Notebook
'Specific Gravities'
1918
with Letter from
Mr. E. A. Baker

NOTEBOOK HEADED

'SPECIFIC GRAVITIES'

1918

Sent by Mr. E. A. Baker

to Dr. J. Wright

with letter of 20-5-2002

E.A.Baker
24 Habberley Lane
Kidderminster
Worcs
DY115JT

29th May 2002

To Dr J Wright

Dear John

I very much enjoyed our trip to Bishopton and regretted to some extent that we couldn't spend longer there. Since coming back I have spoken to 'K' Birdi about a contact at Summerfield.He suggests Bob Bosher whose formal title is Head of Programmes.The address is

Royal Ordnance/Bae Systems
Summerfield
Kidderminste
Worcs
DY11 7RZ

I would suggest that a fairly formal letter with an initial emphasis on "would Summerfield wish to contribute, especially on the Cast Double Base Side"rbut not forgetting that they now have EDB,Composite,Inhibition,etc on site.
I have also spoken to Hugh Roberts at Martin-Baker.He has made enquiries and suggests that the contact should be Andrew Martin. Andrew is the son of Jim Martin. I think that this is one of the two brothers,themselves sons of James, the co-founder.Andrew Martin told Hugh that they had been approached by the Curator some time age and had supplied some film so I think that we need to clarify with the Curator before treading in too heavily.Hugh is fairly certain that MB will be quite happy to supply exhibition material,hardware,etc.He feels that Andrew may not be fully aware of the extent of WA involvement with the propellants,particularly the underseat rocket pack,extending over a period of over 40 years,to say nothing of the 10 years consultancy since my retirement! The address is

Martin-Baker Aircraft Company Limited
Higher Denham
Nr Uxbridge
Middlesex
UB9 5AJ

I thought that you might find the enclosed note -

book interesting.I am not sure where it came from: I don't think that it came over from Woolwich although the clarity is very much in line with other old ledgers and notebooks I saw there. I was particularly intiged at this chap sitting in a the lab determining the density of nitroglycerine using a density bottle and taking it down to 0 degrees C whilst doing so.I am also puzzled why,after several decades of use,it was necessary to determine the densities of GC and NG.Incidentally,the values obtained are almost exactly spot on the values still used.

I am away all next week but will continue the trawl of my 'archives' when I get back.

Best wishes

Eric

E.A.Baker

SPECIFIC GRAVITIES
WASC 2119

5

G. R.

ARMY BOOK 136.

(12195) Wt. W556—M1649. 70000. 5/17 Sir J. C. & S.

1918 Specific Gravities.

July 2.

Sp. G. of lead foil.

Wt. with hair in air, 1·4110

" " " " " water 1·2462

Wt. of water displaced. ·1648 at 21°C.

Vol. of water displaced :

$$\cdot 1648 + \frac{\cdot 1648 \times 3\cdot 03}{1000} = \cdot 1653$$

~~Specific Gravity~~ Density : $= \frac{1\cdot 411}{\cdot 1653} =$ ~~·6555~~ ~~·8530~~

(water was a mixture of tap & distilled.) = 8·536

Density of tin is 7·298 at 15° C.

Repeated in distilled water at 22·5

1·4110

1·2464

·1646

Vol. of water displaced :

$$\cdot 1646 + \frac{\cdot 1646 \times 3\cdot 37}{1000} = \cdot 1652$$

Sp. g. = 8·541

Calculated proportion of tin + lead
from simple mixture law.

Density of tin at 15° is 7.298
lead at 15° 11.352

$7.298x + (1-x)\,11.352 = 8.541$; x is proportion of tin

$x = \cdot 693$

From recorded values for alloys, x = 69.5 %.

July 3. ~~Spec~~ Densities of solids in powder.

Tare of bottle 8.2340

Comparison of thermometer 621978 with standard.

Standard	19.2	20.2	20.1
Corrected standard	19.1	20.1	20.0
621978	19.0	20.1	20.0

Weight of bottle + water up to mark at 20.0 °C.

$$\begin{array}{r} 29.0867 \\ 8.2340 \\ \hline 20.8527 \end{array}$$

July 10 ~~Specific Gravity of saturated solution~~

True volume of the specific gravity bottle
at 20° C.

Density of saturated solution of Methyl C.E. at 20° C.

	29·0868
Tare of bottle.	·8·23406
	20·8528

Methyl C.E. + bottle	9·5570
	8·2340
	1·323

This exp. was abandoned as some of the C.E. was lost in boiling out the air under reduced pressure.

Comparison of thermometers

corrected 621978	Calderaria 1.	2.	3.
20·01	19·97	19·88	19·87
melting ice	0	0	0

July 12. Heater for thermostat.

Length of No. 27 nichrome wire = 617 cm.

At 250° C. the resistance would be about 66 ohms.

Relation between current & temperature when wire is stretched horizontally in the air.

100° C.	·86 ampere.
200° C.	1·3 ampere
300° C.	1·7 ampere.

Heating effect of a current.

A = amperes.

V = Volts.

In one second ·24 V A.

In case of the above heater,

when V = 100 ; A = 1·5.

Heat per sec = ·24 x 150 = 36 cals.

∴ in 1 minute 2160 cal.

Volume of the thermostat is about 17·7 litres.

∴ in one minute the heater will raise it about ·122° C. if there is no loss. i.e. 1° in 8·2 minutes.

With a current of 1·7 amperes V = 125
Heat evolved would be ·24 × 125 × 1·7
= 51 cals. per second
= 3060 cals per minute.
or contents of bath raised 1° in 5·8'

According to Molesworth's pocket book, a lamp of 100 c.p. will give heat enough to raise 115 lbs. of water 10° F in 1 hour. i.e. about ~~5 200~~ 4900 cal. per minute.
or contents of bath rai

July 19th. 1918.

Specific gravity bottle + water at 40°c.

	79·5758
Tare of bottle,	29·8910
	49·6848

Specific G. bottle + water at 20°C.

79·8540
29·8910
49·963

Sp. G. bottle + methyl C.E. 32·0774

This exp. was abandoned because on immersing the bottle in water at 40° C. & sucking with water pump, the methyl C.E. distilled in steam.

July 20.

Sp. G. bottle + M.C.E.	31·0434
bottle	29·8910
	1·1524

at 20° Sp. g. bottle + M.C.E. + water	80·2794
at 20°, bottle + water only	79·8540
	·4254
Wt. of M.C.E.	1·1524
	·4254
Wt. of water displaced.	·727

Sp g = 1·585

Volume of water displaced = ·7270 × 1·002835
= ·72906 (log is 8627639)

Density = 1·58066 say 1·581

Vol. of 1 gram = $\frac{1}{1·5806}$ = ·6326 cc.

Correcting wt. of solid for buoyancy, 1·58163

July 21.

Wt. of sp. g. bottle + M.C.E. + water at 40° C. weighed after standing over night = 79·9876 at 3 pm.
after standing overnight again. 79·9857 at ... am.
lost in 19 hours ·0019

Repeated by refilling with water & again keeping at 40° C. 80·0059
At 40°, bottle + water only 79·5758
·4301

Wt. of M.C.E	1·1524
	·4301
Wt. of water displaced	·7223

Vol. of water displaced = ·7223 × $\frac{1·00706}{·99224}$
= ·72872 (log is 8625610)

Density =

Using figures from previous measurement allow for loss over night ·002.

79·9896	1·1524
79·5758	·4138
·4138	·7386

Volume = ·7386 × $\frac{1·00706}{·99224}$ → log 0004341 → log 9966167 = log 87222

Density = 1·546

Using the mean of the two values 79.9896 and 80.0059

i.e. 79.9977, wt. of water displaced is

1.1524 − (79.9977 − 79.5758) = .7305 gram

Vol. displaced = .7305 × $\frac{1.00106}{.99224}$ = .73695 c.c.

Density = 1.574 ; volume = $\frac{1}{1.574}$ = .6394 c.c.

Coeff of expansion = $\frac{.6394 - .6325}{20°}$ = $\frac{.0069}{20°}$ = .000345

July 22.

~~Sp.~~ Density of saturated solution of Hexa nitro-diphenylamine at 20°.

Bottle + soln.	79.8532
Bottle + H.N.D.	31.8782
Bottle (reweighed)	29.8910
	1.9872

July 23.

Bottle, soln. + HND. at 20°C.	80.7154
~~Bottle~~ + ~~Sol~~n. (average of two) (if taken)	79.8532 ~~6~~
	~~.8622~~
	.8618

Wt. of water displaced = ~~1.9872 − .8622 = 1.1250~~ ; 1.9872 − .8618 = 1.1254

Volume of water displaced = 1.1254 × 1.002835

= 1.1284 c.c.

Density = → 1.7614 ; 1.761~~7~~

Vol. of liq. =

At 40°C.

Bottle + HND + soln at 40° =	80.4436
Bottle + soln at 40°	79.5758
	.8678

Wt. of water displaced = 1.9872 − .8678 = 1.1194

Vol. of water displaced = 1.1194 × $\frac{1.00106}{.99224}$

= 1.1293

Density = 1.7596

Recalculated with 6 figure logs.

$\log_{10}$ 1.002835 = .0012300

$\log_{10}$ $\frac{1.00106}{.99224}$ = ~~.000~~ ~~.0038434~~ .0038434

At 20°. Wt. displaced = 1.125
Vol. displaced = 1.1286 c.c.
Density = 1.7608
Volume ·567931

At 40° Wt. displaced 1.1194
Vol. displaced = 1.129~~46~~ 35 c.c.
Density = 1.7596
Sp. Volume = ·568312 c.c.

Coeff of expansion =

$$\frac{\cdot 568312 - \cdot 567931}{20}$$

= ·000019 per °C.

The bottle + H.N.D. + soln. weighed again: 80.4334
79.5758
·8576

Recalculation for 40°C.

1·9872
·8576
1·1296 = wt. of water displaced.

1·9872

Density = 1·1296 × log⁻¹ ·0038434
= 1·7437
Vol. = ·57349

Coeff. of expansion =

$$\frac{\cdot 57349 - \cdot 567931}{20}$$

$$= \frac{\cdot 00556}{20} = \cdot 000278$$

July 24. Tri-nitro-anisol

Density of saturated solution.
Bottle + soln. at 20° = 79.8562

Bottle + T.N.A. 34.2188
Bottle 29.891
4.3278

abandoned as bulk was too great for convenient boiling out of air.

July 2~~5~~ Powdered

Bottle, T.N.A. + 32·4967
abandoned.

Bottle, + TNA 31·5525
29·891
1·6615

Bottle + TNA + ~~soln.~~ at 20° 80·5153
Bottle + soln. 79

Bottle + TNA + soln. @ 40° 80·2435
after standing longer in case, 80·2426
Bottle + ~~soln~~ 79·~~8569~~
~~Wt of water displaced = ·3864~~
Vol. displaced = ·3864 × ~~1·002835~~ 1·00106
99224
=

Calculation, at 20°.

Bottle + soln + TNA 80·5153
Bottle + soln 79·8562
Increase in wt. ·6591

Wt. displaced = 1·6615 − ·6591 = 1·0024 g.
Vol. displaced = 1·0024 × 1·002835
= 1·00534
Density = 1·65283
Volume = ·60502

Calculation, at 40°.

Bottle + soln + TNA 80·2426
Bottle + soln 79·5788
·6638

Wt. displaced = 1·6615 − ·6638 = ·9977
Vol. displaced = ·9977 × 1·00106
99224
= 1·00656
Density = 1·6507
Volume ·60582

Coeff of exp. = ·00004

(July 27) Tri-nitro-anisol, continued.

Some of the clear solution was ~~boiled~~ removed & the remainder boiled again, at about 30° C., cooled, made up to the mark at 20° C.

Bottle T.N.A. + soln. at 20° : 80·5122

Bottle, TNA + soln @ 40° : 80·2370

Refilled again after removing stopper, to ascertain variation ~~in position~~ due to position of stopper.

~~B.~~

Bottle, TNA + soln @ 20° : 80·5124

Bottle TNA + soln @ 40° : 80·2418

Bottle + soln. only at 20° 79·8566

Bottle + soln. only, at 40°. 79·5844

Recalculation of Density at 20° C.

Bottle + soln + T.N.A.

	80·5153	
A	80·5122	80·5133
	80·5124	

Bottle + soln only.

	79·8562	
B.	79·8566	79·8564

Wt. of T.N.A.	1·6615
A – B	·6569
Wt. liquid displaced	1·0046
Volume displaced	= 1·0046 × 1·002835
	= 1·00745

Density = 1·6492

Volume of 1 g = ·60635

This may be corrected for the greater density of the solution than density of water used in above calculation, i.e. × $\frac{49·9652}{49·963}$, bringing

Density to 1·6493

Volume to ·60632.

Density at 40° C. of solution of T.N.A. ~~saturated~~ at 40°.

TNA was shaken with water at about 50° + cooled down, with occasional shaking to 40° in a thermostat at 40°, then blown through cotton wool into the bottle also in the thermostat;

Wt. of sol. sat at 40° + bottle = 79.5924
Weighed next morning to ascertain loss on standing 79.571

~~As in density determination at 40°, equilibrium could not be established owing to absence of stirring, the solution would not be saturated, but would contain a little more than at 20°.~~
~~The difference in wt. of solution sat. at 40°, at 40°, + soln sat. at 20°, at 40°, is ·008 g.~~
~~an allowance of ·002 g., 1/4 this difference, is added to the wt. of bottle + T.N.A. + soln. at 40°.~~

Calculation at 40°.

Bottle + soln + TNA

80.2426
80.2370 } 80.2405
80.2418

Bottle + solution only 79.5924
Difference ·6481

Wt. TNA 1.6615
Difference ·6481
Wt. liquid displaced = 1.0134

Vol. = $1.0134 \times \frac{100706}{99224}$ = 1.0224 cc.

Density = 1.6251
Vol. of 1 cc = ·615353

Coeff of expansion = ·000457

July 31 Density of Hydrazine Nitrate.

Saturated soln. (at 20°) in benzene,

+ bottle = ~~70~~ ~~73.8~~

73.790

This value is not very reliable as the liquid began to ooze out of the hole during the weighing; the rate of evaporation was 2 m.g. per minute which was allowed for.

July 31 Density of Nitroglycerine.

Tare of pyknometer:	15.7383
NG + pyknometer	19.2692

This solidified at 0° + block up the tube air was disengaged on solidification; escaped on remelting. The pyknometer ∴ could not be used.

Aug 1

N.G. + pyk.	17.8990
at 20°, N.G. + pyk + petr. ether	24.1672
at 20° pyk + petr. ether	22.887
at 20° pyk + water	26.9318
Tare of pyknometer after	15.7382

Aug. 2.

Tare of new bottle + cork	10·0540
bottle + n.g.	18·9338
bottle + n.g. + petr. ether at 0°.	28·995
repeated	29·0002
	2 | 57·9952
average.	28·9976
bottle + petr. ether at 0°.	23·7420
bottle + water at 0°	30·9388

Calculation

Density of petroleum ether at 20°.

Wt. water at 20° : 26·9318
15·7382
11·1936 g.

Volume of pyk. at 20° : 11·1936 × 1·002835
= 11·2254 c.c.

Wt. of petr. ether : 22·8870
15·7382
7·1488

Density of petr. ether at 20° : ·636844

making correction for buoyancy of air.

True wt. of petrol ether is

7·1488 + 7·1488 × ·0016

= 7·1488 + 115

Values by this method were too low owing to solution of petroleum ether.

August 19

The sp. G. bottle was filled with n.g. (by I.M.) which was frozen. The total wt. at 0° C. with another cork was

46·0555 g.

Excess of wt. of new over old cork, ·2676

Wt. with old cork 45·7879

Total wt. when liquid at 19·8° c. was

43·5750

allowance for cork as above ·2676

43·3074

Wt. with old cork when liquid at 0° c.

with my weights : 43·8530 & balance.

with Capt. K's weights. 43·8526 ..

Calculation :

Solid at 0° C.

Wt. N.G. : 30·0497 corrected for buoyancy of air,

: 30·0659 (added $\frac{30·05 \times ·54}{1000}$)

Wt. water : 17·2006 corrected for buoyancy,

: 17·2188 (added $\frac{17·2 \times 1·06}{1000}$)

(log^{-1} 2360602)

Volume of water : 1·000132 × 17·2188 = 17·221 c.c.

Density = 1·74588 say 1·746 g.

Volume = ·572777 say ·5728 cc.

Liquid at 0° C.

Wt. N.G. : 28·1148 corrected for buoyancy,

28·1314

Volume of bottle as above, is 17·221 cc.

Density = 1·63354 say 1·634

Volume = ·612164 cc. say ·6122

At 20° the bottle should hold 17·2006 × 1·001693

= ~~17·2297~~ 17·2297 cc. = log^{-1} 2362781

& almost the same at 19·8° C.

Calculation of density of liquid at 19·8°C; using calculated value of volume of bottle.

~~Wt. of N.G. : 27·5692 / ·0168 / 27·5860 corrected for buoyancy, (added 27·6 × ·61 / 1000)~~

~~Vol. 17·2297~~

~~Density :~~

Wt. of N.G = 33·2534 / ·0202 / 33·2736 corrected for buoyancy

Vol. of bottle at 20° by calculation from that at 0°
= 20·8848 × 1·001693 = $\log^{-1}$ 3271214

Density = 1·56667
Vol. = ·638295

Coeff of expansion : ·638295 / ·618173 / ·020122 in 19·8°C.

per degree = ·020122 / 19·8 = ·001017

Calculation of density of N.G.

Solid at 0°C.

Wt. N.g. : 35·7339 / ~~30·0447~~ / 35·7531 / ~~30·0659~~ corrected for buoyancy (35·7 × ·54 added)

Wt. water : 20·8848

corrected for buoyancy, etc,

Volume = 20·8848 × 1·001192
= $\log^{-1}$ 3203477

Density : ~~1·701~~ 1·710
Volume = ·584837

Liquid at 0°C.

Wt. N.G. = 33·799 / ·026 / 33·825 corrected for buoyancy by adding ·61 × 33·8 / 1000

Density = 1·61767
Vol. = ·618173

August 20. Density of N.G. solid at 0° C.

gross	46·2398
tare	10·0540
	36·1858

Corrected for buoyancy $+\frac{36.2 \times .54}{1000}$: 36·2053

Density : $\frac{36.2053}{\log^{-1} 3203477}$ = 1·7315

Volume : ·57753

at 10°C.

The n.g. was frozen at 0°, allowed to melt a little by standing in the air: some bubbles escaping, then put in a bath at 10° for 4 hours. It did not ~~quite~~ freeze completely, a little liquid being left in the narrow part of the neck of the flask. The following value for the weight is therefore too low. 45·947

1918

Aug 24. Density of Hydrazine Nitrate.

New Sp. G. bottle: tare, with wire loop ~~+ small~~

without cork : 16·1822

with cork : 16·2995

Filled with water at 20°C, by pouring recently boiled distilled water through a funnel into the dry bottle,

weight, with cork, = 67·3994

After emptying, cleaning with chromic acid, + refilling, wiping off the water adhering to the neck,

67·4324

after wiping more carefully, 67·4296

In this case, the greater wt. may be due to the shape of the meniscus. When the water ~~p~~ was put into the dry bottle, the sides were not completely wetted. Wt. taken as 67·4296

after drying again, tare without cork = 16·1820

" " " with cork 16·2980

showing wt. of cork to have altered.

Wt. of cork alone = ·116

Using this tare, + rounding off, wt. of water at 20°

= 67·430 − 16·298 = 51·132 grams

Bottle, cork + ~~hydraz~~ benzene ~~saturated~~ with hydrazine nitrate at 20° = 61·2214

Wt. of cork unchanged. ·1160

61·1054

Bottle, cork + h.n. 18·8160

Bottle cork + h.n. + benzene 62·4261

after standing overthe 62·418

(August 26.) The benzene was boiled again + made up to the mark at 20°C.

Wt. with cork · 62·4280

Wt. of cork ·1157

62·3123

~~(Aug 26)~~ Density of ~~hydrazine nitrate~~ di-cyan-diamide

bottle, benzene saturated, + cork 61·2184

cork ·1159

61·1025

(Aug 27)

bottle, ~~dicyand.~~ + cork · 16·2980

bottle + cork + D.C.D. 18·3648

bottle, D.C.D. benzene + cork · 62·0004

cork ·1156

61·8848

repeating after reboiling

bottle, D.C.D. benzene + cork 61·9978

cork ·1157

61·8821

(Aug 28)

bottle, DCD benzene + cork 61·9966

cork ·1160

61·8806

average of the 3 readings, 61·8828

Calculations.

Hydrazine nitrate.

Vol. of sp. g. bottle at 20° =

51·132 × 1·002835 = 51·132 × log⁻¹ ·0012295,

= 51·277 c.c.

at 20° C. 44·9234 g. sat. soln. in benzene occupies same volume.

Wt. of h.n. = 2·518 g., corrected for buoyancy,

= 2·5194

Wt. of benzene displaced by this = 1·3111

$= \frac{1{\cdot}3111 \times 51{\cdot}132}{449234} \times 1{\cdot}002835$ c.c. ~~water~~

$\text{Density} = \frac{2{\cdot}5194 \times 449234}{1{\cdot}3111 \times 51132 \times 1{\cdot}002835}$

= 1·6835

Dicyan-diamide

at 20° C. 44·9205 g. sat. benzene soln. occupies same vol. as 51·132 g. water.

Wt. of D.C.D. = 2·0668 g., corrected for buoyancy,

= 2·0682 g.

Wt. of benzene displaced by this = 1·2865 g.

$\text{Density} = \frac{449205 \times 2{\cdot}0682}{1{\cdot}2865 \times 51{\cdot}132 \times 1{\cdot}002835}$

= 1·40833

(Aug 30) Density of Guncotton Admiralty

Standard. 16·8889

Tare of bottle only 16·1821

·7068

corrected for buoyancy = ·7109

bottle, G.C. water at 20° + cork 67·6990

cork ·1158

67·5832

67·7400

cork ·1160

67·624

(Sep 2)

67·692

cork ·1157

67·5763

average value 67·5945

with water only 67·314

excess: ·2805

Wt. water displaced = ·4263

Vol. at 20° of this = log^{-1} 63095

Density = 1·663

Water at 20° + bottle + cork 57·4460

cork ·1156

57·3304

The insides of the neck ~~inside~~ was moist.

This being more carefully dried, 57·4432

·1156

57·3276

The water was boiled under reduced pressure ~~befo~~ just as in a density determination.

(Sep. 3) Repetition:

G.C. + wet flask + cork 18·5244

~~G.~~ wet flask + cork 16·6104

cork ·1156

Wt. of G.C. 1·9140

G.C. + water + flask + cork 68·2110

cork ·1156

68·0954

67·3276

0·7678

Calculation of density.

Corrected wt. of G.C. =

1·914 + $\frac{1·914 \times ·58}{1000}$ = 1·915

	1·9140
Increase in wt. due to G.C. in water	·7678
Wt. of water displaced	1·1462

Vol. of water displaced = log⁻¹ 0594899

Density - - 1·66985 = 1·670

Sep. 6. 1918

Molecular Wt. of Mineral Jelly.

Tare of tube + cork, no wire 109·2

Naphthalene was put in the tube, melted at 85° thermometer + stirrer being in it, cooled in a Dewar Vessel in which a similar tube of hot water had been kept.

The rate of cooling decreased as the Dewar Vessel got warmed by successive operations.

Third determination of F.P. -

Time	Temp	Time	Temp
0	7·55	8½	6·773
1	7·14	9	6·77
2	6·84	10	6·773
3	6·63	11	6·773
4	6·7	12	6·770
5	6·73		
7	6·76		
8	6·77		

Degrees of supercooling, ·14°C.

In the 2nd experiment, F.P. was 6·770, supercooling ·06°C.

4th determ. of F.P.

Time	Temp	Time	Temp
0	6·97	5	6·802
1	6·70	6	6·800
2	6·48	7	6·800
3	6·72	8	6·79
4	6·792	9	

Super cooling, ·32° C.
F.P. 6·802

5th det. of FP.
Super cooling ·09° C.
F.P. 6·775

6th Det. of F.P.
Super cooling ·19
F.P. 6·770

Wt. of mineral jelly. 39·0025
38·0228
·9797

Wt. of naphthalene 133·18
109·2
23·98

F.P. of this mixture:
1. Super cooling, ·175°
F.P. 6·325

2. Supercooling ·08° C.
F.P. 6·332

3. Supercooling ·2° C.
F.P. 6·37

4. Supercooling ·21
F.P. 6·375
Rate of stirring 42 strokes per min.

5. Rate of stirring 48 per min.
Supercooling ·18
F.P. 6·32

6. Rate of stirring 51 per min.
Super cooling ·05°
F.P. 6·362

7. Rate of stirring 66 per min.
Supercooling ·065
F.P. 6·34

Wt. of tube + contents after experiments 134·08; loss

Summary

Naphthalene only		Naphthalene + jelly	
Super cooled	F.P	Super cooled	F.P.
·14	6·773	·145	6·325
·06	6·770	·08	6·332
·32	6·802	·20	6·37
·09	6·775	·21	6·375
·19	6·770	·18	6·32
		·05	6·362
average,	6·772	·065	6·34
	Average		6·346

Calculation of molar wt.

·9797 g. jelly in 23·9 g. solvent
i.e. 4·1 in 100.

Molar wt = $\frac{69 \times 4{\cdot}1}{{\cdot}426}$ = ~~654~~ 665

Sep. 11. F.P. of Naphthalene only.

1. Rate of stirring 71
Supercooling ·15
F.P. 7·002

2. Rate 71
Supercooling ·07
F.P. 7·015

3. Rate 66
Supercooling ·07
F.P. 7·00

4. Rate 96
Supercooling ·07
F.P. 7·002

5. Rate 96
Supercooling ·18
F.P. 7·00

6. Rate 96
S.C. ·10
F.P. 6·995

7. Rate 96
S.C. ·08
F.P. 7·00

8. Rate 110
S.C. ·12
F.P. 7·012

Wt. of naphthalene + tube + cork : 133·55
tube + cork, 109·2
naphthalene 24·35

Mineral jelly, 38·0228
36·1638
1·8590 = 7·63 % of naphthalene.

Wt. of tube + contents after exp. = 135·37, loss ·04

1) Rate 70
S.C. ·21
F.P. 6·267

2) Rate 80
S.C. ·05
F.P. 6·34

3) Rate 80
S.C. ·08
F.P. 6·335

4) Rate 81
S.C. ·08
F.P. 6·34

Calculation.

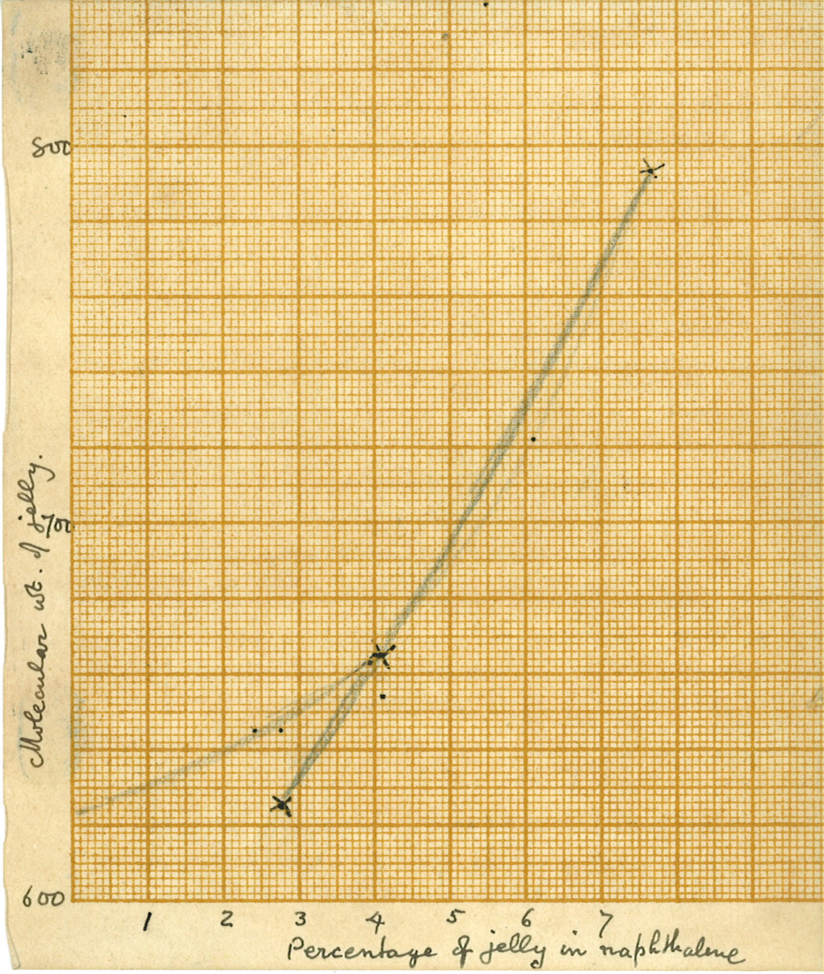
average F.P. of pure naphthalene = 7·002
7·015
7·001
7·002
7·000
6·995
7·000
7·072
8|56·076

average F.P. 7·003

~~Average~~ F.P. of m.j. solution, taking results 6·335, 6·34, 6·34, the ~~three~~ highest, = ~~6·34~~ 6·338

Lowering of F.P. = ·665

Molecular wt. of jelly = $\frac{69 \times 7.63}{.665}$ = 793



800
700
600
1
2
3
4
5
6
7
Molecular wt. of jelly.
Percentage of jelly in naphthalene

Sep. 12 Recalculation of 1st lowering, with 4.1% of jelly, using the 3 highest values; 6.370 for the F.P. of solution.

Molar wt. : $\frac{69 \times 4.1}{.402}$ = 7.03 (~~.347~~)

Using the 5 highest values, 6.332, 6.37, 6.375, 6.362, + 6.34, the molar wt is

$\frac{69 \times 4.1}{.416}$ = 680

F.P. of naphthalene only.

+. Tube charg with 133.35
109.2
24.15 g. of

naphthalene;

Rate	Supercooled	F.P.
1) 74	.12	7.165
86	.08	7.163
90	.03	7.172
88	.03	7.190
90	.10	7.175
70	.11	7.181
70	.10	7.180
average		7.175

Wt. of ~~naphthalene~~ mineral jelly 36.1638
35.918
.2458

i.e. 1.01% of naphthalene.

Stirring Rate	Supercooled	F.P.	
75	.05	7.085	7.085
78	.07	7.083	
76	.01	7.085	

Lowering of F.P. .09°C.

additional mineral jelly 35.918
35.4945
.4235
+ .2458
.6693
= 2.77%

Stirring Rate	Supercooled	F.P.	
72	.05	6.970	
68	.04	6.905	
71	.05	[6.862]	not heated long enough prob.
70	.03	6.915	
70	.04	6.923	
73	.03	6.923	
70	.06	6.935	
average		6.924	

Lowering of F.P. .251

Wt. of tube, cork + substance after exp.	134·05
Wt. of ~~contents~~ tube + cork	109·2
	24·85
Wt. of jelly added	·67
Wt. of naphthalene	24·18

Calculation.

% of jelly	Lowering	Molar Wt
1·018	·09	
2·77	·251	625

Summary of results to be reported.

By C.G.J.:	4·1 %	molar wt.	665
	7·63⁵%	—	793
	2·77%	—	625

Friday

Sep. 13. Molar Wt. of Carnauba Wax.

Tube + contents after exp.	130·62
New tare of tube only,	104·7~~X~~3

Rates, 72, 70; Supercooling, ·04, ·03; F.P. 7·28, 7·28

Wax	·546

% of naphthalene

Rate of stirring.	Supercooled	F.P.
72	·0~~1~~	7·085
"	·015	7·065
"	·045	7·085
"	·055	7·075
"	·04	7·071
"	·035	7·055
	average	7·076

Lowering: ·204 °C.

additional jelly	·572
previous wt.	·546
	1·118

Super cooled	F.P.
·05	6·860
·12	6·855
·035	6·875
average	6·863

lowering ·417

Calculation:

% of wax	Lowering	Molar weight
2·205	·204°	745
4·52	·417	748

The average composition of carnauba wax may be expressed by the formula $C_{24}H_{52}O_2$. The no. of atoms of carbon in the molecules of the substances of which it is said to consist varying from 21 to 30, the hydrogen from 42 to 62 + the oxygen from 1 to 3.
The molar wt of above formula is 372
372 x 2 = 744.

Sep. 16. 1918.
Manufacture of Azo - Will test apparatus.
1. Length of spiral from bottom of trap, 661 cm.
2. Length of spiral " " "

GAS ANALYSIS.

Oct. 3. Analysis of gas from . of ammonal in Bone + Wheeler's apparatus.
Constant volume to mark 100, the capillary tube at top not containing mercury.
Initial pressure reading, 678 mm.
Actual pressure: 678 − 99·5 = 578·5 mm.
temperature 17·5° C.
Nothing was absorbed by KOH or pyrogallol.
The gas was then treated with five successive portion of 3 to 4 c.c. of ammoniacal cuprous chloride with following results:—

No.	Pressure reading	Decrease in P.	Temp.
1	607·5	70·5	17·5°
2	588	90	17·5°
3	582·5	95·5	17·5°
4	579	99	17·5°
Oct 4. 5	577·5	100·5	17·1°

The percentage of carbon monoxide is therefore $\frac{100 \times 100 \cdot 5}{578 \cdot 5}$ = 17·36 %

October 5

Added oxygen prepared by heating potassium permanganate, allowed to stand over night.

October 6

Temperature 17.3° C.

Pressure reading, 613.5

Increase in pressure due to oxygen = 36 mm.

after sparking, pressure reading = 613

admitted hydrogen, pressure reading 646

no explosion on sparking.

admitted oxygen, pressure reading 673.5

October 7

admitted hydrogen. pressure reading 704.5 at 17.3°C

(pressure of hydrogen separately, 152 − 99.5 = 52.5 mm.)

exploded; pressure reading after, 544

absorbed CO_2, by KOH; pressure reading after, 544

absorbed oxygen, pressure reading after, 543

Total press. of oxygen added	63.5
hydrogen	64
Contraction due to combustion of 64 hydrogen,	96
actual contraction	160.5
excess contraction	64.5
corresponds to 2/3 of 64.5 hydrogen, i.e.	41

needing of oxygen for combustion together with

added hydrogen,	52.5
oxygen added	63.5
excess oxygen	11

But only 1 mm. excess oxygen was found. Neglect this discrepancy as due to nitrogen in the oxygen, Composition of the gas is

Hydrogen	7.1
Carbon monoxide	17.4
nitrogen	75.5
	100

Diameter of watch glass 22.3 mm.

Weight of coil of no. 24 nich. wire 25.80

2 feet 1.04 g.

Length of wire in coil, $= 2 \times \frac{25.8}{1.04} = 49.7$ feet.

Length of coil, closely wound part only, 2.6 cm.

Each section must be 2.6 cm, say 2.5.

Oct. 22 Explosion calculation.

Carbon with ammonium nitrate.

Volume of gas at N.T.P. including water vapour.

$C + 2NH_4NO_3 = 2N_2 + 4H_2O + CO_2$

172 grams → 7 × 22.4 litres

1 → ·910

Heat of explosion.

(a) $2NH_4NO_3 = 2N_2 + 4H_2 + 3O_2 - 2 \times 88050$

(b) $C + O_2 = CO_2 + 94300$

(c) $4H_2 + 2O_2 = 4H_2O + 4 \times 58100$

(b) + (c) − (a) = 150,600 cal for 172 g; for 1 gram 876 cal.

Carbon with half above quantity:

Volume of gas at N.T.P.

$C + NH_4NO_3 = N_2 + {\cdot}6CO + {\cdot}4CO_2 + {\cdot}4H_2 + 1{\cdot}6H_2O$

12 80 = 22·4 (1 + ·6 + ·4 + ·4 + 1·6)

1 gram = ·974 litres.

Heat of explosion.

(a) − Formation of amm. nitrate from elements; = 88050 cal.

(b) $\cdot 6C + \cdot 3O_2 = \cdot 6CO + \cdot 6 \times 26{,}300$ cal

(c) $\cdot 4C + \cdot 4O_2 = \cdot 4CO_2 + \cdot 4 \times 94300$ cal

(d) $1{\cdot}6H_2 + \cdot 8O_2 = 1{\cdot}6H_2O + 1{\cdot}6 \times 58100$ cal

(b) + (c) + (d) − (a) = 58,250 for 92 grams,

for one gram, 633 calories.

Carbon with ammonium perchlorate.

Vol. of gas at N.T.P. including water + hydrochloric acid vapours.

$5C + 4NH_4ClO_4 = 5CO_2 + 2N_2 + 4HCl + 6H_2O$

530 grams = 17 × 22.4 litres

1 = ·719 litres

Heat of explosion.

(a) $4NH_4ClO_4 = 2N_2 + 8H_2 + 2Cl_2 + 8O_2 - 4 \times 7970$

(b) $5C + 5O_2 = 5CO_2 + 5 \times 94300$

(c) $6H_2 + 3O_2 = 6H_2O + 6 \times 58100$

(d) $2H_2 + 2Cl_2 = 4HCl + 4 \times 22000$

(b) + (c) + (d) − (a) = 876220 for 530 grams,

i.e. 1652 cal. for 1 gram.

Carbon with half above quantity of perchlorate.

$5C + 2NH_4ClO_4 = N_2 + 2HCl + 1{\cdot}1H_2 + 1{\cdot}9H_2O + 3{\cdot}9CO + 1{\cdot}1CO_2$

60 + 2 × 117·5 = 22·4 (1 + 2 + 1·1 + 1·9 + 3·9 + 1·1)

1 gram = ·835 litres.

Heat of explosion.

(a) Formation of $2NH_4ClO_4$ = 2 × 7970 = 1594 cal

(b) " " $1{\cdot}1CO_2$ = 1·1 × 94300 = 103,800

(c) " " $3{\cdot}9CO$ = 3·9 × 26300 = 102,600

(d) " $2HCl$ = 2 × 22000 = 44,000

(e) $1{\cdot}9H_2O$ = 1·9 × 58100 = 110,300

(b) + (c) + (d) + (e) − (a) = 360700 for 295 grams

i.e. for one gram, 1223 calories

Mineral jelly with ammonium perchlorate.

Vol. of gas at N.T.P. including water + hydrochloric acid.

$5\,C_{20}H_{42} + 122\,NH_4ClO_4 = 61\,N_2 + 122\,HCl + 100\,CO_2 + 288\,H_2O$

15754 grams → 22.4 × 571 litres.

1 → ·812 litre per gram.

Heat of explosion.

(a) $122\,NH_4ClO_4 = 61\,N_2 + 244\,H_2 + 122\,Cl + 244\,O_2 + 122 \times 7970$

(b) $5\,C_{20}H_{42} = 100\,C + 105\,H_2 + 5 \times 447 \times 282$

(c) $61\,H_2 + 61\,Cl_2 = 122\,HCl + 22000 \times 122$

(d) $100\,C + 100\,O_2 = 100\,CO_2 + 94300 \times 100$

(e) $288\,H_2 + 244\,O_2 = 288\,H_2O + 288 \times 58100$

(c) + (d) + (e) − (a + b) = 27,222,000 for 15754 grams

= 1727 calories per gram.

Summary

Exploding mixture.	% of carbon	Litres per gram.	Calories per g.
$C + 2\,NH_4NO_3$	6·98%	·910	876
$C + NH_4NO_3$	13·05%	·974	633
$5C + 4\,NH_4ClO_4$	11·32%	·719	1652
$5C + 2\,NH_4ClO_4$	20·33	·835	1223
$5\,C_{20}H_{42} + 122\,NH_4ClO_4$		·812	1727
Ammon-pulver	15%		

Carbon with 4/5 mol. of ammonium nitrate

~~$5C + 4\,NH_4NO_3 = 4.4\,CO + 1.4\,CO_2 + 5.6\,H_2O + 2.4\,H_2 + 4\,N_2$~~

~~$5 \times 12 + 4 \times 80\,g. = 22.4\,(4.4 + 1.6 + 5.4 + 2.6 + 4)$ =~~

$5C + 4\,NH_4NO_3 = 4\,N_2 + 3.6\,CO + 1.4\,CO_2 + 5.6\,H_2O + 2.4\,H_2$

$5 \times 12 + 4 \times 80\,g. = 22.4\,(4 + 3.6 + 1.4 + 5.6 + 2.4)$ litres.

380 g. = 22.4 × 17 = 381

1 gram = 1·002 litres.

Heat of explosion.

(a) Formation of 4 NH_4NO_3		4 × 88,050	= ~~440,000~~ 352200
(b) "	$3.6\,CO$	= 3·6 × 26300	= 94,700
(c)	$1.4\,CO_2$	1·4 × 94300	= 132,000
(d)	$5.6\,H_2O$	5·6 × 58,100	= 324700

(b) + (c) + (d) − 2(a) = 199,200, for 380 grams.

= 524 = ~~293.3~~ for 1 gram.

% of carbon = 6000/380 = 15·78%

Carbon with 19/20 of amm. nitrate.

$20\,C + 19\,NH_4NO_3 = 19\,N_2 + 12.6\,CO + 29.6\,H_2O + 7.4\,CO_2 + 8.4\,H_2$

$20 \times 12 + 19 \times 80$ g. → 22.4×77 → 1723 litre.

1 gram → 1723/1760 = ·980 litre per gram.

Heat of explosion.

(a) Formation of 19 NH_4NO_3 = 19 × 88050 = 1,672,000

(b) 12.6 CO = 12.6 × 26300 = 331300

(c) 29.6 H_2O = 29.6 × 58100 = 1,718,000

(d) 7.4 CO_2 = 7.4 × 94300 = 698000

(b)+(c)+(d)−(a) = 2747300 − 1672000 = 1075300 for 1760 gram.

per one gram 612 calories.

% of carbon 13.63 %.

By interpolation, when carbon is 14.17 % of the whole, the heat should be 590.

i.e. 11 C + 10 of am. nitrate.

11 C + 10 NH_4NO_3; i.e. 14.17 % of the mixture carbon

Equation :–

$11\,C + 10\,NH_4NO_3 = 10\,N_2 + 7.2\,CO + 15.2\,H_2O + 3.8\,CO_2 + 4.8\,H_2$

$11 \times 12 + 10 \times 80$ → 22.4 (10 + 7.2 + 15.2 + 3.8 + 4.8)

932 g. → 22.4 × 41 = 918 litres

1 gram = ·985 litre.

Heat of explosion.

(a) Formation of 10 NH_4NO_3 = 10 × 88050 = 880,500

(b) 7.2 CO = 7.2 × 26,300 = 189,200

(c) 15.2 H_2O = 15.2 × 58100 = 882,000

(d) 3.8 CO_2 = 3.8 × 94300 = 358700

(b)+(c)+(d)−(a) = 1,429,900 − 880500 = 549400 cal. for 932 gram; i.e. 588 for 1 gram.

Summary.

Exploding mixture	% carbon in whole	Litres per gram	Calories p.g.
$C + 2\,NH_4NO_3$	6.98 %	·910	876
$C + NH_4NO_3$	13.05 %	·974	633
$20\,C + 19\,NH_4NO_3$	13.63 %	·980	612
$11\,C + 10\,NH_4NO_3$	14.17 %	·985	588
$5\,C + 4\,NH_4NO_3$	15.78 %	1.002	524

(Oct. 25) Heating-up-effect.

~~He~~ Electric heater.

Weight of no. 24 nichrome wire used: 25·8 gram.

Weight of 2 feet of same, = 1·04 gram.

Length of wire used = 49·7 feet.

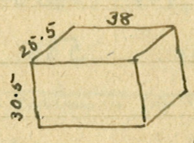
of this, length not used in heating = about 8".

Actual heating wire, 49 feet, in 10 coils, formed by wrapping the wire round a rod 5/16" diameter & 12" long.

Resistance:	79·7°	81·5	83·0	85·0	72·6.
at Temperature:	246°C.	301°C.	357	412°	20°C.

Thermostat.

Internal dimensions:-



38 x 25.5 x 30.4 (deep) cm.

Total volume = 29450 c.c., allowing for bulging say 29500 cc. = 29·5 litres. = 6 1/2 gallon.

If fill only to 2" below the top when cold, volume oil required is 6·5 x 5/6 = 5·4 gallons.

Between 20° & 78° the coeff. expansion of medium lubricating oil is about ·00075 + increases with temperature. Taking it as ·001 between 20° + 120°, the depth of oil at ~~12~~ if ~~2~~ 10" at 20° would be 11" at 120°.

Weight of thermostat 18 7/16 lbs. = 8·4 kilos.

Oil, gross in drum 40·4 lbs. = 18·35 kilos.

Water equivalent of the thermostat,

= ·8·4 x

Oil, net wt. of drum, 7 3/4 lbs. =

additional oil;

1732	1750	1960	1960
320	340	340	320
1412	1410	1620	1640

227

18·35 − 3·52 = 14·83 +

total ~~8·35~~

= ~~14·43 kilos~~ = 20·9 kilos.

Volume displaced by the bomb: π x 5 x 5 x 22 cc.
= 1730 c.c. = 1·8 cm. depth. To fill up to 10" deep
Volume of oil required = − 1730 +
29·5 x 5/6 litres = 24·6 − 1·7 = say 23 litres.
= 23 x ·9 = 21 kilos. = 46 lbs.

If 250 volts is applied to the heater at 20°, current will be ~~2·9 amperes~~ 3·45 amperes

With whole of 120 ohms additional resistance, 1·3 amperes.

With half of .. .. .. 1·89 amperes.

Water equivalent of

Oct. 30 Trial of heater.

Time	Temp		
3.35 pm.	19.5°C.		Height of bath above oil surface = 73 mm.
3.50	20°C.	}	External resistance: 120 ohms.
4.20	28°.		80 ohms

all external resistance taken out

		per 10'	
4.30	38.5		Room temp 16°.
4.40	46.5	} 8	Temp of lagging against outer wall (inside) = 25°.
4.50	55.0	} 8.5	
5.00	62.5	} 7.5	
5.10	70.0	} 7.5	
5.40	89.5	} 6.5	lagging 44°C.
6.00	100.7	} 5.6	
6.47½	128.0		
6.51½	130.0	} 5.0	

Specific heat of oil about .5

Specific heat of iron .1

Water equivalent of oil + thermostat =

$8.4 \times .1 + 21 \times .5 = 11.3$ kilo.

Evolution of heat from 3.45 amps through 72.6 ohms

$= (3.45)^2 \times 72.6 \times .24 = 207$ cal. per second.

This should raise temp 1.1°C. per minute.

At 6.52 pm. the resistance of 120 ohms was added, so that current would be about 1.3 ampere, left over night.

Oct. 31 At

9.25 am.	94°C.	Lagging, 57°C.

Took off some of cover on top of bath.

10 am.	93°C.	Turned off current.
10.35	87°	
11.00	84°	

Electric oven: current used.

Low	1.25	} Voltage 252.5
Medium	2.35 to 2.4	
High	4.75	

11.50 78°

Put on current with 120 ohms resistance; = 1.2 amps.

P.D. at terminals = 90.0 volts. R = 75 ohms

all out, 3.25 amperes. 252.5 volts

turned off current again. Resistance = 76 ohms at 78°. (calculated from tables 75.5)

Theoretical rise of temp for 3.25 amperes:

$$\frac{3.25 \times 3.25 \times 76 \times .24 \times 60}{1000 \times 11.3} = 1.02° \text{ per minute}$$

~~Correction for wire out of bath,~~ 4

at 78° C.

Electric oven:

on plotting values

Amperes	Temp.
1·25	94°
2·4	135°
4·75	215°,

almost a straight line is obtained.

For 150° 2·84 amperes is required.

The resistance at "High" is 53·7 ohms; additional resistance required to give 2·84 amps is 35·2 ohms.

The diff. of potential at oven terminals to give 2·84 amps through 53·7 ohms is

53·7 × 2·84 = 152·5 volts.

Cooling of bath continued.

1·0 pm. Temp. 70° C.
2·30 " 62

Nov. 2. Proposed thermoregulator for oil bath. The coeff. of expansion of mercury at 140° is ·0001825, of glass, ·000025, nett, ·0001575; if regulator is made with a capillary 1·02 mm. diameter, ~~to~~ produce a movement in this of mercury per degree C. over 1 cm., would require a bulb containing 52 c.c. of mercury.

A convenient length would be 24 cm.

Of a tube 1·16 cm. diameter 49 cm. would be required; this is too long; if only 24 cm. movement of mercury for one degree would be 4·4 m.m.

Effect of part of this mercury being out of the oil bath exposed to varying temp of the room.

If volume of bulb is 50 cc, volume extruded by rise of 120° = 50 x 120 x ·0001575 = about 1 cc. = 1/50th

A diff. of 10° in temperature of this ~~corresponds to~~ causes an ~~a rise of~~ expansion of ~~·00515~~ 1/50 cc. cc., which in a tube ·1 02 cm diameter causes a rise of about a ~~small~~ millimetre; i.e. about ·2 °C. in regulating the bath.

Wt. of mercury in regulator:–

Wt. of tube + large bulb = 45·5

Full of mercury at 20° C., in tube ~~or~~ about 10 cm. of capillary, wt: 361·5

Mercury 45·5 volume about 23·3 cc

316 g.

Nov. 8. Proposed arrangement of thermo-regulator + relay.

Current from accumulator is to pass ~~through~~ through magnet, regulator + synthermal regulator in series; regulator to make circuit at rise of temperature, synthermal to break circuit on rise of temp of the limb in the bomb. Making circuit causes magnet to insert resistance in the heating current circuit.

Nov. 13.

Trial of regulator + heater.

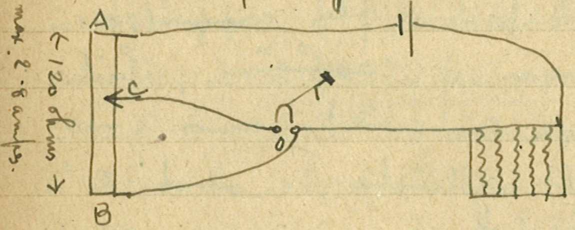


Diagram of connections.

12.15 p.m. ~~Started~~ current, C being at A so that resistance AB was cut out entirely. When the gap D is made by the electromagnet raising the ∩ all the resistance is inserted in circuit. Temp. of oil at start, 19°C.

at 12.50 a.m. temp. 50°C.

2.35 120°C

1.9 amperes was found rather more than sufficient to keep temp at 120°C.

When all ~~external~~ resistance is cut out current which passed was 2.7 amperes but voltage was not known as meter was being repaired.

Nov. 23 – (27)

Test of ~~Synthermal regulator~~ elasticity of bulb.

The bulbs held about 1.7 c.c. They were put in two beakers of water + the diff of temps. when the circuit was closed or broken by the contact between platinum + mercury was noted.

At 16°, start with taps open to equalise pressure;

	circuit broken	circuit closed
Temp. diff.	·25	·12
	·10	·10
	·05	·07
		·04
		·00

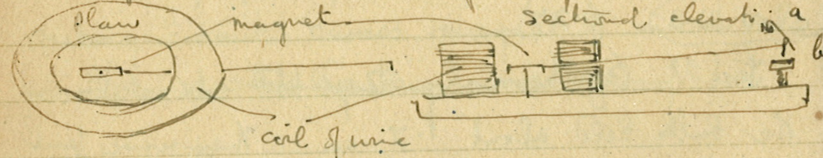
One bulb only was then heated to 24° + allowed to cool again ~~slowly~~ slowly to 20°

~~The taps were not altered.~~

At 20°

	circuit broken	circuit closed
temp. diff ..	·3	·4
		·6
		·3

Proposed electrical temp. regulator.



A dipping needle in magnetic meridian, moved by current from thermocouple so that pointer touches plat. plate. Current of relay passes in ~~at~~ pivot & through pointer, or loose bridge between a + b, pointer being insulating material.

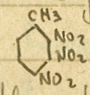
Nov. 28

Starting to heat up thermostat ready for next day. Current at first, through 120 ohms external resistance = 1·1 amp.

Weight of test-tube stand	2·196
test tube and stand	6·814
test-tube only	4·618

Amm. nitrate ·8, Amm. thiocyanate ·1,

β T.N.T. 2 g.



mixed & put into weighing bottle tare 26·673

gross, 36·743

Distance between top of copper tube & top of steel rod carrying the test-tube, 57 m.m.

Distance between under side of lower T piece & top of copper tube 268 mm.

Wt. of weighing bottle & contents after charging the test tube to about 3/4" from the top, 29·93

∴ Wt. of explosive taken = 6·81 g.

Dec. 4. 11·10 a.m. Put in bomb when bath was 89·5° temp. fell, at 11·20 was 85° C. at 12 noon 80° C. on testing current it was found to be only 1·1 amperes & then one of the platinum wires of the relay was found to have been fused into a knob + failed to touch the mercury.

At 12·10 this was rectified + a current of ~~2·5~~ 3·1 amperes passed..

At 12·35 pm. temp was 90°

1 35	92°
1·45	94°
1·53	95°
2·00	96°
·07	97°
14	98°

It was noticed that the synthermal regulator ~~was~~ had closed the circuit but that the magnet had failed to pull up the platinum bridge.

This was done by hand.

2·20	97°
3·20	93

At 3·20 the circuit was just broken in synthermal regulator.

Dec. 5 Proposed new electromagnet.

Assuming that the relay is to be worked by a current not exceeding 1/50 ampere + one accumulator, the resistance of winding on magnet should be about 100 ohms.

There is available about 13 ounces of ~~no 28 S.W.G~~ ~~insulated~~ wire ·014" diameter, having a resistance of about ·19 ohm per metre. To give 100 ohms, 527 metres would be required. The ~~less~~ weight of 78 cm. of this wire is ·83 gram.

+ the length of 13 ounces would be about 350 metres.

If no. 36 wire were used, having a resistance of ·59 ohm per metre, only 170 metres would be needed; if 40 S.W.G., resistance 1·48 ohms/metre only 67 metres would be needed.

A moving coil relay.

In Paul's catalogue is described no. 4744 in E. having normally 5 ohms resistance, ~~and~~ + moving ~~contact~~ pointer 1 m.m. for current of ·4 milliamp. say 3 millivolts, but will make + break a circuit with much less. Can be had with resistance up to 1000 ohms.

~~Sen~~ Current sensitivity proportional to square of resistance.

Carries current of ·2 ampere if desired.

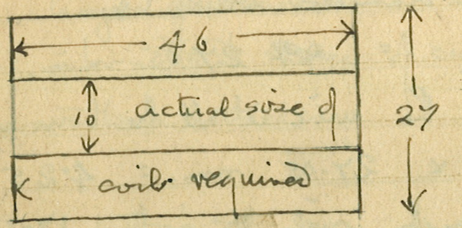
Unipivot relay device or alarm.
Paul, no. 2260. for adapting to
a ~~large~~ galvanometer. Requires also
an intermittent source of current regulated
by a clock-contact.

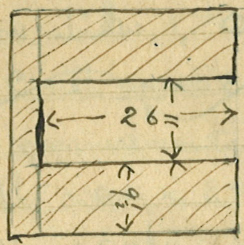
Calculation of size of electromagnet
wound with 170 metres of no. 36 copper
wire silk covered.
By measurement with no. 28 wire, thickness
of silk covering is ·1 mm. that of the no 36
wire is ·193 mm., covered, ·393; but
if the coils are wound in the crevices effective
thickness, or distance between centres of successive
layers of wire is ·342 instead of ·393,
this determined graphically.
If the core of the magnet is 1 cm. diameter
that of the 1st circle is $10 + \frac{\cdot 393}{}$ of the
2nd one, $10 + \frac{\cdot 393}{} + \cdot 342 \times 2$; i.e.
if no. of turns is n its diameter is
$10 \cdot 4 + (n-1) \times \cdot 342 \times 2$
$= 10 \cdot 4 + (n-1) \cdot 684$

The diameter of the 50th turn would be
∴ 43·7 mm. (say 44 outside all)
& the average diameter would be
$\frac{10 \cdot 4 + 43 \cdot 7}{2} = 27 \cdot 05$ mm.
& the length of the wire in all the turns would
be $50 \times \pi \times 27 \cdot 05$ mm. $= 4 \cdot 25$ metres
The number of such coils to contain 170 metres
would be $\frac{170}{4 \cdot 25} = 40$, which would
~~occupy a length of $17 \cdot 3 \times \frac{40}{33} = 21$ mm~~
~~(33 turns of wire~~
occupy a length of $\cdot 393 \times 40 = 16$ mm.
Weight of 170 metres of no. 36 silk covered
copper wire:
Volume of copper $= 170 \times 100 \times \pi \times (\cdot 00965)^2$ c.c.
Weight $= 170 \times 100 \times \pi \times (\cdot 00965)^2 \times 8 \cdot 9$ grams.
$= 44 \cdot 2$ grams.

Size of coils if 25 turns thick:
Diameter of 1st = 10·4 mm
25th = 26·8 mm
Average diameter = 18·6 "
Length of wire in one coil = 1·46 metres.

No. of coils containg ~~117~~ 170 metres = 117.
occupying a length of 46 mm. on core.

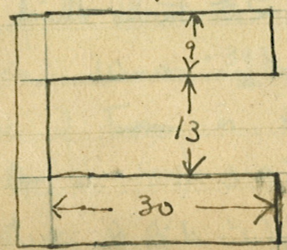




Section of iron core ready-made, actual size.

The number of layers which could be wound on each of the limbs is 17, & to hold 170 metres a length of 39. mm. in each coil would be required.

The larger ready-made core has following dimensions
~~two~~ diameter of limbs 9 mm, distance apart 13.



The number of layers which could be wound on these limbs is 19, & would need ~~three~~ a length of 2 x 36. mm.

Dec. 18.

Wt. of one metre of no. 36 silkcovered copper wire
$= 0 \cdot 2618$ gram

By trial 22 turns side by side occupied a length of 5·5 millimetres, thickness of wire is therefore, $\frac{5\cdot5}{22} = \cdot25$ mm. that is thinner than that calculated from thickness of no. 28 wire; the silk is thinner.

N.B. A three way tap plug about 2" long had a taper of 3 in 50. A ground joint 1" long had a taper of 6 in 50.

When the wire was coiled on a glass rod 4 mm diameter, 3 turns thick gave thickness of 5·2 mm.
∴ 1 turn takes up space of ~~5·2/6~~ $= \frac{5\cdot2 - 4\cdot0}{6} = \cdot3$ mm.

Dec. 20.

The no. 36 wire was wrapped on a bobbin 36·5 mm long & 12 mm diameter, about 150 turns occupied this length.

The diameter was increased from 15·8 to 17·6 mm

by 4 ~~turns of~~ layers of wire, according to this each layer occupies a thickness of ·225 mm.
Six more layers increased thickness from
17·6 to 20·4 mm. = 2·8

$\frac{2·8}{12}$ = ·233 mm. , adding,
4 + 6 = 10 layers increased thickness by 4·6 mm
i.e. 1 layer = $\frac{4·6}{20}$ = ·23 mm
Total number of layers = ~~18~~. 19 or 17
average diameter = 16·2 m.m.
Length of wire = 18 × 150 × π × 1·62 cm.
= 137 metres.
Total number of turns = 150 × 18 = 2700
If repeated on other spool, 5400; + total resistance by about ·59 × 137 × 2 = 162
current from 2 volt cell = $\frac{1}{81}$ ampere.
Ampere turns = ~~27~~ $\frac{5400}{81}$ = 66·7
Wt. of wire wound on the bobbin =
259·05 − 225·23 = ·33·88 gram.
as 1 metre weighs ·2618 gram, length
is 33·88 / ·2618 = 129·4 metres. say 130

2nd bobbin.
Diameter 12 m.m., after winding
6 layers, 14·8 mm.
19 layers (?) 20·5 mm.
Wt. of wire used, = 225·23 − 191·27 = 33·96 gm.
length ∴ = 33·96 / ·2618 = 129·8 metres say 130.
Total resistance of the ~~two bobbins~~ should be
260 × ·59 = 153 ohms.
Current from 1 accumulator is $\frac{2}{153}$ = ·013
ampere or 1/77 ampere.

1919.
Jan 13. Working of the relay.
When alternative external resistances in heating circuit were 120 ohms & 24 ohms
fluctuation in temperature was less than ·1°C.
+ times of make + break of regulator were
Make, 0'0" 1'35" 4'45" 6'25"
Break 0'26" 2'4" 3'35" 5'16"
The temperature fell slowly from 90° to 89·93°, in about 1½ to 2" & rose in about 10" to 15" again to 90°

Temperature to which bath must be raised so that on immersing the bomb, the temp of the whole shall be 90° C.

Water equivalent of Thermostat about 11.5 kilos. (See calculation Oct 30. 1918)

Water equivalent of bomb:-

wt. is about 23 lbs; = 12.7 kilos

sp. heat of steel = ·12

Water equivalent = 12.7 × ·12 = 1.52 kilos.

∴ 1.5 × (90° - 17°) = 11.5 × x ; x = temp. above 90°

x = 9.5 ∴ temperature required is 99.5°C.

Time	Thermometer	
11.16	99.5° C.	put in bomb + turned off current.

In about ½ hour temp was 90° C, + maintained till 5.30 pm. when bomb was removed.

Jan 19. 1919

Bomb opened + charge replaced by fresh one of
4.8 g. amm. nitrate (standard powder)
1.2 g. β. T.N.T. in powder
·06 g. amm. thiocyanate

Dimensions of the Condenser used to prevent sparking in breaking the heating circuit.

Six sheets of tin-foil 60 mm × 100 mm. + six sheets of mica about 1 mm. wider + longer, three of the sheets of tinfoil connected together.

Average thickness of the mica about ·1 mm.

calculated capacity 1.98 × 10^{-2} micro-farad (if mica has K = 6.2)
measured capacity 2.1 × 10^{-2}

Jan. 21

Trial of new charge put in Jan 17.

Time

10 a.m. Bomb put in bath at 93° C., temp of bath regulated to 90° C.

11 a.m. Only a very slight expansion of the air in the bomb-bulb having occurred in the last 20', at 11 a.m. the Syntherma regulator was put in series with the bath regulator, which had hitherto kept the temp. between 89.97 + 90.03° C. (extreme limits).

No change occurred till 5.30 p.m. when the experiment was stopped.

Jan 24 — Same charge at 110° C.

Time

(0) 11 a.m. Bath at 99°, put in bomb; 110° at 11.50 a.m.

12 noon Synthermal regulator put in series, only just making contact when bottle taps were open. The temp. remained

12.10 constant for 10' & suddenly the mercury in the bomb limb of SYN.R. was depressed about 3 mm.

A little cold air was blown into the bomb to avoid a possible explosion, but the mercury did not rise again; perhaps because the temp of bath was rising.

(81) 12.21 Bath heater had caught up with the bomb, at 114° C.

Temp. gradually rose, syn. r. acting badly through vibration of the mercury surface which should be

(120) 1.0 pm. smaller to 116.5°,

1.10 " 117° C.

Stopped experiment.

Jan. 27.

Proposed electrical synthermal regulator.

Iron constantan thermo couple ~~actuating~~ ~~two~~ furnishing a current through two coils of copper wire in parallel surrounding two astatic magnetic needles.

E.M.F. from one junction, temp. diff 1/10° C = .005 millivolt

Size of Eureka wire in stock: no. 24 & 26 S.W.G.

• Resistance per metre of no. 24 : 1.93 ohms.

$\frac{\text{Spec. R. of iron}}{\text{Spec. R. of copper}} = \frac{18 \times 10^{-6}}{2.36 \times 10^{-6}} = 7.63$

Resistance of no $\left\{ \begin{matrix} 20 \\ 24 \end{matrix} \right.$ iron wire $\left\{ \begin{matrix} .2 \\ .534 \end{matrix} \right.$ ohms per metre.

Probable resistance of circuit besides galvanometer.

.53 metre of eureka wire = 1 ohm.

2.0 metres iron wire size 20 = .4 ohms.

Resistance of any copper leads negligible; total 1.4 ohms.

~~Current obtainable is therefore $\frac{.005}{1.4}$ = .00357 milliamp.~~

The resistance of the relay should be also about 1.4 ohms total 2.8, current will be ∴ $\frac{.005}{2.8}$ = .001785 m.a.

& resistance of each coil may be 2.8 ohms so that in parallel their combined ~~that~~ resistance is 1.4 ohms.

4 coils in parallel, each 1.4 ohms will be; .35 ohm.
+ by using thicker eureka wire other resistance may be reduced.

If copper wire size 20 S.W.G. is used for the coils each would require $\frac{2.8}{.026}$ = 108 meters. When wrapped on a cylinder, each ~~thickness~~ turn of no. 20 cotton covered & enamelled occupies $\left\{\begin{matrix}1.29\\1.28\end{matrix}\right\}$ m.m. of the length of the cylinder.

The volume of 108 meters would be therefore about $\pi \times (\cdot 063)^2 \times 10800$ c.c. = 135 c.c.

If only enamelled, thickness is of 0°914 mm.

∴ volume would be

$\pi \times (\cdot 0457)^2 \times 10800$ cc = 71° cc

The weight required will be about 3 lbs.

Jan 29. 1919. Heating-up at 100°C.

The old charge was removed from the bomb & replaced by a fresh one same as before, viz. 4.8 g. standard powdered amm. ~~nitrate~~.

1.2 g. β T.N.T.

·06 g. amm. thio-cyanate.

After standing over night in corked bomb it was put in bath at 94° at 10.15 am. & after the mercury in synthermal regulator ceased to move, the syn. reg. was put in circuit. The bomb was hung from the ceiling to stop vibration.

Time	Bath temp	
10.15	94°	Bomb immersed.
10.40	100°	
11.25	100°	Syn. reg. in circuit.
12.00 noon	100°	
12.15	100.05	Syn. reg. began to act
12.20	101.5	An explosion which shook the building caused the mercury in the S. Reg. to fall about 2 mm. = 3° so that the heater did not keep pace with it.
12.25	104.3	The heater had not yet overtaken the S. reg. the gap between mercury & point was about 1/3 m.m.; after wards increasing
12.30	107	Gap now about 3 mm. = 4°C
12.35	109.5	" " " 5 mm. = 7.5°C
12.40	112	" " " 6 " = 9°
12.45	114.5	10 " = 15°C

Removed bomb from bath & blew air through it.

Value of the gap in the syn. regulator in temperature difference between the bulbs.

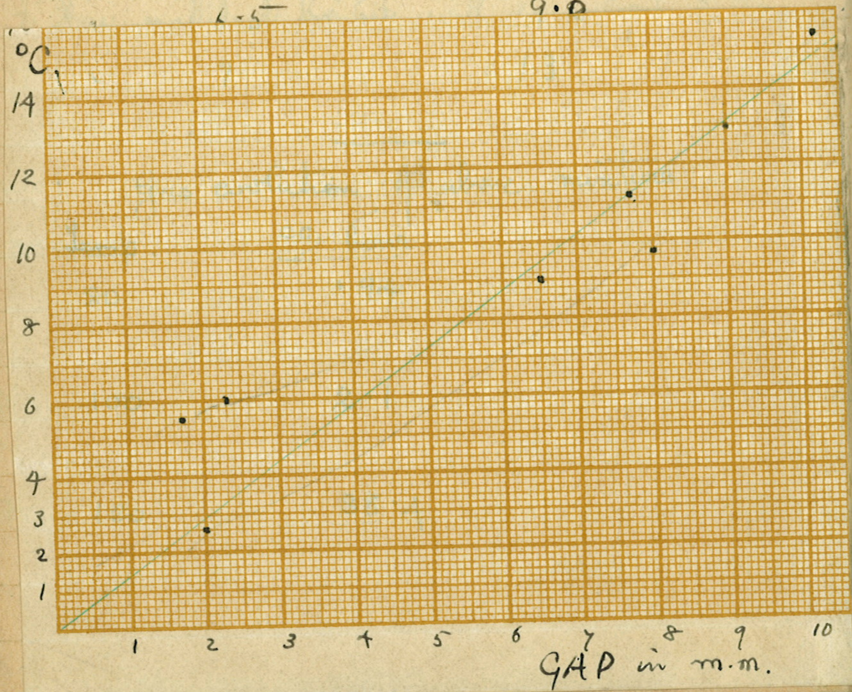
	Gap. m.m.	Temp. difference
rising	1·7	5·5 ?
	7·7	11·2
	10·2	14·7
falling	8	9·7
falling	2	2·6
rising	2·3	6
"	6·5	9·2
"	9	13

Gas evolution of above mixture.

Temp.	c.c./hour
80	·94
100	2·1
120	38·4

Value of the gap in the syn. regulator in temperature difference between the bulbs.

	Gap. m.m.	Temp. difference
rising	1·7	5·5 ?
	7·7	11·2
	10·2	14·7
falling	8	9·7
falling	2	2·6
rising	2·3	6
	6·5	9·0



Specific heats.

Glass.	·16
solid T.N.T.	·233
liquid T.N.T.	·4 ?
Amm. nitrate.	·422

Water equivalent of the testtube & contents.

test-tube	2·6 × ·16 =	·416
β T.N.T.	1·2 × ·233 =	·28
Amm. nitrate	4·8 × ·422	2·02

For bulb of regulator allow ·3 + 2·7 grams water.

During the last exp. the no. of calories evolved in the decomposition was therefore at least
·3 g. × 30° C = 90 calories,
in 30 minutes, i.e. about 3 cal. per min.

In the first experiment. the no. of calories in 50 minutes (after the 1st 10′) was
3 g × 2·5° C = 7·5 calories = 9 cals/hour

Feb. 6. 1919.

Proposed electrical syntherimal regulator.

Revised dimensions.

Black enamelled copper wire size 20 S.W.G to be wound in 4 coils round a core 6.5 mm. thick, 50 mm. long + 20 mm. wide, to a depth of 20 mm.

Diameter of wire ·0915 cm.

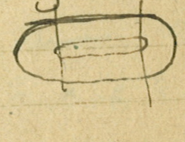
The distance between the centres of the wire in successive layers is owing to partial occupation of interstices only ·876 of the diameter of the wire.

In the case of no. 20 wire it is

·915 × ·876 = ·8 m.m.

A depth of 20 mm. will therefore hold about 25 layers. & if a width of 20 mm. about 22 coils side by side.

The straight parts of the coil will contain therefore



2×25 × 22 × 4·7 = 5170 cm.

curved, 25 × 22 × π × 2·6 = 4500 "

Total 96·7 metres.

of resistance 96·7 × ·026 = 2·5 ohms.

If 4 are in parallel R = about ·6 ohm.

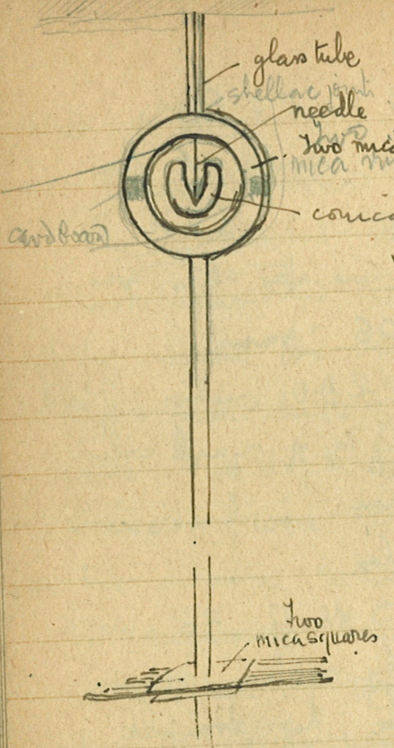
Exact weight of the wire. (Feb. 7)

39 c.m. of enamelled no. 20 wire after cotton was stripped off weighed 2·2006 grams

Three pounds will therefore contain 240 metres, of total resistance, 6·23 ohms; if in 4 equal coils in parallel ~~1·56 ohms~~ ·39 ohm.

The magnetic needles.

Pieces of needle steel S.W.G. 22. were heated to redness & slowly cooled, drawn out (slightly) till they broke, the straight pieces thus obtained cut to 47 m.m. long, again heated to redness with graphite in a copper tube & dropped into cold water. They were magnetised by being placed in the middle of a coil of no. 20 S.W.G. copper wire, enamelled & cotton covered, in six layers round a core 7·5 m.m. diameter & 80 mm. long, through which a current of 2 amperes was passed for 150'



Feb. 8. 1919.

Suspension of magnets.

Two mica rings 1 outside diameter 20·5 mm were stuck with melted shellac onto opposite sides of thin glass capillary outside diameter 1·3 mm, which was afterwards broken away inside the ring. A fine needle was further sharpened & reduced in diameter by solution in nitric acid so that it fitted the glass capillary. (Feb 12) 4 magnets were stuck by shellac varnish between two squares of mica pierced with a central hole through which the glass tube passed.

Wt. of the magnets, average, ·562/4 = ·14
Repulsive force between two like poles at about 8 mm. distance = about 1 mgram.

Repulsive force more exactly.

Distance of poles	wt.
8·5	·7 mg.
15·5	·2
25	less than ·1 mg.
Magnets horizontal thus:	
12	·6
19	·3

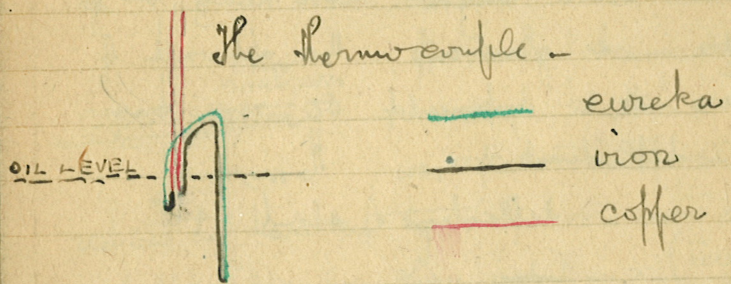
When two such magnets were hung on a needle in a glass cup, the approach of others at a distance of 60 mm. caused marked deflection viz. (←60→)
At 20 mm. deflection of about 40°.

(Feb. 13) Rough calculation of probable forces exerted by difference of temperature of ·1° C.
E.M.F. = ·005 mv, through 1 ohm = ·005 milliamps
If there are 54 metres of wire in each of 4 coils & radius is equivalent to a radius of 1 cm. the field in each pair will be ·0058 absolute units.
If moment per gram of the magnets is 50, that of 4 magnets is 28·2 units; turning couple when angle is 90° = ·18 dyne cms. That is, at a

distance of 1 cm. from pivot the force will be
$\frac{\cdot 18 \times 1000}{981} = \cdot 183$ milligrams;
adding the force for the other coils & needle,
$\cdot 366$ milligram.

The earth's magnetic field is $\cdot 475$,
the horizontal component, $\cdot 185$, i.e. about
30 times the field produced by one of the
coils.

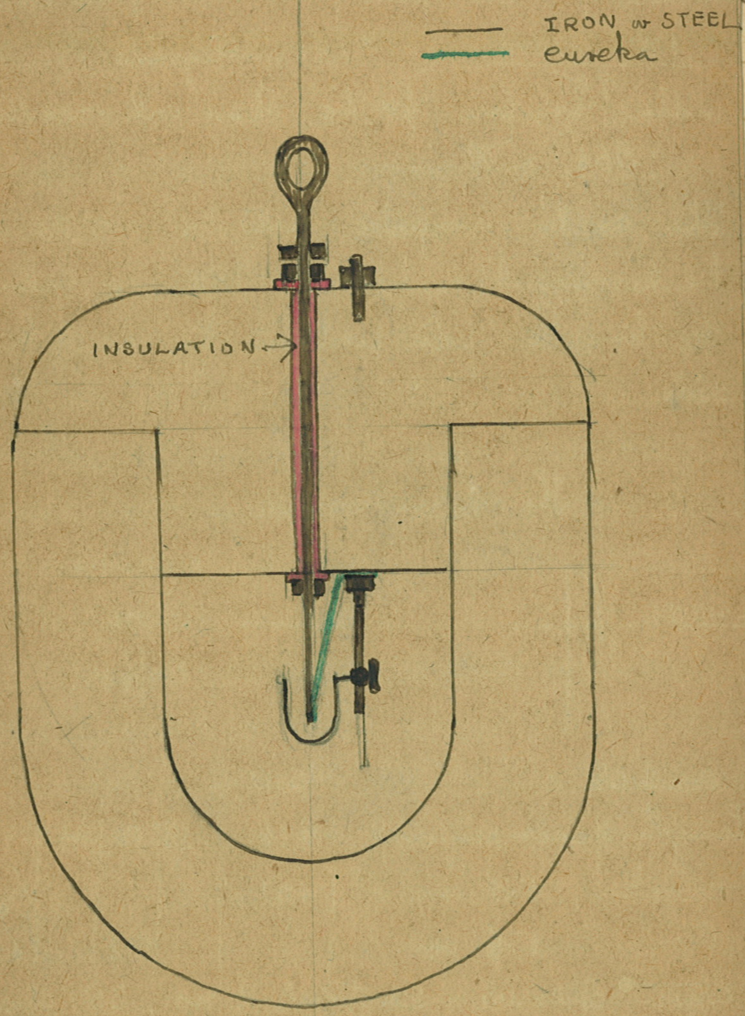
The thermocouple —



~~available~~ S.W.G.:—

Length of each required:	~~18~~ 16	19	20	24	
eureka, 53 cm.	·121				ohms.
iron 5~~6~~ cm.			·112		

copper ~~flexible~~ flexible, 23 strands of no. 35 wire
resistance per metre = ~~23~~ ~~·49~~ 23 · ·0215
Thus with copper flexible leads 3·5 metres long, doubled,
the resistance would be ·121 + ·112 + ·15 = ·383 ohms,



The bomb itself maybe a part of the thermo couple as in the sketch :- In this case the wires of iron & eureka might be thin & short in ~~have~~ the region of temperature variation & have the same resistance as the longer wires for the old bomb if they were :-

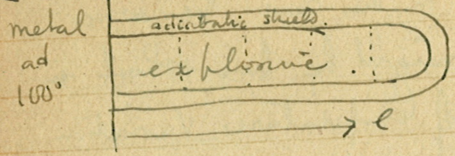
Material.	Length	S.W.G.	Ohms	Calories per minute
~~Steel~~	2 cm.	36	·09	·0000965
Eureka	2 cm.	30	·12	·00006

if the difference in temperature at their two ends were ·1 °C..

Feb. 14.

Propose to adapt present bomb by removing wide copper tube & passing through the two holes ·2" diameter no. 12 wires of iron & eureka insulated with glass & with fibre washers. copper wires maybe attached direct to their ends outside, & the part of the wires in the explosive may be much thinner.

(Feb. 18. 1919)



If an explosive is in an adiabatic tube with the open end against a metal plate kept at constant temperature & if heat is being produced by chemical reaction at a uniform rate, when a steady state is attained the temperature gradient along the tube will be equal to a constant less the distance away from the metal. $\frac{dT}{dl} = k(a - l)$ ~~or reckoning~~ ~~from the other end, $\frac{dT}{dl} = kl$ i.e.~~

Value of T at any point $= \frac{k}{2}\, 2Ll - l^2$

where L = length of the tube; T = temp above 100°.

(Feb 19.) Calculation of best shape of bobbin.

r = radius of coils

p = distance of outside coil from magnet.

Field due to unit length of wire $\propto \frac{r}{p^3}$; to get best effect this must be constant — when $p = r$, $(\theta = 90°)$ let it be fixed that $p = r = 23$ mm.

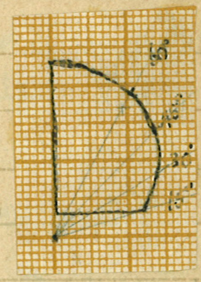
Then $\frac{r}{p^3} = \frac{1}{p^2} = \frac{1}{r^2} = \frac{1}{23^2}$.

& as $r = p \sin\theta$, $\sin\theta \times (23)^2 = p^2$.

p. Values for various angles.

Angle θ	sin θ	p^2	p.
90°	1	529	23
75°	·966	510	22·6
60°	·866	458	21·4
45°	·707	374	19·3
30°	·5	264	16·25
15°	·259	·137	12·7

ACTUAL



SIZE REQUIRED.

Generally the rule may be stated, if the coil is to have rectangular section that ratio ~~length~~ height to breadth = 1·65 reckoning height from centre of magnetic field.

(Feb. 22.)

Sundry Values

Specific heat of glass ·16

" " " T.N.T. solid 0·233; 0·308; liquid 0·413

" " ammonium nitrate 0·422

Latent heat of T.N.T. : 25

Conductivity for heat of glass ·0025; ·0016 @ 18°; ·0029 @ 50°

" " ... T.N.T. ·00206

" " ... Ammon. nitrate

Cordite.

fine sand at 20°, 31·8% air; ·000287

General expression for rate of change of temperature with distance along a tube containing explosive which develops heat uniformly throughout & from which heat can only escape from the open end to a metal wall at constant temp.

t = current temp. above that of metal wall

l = " distance from ~~metal~~ wall

L = total length of tube

Q = total quantity of heat produced per second.

k = conductivity for heat.

a = cross-section area of tube

$$\frac{dt}{dl} = \frac{Q}{ak} - \frac{Q}{akL}\,l = \frac{Q}{ak}\left(1 - \frac{l}{L}\right)$$

a linear function of l.

Feb. 25.

Temperature gradient in a sphere of explosive spontaneously evolving heat, the outside kept at a constant temperature.

Let radius of sphere be R & distance r, variable, reckoned from centre.

Let q = the heat produced per second per c.c. of explosive.

Let k = conductivity for heat of the explosive.

At any distance r from the centre the quantity of heat escaping per second when a steady state is attained =

$q \times \frac{4}{3}\pi r^3$, that amount of heat being produced per second in a sphere of radius r.

The temperature gradient must be such as to permit of this heat escaping & is equal to

$$\frac{\text{heat produced per second}}{\text{conductivity} \times \text{area} \perp^r \text{to direction of flow}}$$

i.e. $$-\frac{dt}{dr} = \frac{q \times \frac{4}{3}\pi r^3}{k \times 4\pi r^2} = \frac{q\,r}{3k}.$$

The total fall of temperature as r changes from 0 to r is

$$t = \int_0^r \frac{q\,r\,dr}{3k} = \frac{q\,r^2}{6k}$$

On obtaining the value of t from this equation for ~~any value of~~ $r = R$, ~~=ΔT the actual temperature above that at R,~~ the outside ~~of the sphere~~ the radius of the sphere, equal to say ΔT, the actual temperature at any point may be calculated from $T^\circ C = T_R + \Delta T - t$. where t is value at any point r.

$T°C.$ = actual temperature at point r

T_R = actual temperature at point R

ΔT = total drop in temperature from $r = 0$ to $r = R$.

Eg. if q = ·01 cal per sec. per c.c. explosive

k = ~~·0033~~ ·00167 cal per sec per sq cm per °C.

then $q/6k = \frac{·01}{6 \times ·00167} = 1$.

t is then $= r^2$.

Suppose R = 10 c.m., when $r = R$, $t = 100 = \Delta T$

If T_R = 100 $T°C.$ when $r = 0$ is 200°.

& for any value of r = 100 + 100 − t.

Eg. A sphere of T.N.T. is stored at the ordinary temperature say 15° C. It's radius

R = 100 c.m. Its conductivity

k = ·00206, specific heat ·308

Suppose heat is produced at a rate which would cause its temperature to rise 1° C. in a week if contained in an adiabatic envelope.

that is, $q = 8·16 \times 10^{-7}$, using specific gravity 1·6.

The whole drop in temperature from centre of sphere to the outside $= \frac{q R^2}{6 k}$

$= \frac{8·16 \times 10^{-7} \times 10^4}{6 \times ·00206} = \frac{8·16}{6 \times 2·06} = ·66° C.$

That is, the temperature of the centre of a block of T.N.T. 2 metres diameter will always be ·66° C. above that of its outside if assumption that $q = 8·16 \times 10^{-7}$ is correct.

If q increases with rise of temperature the difference in temp between outside & inside will increase slowly with the age of the block.

This is on the assumption that the conductivity for heat remains constant or does not increase with temperature at a rate sufficient to counteract the increase in q, rate of production of heat.

Increase in specific heat with temperature will only affect the time to attain equilibrium between q & k.

From Lee's experiments, Phil Trans A 1898, 399, the conductivity of window glass maybe represented

by $k = ·00245 + ·0000613 t$ where ·00245 = value of k at 35° & t = degrees centigrade above 35° C.

i.e. k increases 2·5 % per degree centigrade.

Equation representing q + k as function of t;

$$-\frac{dt}{dr} = \frac{(q_0 - at)r}{3(k_0 - bt)}$$