flexibility when heated or immersed in boiling water and with a high tensile strength (up to 6,500 psi) its toughness and extensibility make it an ideal material for a wide variety of applications,[10] though it lacks the high elasticity of rubber. As far as mining was concerned, because of these properties, it became possible to use the product for accident prevention and cost saving.

How and where used

After Whishaw's experiment in which he produced a lathe band and piping using gutta percha, a patent for manufacturing was quickly secured by Charles Hancock and William Bewley.[11] In 1845 they set up the Gutta Percha Company Ltd at Wharf Road, City of London, and published a catalogue of applications.[12] One of many quickly established companies, it remained in business until 1945. Using this new material in industry required new machinery to be developed, resulting in Hancock and Bewley constructing a steam-operated slicing machine. This machine consisted of a circular iron plate to which knives were fixed to cut the gutta, the thickness being controlled by the projection of the knives. Mincing cylinders and rollers, and addition of various chemicals, for example, sulphur and zinc chloride, were also employed in the processing of the raw gutta percha.[13] When exhibited at the Great Exhibition of 1851 and at that of Paris in 1855 the many new products created a favourable impression, though even prior to this the Birmingham water-works had proved the material's utility. The company had made several experiments with gutta percha tubes of varying dimensions by subjecting them to a great pressure of water, without any sign of deterioration, thus allowing domestic water reticulation to become a possibility.

Mining, Engineering, Arts and Technology journals, Cyclopedias and catalogues of both general and mining articles began to publish descriptions of items and possible uses for gutta percha. Items ranged from domestic to decorative objects, including daguerreotype and photograph frames, curtain rings and poles, brooches, buckets, galoshes, pianoforte hammers, walking sticks and ear trumpets and even a varnish to replace shellac for waterproofing, to name but a few (Fig. 3). Items available for more industrial purposes included piping for water reticulation, cisterns, cotton spinning rollers, hogar pipes, cable insulation, siphons and miners protective headwear. This happened just in time for the product to be used in the American Civil and Crimean Wars and even World War l: items relevant to warfare such as communication cabling; blasting equipment; folding boats; and revolver cases were all offered for sale (Fig. 4).[14]

Figure: 3: *Illustrated list of ornamental and useful applications of Gutta Percha*



Source: G.W. Cant & Sons, High Holborn, London 1850**.**

As telegraph wires could now be insulated with a material that could withstand immersion in salt water, the laying of telegraph cables began, first across the English Channel and later across the Atlantic Ocean. The Gutta Percha Co. Ltd prepared cable for the India Office (UK), who laid it in the Persian Gulf,[15] and as the Atlantic cable began its trajectory from Porthcurno, Cornish miners were to be employed in its laying.

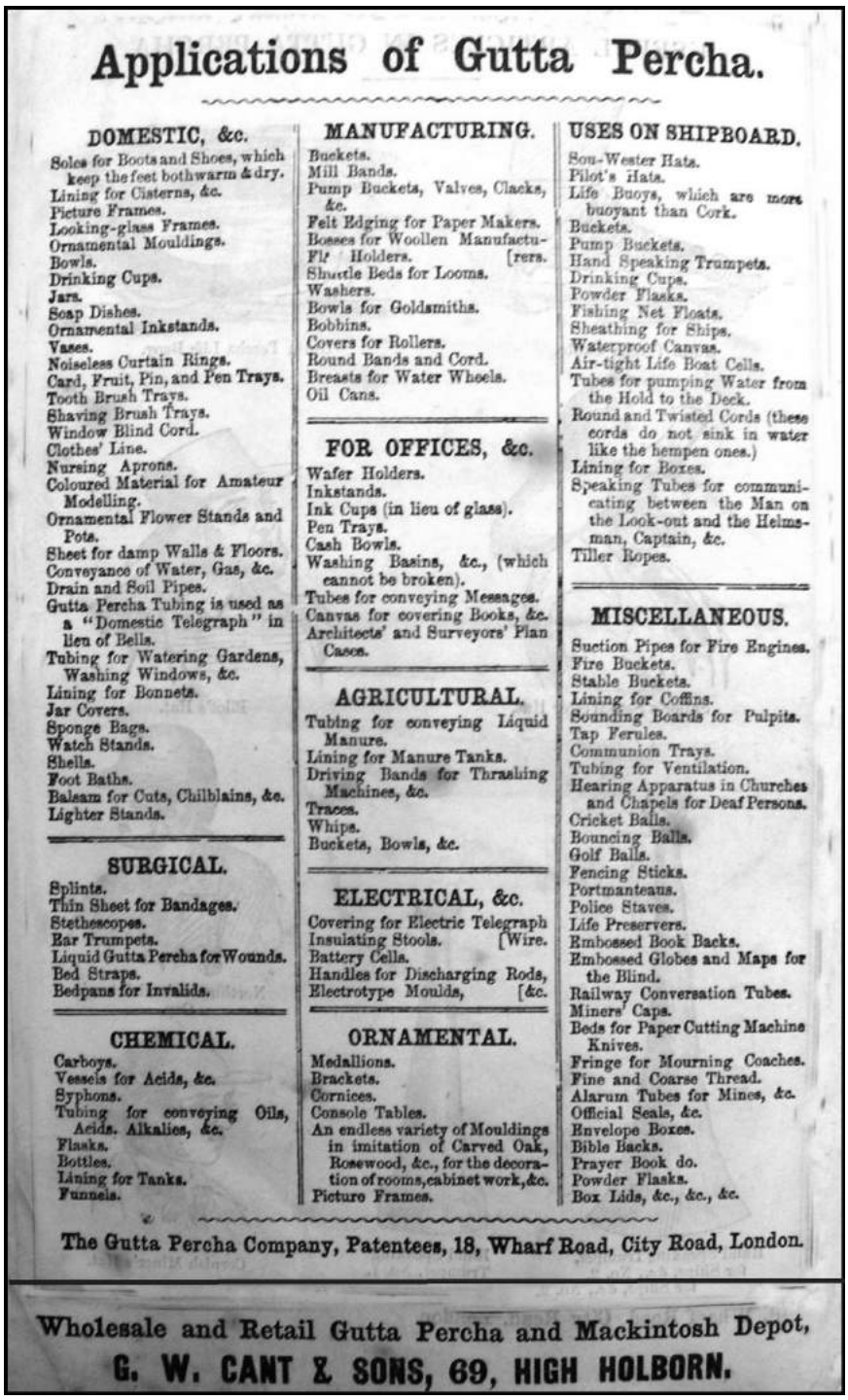
Mining applications

By the 1850s, reports and testimonials by mining companies of the various experiments made at the Gutta Percha Co. Ltd factory began to appear in the press. *The Perth Gazette* of January 1852 quoting from the *Woolwich Gazette* (UK), reported:

> … Experiments at the Gutta Percha Co. accidentally discovered that the electric spark preserving its powerful igniting properties could be conveyed underwater to a considerable distance when the wire was covered with a coating of gutta percha … a series of experiments were afterwards made with this new

application of gutta percha tubing … The simplicity with which this discovery can be applied, renders it invaluable and perfectly safe for mining purposes, or for blasting rocks above or under water at any depth ....[16]

Figure: 4: *A catalogue list of the various applications of gutta percha.*



Applications of Gutta Percha.

DOMESTIC, &c.

Soles for Boots and Shoes, which keep the feet both warm & dry.
Lining for Cisterns, &c.
Picture Frames.
Looking-glass Frames.
Ornamental Mouldings.
Bowls.
Drinking Cups.
Jars.
Soap Dishes.
Ornamental Inkstands.
Vases.
Noiseless Curtain Rings.
Card, Fruit, Pin, and Pen Trays.
Tooth Brush Trays.
Shaving Brush Trays.
Window Blind Cord.
Clothes' Line.
Nursing Aprons.
Coloured Material for Amateur Modelling.
Ornamental Flower Stands and Pots.
Sheet for damp Walls & Floors.
Conveyance of Water, Gas, &c.
Drain and Soil Pipes.
Gutta Percha Tubing is used as a "Domestic Telegraph" in lieu of Bells.
Tubing for Watering Gardens, Washing Windows, &c.
Lining for Bonnets.
Jar Covers.
Sponge Bags.
Watch Stands.
Shells.
Foot Baths.
Balsam for Cuts, Chilblains, &c.
Lighter Stands.

SURGICAL.

Splints.
Thin Sheet for Bandages.
Stethescopes.
Ear Trumpets.
Liquid Gutta Percha for Wounds.
Bed Straps.
Bedpans for Invalids.

CHEMICAL.

Carboys.
Vessels for Acids, &c.
Syphons.
Tubing for conveying Oils, Acids, Alkalies, &c.
Flasks.
Bottles.
Lining for Tanks.
Funnels.

MANUFACTURING.

Buckets.
Mill Bands.
Pump Buckets, Valves, Clacks, &c.
Felt Edging for Paper Makers.
Bosses for Woollen Manufacturers.
Fly Holders.
Shuttle Beds for Looms.
Washers.
Bowls for Goldsmiths.
Bobbins.
Covers for Rollers.
Round Bands and Cord.
Breasts for Water Wheels.
Oil Cans.

FOR OFFICES, &c.

Wafer Holders.
Inkstands.
Ink Cups (in lieu of glass).
Pen Trays.
Cash Bowls.
Washing Basins, &c., (which cannot be broken).
Tubes for conveying Messages.
Canvas for covering Books, &c.
Architects' and Surveyors' Plan Cases.

AGRICULTURAL.

Tubing for conveying Liquid Manure.
Lining for Manure Tanks.
Driving Bands for Thrashing Machines, &c.
Traces.
Whips.
Buckets, Bowls, &c.

ELECTRICAL, &c.

Covering for Electric Telegraph Wire.
Insulating Stools.
Battery Cells.
Handles for Discharging Rods,
Electrotype Moulds, &c.

ORNAMENTAL.

Medallions.
Brackets.
Cornices.
Console Tables.
An endless variety of Mouldings in imitation of Carved Oak, Rosewood, &c., for the decoration of rooms, cabinet work, &c.
Picture Frames.

USES ON SHIPBOARD.

Sou-Wester Hats.
Pilot's Hats.
Life Buoys, which are more buoyant than Cork.
Buckets.
Pump Buckets.
Hand Speaking Trumpets.
Drinking Cups.
Powder Flasks.
Fishing Net Floats.
Sheathing for Ships.
Waterproof Canvas.
Air-tight Life Boat Cells.
Tubes for pumping Water from the Hold to the Deck.
Round and Twisted Cords (these cords do not sink in water like the hempen ones.)
Lining for Boxes.
Speaking Tubes for communicating between the Man on the Look-out and the Helmsman, Captain, &c.
Tiller Ropes.

MISCELLANEOUS.

Suction Pipes for Fire Engines.
Fire Buckets.
Stable Buckets.
Lining for Coffins.
Sounding Boards for Pulpits.
Tap Ferules.
Communion Trays.
Tubing for Ventilation.
Hearing Apparatus in Churches and Chapels for Deaf Persons.
Cricket Balls.
Bouncing Balls.
Golf Balls.
Fencing Sticks.
Portmanteaus.
Police Staves.
Life Preservers.
Embossed Book Backs.
Embossed Globes and Maps for the Blind.
Railway Conversation Tubes.
Miners' Caps.
Beds for Paper Cutting Machine Knives.
Fringe for Mourning Coaches.
Fine and Coarse Thread.
Alarum Tubes for Mines, &c.
Official Seals, &c.
Envelope Boxes.
Bible Backs.
Prayer Book do.
Powder Flasks.
Box Lids, &c., &c., &c.

The Gutta Percha Company, Patentees, 18, Wharf Road, City Road, London.

Wholesale and Retail Gutta Percha and Mackintosh Depot,

G. W. CANT & SONS, 69, HIGH HOLBORN.

Source: Gutta Percha Works Circular, Gutta Percha Co. Ltd, London, 1851.

Soon the Australian press was publishing lists of imports to the country showing receipt of such articles as gutta percha belting and buckets, destined no doubt for developing mining fields, as were the many domestic items of gutta percha which were carried by

the miners and their families.[17] Miners and mining companies also began to utilise items which contributed to both safety and cost saving. These ranged from siphons, buckets, hogar pipes, clack seals, lathe belts, tubing for surface to underground communication, insulators for blasting equipment, diaphragms for air compressors and head protection and boots for miners which were waterproof, cheap and durable. Mining manuals could be waterproofed, as could miners' blankets, while mine models could be produced from the easily moulded material.[18]

These products of gutta percha, especially made for mining operations were disseminated world wide. An early mention occurs in reference to miners who carried among their supplies, blankets waterproofed with gutta percha when seeking gold in the California Goldrush. In New South Wales, James Dick of Glasgow (Scotland), supplied the gutta percha sheets used on the concentrating tables at the Mitchell's Creek Freehold Gold Estate, which he owned at this time. In 1885 Dick Brothers supplied cheap shoes and 3,000 feet of gutta percha belting (Dickbelt) to a Potash mine in Alsace[19] and by 1865 the gutta percha belts manufactured in Scotland by the Dick Brothers were being used in mines and pug mills in the Thames area, New Zealand.[20]

The Melbourne *Argus* published a report from the *Bendigo Advertiser* in October 1859 of a new gold washing cradle near Castlemaine under a heading 'The New Galvanic Cradle':

> … the cradle does not differ in outward appearance from the puddler's cradle in general use, on the ridge is rivetted a piece of gutta percha which slightly overlaps and fully prevents the escape of any quicksilver into the next dish.

It further noted that 'This piece of equipment patented by a Mr Meyerhoff, … [was demonstrated] at Mr Cohn's, Bridge St.'[21] This report also appeared in *The Sydney Morning Herald* and *The South Australian Advertiser*[22] and orders were soon made for the cradle by the Bendigo Steam Puddling Company. By August 1860 the machinery in operation at the Old Quartz Hill Company (Castlemaine) included a Meyerhoff''s patent galvanic cradle.[23] In Ballarat, (Victoria), sheets of gutta percha were sold for mine purposes as were pump clacks at three shillings and three pence per pound weight and tubing at four shillings and four pence per pound.[24]

Safer mine operations were promoted when mine horses could have their hooves covered by overshoes of gutta percha and miners could wear gutta soled boots, thus avoiding the dangers associated with sparks being struck by hooves or feet of the miner workers. This was especially relevant in the safe operation of coal and anthracite mines. By the 1850s in Pennsylvania (US) powder for blasting at anthracite mines was being produced at the Du Pont Powder Hole explosive facility. To avoid explosions, the workers here were using wooden tools and equipping the horses with horseshoe coverings of gutta percha.[25]

Miners could also protect their heads with the new gutta percha miners' hats, and should a prospector or miner require protection from the elements a whole suit of gutta percha could be obtained. As one visitor described in correspondence to the *Sydney Morning Herald*, 'I provided myself a complete suit of gutta percha from head to foot'.[26] The purchase of such a suit in 190l may well have been prohibitively

expensive as the Australian government introduced a Federal Tariff proposal on various imported materials including gutta percha.[27]

Mr C. Tripptree, however, was more concerned about the operation of his gold mine at Mangana Richmond Creek, on the Fingal goldfield (Tasmania) when he wrote a letter to the editor of *The Mercury* (Hobart)[28] in which he said

> I now respectfully solicit the public to assist me with 2 pumps of 2¼ inches to 2½ inches bore with a hose of 30 feet of Gutta Percha or vulcanized India Rubber ... hoses the same calibre with a spiral ring for each pump.

The pumps were needed to get rid of the water, as he had obtained some gold at about 27 feet down in the bed of the creek and a borrowed pump was too large to be operated by a man working on his own. Another letter in the same publication notes use of a gutta percha scraper instead of one of iron, in a patent application for an adaptation of a Munday Borlase Buddle by a Mr W.H. Kayser (later manager of Mount Bischoff Tin Mine)[29]

Archaeological investigations at nineteenth century mining sites in England have produced evidence of clack valve seals in various machinery pieces not only of leather (a commonly used material) but also of gutta percha.[30] In the UK, at least one mining journal records that electrical signalling was carried out by means of copper wires insulated with gutta-percha and that miners were required to wear boots soled with the same material.[31] However, not all mining sites show its use. Archaeological site investigation of the Burra mine in South Australia during the 1980s revealed that where there was a need for seals in machines, horse blanket was the material of choice.[32]. Perhaps this is an extreme example of cost saving through recycling?

Apart from its use on concentrating tables, especially noted in gold mines in Victoria and New South Wales, gutta percha could also be found on drilling pieces such as that displayed at the International Exhibition of Art, Manufactures and Products of the Soil and Mine held 1876 in Philadelphia, USA to commemorate the 100th anniversary of American Independence. The exhibit, from the Mining Equipment section is described as a Stow's flexible power transmitter pointed out that it:

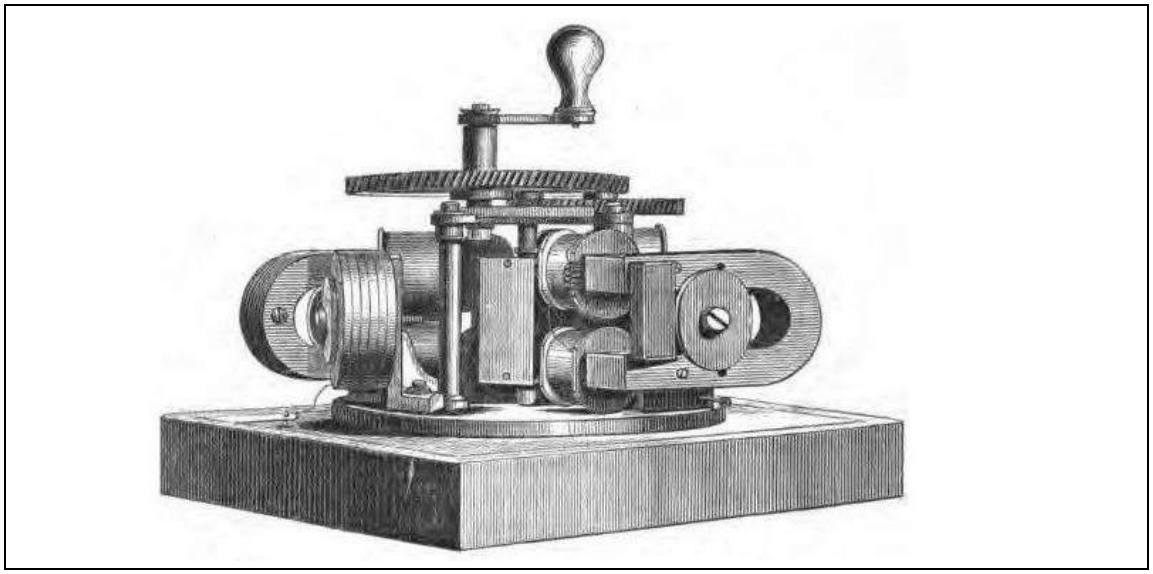
> may be used for almost any purpose, quarrying, drilling iron, wood or other material at any angle and in any position. A flexible shaft consisting of a solid coil of steel wire encased in gutta percha or leather, is fixed by a pulley to an ordinary driving belt, the drill or auger being attached to the opposite end of the coil.[33]

Letters and articles began to appear extolling the safety of gutta percha insulation in blasting activities. As early as 1847 recommendations for the use of gutta percha coated wires for mine blasting, which could save life and money, appeared in the UK press. Writing in 1851, one such writer, 'Rayo', suggested that the greater use in mines of gutta percha conductors for blasting would contribute to cost saving and accident prevention, for 'cost saving as only a small portion of the terminal point in contact with the charge is lost and the conductor preserved', and as far as accident prevention was concerned '… miners try to save the charge when there are misfires'.[34]

The Perth Gazette of May 1852 reported a suggestion by Captain Addison of Bombay that accidents in coalmines could be avoided by placing charge wires covered in gutta percha into coal chambers where fire damp occurred. By such means an explosion of a small quantity of gunpowder could be made before each shift, thus lessening the possibility of accidents. It is not known whether any coal mine took up Captain Addison's suggestion.[35]

Accidents related to poorly insulated blasting materials were not uncommon, as illustrated by an inquest into an accident at the Great Laxey Mine on the Isle of Man, one of the largest producers of zinc, lead and copper in England during the nineteenth century, which found that it was lack of gutta percha insulation on the charges that was responsible for a death. Edward Kelly giving evidence at the inquest described what happened as he and three others were working in Dumbell's shaft at the 170 level. He said that the explosion occurred during the act of charging the fuse of straw (used to fire off the blast). John Kelly (the victim) was wadding the powder with a charger of tinplate and wood at one end and a pricker of copper at the other end, and further stated, 'in my opinion a leather charger or a gutta percha would be equally safe'. This dangerous action occurred despite an abstract of the Metalliferous Mines Act of 1872[36] being posted in the mine. The abstract detailed regulations relevant to health and safety and how explosives were to be used underground, though Kelly claimed to be ignorant of its existence. Thomas Carpenter writing to the editor of the Melbourne *Argus* in 1871 warned of the dangers with 'fuzes' suggesting that miners be instructed in the use of gutta percha or india rubber insulation on the 'fuzes' to avoid accidents.[37] By this time, Wheatstone's Magnetic Exploder was on the market (Fig. 5). This was an electric blasting machine with gutta percha insulated copper wire charges and was advertised as being used extensively on colonial (mining) fields.[38]

Figure 5: *Wheatstone's Magnetic Exploder*



Source: Henry M. Noad, *The Students Textbook of Electricity*, Crosby, Lockwood & Co., London, 1867.

Gutta percha could also save the lives of miners when there was an accident such as mine collapse. When two miners at the Whiteway and Co. clay pit (Dorset, UK), Charles Woolfries aged 57 and a youth named Bartlett aged 17 years, were caught in a collapsed area for four days in 1859, they were saved by means of forcing air channelled into the collapse via gutta percha tubing attached to a bellows. After enlargement of the tunnel both men were rescued 'alive and well'.[39] Transactions of the North of England Institute of Mining and Mechanical Engineering Society note that flexible gutta percha air pipes were in use as rescue items in case of accident where there was gas in a mine and that miners were required to wear boots soled with gutta percha. [40]

A more recent application of life-saving gutta percha occurred in 1956 at the Anglo-American Merriespruit Mine, Orange Free State, South Africa, when water flooding into the mine was controlled using gutta percha sealed thick walled steel pipes. 'The through pipes were 10 metres in length bolted together at the planned mid elevation of the plugs through heavy duty grooved flanges sealed with gutta percha gaskets'[41]

Although there were lives saved by these gutta percha products their manufacture was not without health hazard. An example of this is seen in the manufacture of waterproof fuses insulated with gutta percha produced by Bickford, Smith and Davey Company, at their Camborne, Cornwall factory. The manufacture of these fuses led to the hospitalisation of one of the young female employees. During part of the work process, the girl licked the end of the fuses time and time again, and in so doing ingested minute amounts of gutta percha which over time accumulated and led to the need for her operation.[42]

More recent developments

With cotton weaving facing decline in the early twentieth century, Lancashire cotton mills changed their operations to produce conveyor belts for the mining industry that incorporated gutta percha into their manufacture.[43] This was particularly so in the years between the two World Wars. Before and after the 2nd World War, supplies of the raw material continued to be harvested in Malaysia. Exploitation of *palaquium gutta* continued with the timber also being used for poles for mining purposes.[44] Gutta percha is now largely superseded by newer materials such as polyethylenes and plastics, especially in the case of cable insulation, a change almost certainly accelerated by lack of access to the better grades of the raw material during World War Two.

Numerous companies operating today, can, if they comply with the various standards of manufacture,[45] supply belts, lathe bands and pulsating pressure cords to the mining industry. The list of these companies includes GP Rubber Ltd Toronto which incorporates gutta percha into the manufacture of its fire resistant belting, and Goodyear U.S. Chinese companies such as Rimpex and Henan Boom Ltd[46] continue to manufacture a wide range of products such as seals, radar antennae, golf balls, containers for chemicals, tyres and various medical items, especially those used in

modern endodontic dentistry, all of which incorporate gutta percha in the manufacturing process.

Summary

Following the introduction of gutta percha to the West and the ensuing recognition of its many properties which facilitated its commercialisation, there was rapid development of a wide range of products that enhanced health, safety and comfort. As well as the many domestic products that became part of every household, local authorities were enabled to improve the safety of water reticulation and sewage removal for householders. Speed of communication was increased as telegraph cables were rapidly laid down. The use of gutta percha in a wide variety of manufactured products both domestic and industrial became the norm throughout the second half of the nineteenth and early twentieth centuries. Such products could be found world wide assisting not only medical and domestic life, but the waging of war. They were especially notable for the contribution that was made to industry and to mining in particular. The global mining industry was enabled to operate more safely and became more cost effective when the numerous gutta percha products specific to mining applications such as insulated blasting equipment, seals, siphons, communication tubes, boot-soles and miners headwear were utilised.

Some of the mining specific products continue to be produced today and the development of modern products and endodontics has provided a continuation of the gutta percha trade and manufacturing. When considering the uses to which gutta percha was put we should not forget that authors and playwrights were motivated to incorporate its name into their works viz. 'The Gutta Percha Girl,' (a farce performed in the early twentieth century by amateur companies in places such as Nome Alaska) and 'Gutta Percha Willie' a story primarily written for children by Scottish author George MacDonald.[47] Even modern artists can be inspired by the material, as witnessed by Anna Slilivonchik (of Belarus) in her 2008 painting 'The Gutta Percha Girl' which admirably suggests the products flexibility![48]

Acknowledgements

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Endnotes

[11] R.P. Leith, *The John Tradescants: Gardeners to the Rose and Lily Queen*, Peter Smith, London, 1984.

[2] R. Hunt (ed.), *Ure's Dictionary of Arts, Manufactures and Mines,* vol. ll, Longmans, Green and Co. 6th edtn., London, 1867, pp. 565-72.

[3] Bougies are thin, flexible instruments used to dilate body passages such as the urethra, when there may be narrowing.

[4] M. Faraday, 'On the use of gutta percha in electrical insulation', *Philosophical Magazine, vol. 32, issue 214, March 1848,* London, pp. 165-67.

[5] W.J. Hooker (ed.), *The London Journal of Botany,* Reeve, Benham & Reeve, London, 1848, vol. 7, p. 219. Hooker comments on the new journal and notes that Thomas Oxley, senior surgeon Prince of Wales Island Singapore, publishes in edition number one a description of this tropical plant, (possibly for the first time) he also notes that Dr D'Almeida provides information in edition number two.

[6] A.F. Hill, *Economic Botany – A textbook of useful plants and plant products* McGraw Hill, New York, 1952.
[7] Penoyer L. Sherman, *The Gutta Percha and Rubber of the Philippine Islands*, Bureau of Public Printing, Manila, 1903. The Spanish American War 1899 - 1902 led to the termination of a long period of Spanish rule of the Philippines and although the United States colonial rule of the Philippines did not officially commence until 1905 Sherman was working for Department of the Interior, Bureau of Government Laboratories as a chemist. He submitted a report of his investigation into the forest resources (which included gutta percha trees) as no revenue from them was forthcoming to the Government.
[8] Sherman, *Gutta Percha and Rubber,* pp.16-20.
[9] C.W. Bunn, 'Molecular Structure and rubber like elasticity ll The Stereochemistry of Chain Polymers', *Proceedings of Royal Society of London Series, A Mathematical and Physical Science,* Royal Society, 1942. Bunn used x-ray and electron diffraction patterns to determine the structure.
[10] Hunt (ed.), *Ure's Dictionary of Arts, Manufactures and Mines.*
[11] R. Sullivan, 'England's Age of Invention - the acceleration of patents and patentable invention during the Industrial Revolution', *Explorations in Economic History,* vol. 26, 1989, pp. 424 -52.
[12] *Illustrated List of Ornamental and Useful Applications of Gutta percha Manufactured by Gutta Percha Company Ltd*, 18 Wharf Road City Road, London, 1850.
[13] C. Tomlinson (ed.), *Cyclopedia of Useful Arts, Mechanical and Chemical Manufactures, Mining, and Engineering,* vol. 1, George Virtue & Co, London & New York, 1854, p. 228.
[14] G. Dodd, *The Curiosities of Industry and the Applied Sciences*, G. Routledge & Co., London, 1852, pp. 5-13. Although this entry describes in detail the many products being manufactured in india rubber, they were soon to be replaced by the cheaper alternative of gutta percha, as discussed in the latter part of the article. Hogar or Hogger pipes referred to, denote delivery pipes at the top of a sinking pump. Albert H. Fay, *A Glossary of the Mining and Mineral Industry*, Department of the Interior, Bureau of Mines, Washington Government Printing Office, 1947, p. 342.
[15] *The Mercury*, Thursday 31 December 1863, p. 2.
[16] *The Perth Gazette and Independent Journal of Politics and News*, January 1852.
[17] *Ibid.,* Friday 1 August 1851, p. 2c.
[18] Gutta Percha Co. Ltd. Catalogue, London, 1851, *Gutta percha and its uses* Mathews and Hazzard, London, 1851.
[19] T. Chalmers, *One hundred years of Gutta Percha – R. & J. Dick Ltd*., London, 1946, pp. 7-20. Robert Dick a watchmaker and his brother James an upholsterer, became interested in gutta percha about 1846 and set up in business soling shoes and then making them from gutta percha. They went on to sell items manufactured by the Gutta Percha Company. Later they manufactured lathe belts for export. They manufactured at various locations in Great Britain and the US. James later lived in Australia where his mining interests extended to Broken Hill and Mount Morgan.
[20] L.J. Truttman, *A Place called Opou*. Talk given to West End Friendly Circle New Zealand, April 2008 (Opou or Opoutuheka present day Cox's Creek). The Caledonian Brickworks at Richmond employed the use of gutta percha belts that were later (1868) being used at the Royal Blue Mine, Thames, New Zealand.
[21] Melbourne *Argus,* Monday 31 October 1859, p. 5, *Bendigo Advertiser*, 1859.
[22] *Sydney Morning Herald,* Friday 11 November 1859, p. 8; *South Australian Advertiser*, Thursday 10 November 1859, p. 3. No information has been forthcoming to identify Meyerhoff and his connection to mining.
[23] David Bannear, 'Historic Mining sites in Castlemaine, Fryars Creek Mining Divisions', ref. xviii, *Mining Surveyors quarterly report*, Department of Conservation and Natural Resources, North West Area, Bendigo, 1993.
[24] R.B. Smyth, *Old Goldfields and mineral districts of Victoria with notes on the modes of occurrence of gold and other metals and minerals*, J. Terres, London, Melbourne, Trubner & Co., Government Printer, 1869, p. 54l.
[25] Roger W. Gilbert, *A Short History of Dupont Powder Works located at Wapwallopen,* Spiny Anteater Production, 1999.
[26] George A. Lloyd, 'A Trip to the Diggings', *Sydney Morning Herald,* 24 June 1851, p. 2. Mr Lloyd had a series of articles on his trip in several editions of the *Sydney Morning Herald*. Although they do not state to which diggings he refers, the trip description would seem to refer to 'diggings' on the Turon field.
[27] *Argus*, October 1901. This proposal for a Federal tariff on the imported gutta percha among other things, met with a negative response from mining areas and the Melbourne Gutta Percha Co., as it would affect the waterproofing of materials relevant to their operations.
[28] C. Tripptree, Letter, *The Mercury* (Hobart), Tuesday 9 May 1865, p. 2d.

[29] 'Patent Mining Machinery', *The Mercury* (Hobart) 26 September 1882, p. 3; 'The Munday Borlase Buddle a Cornish invention', *The Mercury*, 26 October 1882, p. 3, including a published letter from a William Bartle of Launceston, Tasmania, claiming that Borlase had obtained a patent in England and that it was in constant use at Dolcoath, The Croft, and Carn Bra(y) mines, and that John Munday from England had obtained a patent in Victoria in the 1860s improving on the Borlase Buddle. He suggested that Mr Kayser should not take it as his own invention.
[30] *North of England Institute of Mining and Mechanical Engineers Transactions*, 1853, vol. II, pp. 87-91.
[31] *Engineering and Mining Journal,* vol. 28, 1884, p. 123.
[32] J.E. Connell, 'Burra Burra Mine: a Study of Pipes, Bolts and Gaskets from the Cornish Pump in Morphett's Shaft', *Unpublished report to Department of Environment and Planning,* Adelaide, 1986, in Jack Connell Papers, State Library of South Australia, PRG 1152.
[33] The International Exhibition, from our Special Reporter *Sydney Morning Herald,* 31 August 1876, p. 3b.
[34] Rayo, Letter, *Mining Journal and Atmospheric Railway Gazette*, London, 1851, p. 409.
[35] *Perth Gazette and Independent Journal,* May 1852.
[36] Inquest report, *Mona's Herald*, 9 September 1875, in *Manx Mines, Rocks and Minerals*, Manx Heritage Foundation 1994. Before 1814 it was not customary to hold inquests on miners killed by accidents but after introduction of the Metalliferous Mines Regulation Act of 1872 regulations for use of explosives were to be displayed in mines. Great Laxey Mine was probably first mined in the latter part of the eighteenth century, its peak operating time being 1870s-90s. At the time Kelly was killed there were c.850 employees. Operations finally ceased in 1934.
[37] T. Carpenter, C.E.M.E., 'Mining Accidents', *Argus*, Melbourne, 13 May 1871, p. 1s.
[38] S. Roberts, *A History of Telegraph Companies in Britain, between 1838 and 1868*, Distant Writing, 2010. Wheatstone developed theories and practical applications in the field of physics, inventing and developing a variety of instruments such as a cryptograph, an electric generator and the magnetic exploder.
[39] *Poole and Dorset Herald/Poole Advertiser,* March 1859.
[40] *North of England Institute of Mining and Mechanical Engineering Transactions*, vol. 11, 1853-54, pp. 87-91.
[41] A.A.B. Douglas, History of the development and deployment of the parallel sided mortar intrusion concrete watertight bulkhead in underground mines, *Journal of South African Institute of Mining and Metallurgy*, vol. 106, 2006, p. 312.
[42] B. Earl, *Cornish Explosives*, The Trevithick Society, Camborne, 1978. Devon born William Bickford is considered by the Cornish to be the inventor of the safety fuse, which he first patented in 1831 as the Patent Safety Fuze. This fuse used jute wound round a core of gunpowder that was then waterproofed by varnish. J. Telfer Thomas MRCS.Eng., 'Memoranda Intestinal obstruction from an unusual cause', *British Medical Journal* 24, February 1912, p. 426.
[43] Hunt, *History of Leyland and District, Preston, Lancashire*, Carnegie Press, 1990.
[44] G. Siew Ling*, The Certification Process in Malaysia – a case study,* Pilot project submitted in partial fulfilment for Certificate in International Training program on Forest certification, Sweden, June 2000, South Africa, November 2000.
[45] US Department of Labor Mine Safety and Health Administration, code Title 30, Part 18, Section 1865, 11 February 2009.
[46] Rimpex Rubber Import and Export Co. Ltd, Fujian Province, China, grows its own trees for raw gutta percha. Among its products are air compressors for dental work and environmental machinery such as industrial dust collectors in which the desulphurization is achieved during the second cleansing by means of gutta percha, which catches the soot particles**.** Rimpex Rubber and Henan Boom Gelatin Co. Ltd. Henan Province, China, Company advertisements, catalogues at tradepad.net.rubberimpex.com.
[47] George MacDonald, *Gutta Percha Willie –The Working Genius,* H.S. King, London, 1873.
[47] Anna Slilivonchik 2008 painting, Amsterdamartgallery.com. The oil painting of contorted girl can be viewed at this site and is available for purchase at $1,500.