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THE USE OF SIGHT GRATICULES FOR LEAD, ELEVATION, DRIFT AND CORRECTION OF FIRE

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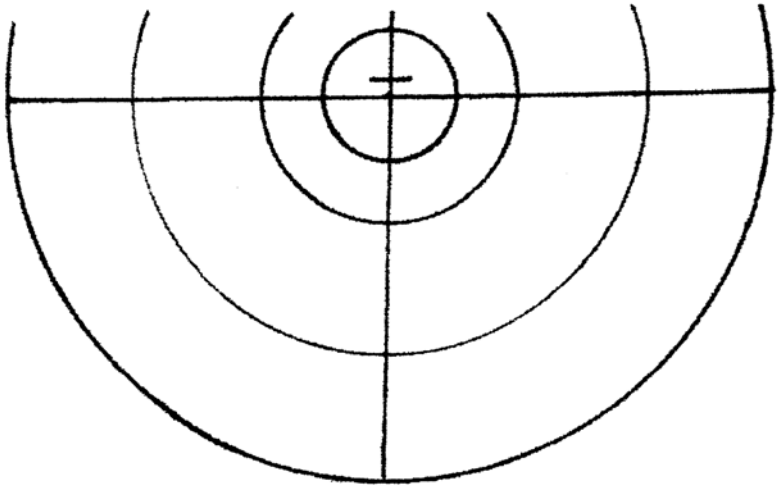
Here is a dot graticule (or it can be seen as the beam from a laser sight):-

It enables you to hit a stationary target at the range at which it was zeroed.

But try to hit a moving target with it! You have no means of assessing lead.

The RAF did the BISTRE trial in 1993 to see how they could help a gunner to hit targets firing a machine gun sideways from a helicopter. They had started using a laser sight but asked Ring Sights if we had a red dot sight to do this. We supplied our standard LC-40-100 fitted with a red dot (I have the actual one here). But besides the red dot I put a cartwheel around it so that the gunner had help with lead and elevation. In no time the RAF gunners had discarded the red dot leaving only the cartwheel. Here it is:-
Pattern 44

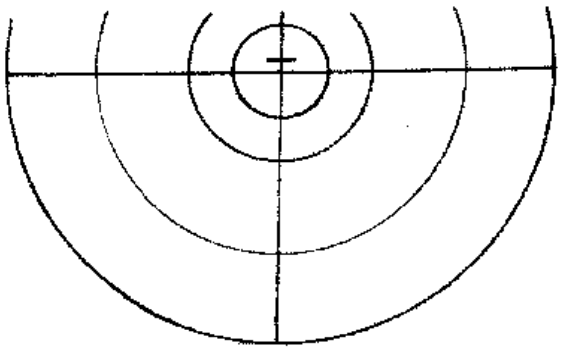


In this simple pattern the circles are at radii defined in mils: actually diameters of 25, 50, 100 and 150 mils. The gunner has to learn how to relate these to target crossing speeds so that he can choose the correct place on the graticule to ensure that the target arrives at the centre of the cartwheel when the bullets get there. It all depends on the time of flight to the range at which the target is to be hit. I will return to this later.

For the bullets to hit the centre of the cartwheel the graticule has to be zeroed to the gun i.e.elevation has to be applied when zeroing to the gun and this elevation is chosen to suit the elevation for the chosen engagement range. Here is a cartwheel graticule with a boresight

mark: the elevation is for the 0.5" HMG at 750 metres.

Pattern 40

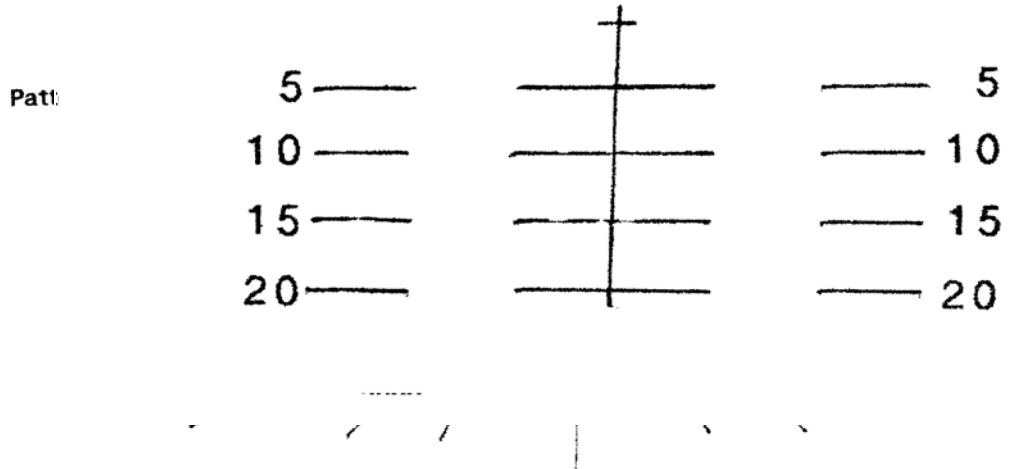


You will see that the centre of the cartwheel is higher on the graticule plate. This pattern is for the HMG in the surface to air role to engage attacking aircraft. Lead for these is small when the aircraft is distant but increases as the aircraft approaches reaching a maximum as it passes overhead (if you haven't killed it before). Engagement of receding aircraft is unlikely so the upper part of the cartwheel is not needed. The gunner has to estimate target crossing speed and use the appropriate ring (or position between the rings); the target must always be flying towards the centre of the cartwheel since this is where the bullets will be when the target and bullets arrive at the chosen engagement range.

To use the cartwheel successfully the gunner needs training, best done on a simulator where realistic crossing rates can be achieved. By training he learns where to place the target to hit it reliably. An old Assistant Instructor in Gunnery who worked for me long ago had been used as the gunner for early predictor demonstrations before WW2: often the predictor was faulty so he just did it himself and they got the next tranche of money to go on with development. Of course crossing rates were slower than they are now but for shooting at approachers a good gunner can achieve hits after training.

It can be made easier for him if the target course is defined: this is traditional anti-aircraft gunnery where ellipses are calculated for a particular course.

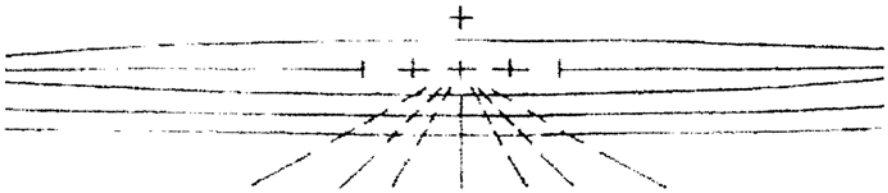
Here is such a graticule:-



This is for the GPMG with an impact range of 700 metres, target height 100 metres and target speeds of 100, 200 and 300 metres per second. The radial lines are to help him getting the target flying towards the centre of the graticule (where the bullets will be).

For the 0.5" HMG with an impact range of 1500 metres the other conditions being the same the pattern contracts vertically since the muzzle velocity is higher (but the time of flight to the impact range is much the same).

Pattern 82

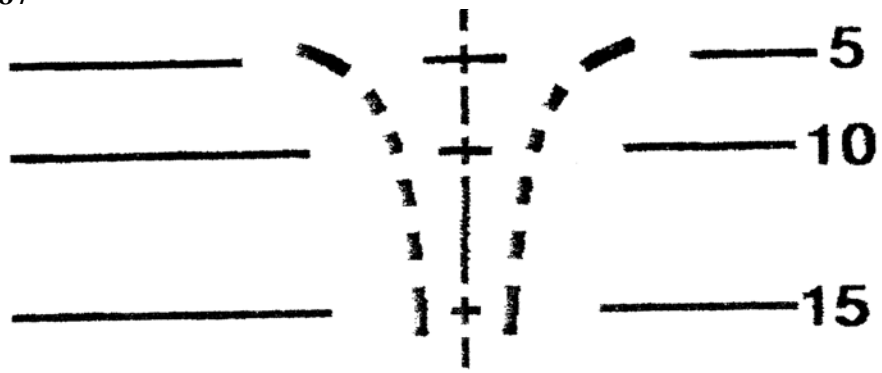


It is worth noting that, for the same reason, the tangent elevation is much the same so the boresight mark position is in about the same place.

You can have what pattern you want though if I was an attacking pilot, and I knew what ellipses you had, I would choose a course to make engagement of me unlikely to succeed. You cannot do this against a cartwheel.

You will see, in the middle of the ellipses, the lead marks for engaging surface targets which have been calculated for crossing speeds of 10 and 20 metres per second. Once again the gunner needs training to use these but these are only useful at one range. He can be given more help.

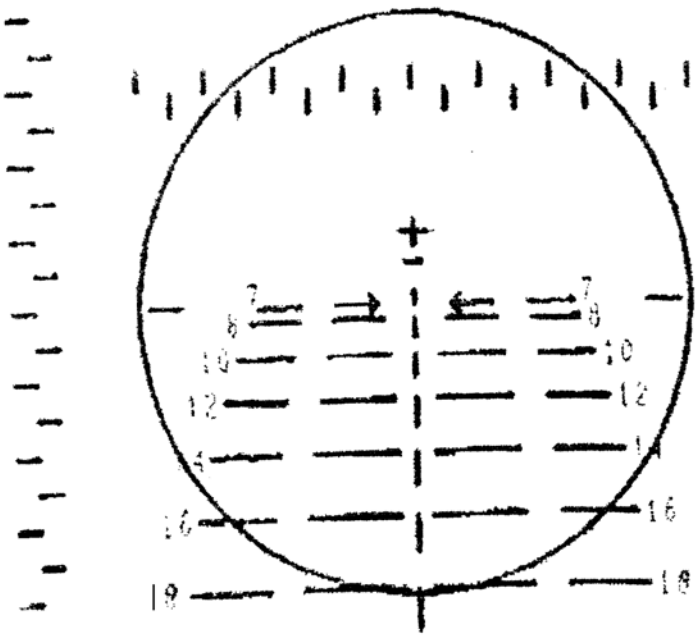
Pattern 87



This is a graticule we designed to be used for firing the Vammas 155mm medium gun directly at moving targets: very simple, range in hundreds of metres, a boresight mark and leads shown by the breaks in the lines. A similar graticule is used in our RC-12 sight on the UK LAW 80.

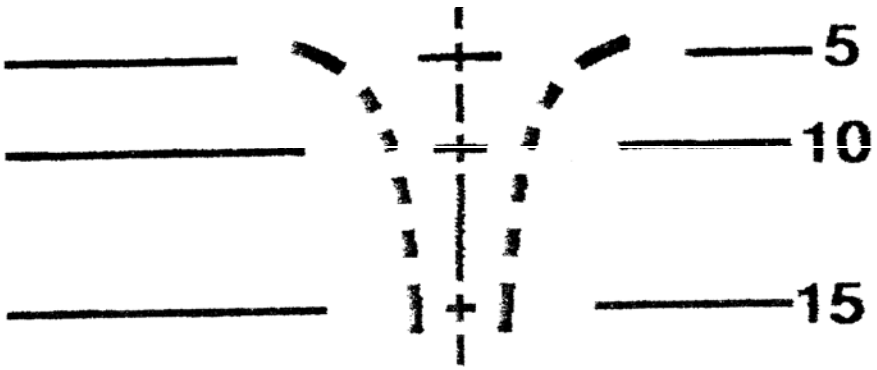
That was about the least we could do. GIAT use this on their 30 mm cannon but the principles are the same.

Pattern 49



One of the problems is range estimation. Stadia lines can be added to help,as in this graticule for the ASP-30, where the tank fills the gap between the curved lines.

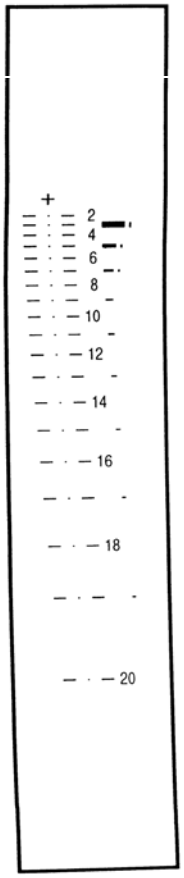
Pattern 41



But we found during the LAW 80 sight research programme that stadia range estimation was only good to about 20%. You can use a laser rangefinder to advantage, either for making a range card, or during the engagement. The Ring Sights can have a pre-aligned dovetail for the lrf.

Accurate range is most important with sub-sonic trajectories such as that of the 40 mm MK19 Automatic Grenade Launcher. The maximum useful range is about 2000 metres but the elevation is nearly 30E and the chance of a first burst hit is greatly improved if the range is known accurately. The WC-30 solid glass sight we have designed for this has this graticule (or, for a US weapon, I mean reticle).

Pattern 62

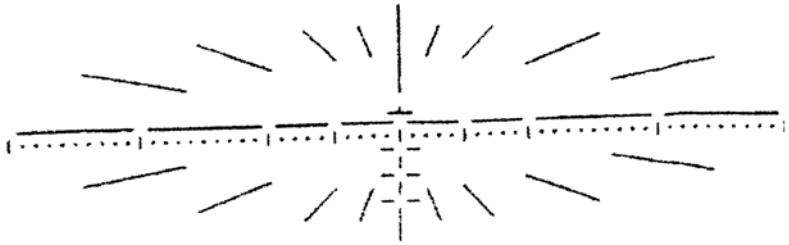


Elevations every 100 metres, even ones numbered. The drift on this weapon is considerable so you can see that it is allowed for by the aiming points being placed laterally to suit.

However good the gunner is at using these graticules, he doesn't always get it right. The wind blows the bullets too so the target is missed. He can, with all the graticules. correct his fire by using "Burst on Target". All he has to do is to maintain his aim as it was when he fired throughout the time of flight, observe the strike (or where the tracer passes the target) against the graticule and put this point on the target for the next burst. This takes out all the errors in elevation and lead, always providing that the target keeps its course the same and means that the next burst will hit.

The helicopter gunner can do all this too. The RAF decided that the cartwheel they had been using on the prototypes could be improved and this is what is on the production sights, now out in Bosnia.

Pattern 47



Same old boresight mark for 400 metres so the bullet strike is central at this range on the solid horizontal line. For 500 metres the dotted line is used and for greater ranges the lines below. Lead is more complicated when shooting sideways as aim off is required for helicopter movement: the bullets start with a forward velocity which is gradually lost by air resistance
(depending on the ground wind). The angle of fire relative to the helicopter movement also affects aim off. But the gunners achieve first burst hits after not too much training which they could not do before. The radial lines are for shooting at targets in the air but I don't think that they have much practice at this (yet!). I might just add that shooting sideways from helicopters
is similar to naval gunnery: the gun platform is moving, the target is moving, the wind is blowing: I think that there are no naval gunners here to explain all this.

The graticule patterns I have shown have been those for the following sights:-

LC-40-100-NVG	Helicopters, Cannon, Machine guns
LC-31-83	Machine guns, Artillery direct fire sight
WC-30	Automatic Grenade Launcher sight

You can try these sights on a FATS simulator in the display area.

You may wonder why the artillery have any interest in these small arms sights. It is because they want to shoot at night with Night Vision Goggles and these sights can be used with NVG by night just as by day. This is one of the many reasons why the RAF, and now the Army Air Corps and the RNAS want the LC-40-100-NVG. The same applies to the other sights: up to now the MK19 AGL had to have the elevation set on an elevating screw and the open or other sight did not have a reticle capable out to 2000 metres so correction of fire was slow, burst on target difficult and quick engagement of one target after another impossible by day, let alone at night.

Comparing the use of a graticule on a Ring Sight with a computing sight:-

The computing sight can deal with higher rates than the Ring Sight: however these higher

rates only apply those air targets which are better engaged with GW.

The computing sight depends on its inputs being reasonably constant and right: probably surface wind is the source of greatest error.

Correction of fire is not easy with a computing sight: change to a fixed mode needs the same sort of graticule as a Ring Sight. Change back entails a settling time. It will be quicker to engage a series of targets with a Ring Sight: and the gunner is in control (if the computing sight has a error, what is the gunner to do?).

Finally the Ring Sight is cheaper, more robust and needs much, much less maintenance.

So I urge you to go to try all this out on the simulator. Forget the dot in front of your eyes and aim off so the bullets arrive simultaneously with the target.6