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APPENDIX.

REPORT

OF THE

EXPLOSIVES COMMITTEE,

APPOINTED JOINTLY BY THE

ROYAL CORNWALL POLYTECHNIC SOCIETY.

THE MINERS' ASSOCIATION OF CORNWALL & DEVON,

AND

THE MINING INSTITUTE OF CORNWALL.

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1880.

REPORT OF THE EXPLOSIVES COMMITTEE.

IN the Autumn of the year 1879,—at the request of many practical mine agents, engineers, and others interested in mining,—a committee on Mining Explosives was appointed jointly by the Royal Cornwall Polytechnic Society, the Miners' Association of Cornwall and Devon, and the Mining Institute of Cornwall, to enquire into the nature, economy, efficiency, and safety of the various explosives in use, or proposed for use in the mines of Cornwall and Devon.

The following gentlemen formed the original Committee, six being appointed by each Society.

Mr. J. P. BENNETTS, <i>Falmouth.</i>	Mr. B. KITTO, <i>Camborne.</i>
„ J. L. BOLDEN, <i>Camborne.</i>	„ F. W. MICHELL, <i>Redruth.</i>
„ J. H. COLLINS, <i>Truro.</i>	„ JOHN F. PENROSE, <i>Redruth.</i>
„ JOHN DARLINGTON, <i>London.</i>	„ THOS. B. PROVIS, <i>Camborne.</i>
„ HOWARD FOX, <i>Falmouth.</i>	„ RICHARD TAYLOR, <i>London.</i>
„ WM. M. GRYLLS, <i>Falmouth.</i>	Capt. WM. TEAGUE, <i>Treliske.</i>
Dr. R. S. HUDSON, <i>Redruth.</i>	„ WM. TEAGUE, JUN., <i>Tincroft Mine.</i>
Mr. WM. HUSBAND, <i>Hayle.</i>	„ JOSIAH THOMAS, <i>Dalwath Mine.</i>
Capt. JOHN HOSKING, <i>Tehidy Office.</i>	„ R. H. WILLIAMS, <i>Wheal Elizat.</i>

Dr. C. Le Neve Foster, who had at first been proposed as a member of the Committee, declined to act as such, but signified his willingness to give evidence, or otherwise to assist the Committee by any means in his power.

At an early meeting Mr. J. H. Collins was appointed Secretary, and the following gentlemen were added to the Committee :—

Mr. T. CLARK, <i>Truro.</i>	Capt. ROSEWARNE, <i>Wheal Sisters.</i>
Capt. MAYNARD, <i>East Pool Mine.</i>	„ RUTTER, <i>West Wheal Seton.</i>
„ ISAAC RICHARDS, <i>Devon Great Consols.</i>	Mr. GEO. J. SMITH, <i>Tuckingmill.</i>

It was also agreed that the enquiry should be confined to explosives in actual use, or likely to be used, in the mines of Cornwall and Devon, and the Secretary was requested to obtain information regarding such experiments as had already been made by the Government, or by other public bodies, for the information of the Committee.

The following explosives were considered more especially to come within the scope of the enquiry.

A—GUNPOWDER :

- 1 Large grain.
- 2 Medium grain.
- 3 Small grain.
- 4 Compressed
- 5 Special strong.

D—TONITE.

E—TITANITE.

F—DYNAMITE :

- No. 1.
- No. 2.

G—BLASTING GELATINE.

H—LIVERPOOL COTTON POWDER.

B—ESPIR'S EXPLOSIVE POWDER.

C—GUNCOTTON.

As to the nature of the various explosives here mentioned, the following information is believed to be correct,

A—GUNPOWDER, large grain (1), medium grain (2), small grain (3), compressed (4) :—

Charcoal... ..	15	p.c.	} approximately.
Sulphur	15	"	
Nitre	70	"	

A—GUNPOWDER, special strong (5). Composition not stated.

B—ESPIR'S EXPLOSIVE POWDER :

Nitrate of Soda ...	60	p.c.	} approximately.
Sulphur	14	"	
Hardwood sawdust	26	"	

C—GUNCOTTON.

Pure cotton fibre which has been chemically acted on by strong acids.

D—TONITE. Said to be guncotton, combined with nitrate of baryta.

E—TITANITE. No information.

F—DYNAMITE.

No. 1. Nitroglycerine ...	75	p.c.	} approximately.
Kieselguhr*	25	"	

No. 2. Contains less nitroglycerine, together with varying proportions of charcoal and a nitrate.

G—No. 2. BLASTING GELATINE.

"Collodion cotton 7 to 10 parts, combined with thoroughly purified nitro-glycerine 90 to 93 parts, at least 95 p.c. of the collodion cotton to be soluble in ether and alcohol."

H—LIVERPOOL COTTON POWDER. Said to be guncotton combined with nitrate of potash.

*Infusorial earth consisting of the siliceous skeletons of microscopic organisms.

The economy of the various explosives was evidently a very important part of the enquiry, and the Committee has carried out two series of experiments with a view to gaining information on this point, besides which it has addressed a series of questions to practical and experienced miners, which questions have been answered by 35 such persons.

The first series of experiments was made at Sevecock Quarry, near Chacewater, on the 2nd December, 1879, the special object being to determine the relative efficiency of the different explosives in open quarry work. The conditions laid down by the Committee were as follows, but the 4th condition was subsequently modified at the request of the representatives of Dynamite and Tonite, so as to allow all competitors to use whatever quantity they might think proper of their several explosives.

Regulations for the Experiments at Sevecock.

"The first series of experiments will be made at Sevecock Quarry, near Chacewater, on Tuesday, December 2nd, at 2.30 p.m.

The object of this first series is simply to test the relative economy of the different explosives as used in hard ground.

The following are the arrangements for the trial.

1. A number of holes will be previously bored in different parts of the quarry, to depths varying from 20 to 40 inches, but burdened equally as far as possible. These holes will be numbered.

2. The holes will be selected in rotation by the competitors, the order of selection will be determined by a preliminary ballot. If possible, each competitor will be allowed to select three holes.

3. The holes will be charged and fired as far as possible in the order settled by the preliminary competition, except that those to be charged with common powder will be fired first.

4. The representative of powder will be allowed to use what quantity he pleases, but the total weight used for the three holes will be registered, together with the depth of the holes; the value of the powder so used will be the standard by which the amounts allowed to the other competitors will be determined, with reference to nett market prices.

5. After each set of holes has been fired, the umpires shall examine and record the results of the shots.

6. The Secretary of the Explosives Committee will act as umpire for the Committee, and the competitors present will choose some one to act as their umpire with him.

7. In case of disagreement of the umpires, they shall themselves choose a referee from among the gentlemen present, whose decision on the point in question shall be final.

8. The following explosives will probably be tried:— Powder, compressed do., Espir's do., Tonite, and Dynamite.

Should the representatives of any other explosives desire to compete, they must send in their names to the Secretary before Saturday, November 29th, with a reference to some Cornish mine where the explosive is in use.

9. All explosives, if already in the market, will be provided by the Committee, and will be drawn from stocks recently supplied to the mines in Cornwall."

(Signed) J. H. COLLINS, Secretary.

November 22, 1879.

A large number of gentlemen interested in mining, including a good many mine agents, and a majority of the Committee, attended the experiments.

Capt. H. Trevethen was chosen as umpire by and for the competitors, to act with Mr. J. H. Collins as umpire for the Committee; Capt. Whitburn was chosen as referee by the two umpires, in case of any disagreement among themselves. Nothing arose, however, making it necessary to refer any point to him.

The following report was subsequently made to the Committee by the umpires:—

*Report on the Experiments at Chacewater (Seveock Quarry),
December 2nd, 1879.*

The following explosives were tried:—

1. Common powder, manufactured by the Kennal Vale Powder Co.
2. Compressed do. (*Davey & Watson's patent*), manufactured by the Kennal Vale Powder Co.
3. Special strong powder, manufactured by the Kennal Vale Powder Co.
4. Espir's Powder.
5. Liverpool cotton powder.
6. Dynamite.
7. Tonite.

All these, except the 3rd and 5th, were obtained from mines where they have been supplied in regular course of business. Nos. 3 and 5 not being in the market as yet, were supplied by the respective agents.

Full particulars of the trials are given in the accompanying tables—

NO. OF HOLE.	DEPTH.	EXPLOSIVE.	QUANTITY.	VALUE.	REMARKS.
12 ...	17in.	Powder ...	1lb. ...	4d....	} Good shot. Very good shot. Not enough powder, rock cracked only.
18 ...	26in.				
19 ...	20in.				
21 ...	24in.	Compressed Powder	9½oz....	3½d....	} Good hole, very tight Pretty fair.
17 ...	17in.				
20 ...	19in.	Special do.	5½oz....	4½d....	Strong hole, good.
9 ...	21in.	Espir's do.	17½oz ...	4½d....	} Good. Very good. Good.
15 ...	17in.				
16 ...	21in.				
5 ...	24in.	Liverpool Cotton	5¼oz	9d....	} Good. Good.
7 ...	19in.				
12 ...	12½in.	Powder	3 detonators ...		Good (large loose rock).
11 ...	16in.	Dynamite*	10 oz.	1/4...	} Good. Very good Very good
3 ...	26in.				
10 ...	15in.				
13 ...	21in.	Tonite ...	9oz.	1/2½...	} Good. Fair. Very good.
1 ...	24in.				
8 ...	23in.				

It will be observed that most of the shots were fully successful, while none were entire failures. Most of the holes were 1in. diameter, a few were 1½in. Nos. 19, 17, and 1 had scarcely enough explosive, although the fractured rock might no doubt be worked out.

Assuming the work done to be approximately proportionate to the depths of the holes, we have the following results as regards economy.

EXPLOSIVE	COST PER FOOT OF HOLE
Common powder ...	¾d. nearly.
Compressed powder ...	1d. nearly.
Espir's powder ...	1d. nearly.
Liverpool cotton powder ...	2d. nearly.
Tonite ...	2½d. nearly.
Special strong powder ...	3d. nearly.
Dynamite ...	3¼d. nearly.

(Signed) J. H. COLLINS, *Umpire for the Committee.*

H. TREVETHAN, *Umpire for the Competitors.*

This first series of experiments having indicated a marked difference between the so-called "strong" and "weak" or "high" and "low" explosives as regards their economical use in quarry work, a second series of experiments was undertaken to test their relative economy in driving

*Sold at 2/- per lb. The sale value of No. 1 Dynamite in Germany is 2/1 per kilo, or say 11½d. per lb.

levels. The hard elvan at Sevecock was again selected, and the following were the conditions agreed upon by the Committee on the 15th Jan., 1880.

Conditions of the Second Series of Experiments.

"The second series of experiments will be commenced at Sevecock, Chacewater, early in February, when the various explosives in competition will be tried in "driving" under the following conditions:—

1. Two levels, A and B, will be driven simultaneously, two men working in each. The levels will be not less than 7 feet high, and 4½ feet wide.

2. Level A will be driven for successive periods of not less than one week each, by means of Dynamite, Tonite, and Liverpool Cotton Powder; level B in a similar manner by common powder, Espir's powder, and compressed powder.

3. Each level will be driven in at least 3 feet from the face, by workmen employed by the Committee before the competition commences.

4. The manufacturers of the different explosives, or their agents are invited to send their own pare of men to work for a period of not less than one week under the supervision of the agent of the "Explosives Committee." Should they fail to do so the Committee will appoint two men to do the work.

5. The explosives used will be provided by the Committee, as in the first series of experiments.

6. Manufacturers of explosives not mentioned above (in par. 2), who may desire to compete, must send in their names to the undersigned, not later than Saturday, February 7th."

The representatives of the following explosives signified their intention of competing, and of sending their own men.

Gunpowder, common	} Kennall Vale Co.
Gunpowder, compressed	
Liverpool Cotton Powder.	
Espir's Explosive Powder.	

The representatives of Dynamite preferred to leave the whole matter in the hands of the Committee. The representatives of Tonite sent one man, and the Committee provided another to work with him.

The experiments were carried out in accordance with the rules, except that level A was abandoned after the dynamite party had worked their week, owing to a great change having taken place in the ground. All the rest of the work was done in level B, the rock in which continued very uniform in character throughout.

The results are given in the following tabular statement:—

ABSTRACT OF RESULTS OF SECOND SERIES OF EXPERIMENTS,
February 28th to March 27th, 1880.

Week Ending	Explosives.	Days Worked	Distance driven, in feet		Speed per Day.	No. of Holes.	Average Depth.	Average Time per foot.	No. of Drills per ft.	Ft. bored for each ft. driven	Materials, Cost per ft. (nett.)	Labor Cost per foot, (nett.)	Total Cost per foot
			gross.	nett.									
February 28	Dynamite	6	8'4	6'3	12½	22	15½	32'8 min.	7	3 4½	£ 0 1 10½	£ 0 5 9½	£ 0 7 7½
February 28	Espir's	6	6'1	6'1	12½	25	17	31'35 "	7½	5 10	0 1 6½	0 5 11	0 7 5½
March 6...	Liverpool C. P.	6	7'10	7'2	14½	26	19	30'15 "	10	5 3	0 3 0	0 5 0½	0 8 0½
March 13	Comp. Powder	6	9'4	8'11	17½	24	18½	32'4 "	7	3 11½	0 1 1	0 4 0½	0 5 1½
March 20	Com. Powder	6	8'2	8'2	16½	27	18½	30'0 "	8	5 1	0 1 1	0 4 5	0 5 9½
March 27	Tonite	5	5'11	5'11	14½	25	18	25½	6½	6 2	0 3 6	0 5 0½	0 8 6½
Average.					14'7	25	17'7	30'4	7½	4 11	0 2 0½	0 5 0½	0 7 1½

The following memoranda was made immediately after the experiments were concluded. They explain why the 4th and 5th columns are not identical.

Dynamite.—"Bottom not cleared to proper width, at least two more holes required, say half a day more, or one twelfth of total drivage to be deducted. Also, north side of level has come into killas about 6 feet from end, in fact only about 2 feet 6 inches of total drivage has been driven with elvan on both sides of level, ground therefore much easier, a long piece driven on Saturday. One sixth should be deducted from total drivage from this cause. Nett length of drivage to be reckoned therefore will be $8' 4'' - (\frac{1}{12} + \frac{1}{6}) = 6' 3''$.*

Signed. J. H. COLLINS.
THOMAS CLARK.

Espir's.—"End very well squared, and more than full width. Work exceedingly well done. Nothing whatever to deduct." J.H.C. & T.C.

Liverpool Cotton Powder.—"End very solid all the time, no breast-heads till the finish. Half a day = $\frac{1}{12}$ th of whole drivage deducted for narrowness of level." J.H.C. & T.C.

Compressed Powder.—"Two hours = $\frac{1}{4}$ th to be deducted for stuff not cleared from level." J.H.C. & T.C.

Common Powder.—"Nothing whatever to be deducted, end capitally squared." J.H.C. & T.C.

Tonite.—"Nothing whatever to be deducted, end capitally squared." J.H.C. & T.C.

With the exception of level A, in which killas was met with, it is evident from the tables that the rock varied very little in hardness, or in general character throughout the trials. This especially appears from the number of bits blunted, the depths of the holes, and the time per foot taken up in boring the holes. All the boring was done with the same sized bits, except for the tonite, when the bits were made a little narrower. This accounts for the greater speed of boring shewn in the above table.

The variations in the amount of jointing in the rock will appear from a study of column 11. Here it will be seen that the number of feet bored per foot of advance varied from three feet four and a half inches (dynamite), to six feet two inches (tonite).

*Of course the deductions proper to be made for the reasons stated in this and the following cases are merely matter of estimate. They are inconsiderable, except in the case of the dynamite. Several Members of the Committee have seen the "end" A as it was left by the dynamite party, and they agree with the deduction made in the text.

The results shew very clearly that for a dry end and in pretty solid ground, if not *extremely* hard, the cost at current prices of driving with gunpowder, compressed powder, or Espir's powder was less than with dynamite, tonite, or Liverpool cotton powder. In other words the "strong explosives" did not recommend themselves for such ground, either on the score of economy or speed.

The Committee would gladly have arranged for further experiments, especially in wet and exceptionally hard ground, but the funds at their disposal did not suffice. Desiring, however, to carry the enquiry as far as possible, they issued the following series of questions, addressed to mine agents and others who might be supposed to have had experience in the use of explosives. About 250 of these were sent out to most of the leading mine managers in Cornwall, as well as to others in various parts of the United Kingdom; 35 replies were received to these circulars, and their substance is given below.

QUESTION.	REPLY.
1st.—Please state what experience you have had in the use of various Explosives, such as	Experience varied from "few" to 4 years.
1. Gunpowder :—	
a. Large grain... ..	Experience varied from "a few" up to 40 years, 22 replies.
b. Medium grain	From 8 to 40 years. 27 replies.
c. Small grain... ..	From 11 to 40 years. 19 replies.
d. Compressed	7 had used it; 4 "a little," 3 "a good deal."
2. Espir's Explosive Powder.	3 had used it; 2 "a little," 1 "a good deal."
3. Guncotton	10 replies; 2 to 5 years.
4. Tonite	10 replies; 5 had used it "a little" 3 "some years," 2 "two years."
5. Titanite	2 replies; "a little."
6. Dynamite :—	
a. No. 1, or ordinary ..	19 replies; 3 "a little," 8 "some years," the rest from 3 to 8 years.
b. No. 2	8 replies; 4 "a little," 4 "some years."
7. Blasting Gelatine	1 reply; "a little."
8. Any other Explosive ...	Nitroglycerine, Liverpool Cotton Powder, Lithofracteur, Pea Powder, Pudrolythe.—Most of those who had used these had had no long experience with them.

2nd.—Have you found the quality of any of these Explosives, as supplied by the makers or their agents, to vary from time to time; and, if so, to what extent?

10 replied "No."
8 replied "yes," from 5 to 15 per cent.
1 had found Guncotton to vary from time to time as sent out by the makers.
5 had found Dynamite do. do.
1 had found Tonite do. do.
4 had found Gunpowder do.
2 considered the Blasting Powder now sent out was better than formerly.

3rd.—What is your opinion as to the relative cost of these Explosives for doing an equal amount of work, under different conditions, such as

- A. In wet ground 31 replies; Dynamite best 26, coarse Powder best 3, Tonite best 2.
- B. In very dry ground... .. 23 replies; Dynamite best 3, Powder best 10, fine Powder best 2, large Powder best 2, medium Powder best 2, compressed Powder best 2, Tonite best 2.
- C. In loose or fissured ground 23 replies; Dynamite best 18, Powder best 2, Tonite best 2, large Powder best 1.
- D. In ends 29 replies; Dynamite best 13, Powder best 9, Tonite best 2, Dynamite if wet or hard, Powder if dry or moderate 5.
- E. In back stopes 18 replies; Dynamite best 7, Powder best 5, medium Powder best 1, small Powder best 1, compressed Powder best 1, Dynamite if wet or hard Powder if dry or moderate 3.
- F. In sinking 23 replies; Dynamite best 14, Powder best 3, large Powder best 2, small Powder best 1, Dynamite if wet or hard, Powder if dry or moderate 3.
- G. In open quarry work. ... 13 replies; Powder best 8, large Powder best 1, Dynamite best 2, Pudrolythe best 1, Dynamite where small stones are required 1. One reply said Dynamite is best under *all* circumstances.

4th.—Have you found any of these Explosives to alter or deteriorate during storage; and if so, to what extent?

12 replied "No, if kept dry."
3 replied "yes," as to Dynamite.
2 replied "yes" as to Gun Cotton.
1 said he "had known Gun Cotton to lose 33 p.c. of its strength when kept in a *dry* magazine."

5th.—Please state your opinion as to the relative safety or danger in using these different explosives, or in boring holes after their use.

Replies to this query were very conflicting, the majority considered Dynamite to be safer in use than Powder, but that it required more care *after* use, *i.e.* in working the rock after it has been used.

One reply states that the writer has used 2 tons of Dynamite per ann. for many years without accident.

Capt. Henry Eddy, of North Levant mine, answers this question as follows:—

"Dynamite extremely dangerous.
Lithofracteur highly dangerous.
Powder moderately dangerous."

Captains Jas. Vigus and Wm. Gribble say "Tonite safest, Dynamite next, Espir's Powder next, then gunpowder."

6th.—State your opinion as to the effect of the fumes or smoke upon the men after a shot underground.

All except two agree that the fumes from Dynamite are the most injurious. One of these, Capt. Abraham James, of South Frances mine, says "the fumes from Dynamite are comparatively little when compared with powder, and with ordinary caution men need not suffer much from Dynamite. I believe Powder smoke in close places, to be far more injurious." Capt. R. H. Williams, of Wheal Eliza, says, "We do not find dynamite injurious in ventilated places. We find the resultant gases from blasting much thinner and lighter than powder-smoke. We use dynamite almost exclusively, not from compulsion, but from

the choice of men and agents." Most say that the fumes from Powder are the least injurious, but one says they are the worst. Other explosives are believed to be intermediate in this respect.

7th.—Have you found any decided advantages as regards economy or efficiency result from combining different Explosives in the same bore-hole; and, if so, to what extent?

Nine reply decidedly "No," five think there is an advantage in using Dynamite or Pudrolythe at bottom and Powder at top. One thinks there is an advantage in using Dynamite or Tonite at top and Powder at bottom. Many think such combinations are highly dangerous. One thinks there is an advantage in using mixed coarse and fine-grained Powder.

Some of the replies were very brief, a few were somewhat elaborate; a number of extracts are given below from the "general remarks."

As to economy, Capt. Charles Thomas, of Cook's Kitchen mine, thinks "the stronger explosives are often wasted through the miners taking too light burdens. If holes were bored deeper, and more heavy burdens taken there would be an advantage in using strong explosives."

Capt Raw, of the Swaledale Mines, Yorkshire, says the men in his mine would rather buy Dynamite than use any other explosive, if it were given to them.

Capt John Barkell says:—As a rule I think all good miners will give the preference to those blasting agents which are either plastic in their normal condition, or capable of being rendered so, and thoroughly impervious to water. Such explosives as Tonite, Liverpool Cotton Powder, &c., possess the advantage of Dynamite in "handiness" for charging (though they are not waterproof), and approach that explosive in effectiveness within 15 or 20 p.c., but as this much depends upon the holes being of uniform size with the cartridges, and such holes are liable to vary considerably in size, it is a decided and even recurrent disadvantage to adopt them for general mining work."

Capt. Simon Whitburn and others say that there should be several kinds of explosives kept on every mine, so that the working miner might have his choice.

Capt. White, of Wheal Peevor, considers that Dynamite only should be used in wet or loose fissured ground; Powder being cheapest and best in dry solid ground.

Mr. P. H. Argall, lately of the Cronebane Mines in Ireland, expresses the same opinion; he states that he has known an end to be so loose and "vughy" that powder was perfectly useless.

Capt. Abraham James (of South Frances) says "in this mine we use nothing but Dynamite, not because we think it more economical than powder, but simply for want of good ventilation. The mine will be thoroughly ventilated in a few days, we shall then insist on the men using powder in many places where Dynamite is used now. We consider we pay equally as much now for drivage as when no other explosive was used than powder. The workmen prefer Dynamite because in the first place it is a little stronger, it requires no tamping, makes less smoke. It is a boon to the workman, but little or no profit to the adventurer. In my opinion Powder for ordinary ground is by far the cheapest explosive."

Sir Geo. M. Denys writes,—“We have of course tried various kinds of Gun-Cotton, Powder, and Tonite, but prefer No. 2 Dynamite to anything else, and use it almost entirely. In wet ground it is invaluable, it requires no tamping. It is safer than Powder or Cotton. In favourable places in roof or sole we can bore with a machine to a depth of 6 or 8 feet, and charge accordingly, bringing enormous burdens. In ore places, if not cautiously used, it smashes the rock, I think, over much.”

Mr. Hort Huxham, M.I.C.E., writes, "for breaking up large masses of cast iron, "horses" from the bottoms of the iron-smelting furnaces, and such-like refractory material, Gunpowder is practically *non-effective*, and the desired effect can only be obtained with dynamite or nitro-glycerine.* For penetrating the very hard siliceous "Pennant" sandstones and other hard rocks of this district, especially when heavily watered, the greatest economy and efficiency is arrived at when using a quick powerful explosive, such as Dynamite, *with bore holes of small diameter*. For dealing with moderately hard rocks and strong ground, other conditions, such as quantity of water, thickness and inclination of the beds, fissures and joints, size of pit or heading, ventilation, &c., would govern the economical and effective use of the explosive. For shales and other soft ground the slower acting explosives, gunpowder—used with bore-holes of larger diameter—are much superior to Dynamite in effectiveness and economy, and for even the hardest coal the latter explosive is useless. Practically, only Gunpowder and Dynamite are used in this (S. Wales) district."

* This remark is inserted here, notwithstanding its direct reference to foundry operations, because it indicates a possible use for dynamite, or other "strong" explosive in breaking up exceptionally hard rocks—or in piercing them, as, for instance rocks like the Cornish "ire-stones."

From the foregoing experiments and returns it appears certain that for all ground which is not of great hardness or very wet, the explosives of moderate power, such as compressed powder and common powder, are most advantageous—the relative economy being in the above order. Next comes Espir's powder, while the special strong powder seems to be practically out of the competition, owing to its very high price.

The Committee has not enough information before it to enable it to decide as to the relative merits of coarse, medium, and fine-grained powders.

Where the ground is damp the compressed powder has a special advantage, as it may be used without preparation, while the other powders must be made up into cartridges or the holes must be clayed.

For ground of extreme hardness, or which is very wet, the stronger explosives should be used, such as Dynamite, Liverpool Cotton Powder, and Tonite.

In hard and fissured ground there is a great advantage in using Dynamite, Tonite, or Liverpool Cotton Powder, but with dynamite this is accompanied by a corresponding danger, viz., that some of the unexploded material may be driven into fissures, where the nitro-glycerine may exude, and subsequently explode accidentally. The two latter are free from this disadvantage.

In wet ground there is always a danger of the exudation of nitro-glycerine from dynamite, we therefore think that it should be always made up into waterproofed cartridges for use in such ground.

As to danger—Capt. Tregay says “In fissured ground there is always danger when using Dynamite, from some of the explosive being driven away into the fissures instead of exploding. Under such circumstances, there are sufficient causes for the nitro-glycerine becoming detached by exudation, and liable to explosion from the slightest blow. We had an accident in Pednandrea in this manner, in hard close killas, with no more fissures than usually occur in such rock.”

“The detonator *necessary* for the explosion of Dynamite is an ever-present danger, as it explodes with the slightest blow; it is dangerous for the men to keep about them while working, and equally dangerous to lay aside where other men or boys are about. I have known an accident from their having been laid aside and not picked up again. It is I think desirable that the price of Dynamite should be kept *up* as it may tend to the introduction of a *safer* and more economical explosive, which I look for in Gunpowder, greatly compressed, and of a much higher quality than heretofore used in blasting operations. . . . By care and

skilful use *every accident with gunpowder may be avoided*, while with Dynamite no one knows how accidents occur, consequently *no amount of care can protect.*”

Capt. Chas. Thomas says—“The chief danger in using Dynamite is exudation of nitro-glycerine, hence care should be taken to explode the whole charge.”

Sir Geo. M. Denys says—“We have never yet had an accident with Dynamite, and only once with Gun-cotton, in stemming.”

Mr. A. L. Stevenson, of Durham, says,—“My opinion is that Gunpowder, when used with safety-fuse, and supplied to the men in small cases or in cartridges, is the safest, but if carelessly used, or carried loose, or in bags (as was frequently the case some years ago), I think it more liable to accident than Dynamite. If gunpowder be used in the form of a cartridge, with safety-fuse attached, and carefully rammed with a copper rammer, with dry clay or other like material, free from grit, there is I believe no safer explosive in the market. Dynamite, on the contrary, should be used without tamping of any description, other than water or fine dry sand, poured in loosely, so as to avoid the danger of concussion from tamping with a rammer.”

“In regard to boring holes after the use of Dynamite, I heard of a case where in boring a fresh hole, an explosion took place with fatal results, upon the boring chisel striking into a slight fissure in the limestone rock, at a depth of two feet, into which it is supposed some nitro-glycerine from Dynamite must have percolated from another hole that had been charged in its vicinity.”

“The fumes of gunpowder are very readily dealt with by the ordinary means of underground ventilation, and in no case have I ever seen or heard of the densest fumes seriously affecting the men, but if the air is allowed to be constantly loaded with them, and no sufficient ventilating current established, then the constant inhalation prejudicially affects the men.”

“When dynamite is properly exploded, the amount of noxious gases given off is small, and by waiting a very short time the slight fumes are carried off by the ventilating current. If, however, Dynamite is *not* thoroughly exploded, and partly or wholly *burns* away, the resulting nitrous gases are considerable in volume, and highly dangerous for the men to breathe. Fatal results have from time to time arisen from this cause, by the men returning before the fumes have cleared away. In any unventilated pit or drift, or other confined working place, I should consider it dangerous for the men to return after an explosion of Dynamite, without allowing a considerable time to elapse.”

The following return from the Report of H.M's Inspectors of Explosives, for the year 1878, is here given so far as it relates to accidents from explosives in mining proper and quarrying, *i.e.* in working or preparing to work. Accidents in the process of manufacture are not here reported.*

DATE.	EXPLOSIVE.	LOCALITY.	RESULTS.	
			Killed.	Injured.
January 17, 1878...	Tonite	West Basset	0	1
" 24, " ...	Dynamite	Llanberis	2	0
" 30, " ...	Tonite	West Basset	0	1
February 4, " ...	Dynamite	Wheal Uny	0	1
" 6, " ...	Dynamite	Festiniog	0	4
" 23, " ...	Dynamite	Llanberis	0	1
March 8, " ...	Dynamite	Festiniog	0	1
" 11, " ...	Gunpowder	Festiniog	0	1
" 30, " ...	Dynamite	Wheal Agar	1	0
April 10, " ...	Guncotton	Halkyn Level	1	118
June " ...	Tonite	Llanberis	1	0
May 14, " ...	Dynamite	Yarlside Barrow	1	0
June 20, " ...	Dynamite	West Seton	0	1
" 22, " ...	Gunpowder	Gorsedd Mine	0	2
July 4, " ...	Dynamite	Yarlside Mines... ..	0	1
" 6, " ...	Gunpowder	Henry Pit, Whitehaven	1	0
" 2, " ...	Dynamite	Stainton	0	1
May 3, " ...	Guncotton	Park Slate Quarry	0	1
July 23, " ...	Gunpowder	Dolcoath	1	0
August 5, " ...	Dynamite	Moor Row, Whitehaven	1	0
" 7, " ...	Gunpowder	Assheton Mine... ..	0	1
" 23, " ...	Gunpowder	Wheal Sisters	0	1
Sep'r 19, " ...	Gunpowder	Festiniog	0	1
" 26, " ...	Dynamite	Festiniog	1	4
" 27, " ...	Dynamite	Carn Brea Mine	2	3
" 27, " ...	Gunpowder	Mount Batten	1	0
October 14, " ...	Gunpowder	Roanhead Mines	0	2
August 2, " ...	Gunpowder	Llanelly	1	0
October 15, " ...	Gunpowder	Festiniog	1	0
" 20, " ...	Gunpowder	Carn Brea Mine	0	2
" 14, " ...	Gunpowder	Crumner	2	0
Nov'r 7, " ...	Gunpowder	Deal and Dover Railway... ..	0	1
" 21, " ...	Gunpowder	Red Hill Cutting	0	2
" 22, " ...	Dynamite	Carn Brea Mine	0	2
Dec'r 4, " ...	Dynamite	Letterwood	2	0
" 7, " ...	Gunpowder	Rhiwbryfdir	0	1
" 10, " ...	Gunpowder	Craigton Quarry	1	0
" " ...	Gunpowder	Llanberis	1	0
" 21, " ...	Dynamite	Talargoch... ..	1	1
January 5, " ...	Tonite	West Basset	0	2
Feb'y 20, " ...	Gunpowder	Allet... ..	0	1
April 5, " ...	Gunpowder	Dolcoath	0	1
May 8, " ...	Gunpowder	Phœnix	0	2
			23	54

* It should be noted that this Report is not complete as regards accidents in mines. Seven non-fatal accidents which occurred in Cornwall and Devon during the year 1878, of which four occurred while working or preparing to work, are here added to the return of the Inspectors of Explosives. Of others which occurred in other districts we have not been able to gather the particulars.

Explosive.	Total No. of Accidents.	Men Killed.	Men Injured.
Tonite	4	1	4
Guncotton	2	1	12
Dynamite	16	12	20
Gunpowder... ..	21	9	18
	43	23	54

In estimating the value of the facts above stated, it should be borne in mind that we have no account of the relative amounts of the different explosives used.

The danger of using Dynamite at the bottom of a hole and Gunpowder or other explosive above, is illustrated by the Maen Offeren Slate Quarry accident, where a hole 2 feet deep was bored, a ball of Dynamite was placed in the bottom, and the charging was completed with powder. The powder was then exploded, but the Dynamite appears to have been driven into the fissures. In subsequently drilling out, the hole exploded.

We think that in no case should "high" and "low" explosives be placed one over the other in the same hole.

CONCLUDING REMARKS.

We much regret that we are not able to carry out any further experiments beyond those detailed above. We especially desired to institute further experiments as to the actual relative economy of the explosives in each class under conditions selected as most suitable for their respective use.

Again, experiments are much needed with a view to the discovery of simple tests, capable of being applied by the miner to the different explosives supplied, as well to secure uniformity of character and composition as to enable him to make a choice between explosives of the same names supplied by different makers.*

§ *Halkyn Level Accident.*—This very serious accident was traceable to a statement made and published by the Gun Cotton Manufacturers, that "in close workings the absence of smoke or noxious gases renders the use of Guncotton doubly valuable." This statement has since been withdrawn, but it is evident that a similar impression is widely prevalent as regards Dynamite fumes. Indeed the average workman is always too ready to suppose that where there is no black smoke there can be nothing injurious.

‡ *Roanhead Accident.*—The hole had been previously charged with Dynamite, which "did not throw its burden, so they subsequently charged it with Gunpowder, and while putting down the first lot of stemming it exploded, and seriously injured them."

* There is much reason to believe that the quality of blasting powder in particular, as met with in the market, varies considerably. The examination of a sample of gunpowder should include such observations and tests as follows:—

1. Condition as to colour, glaze, hardness, freedom from dust, &c.
2. Specific gravity or density.
3. Whether the powder be properly incorporated.
4. Its chemical composition.
5. Its power of withstanding the absorption of moisture.

REPORT OF THE EXPLOSIVES COMMITTEE

We also desired to make comparative experiments as to the qualities of the different kinds of safety-fuse in the market, on the detonators used for exploding dynamite, tonite, &c., and on the nature of the fumes evolved when the various explosives were partially or completely exploded. All this was found to be impossible, owing to the very limited response which was made to our appeal for funds from those specially interested.

The foregoing report was finally adopted unanimously (after considerable discussion), at a meeting which was attended by the following members.

Capt. R. H. Williams, *Chairman*

Mr. Thomas Clark.

Mr. B. Kitto.

Mr. Howard Fox.

Mr. F. W. Michell.

Capt. John Hosking.

Mr. J. F. Penrose.

Dr. Hudson.

Mr. G. J. Smith.

Mr. J. H. Collins, *Secretary*.

The following members who were prevented from attending have also signified their assent.

Mr. John P. Bennetts.

Mr. John Darlington.

Mr. Wm. M. Grylls.

Capt. Josiah Thomas.

No member of the Committee has expressed dissent to this report.

(Signed)

J. H. COLLINS, *Secretary*.

By order of the Committee.