

**IX.—***On the Accidents which occur in the Mines of Cornwall, in consequence of the premature explosion of Gunpowder in blasting Rocks, and on the methods to be adopted for preventing it, by the introduction of a Safety Bar, and an instrument termed the Shifting Cartridge.*

By JOHN AYRTON PARIS, M.D. F.L.S.

MEMBER OF THE SOCIETY.

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**T**HERE is no maxim more erroneous than that which ascribes to mankind an innate love of novelty ; the history of almost every art and invention affords a proof that the very contrary obtains, whilst at the same time it furnishes the no less important fact, that in overcoming the powerful prepossessions of habit, and the obstinacy inseparable from routine, the influence of rank has not unfrequently proved more successful than the force of argument, and that the human mind, thus warped, has yielded to

the impulse of fashion that compliance which it had denied to the claims of truth, and the solicitations of reason. Thus it was that Louis XV, by wearing a bunch of the flowers of the potatoe, in the midst of his court, on a day of festivity, did more towards the eradication of the vulgar prejudices which then existed against the introduction of that valuable root, than all the philosophers of Europe for more than two centuries. I relate this anecdote with a view to vindicate the propriety of an appeal to the nobility, and gentlemen of personal influence in the county, for their countenance and support, or even of an application to his Royal Highness the Prince Regent, who has graciously condescended to become the patron of our Geological Society, for his recommendation of a plan which has no less an object than that of the PRESERVATION OF A LARGE AND VALUABLE PORTION OF THE COMMUNITY FROM SEVERE BODILY INJURIES, AND UNTIMELY DEATH, but which has to contend with all the inveterate prejudices which exist against every innovation upon an established system, however erroneous it may be in principle, or dangerous in application. From what I have thus stated, the duty of the Royal Geological Society of Cornwall becomes apparent; and the efforts which it has made, and still continues to make, in order to facilitate the introduction of the SAFETY INSTRUMENTS, which form the subject of this paper, must be regarded as no less appropriate

than laudable: for it may be truly said to have concentrated within itself all the rank, talent, and science of the county. It is by the desire of the Council that this essay is printed; and in stating to the public the grounds upon which such a resolution became expedient, I cannot conceal the fact, that the efforts of the Society have been treated by many MINE AGENTS with coolness, and by some even with hostility; that the extent and frequency of the calamity, arising from the accidental explosion of gunpowder have been denied; and that letters addressed to me through the medium of one of the provincial newspapers, have called upon me to produce evidence in support of the truth of such an assertion. I have accepted the challenge, and I now produce such a catalogue of human woe as has been but rarely witnessed; and which, whilst it must chill with horror the blood of every person who peruses it, will, I trust, forever set at rest the question, and silence the voice which would contend against the necessity of some immediate and effectual remedy. In alluding to the angry letters addressed to me upon the subject, I am sure that I entertain no feeling of personal acrimony towards their authors, nor indeed can I see why the subject should awaken ill humour, and much less excite invective, for it alone respects the public good, and the interests of humanity; but since necessity obliges me to

declare the opposition experienced from some of the mine agents, so candour, on the other hand, demands that I should acknowledge with gratitude the liberal assistance and co-operation which has been received from others; whilst by ALL, a sense of the utility of the SAFETY BAR has been frankly acknowledged, or unintentionally betrayed.

The limits of this paper will not admit of a diffuse disquisition upon the nature and theory of the different processes employed for blasting rocks with gunpowder; the injuries however which arise from them, and the methods by which the operation may be disarmed of its dangers, must form a subject of general as well as local interest, since rocks are rent in every part of the globe, either for the purpose of preparing the surface of the earth for the cultivation of its fruits, or for that of penetrating its interior for the discovery of its treasures. I have therefore thought it expedient to offer a popular account of the operation of blasting, as it is performed in the county of Cornwall, in order that the measures of safety, which we are so anxious to introduce, may be generally understood, and their value more fairly appreciated.

The first part of the operation consists in boring a cylindrical hole, about an inch in diameter, and two or more feet in depth; as circumstances may require; this is effected by means of an iron instrument, resembling a

blunt "*cold chisel*" which is held by one miner, who shifts it gradually round after every blow which it receives from a mallet directed by another, the abrasion of the rock being at the same time facilitated by the occasional affusion of water. When the hole has been thus effected, it is "*swabbed out*" by a staff, the ends of which are beaten open, somewhat like a brush; it is then ready for the reception of a charge of gunpowder; but the awkward and slovenly manner in which this is introduced, constitutes one of the most imperfect parts of the operation. The gunpowder is poured from a common flask, its quantity being only estimated by guess, so that the requisite proportion is generally exceeded, and not unfrequently to such a degree as to fill the hole. This excess is gradually removed by dipping a wet reed, or perhaps the *swabbing stick* into the powder, and then shaking off the grains which are thus made to adhere to it. But we have yet to recount an inconvenience and loss of still greater magnitude. Suppose the hole, instead of being perpendicular, should be horizontal, or more or less inclined, when it is technically termed a "*back hole*;" in such a case the miner usually prepares upon the spot, a cartridge of paper, cementing together its edges with the tallow of his candle. In this frail machine he encloses the gunpowder, and then with his iron *neele*, or bar, pushes it to the extremity of the hole; it is scarcely necessary

to add that the cartridge is rarely deposited without the loss of some, and frequently the whole of its contents ; indeed some miners are so well aware of this difficulty and waste, that, rather than intrust the powder in a cartridge, they deliver it in small quantities at a time, with an iron rod having a concave surface, resembling in some degree the shape of a marrow spoon. But here again another difficulty occurs, for by such means the powder instead of being conveyed to the extremity of the hole, is of necessity, scattered in a train along its sides ; to remedy this, the miner has recourse to a most hazardous and frightful expedient, that of thrusting forward the uncovered powder with his iron *tamper* ! After the gunpowder has been deposited, clay, or sometimes oakum, is pressed down upon it. A communication must then be secured through the matter which is immediately to be rammed over it, and this is effected by one of two methods, viz. by "*driving the neele*," (a corruption, I presume, of the word needle), which is an iron skewer about two feet long, having a large eye resembling that of a needle, as represented in plate III, fig. IV ; or by introducing into the charge a cylinder composed of quills, and filled with bruised gunpowder tightly rammed together. One of these arrangements having been adopted, the operation of *tamping* next proceeds, which is that of ramming down a quantity of *killas*, pieces of common brick, or

the fragments of any stone which may be at hand, with an iron rammer, called a "*tamper*" or "*tamping bar*." A solid arch\* is thus formed over the charge, which is capable of offering a most powerful resistance to the explosion of the elastic fluids which are generated by its combustion.† After the tamping is finished, the *neele* is withdrawn, by introducing the bar into its eye, and then striking it upwards with a hammer; the cavity thus left, and which

\* The influence of pressure in converting angular fragments into solid masses has been curiously illustrated by a process lately practised in France, which is that of converting moistened rubbish into building stone by two or three strokes from a stamping engine.

Birkbeck's Tour through France.

† It has been a problem to discover a method by which the necessity of *tamping* might be rendered unnecessary. In blasting *boulders*, or insulated masses of rock, the pouring in of dry sand upon the charge without any tamping, is sufficient; the Italians blast the Alps in this manner, and the same method is at present practised with effect, at Saint Ives, for the purpose of obtaining stones for the formation of a *breakwater*: I have, however, been informed by some intelligent miners that in hard and solid ground, this is not sufficient, and that in "*back holes*" it is quite inadmissible; I ought, however, to observe, that since the publication of the Report of the Geological Society upon this subject, Mr. Teague, of *Treskerby Mine*, has suggested the practice of driving a plug into the hole, and he states that it has been attended with success.—It sometimes happens that without any compression upon the powder, its combustion will heave its burthen. The explanation which Mr. Oke Millet has given of this circumstance appears to be correct, "the air which

forms a direct communication with the charge, is filled with gunpowder, and a hollow rush or reed, containing powder also, is then inserted, and kindled, or in case of quills having been employed, their contents are ignited by the contact of a snuff of a candle. By such means a sufficient interval elapses for the escape of the miners, before the fire reaches the charge; when the rock is burst asunder. Such is the succession of the different stages of this process, provided all goes on well; but too frequently, an unexpected explosion takes place during the operation, when the unhappy miner is either killed on the spot, deprived of sight, or so mangled as to remain a helpless object of misery for the rest of his days; whilst his wife and children, and perhaps an aged parent dependant upon him, are driven in a state of destitution, to the hard necessity of seeking from charity that pittance which honest industry can no longer supply.

In investigating the causes from which such a catastrophe may arise, it is evident that the concurrence of two circumstances is indispensable; the production of fire, and its trans-

is disengaged from powder acts more powerfully on the sides of holes than on the ends, because more surface of rock is exposed to its action; thus the *tamp* is not blown out, without the separation of the rock: that part of a mortar which contains the powder, forms the segment of an oval, by which contrivance, the air, that is set free from the powder, acts in the most powerful manner."



mission to the mass of gunpowder at the bottom of the hole : this consideration naturally suggests the following arrangement.

I.—*Causes which may elicit Fire.*

1. The collision of the *iron tamping bar* with siliceous or sparry matter,\* or with *mundic*, &c.
2. The attrition of the different substances which compose the *tamp* with each other.
3. Driving the iron *neele* with such violence as to strike fire against the bottom of the hole.
4. The friction occasioned by the extraction of the iron *neele*.
5. The vibration and concussion of the extremity of the iron *neele*, principally during the *tamping* of the second layer of rubbish, before it has acquired steadiness and support from the filling up of the hole.

II.—*Causes which occasion a communication with the charge of Gunpowder, and thereby expose it to accidental ignition.*

6. The careless manner in which the powder is scattered about the collar of the hole, or left to adhere to its sides.

\* *Spar* is synonymous with *quartz* in the vocabulary of the Cornish miner. *Mundic* is iron or arsenical *pyrites*, which strikes fire with amazing facility, and is generally employed for that purpose by the miner in preference to *quartz*. Pliny mentions this application of *pyrites* very particularly. The term seems to be derived from this quality.

7, The accidental fracture of the cylinder of quills, from the abrasion of the *iron tamper*, or the escape of gunpowder from some one of its joints.\*

8. The forcing up a quantity of powder from the body of the charge, by carelessly ramming down too hard and improper rubbish immediately over the clay.

There is also another fertile source of accidental explosion which ought to be noticed, although it has no connexion with any of the above causes, it being solely dependent upon fool-hardiness induced by a desire to save a small quantity of gunpowder, as the following statement given me by an experienced miner will evince; when a hole from any mischance does not explode, it is necessary to remove its contents in order to recharge it, and this is effected with an *iron scraper*, when, in order to avoid spoiling the powder, the miner frequently omits the important precaution of first pouring into it a quantity of water, which would effectually obviate every possibility of an accident.

As the principal causes of accidental explosion thus dispose themselves under two heads,

\* I would here observe that such an occurrence is by no means rare, the very operation of *tamping*, by compressing and diminishing the diameter of the quills, necessarily opens the joint immediately above such pressure; for obvious reasons, this will first occur during the second layer of tamping.

so will the measures of safety which are to be adopted for their prevention, viz.—*The introduction of tools which will not strike fire, and the invention of an instrument which will deliver a charge of gunpowder without loss.*

*I.—The introduction of Tools which will not strike fire,*

The necessity of introducing some SAFETY BAR, instead of the fatal tamper in common use, was first suggested to me by my friend Sir Rose Price, more than three years since, his attention having been directed to the subject by the occurrence of several terrible accidents upon one of his farms, in blasting the boulders of granite which impeded the progress of its cultivation:—he at that time succeeded in procuring a metallic bar which would not strike fire, although its too great malleability prevented its introduction into general use; at this period, the Geological Society was established, and it was reserved for its members to give a general and public impulse to the investigation which Sir Rose Price had so humanely suggested; their activity, as might be expected, soon awakened a kindred energy in many of the more liberal and intelligent agents, whose zeal upon this occasion cannot be too highly appreciated, but they will receive from the approbation of their own hearts a more satisfactory and solid recompence than from any eulogium which it is in my power to bestow. At the suggestion of John Williams,

Esq. to whom I had sent several bars for trial, and who reported that "they bent, and were unable to stand the work," the extremity of the *tamper* was merely shod with an alloy, Mr. Chenhalls of St. Just, at the same time, had a number constructed upon a similar plan, which he introduced into all the mines over which he had influence, or control, and the principle appeared to answer; it was, however, necessary to ascertain the exact proportion of copper and tin, which would produce the best possible alloy for the purpose; to discover this I made some experiments, and submitted to Mr. Chenhalls different specimens for trial, and I learn from him that the one which answers best is a composition of 86 parts of copper, and 14 of tin.\* The SAFETY BAR thus constructed is presented in the plate, fig. III, the alloyed end (*b*), if injured, can easily be replaced for a few pence, the cost of the bar is 1s. 6d. that of the common tamper 1s.

The SAFETY BAR has been in general use for more than twelve months in most of the mines in the western part of the county, and in addition to the evidence already published in the last Annual Report of the Geological Society,

\* To those who manufacture the SAFETY BAR, I beg to suggest that they will do well to keep the metals in fusion for some time, and constantly stirred, otherwise the greater part of the *copper* will sink to the bottom, and that of the *tin* rise to the surface, and in consequence there will be found two different alloys, possessing very different properties,

I have the satisfaction to add the following respectable and gratifying testimony of its efficacy.

*“ We, the undersigned Mine Agents, have great pleasure in bearing testimony to the security afforded by the introduction of the SAFETY BAR, recommended by the Royal Geological Society of Cornwall, against those terrible explosions so frequently attendant upon the use of the iron tampers, and that they are quite unobjectionable in their application, and have been the only ones used in the different mines of which we are respectively the agents; viz. in BOTALLACK for 15 months, in BOSWORLAS MOOR for the same period, in DING-DONG for ten months, in PARK NOWETH for 14 months, in LITTLE BOUNDS for 15 months, and in HUEL OLDS for 13 months.” Dated 30th December, 1816.*

*Signed,*

NICHOLAS GRENFELL, *Botallack.*

THOMAS OATS, *Bosworlas Moor.*

N. WHITE, *Ding Dong.*

JOHN CLEMENS, *Park Noweth.*

JAMES NICHOLAS, *Little Bounds.*

RICHARD BOYENS, *Huel Olds.*

To JOHN AYBTON PARIS, M. D. &c.

“ We, the undersigned, SURGEONS of the principal mines in the parish of St. Just in Penwith, do hereby certify, that since the general introduction of the SAFETY BAR into the mines of that district, no accident has occurred from the premature explosion of gunpowder in blasting rocks, and that such accidents did frequently happen when the common iron tamping bar was in use,” Penzance, 27th December, 1816.

Signed, WILLIAM BERRYMAN,  
EDWARD COLLINS GIDDY

TO DR. PARIS.

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It is necessary to state that the *neele* is never used in the mines just alluded to, the fuze being constantly made by quills, and that therefore they have not been exposed to the 3rd, 4th, and 5th causes of explosion.

The IRON NEELE is an instrument no less dangerous in its operation than the *iron tamper*, indeed it appears from the 5th cause of explosion, that during the act of tamping with a SAFETY BAR, an accident is liable to take place if the iron *neele* be employed. In some of the greater mines, a copper *neele* has been for some time in use. Lord Dunstanville, the active and munificent patron of every thing which tends to promote the interest of the county, and the welfare of its population, has, upon this occasion, exerted his influence with considerable effect.

The *neele* is represented in the plate by fig. IV. its eye (*ab*) may be composed of iron, as copper is too ductile for that purpose; its body and point should be *copper*, combined with about a twelfth part of *tin*.

II.—*The introduction of an instrument which will deliver any charge of Gunpowder without loss.*

From what has been already stated with respect to the awkward manner of charging holes with gunpowder, the necessity of some expeditious, economical, and safe method of effecting it, is sufficiently apparent. The instrument which I am about to describe and recommend, completely meets such an intention, and will not only obviate several causes of accidental explosion, but will economize one fifth of all of the gunpowder consumed in the operation of blasting, and thus SAVE to the mining interest of Cornwall a *sum exceeding six thousand pounds* annually! To those who have not considered the subject, such an estimate may appear chimerical, but I am fully prepared to shew that it is a fair approximation; it is well known that the cost of gunpowder used in all the mines of Cornwall, amounts to more than THIRTY THOUSAND POUNDS a year, and I would ask any agent acquainted with the slovenly inanner in which it is applied, (taking of course the average of the loss in the charges of perpendicular and inclined holes) whether one

fifth of it, at least, is not entirely wasted?—  
 The idea of delivering gunpowder at the bottom of a hole by means of an instrument capable of adapting its capacity to any given quantity which might be required for a charge, suggested itself to Mr. Chenhalls (whose name I have before mentioned) more than fifteen years ago, but no attempt to convert it to a practical purpose was made, until the Geological Society entered upon the present investigation; Mr. Chenhalls then sent me an instrument, which, after some additions, and farther improvements, is that which I am about to describe, and to which the name of **SHIFTING CARTRIDGE** has been given. Figures I and II of plate 3, represent a view and section of this instrument; it consists of a copper cylinder (*ab*) two feet in length, and one inch in diameter, containing a moveable rod (*c*) which is graduated in inches, and has affixed to its extremity a leaden plug (*d*), the cap (*g*) is made to take off, in order, at any time, to allow the removal of the rod for cleaning the interior.—**MANNER OF USING IT**—Draw out the rod as many inches as you require it to deliver of gunpowder, then invert the instrument, fill it, and place a piece of moistened clay upon the mouth of the cylinder; it is now to be inserted into the hole, when, by pressing down the sliding rod, the whole charge is immediately delivered in a mass without any loss; before the instrument is withdrawn, the rod should



be rammed down smartly several times upon the mass of gunpowder.

In charging "BACK HOLES" the only difference which it is necessary to observe in its application is, that the clay should be stuck upon the end of the plug (*d*) previous to the introduction of the powder into the cylinder. When quills are used for a fuze in preference to the *neele*, it will be found advantageous to affix in the cylinder a small tube for their reception, as represented in the plate, by fig. II (*ef*) by which contrivance they may be inserted into the centre, instead of upon the surface of the charge, the result of which is a more instantaneous and consequently a more certain and effective combustion:\* thus, suppose the instrument is to carry a charge of four inches, the rod should, in such a case, be pressed down only two inches before the insertion of the quills, and the remaining two after it.

Having thus communicated in detail, the results of an enquiry into the causes of accidental explosion, and described the methods by which so dreadful a calamity may be averted, I may be allowed to hope that I have performed a service of some importance to the county of Cornwall; at all events, I feel that under the circumstances which I have stated, I could not have shrunk from the performance

\* It is the application of the same principle that gives superiority to Manton's well known patent breech.

of such a task, without forfeiting every claim to the character, which, of all others, I am most ambitious to sustain; that of a diligent and humane physician, whose duty it is to prevent as well as cure the diseases and accidents to which those around him are more immediately exposed, and by his influence and counsel to correct the habits, and remove the prejudices which are most active in producing them. Let this be received as my reply to those who have censured me for interfering in the concerns of an art, of which I must be entirely ignorant; and if I have ventured to descend into the dark regions of the earth, and have presumed to enquire into the occupation of the intrepid beings who labour in its caverns, it was not without a claim upon the support of a protecting Sibyl, whilst to those perturbed spirits who might oppose my adventure, I was prepared to present this essay as the "*DONUM FATALIS VIRGÆ*," which should at once appease the fury of their indignation.

[*Here followed a tabular view of ninety-eight cases of accident; the consequences of a large proportion of which were, disability or death.*]

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POSTSCRIPT.

As more than twelve months have elapsed since this paper was read before the Society, and, by a Resolution of the Council, circulated amongst the mine agents in the county, it becomes my duty to state in this publication, that the **SAFETY BAR** has continued

in use in the western mines above enumerated, and that no accident has occurred since its introduction. To what extent it has been adopted in the eastern districts of the county I am not able to state, as I no longer reside in Cornwall, but I indulge a hope that the "iron age is passing away," and that the next volume of this work will announce its final departure.

As an historical document of interest and importance, as a gratifying testimony to the humanity which has ever characterized Cornish Gentlemen, and as a powerful authority in support of the cause I have so zealously advocated, I feel it my duty to place upon record, in this volume, the following Resolution of the Grand Jury of the County of Cornwall, assembled at the last Lent Assizes—Dated, "Grand Jury Chamber, Launceston, March 28, 1817." "*Mr. Justice Abbot having, in his charge, directed the attention of the Grand Jury to the numerous accidents which occur in the mines of Cornwall, from the present methods of blasting rocks with gunpowder, and he having referred to an essay written by Dr. Paris, describing INSTRUMENTS OF SAFETY, the success of which, in preventing accidental explosion, has been satisfactorily proved by the testimony contained in the printed Reports of the Council of the Royal Geological Society of Cornwall; WE, THE GRAND JURY OF THE COUNTY OF CORNWALL, assembled at the Lent Assizes, at the town of Launceston, feel it to be our duty strongly to recommend the speedy and general introduction of the said "SAFETY INSTRUMENTS," to all agents of mines in the said county, and to request the Clergy, Magistrates, and Gentlemen, to give every possible publicity to this Resolution, throughout their respective districts.*"

(Signed)

REGINALD POLE CAREW, *Foreman.*

SAFETY INSTRUMENTS.

