Slide Rule GAZETTE
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Apparatus, Observation of Fire Slide Rule - Latest Survey

John Hunt Snr.

The "Handbook of Artillery Instruments 1914", published by the War Office, gives illustrated instructions for two slide rules, a commercial 10 inch slide rule, and a custom rule made of aluminium measuring 18 5/16 inches.

The commercial rule was a Mannheim rule made by John Davis of Derby – blatantly copied from Nestler. It was intended for use by artillery officers.

The longer duplex slide rule, the Apparatus for the Observation of Fire (App. Obs. of Fire), was primarily designed to be used by NCOs, mainly lance-corporals or corporals.

Quoting from the 1914 handbook, - "There are six Marks of this slide rule in the service. They differ principally in:

1. The material of which they are made, the earlier Marks being of boxwood and the later ones of aluminium.
2. The number of yard graduations, the earlier Marks extending to 5,000 yards, the latter ones to 10,000 yards.
3. The form of the cursor and clamp."

Fig.1 Visual comparison between extant marks of App. Obs. of Fire rules.

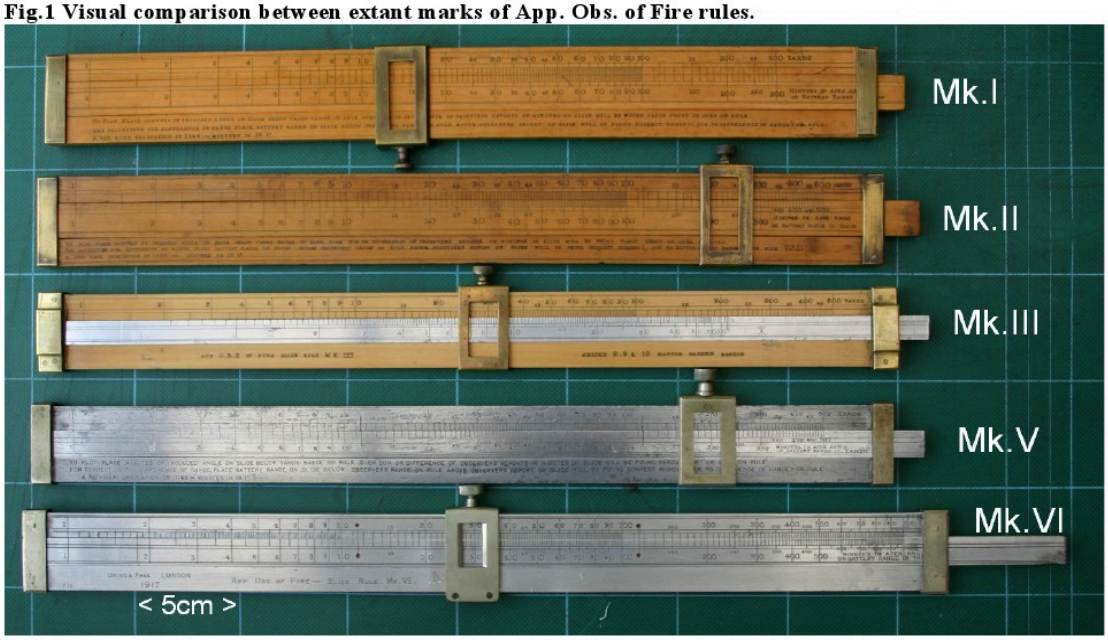

Table 1 Apparatus for the Observation of Fire (App. Obs. of Fire)

Mark	Length of rule (mm)	Max. Range (yards)	Material			Cursor	Earliest Known Specimen
			Stock	Slider	Straps/Cursor		
Mk.I.	375	300	Boxwood	Boxwood	Brass	SS	?
Mk II.	386	500	Boxwood	Boxwood	Brass	SS	1902 ?
Mk.III.	385	500	Boxwood	Aluminium	Brass	SS	?
Mk.IV.							?
Mk.V.	390	500	Aluminium	Aluminium	German silver	SS	1904
Mk.VI.	407	1000	Aluminium	Aluminium	German silver	DS	1914

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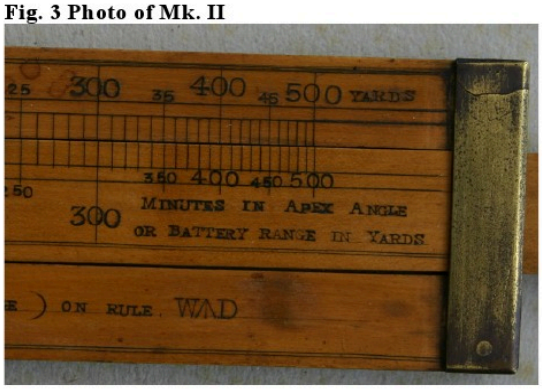
Table 1 elaborates all the specific variations of the extant Apparatus for the Observation of Fire slide rules. Question marks are shown for uncertain attributes. German silver is an alloy of copper (60%), nickel (20%) and zinc (20%) now more commonly referred to as nickel silver. The Range is labelled as 300, 500 and 1000 yards. In slide rule parlance this could be increased by a factor of 10 to give ranges of 3000, 5000 and 10000 yards.

Fig. 2 Photo of Mk. I

Fig. 3 Photo of Mk. II



The wholly wooden rules, Mk I and Mk II are not stamped with the mark number or any manufacturing date and are very similar in appearance. Common sense indicates that the rule of Range 300 is the Mk.I and the rule of Range 500 is the Mk.II. Clearly indicated in Fig. 3 is the War Department stamp with the crows-foot. No crows-foot is stamped on the Mk.I but it could be a special rule since the serial number stamped on the end is 1!

Although the Mk.VI. is physically bigger than the other marks, colloquially referred to as an "18 inch rule", it is of the **same accuracy** as all the other marks. All rules have the same length of logarithmic cycle of 125mm. Mk.1 to Mk.V have 2+ cycles. Mk.VI. has 3 cycles. For comparison, 125mm is the normal length of a Mannheim of a logarithmic cycle on the A and B scales.

Using an App.Obs. of Fire rule gives the **same accuracy** as using a Mannheim on scales A and B.

Now the big question – what are the attributes of the missing/lost Mk.IV rule?

Looking at Table 1 and inferring that Mk.III to Mk.IV and to Mk.V is a progressive improvement:

a) Range of both Mk.III and Mk.V is 500 yards – no change for Mk.IV.
b) Stock material for Mk.III is boxwood but Mk.V is aluminium. This means stock material for Mk.IV **could** be either boxwood **or** aluminium.
c) Material for the slider in Mk.III and Mk.V is aluminium – no change for Mk.IV.
d) Material for the straps/cursor in Mk.III is brass but for Mk.V is nickel silver. This means the material for the straps and the cursor **could** be either brass **or** nickel silver.
e) Cursors of Mk.III and Mk V are single sided - no change for Mk.IV.

Analysing these convoluted attributes, and assuming that any change are made for an improved slide rule, we are looking for a Mk.IV App. Obs. of Fire: of 2+ cycles, range 500 yards, stock material **either** aluminium **or** boxwood with an aluminium slider and a single sided cursor made **either** of brass **or** nickel silver and straps made of the same material. It may or not be dated – but definitely would be stamped as a Mk.IV.

A break-up of a family photograph album[1] (the late Lt.Col. H.J. Humphreys of Surrey) reveals the earliest known photograph of App. Obs. of Fire slide rules in use – albeit in a training rôle.

Fig. 4 Class of Observers, Shoeburyness 1902

In Fig. 4, this group of 22 men plus their instructor formed the 23rd Company (ST) Royal Garrison Artillery (RGA).

The men were all Volunteers or Militia in the Kent Artillery. These Volunteers were later reorganised into the Territorial Army. They were on their 1902 summer camp, attending an Observer's Class in Shoeburyness. The Course Instructor was a 1st Lt. H.J. Humphreys, back row 4th from the left, in the pill box hat.

The photograph shows the complete equipment of a Ranging Company; two sighting telescopes with directors on tripods, flags and telephone. In use, the directors were several hundred yards apart located by a flag as an aiming point for the other director to get the angle of the observed enemy fire. Also a telephone link to communicate results to the Battery Commander – normally a subaltern. Three lance corporals are displaying the App. Obs. of Fire slide rules and their leather sheaths. But the question is – what Mark number is being displayed in the photo?

According to the Siege Artillery Drill, printed by Her Majesty's Stationery Office, and published in 1891, the preferred method of range finding was using the Nolan's Range Finder (Reprinted as an UKSRC booklet 2006). The Nolan equipment consisted of two sighting telescopes mounted on tripods and capable of measuring the angle between the target and a fixed point.

The sighting telescopes shown in Fig.4 are an old fashioned type, a mixture of an alidade with a sighting telescope. Later telescopes have the cross wires incorporated in the telescope. I have a sneaking suspicion that the two sighting telescopes in the above picture were from old rescued Nolan's equipment.

In the approximately twenty years between the ditching of Nolan and the reference to App. Obs. of Fire slide rule in the 1914 handbook, the Army had gone through five versions of the rule without any lasting mention let alone instructions as to its use.

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Fig.5 Enlargement of corporal holding App. Obs. of Fire slide rule

Referring to Fig.1: comparison of the open window cursors clearly shows the soldiers are holding the Mark I or Mark II.

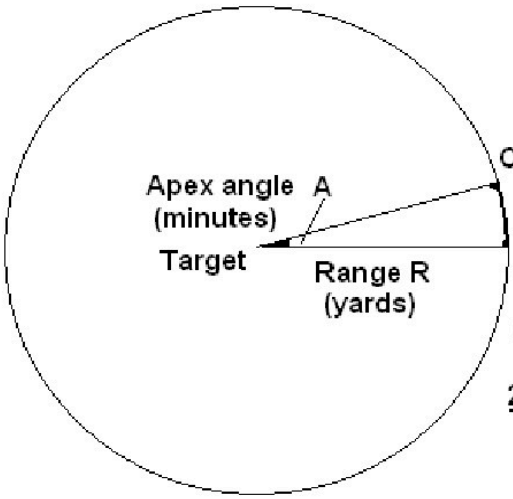
In 1915 these observer units were reorganised as Field Survey Companies, and afterwards as their numbers increased as Field Survey Battalions.

Efficient use of the App. Obs. of Fire slide rule involves a good grasp of trigonometry and in particular, the Sine Rule. The two faces of the slide rule are intended to solve two sorts of problems.

Obverse Face.

This consists of only two identical scales A and B of three logarithmic cycles covering 1(0), 10(0), 100(0) and 1000(0) yards. Two red balls indicates the location of the "Gunner's gauge mark" of 1146. These scales are intended to solve problems of Range involving right angled or approximating to a right angle triangles. Fig. 6 show the origin of the "Gunner's gauge mark"

Fig. 6 Gunner's gauge mark; 1146.



$$2.\pi.R \propto 360^\circ \quad \text{and} \quad a \propto A$$

$$\frac{2.\pi.R.3}{a} = \frac{360.60}{A}$$

$$R = \frac{360.60.a}{2.\pi.3.A}$$

$$R = 1146.\frac{a}{A}$$

R yards, a feet, A minutes

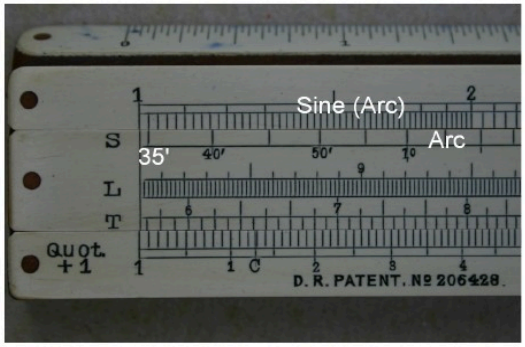
This formula for Range is a typical English jumble of units, but it does the job. A single setting on the slide rule; the apex angle (minutes of arc) divided by the distance between observers (feet). The remaining subject for confusion – what is a triangle "approximating to a right angle"? The answer is – it depends on what accuracy you want!

Example of the possible confusion over Range is given below.

Reverse Face

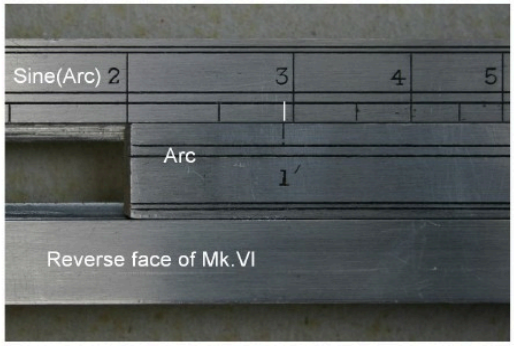
Two scales: the A scale is identical to the A scale on the obverse face - three logarithmic cycles 1(0),10(0),100(0).1000(0) yards. The B scale is a Sine scale – similar to the Sine scale on the reverse slider in a commercial Mannheim rule. The only difference between a Mannheim and the Mk. VI is that the Mannheim goes down to 35 minutes (35') of arc and the App. Obs. of Fire Mk. VI goes down to 1 minute (1') of arc. This, on the latter, is achieved by having an extra-long slider.

Fig 7. Minimum Sine values on a Mannheim. Reverse slider.



Sine (35') = 0.0102

Fig 8. Minimum Sine values on a Mk. VI. Reverse face.



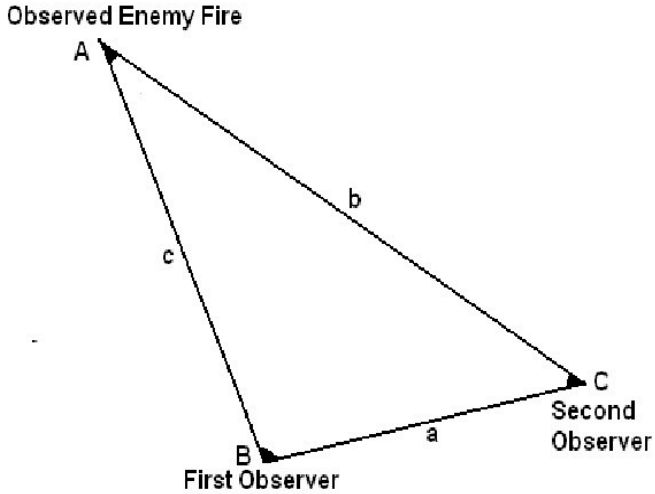
Sine (1') = 0.000291

Incidentally, on all the previous Marks from Mk. I to Mk. V, the Sine scale only goes down to 35' of arc – exactly the same minimum Sine values as a commercial Mannheim!

Fig. 9 shows a typical triangle involving the observed enemy fire and the two observers. Normally, the distance between the observers, **a**, is known or could be measured conventionally. The angles **B** and **C** are measured from the flag pole at each of the observers to the observed fire.

For illustration, the "Handbook of Artillery Instruments" gives an example.

Fig. 9 Triangle of Observers and Enemy Fire



Sine Rule: $\frac{a}{\text{Sine } A} = \frac{b}{\text{Sine } B} = \frac{c}{\text{Sine } C}$

Calculation involves the apex angle **A** and the distances **b** and **c.** Depending on the Director in use, the triangle could be 3D and measure height or depression of the observing fire with an altimeter and/or maps. All this involves simple 3D trigonometry.

How does the App. Obs. of Fire slide rule measure-up to the calculations?

In practice, the apex angle A is extremely small, particularly when the Range is increased

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The "Handbook of Artillery Instruments" gives an example on page 66.
Variables:
A = 20°; B = 87°; C = 73°; a = 750 yards…….Triangle 1

Table. 2 Calculation of opposite sides of Triangle 1				
	Electronic Calculator	Five Figure Log. Tables	App.Obs of Fire Mk VI	Method used by the App. Obs. of Fire Mk. VI
b yards	2097.036	2097.1	2100	Reverse side using Sine Rule.
c yards	2189.848	2189.8	2200	
b = c yards	2148.750	2148.7	2150	Obverse side using "Gunner's mark" b and c are treated as identical.

The Five Figure Log Tables used were provided by the Army "Artillery Survey Pocket Book". Using the reverse side of the App. Obs. of Fire slide rule with the Sine Rule gives a good approximation to the true values of the side **b** and **c**. This was achieved in a fraction of the time taken by the five figure logarithms.

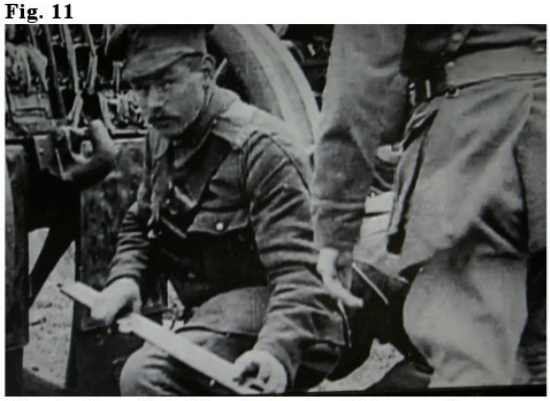
Using the obverse side and the "Gunner's mark" of 1146 the sides **b** and **c** are treated as the two long sides of an isosceles triangle giving ± 50 yards difference from the true value and providing a ±2.3% accuracy.

The question about what is or isn't a right angled triangle is decided by the Battery Commander – normally a Captain or Major. Presumably it would be decided in training and manoeuvres. But the above example shows that the App. Obs. of Fire is capable of delivering ranges in minimum time and within accuracy of all other variables viz: temperature of powder, barometer readings, wear on guns, accuracy of laying, etc.

Fig. 10

An officer – supervising or curious?

Fig. 11



Gawd – have I got the decimal point wrong?

Fig.10 and Fig.11 are rare photos[2] of soldiers actually using the App. Obs. of Fire in the front line or trenches of the Great War. The time line is unknown but must be before the autumn of 1915 because all the soldiers are wearing felt hats. 'Brodies' or tin helmets were compulsorily introduced in late 1915. It could be around the summer of 1915 because neither the officer nor the soldier is wearing shoulder regimental flashes. This requires an explanation – a little prolonged – but necessary.

Artillery Survey Section

The Royal Artillery was divided into three groups: the Royal Horse Artillery (RHA) and the Royal Field Artillery (RFA) were one group; coastal defence, mountain, siege and heavy batteries were a second group named the Royal Garrison Artillery (RGA). The third group continued to be titled simply Royal Artillery (RA), and was responsible for ammunition storage and supply.

The RHA supported the Cavalry; the RFA supported the Infantry and these gunners had good rapport with the Infantry and the Cavalry. The ordinary troops could see the gunners and in their eyes they were part of the fighting unit. The RGA was not so well regarded – they were stationed well back from the fighting line – unseen and relying on this 'bloody' trigonometry for support. To call them cowards would seem a bit harsh but

they had an easy role. There was snobbery between the officers, all centred on the horse. The RHA and the RFA had hounds for fox hunting, hunt balls, polo, gymkhanas, and all the paraphernalia associated with the horse. It was not possible to be an officer in the RHA or the RFA without a private income. Ranging in the RHA and the RFA was simple – when the enemy was sighted, one rider, a subaltern would ride three hundred yards to the front and a little to the side of the guns. He would indicate "short" or "long" when the first shots were fired. This direct ranging was totally unsuited to trench warfare. Here the artillery had to go for "indirect firing" for which the RHA and RFA were ill-equipped and they wasted shells in quantity by unsuitable probing of unseen targets.

Around November 1914, when the troops had dug-in, the arguments between the War Office in London, the General Staff and the GHQ of the British Expeditionary Force (BEF) led to confusion about how to respond to overwhelming German artillery superiority – 800 heavy German howitzers hidden out of sight firing indirectly. The shortage of shells scandal in May 1915, when gun batteries were only allocated a daily handful of shells, brought heads together and officers of the Royal Engineers (RE) took the opportunity to suggest a reorganisation of map and survey work combined with artillery targets.

The reorganisation was aimed at three targets:

1. The provision of fighting maps 1:20,000.
2. The location of targets for the artillery.
3. "Map Shooting" (known as "predicted shooting") by the artillery.

Each of these involved an organisation and methods for which there was no precedent and had to be created. The RE – responsible for map production, balloon and kite survey and communications: the Royal Flying Corps (RFC) responsible for aerial photography: the RGA responsible for flash observing. All of these RGA observer companies, illustrated in Fig.4, were collected together and passed to the RE. The Army designated them as the **Artillery Survey Section**. In the British Army it is customary to refer to units by the initial letters in their name but this contracted into **ASS**. The raucous guffaws, humour and teasing of the ordinary Tommy can only be imagined with this insignia. Many soldiers declined to wear the **ASS** shoulder flashes until, around November 1915, the Army changed the designation to Artillery Survey Detachment.

It was a damaging mistake by the Army, who were trying to educate and change old fashioned attitudes in officers towards maths and ensure that the new observer/survey units and their predictions were a source of intelligence that could be relied upon by the rest of the army – in particular the "horsy brigade" of the officer class of the RHA and the RFA.

In 1916 the French technique of ranging by the sound of gunfire was taken-up and refined by Major W.L. Bragg with his hot-wire microphone. These new sound units together with the old observer units were known colloquially as Flash Spotters and Sound Rangers.

In August 1914 the survey staff of the BEF consisted of one clerk and one officer. By Armistice 1918 it consisted of 400 officers and 6000 other ranks. By the end of the war the British Army was almost certainly ahead of both its allies and enemies in all three of its aims. By 1919 the Observer and Survey units were dispersed and returned to the RA.

The Manufacture of App. Obs. of Fire Slide Rules

Table 3 is a compilation of the late Colin Barnes, Francis Wells, David Rance, Peter Hopp and my own collections – 30 rules in all. Judging by the serial numbers Dring & Fage (1917) and E.J. Woollams-Senney (1918) there should be more extant specimens. It is a mystery as to what has happened to them.

Table 3

Maker	Made	Mk.	Specimens	Highest Serial No.
Aston & Mander	?	I ?	2	92
A. Edgell	?	II ?	1	3
J. Hicks	?	III	1	201
	?	IV ?		
A. Edgell	1904	V	2	132

Initially the Mk. VI was manufactured by Aston & Mander (1914-1915). Later in the war other traditional slide rule manufacturers appeared viz: Dring & Fage, J.A. Nichols, A Edgell, Mavitta and relatively unknown manufacturers, Fountain & Seeney

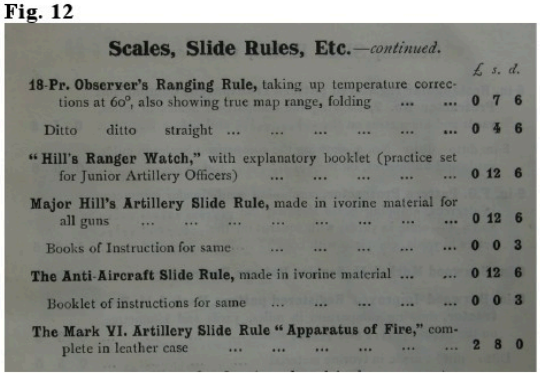
Aston & Mander	1914	VI	1	55	and E.J. Woollams-Seeney.
Aston & Mander	1915	VI	4	89	
Dring & Fage	1916	VI	1	36	Specimens of the Mk VI, used throughout the Great War, have survived in numbers. They occur in Britain, Canada, Australia and the US. The US specimens tend to be in pristine condition – they have not seen active service!
J.A. Nicholl	1916	VI	3	90	
A. Edgell	1916	VI	1	56	
Mavitta	1916	VI	1	2	
Dring & Fage	1917	VI	2	715	
J.A. Nicholl	1917	VI	3	99	
Fountain & Seeney	1917	VI	4	95	
E.J. Woollams-Seeney	1918	VI	3	659	
J.A. Nicholl	1918	VI	1	12	

About 1906 the US Artillery dispensed with the traditional system of degrees and minutes of arc and went over to the French system of mils (1600 mils = 90^0). When, in April 1917, the USA declared war on Germany a quantity of war material, including the App. Obs. of Fire slide rule, was sent to the US Army. They were rejected and eventually sold on the open market. The American Army designed its own equivalent of the App. Obs. of Fire – the "Slide Rule Model of 1917"[3] designed by J.H. Weil and manufactured by George H. Richardson. This was based on the Cosecant Rule, and was in mils not degrees and minutes of arc.

Conclusion of this Survey

It is quite clear from the results of Table 2 that the Mk. VI does its job more than adequately. But the puzzling question is, why was it designed and built at all? This series of artillery slide rules was started around the turn of the 19/20th century. Mk.1 to Mk.V was no better, and, one could almost say inferior, to any number of commercial Mannheim slide rules, because the engraving on the aluminium was inferior to the ivorine of commercial products. Fig.12[4] and Fig.13[5] show some costs of contemporary rules. The cost of the Mk.VI was £2 8s 0d. The cost of a 25cm Mannheim was half this and a 50cm Tavernier-Gravet rule could be purchase for £2 10s 0d.

Fig. 12



Scales, Slide Rules, Etc.—*continued.*

	£	s.	d.
18-Pr. Observer's Ranging Rule, taking up temperature corrections at 60°, also showing true map range, folding	0	7	6
Ditto ditto straight	0	4	6
"Hill's Ranger Watch," with explanatory booklet (practice set for Junior Artillery Officers)	0	12	6
Major Hill's Artillery Slide Rule, made in ivorine material for all guns	0	12	6
Books of Instruction for same	0	0	3
The Anti-Aircraft Slide Rule, made in ivorine material	0	12	6
Booklet of instructions for same	0	0	3
The Mark VI. Artillery Slide Rule "Apparatus of Fire," complete in leather case	2	8	0

Fig.13

TAVERNIER-GRAVÊT SLIDE RULE,
WITH IMPROVED TRANSPARENT CURSOR.

	£	s.	d.
10in. (25 c/m) **Boxwood Rule,** faced with celluloid ... ... Case extra, 1s. 6d.; postage 3d., or to the Colonies 1s. 6d.	0	10	6
14in. (35 c/m) **Boxwood Rule,** faced with celluloid ... ... Case extra, 2s.	1	5	0
20in. (50 c/m) **Boxwood Rule,** in wood case	2	10	0

Sole Maker of Hall's NAUTICAL SLIDE RULE for NAVIGATORS, 17s. 6d. post free.
CATALOGUE OF SURVEYING INSTRUMENTS GRATIS, POST FREE.
J. H. STEWARD, OPTICIAN to the BRITISH and FOREIGN GOVERNMENTS,
406 & 457, STRAND, LONDON.
Telegraphic Address: TELEMETER, LONDON. Telephone: 1867 GERRARD.

Perhaps the series of the App. Obs. of Fire was designed for robustness. There is no question that, if this was the object, the designers have achieved their brief. The open window cursor gives some credence to this view since it was certainly designed for robustness.

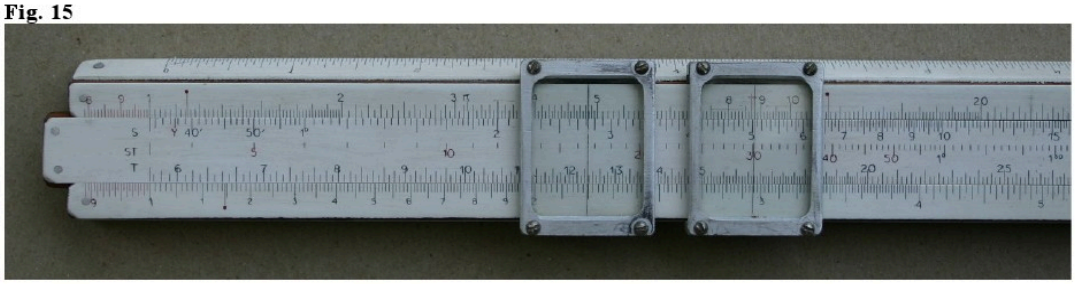
One criticism of the Mk.VI was their lack of subdivisions on the lower numbers on the scales. My criticism was anticipated by some unknown "Flasher" on a Dring & Fage Mk.VI - he accurately engraved the 1/10 intervals from 1 to 10 on the obverse face; see Fig.14. I look out for these modified Mk.VI's. They give some credence that they had been used in the Great War and are preferable to the pristine and sterile specimens that come from the United States. Incidentally, in Fig.14, the serial number is stamped on the lower left of the obverse face - 715.

Fig. 14

At the Armistice in November 1918 the manufacture of the App. Obs. of Fire was terminated.

As a postscript: the extra-long slider to give an apex angle of 1' was not reproduced in the next British slide rule designed for the artillery. Fig.15 illustrates a PIC rule with upset slider. The designers gave an extra scale, the ST scale that gave a practical minimum of 4'.

Fig. 15



Notes:

1. In the collection of the author.
2. Fig 10 and 11 are taken from a Channel 4 video of the Great War.
3. Slide Rule Model of 1917. John Hunt. Published in Slide Gazette, Issue 10, 2009
4. Advert: Artillery Lines of Fire. Arthur L. Hunt. Published 1916 Forster Groom & Co.
5. Advert: The Slide Rule, a Practical Manual. C.N. Pickworth. Edition 10, 1906

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2. Survey Work in Modern War. Major M.N. Macleod. Published in The Journal of Royal Artillery, Vol. XLVIII 1921-1922.
3. Flash Spotter & Sound Rangers. John R. Innes. Published by Allen & Unwin 1935.
4. Artillery: Lines of Fire. Arthur L. Hunt Published by Forster Groom & Co. 1916. Advert.
5. Artillery Survey Pocket Book. Five Figure Logarithms. Published by the War Office 1924.
6. The Slide Rule, a Practical Manual. C.N. Pickworth. Edition 10, 1906