In this chapter the practical aspects of aiming using metallic sights will be considered. The dimensions of the target will be considered in connection with obtaining optimum results on the firing line. This is an area in which opinion and personal experience of either competitors as well as that of the writer will be given.

The Aperture Front Sight

The use of the aperture front sight in target shooting allows the shooter to use the principle of concentric circles in aiming, as shown in Figure 5.1. The shooter can now line up the outer rim of the sight and the aiming mark, the inner aperture would then be used to contain the circular aiming mark surrounded by a ring of white. This technique is superior to the blades since the shooter is better able to control the vertical and horizontal deviation of the front sight on the aiming mark.

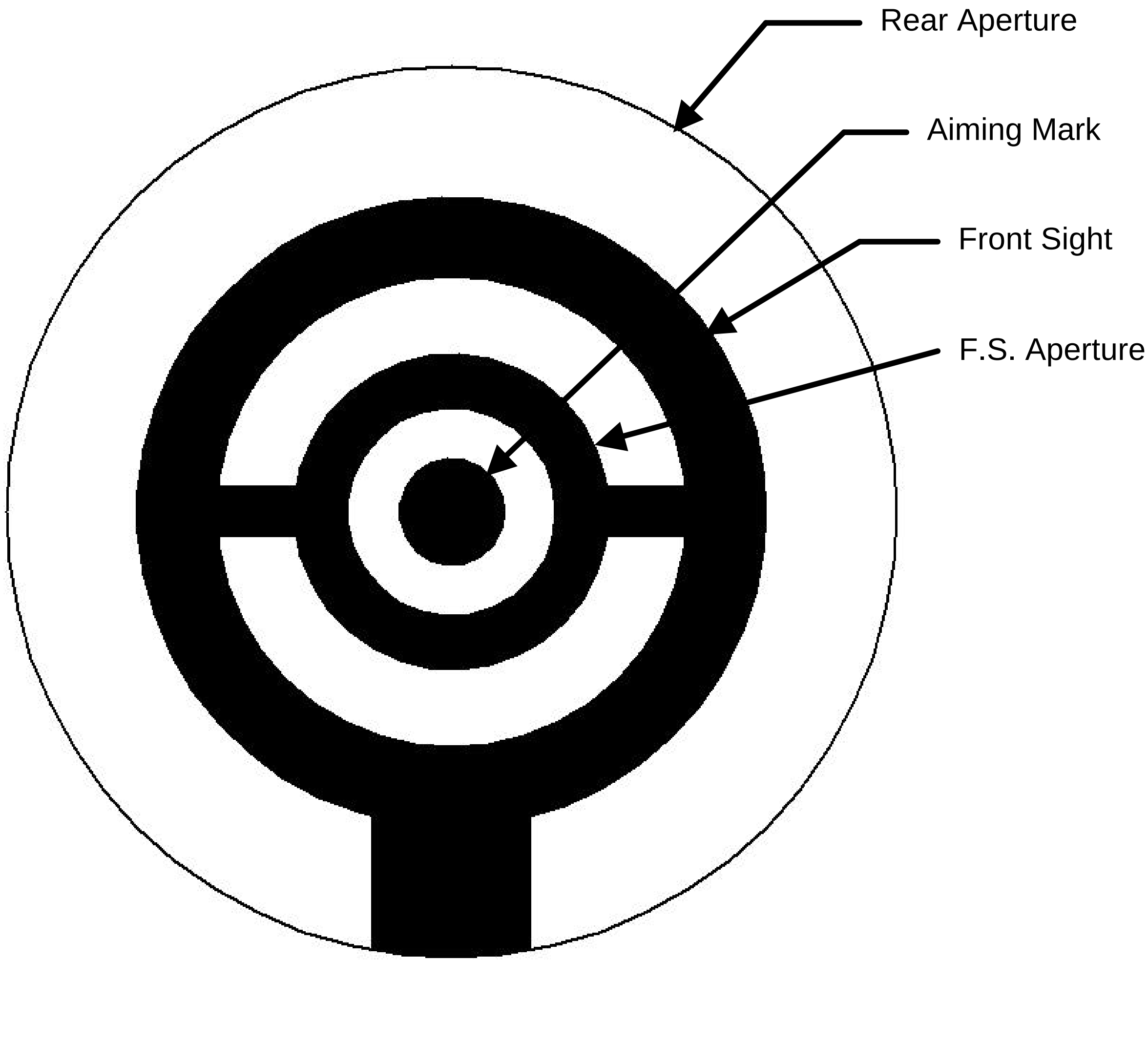

Figure 5.2: Aperture front sight picture showing concentric circles.

Optical interference and diffraction effects will occur when a front sight aperture is used which is too small in size for the aiming mark. Alternatively, should an aperture, which is too large, be used, it'll be difficult to center the aiming mark. The ideal situation appears to be one which will allow maximum discrimination between aiming mark and front sight aperture, with resultant minimum horizontal and vertical dispersion of shots on target.

Various rules of thumb have been given to determine the size of the front sight aperture with a specific aiming mark. Some references state an empirical relationship of 1.5 to 1.75 times the apparent size of the aiming mark when seen through the sights. There are, however, no instructions given in current literature based upon known scientific principles upon which selection of the diameter of front sight may be made.

The structure of the human eye is such that the photoreceptors, or cones, occur at maximum density around the fovea or visual axis of the eye. At this central point, the individual cones are clustered most tightly, but still separated by a finite distance of 1 micron or .00004 inch. In order to see too objects separately, their images must fall on two separate cones receiving the two separate objects. Maximum acuity, or visual sharpness, is obtained when a minimum of one cone separates the two individual cones receiving the two separate images.

Medical measurements have placed the cones at the equivalent of one minute of angle in separation within the human eye. This number will vary slightly with individuals, slightly more, or less, however on the average, the human eye corrected to 20/20 vision, will have a separation of one minute of angle between photoreceptors, or cones. This information may therefore be used in the determination of minimum sizes of aperture inserts with various sizes of aiming marks.

From the preceding discussion, it is evident that visual Iimitations have been reduced by the use of the telescope sight. With the magnification of the target, and the aiming reticule in the same plane as the target, visual accuracy is increased. Telescope sights, by their visual advantage, are not permitted under DCRA rules, except for specific matches and separate classifications. They are allowed in the Any Rifle, Any Sight classification, and in Class F classification. In the National Matches of USA, telescope sights are legal for the Match Rifle class as used for the 1000 yard Wimbledon Match.

As a starting point the aperture sizes were calculated in true minutes of angle for the various distances from the shooters eye to the front sight aperture for aperture sizes of 1.4 mm to 4.0 m. Equivalent decimal sizes included for reference. These values are shown in Table 5.1. Showing True MOA of F.S. Aperture. Figure 5.3: Inner Front Sight Aperture for sizing purposes only.

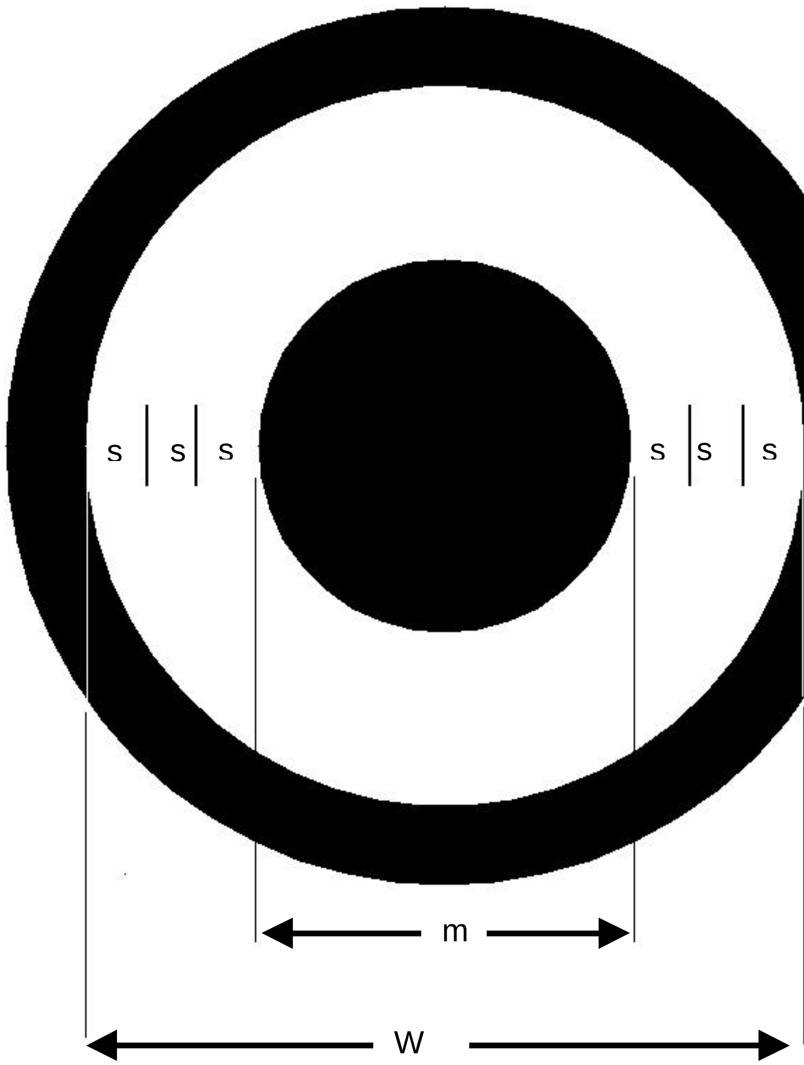

Figure 5.3: Inner Front Sight Aperture for sizing purposes only.

From Figure 5.3, we shall define the following:

Let W = size of front sight aperture, in minutes of angle

m = size of aiming mark, minutes of angle

s = space between receptors or cones of the eye, minutes of angle

We may now define, for maximum acuity, or visual sharpness, the following:

Left inner edge of front sight aperture – 1 MOA

Width of white band – 1 MOA

Left edge of aiming mark – 1 MOA

Width of aiming mark – as found, MOA from table 5.2

Right edge of aiming mark –1 MOA

Width of white band on the right side – 1MOA

Then from Figure 5.3, the minimum size of the front sight aperture W may be given by the following:

$$W = m + 6s$$

The minimum size of front sight aperture must therefore be equal to the width of the aiming mark, in minutes of angle, plus six minutes of angle.

Example

From Table 5.2, the aiming black at 800 yards *(U.S. Target) is 5.25 MOA.* For “s” equal to 1 MOA,

$$W = 5.25 + 6 = 11.25$$

For purpose of this example assume that the distance from the shooter’s eye to the front sight aperture is 36 inches. From Table 5.1, the front sight aperture nearest to the 11.25 MOA for the given sight radius appears to be *3.0 mm.*

Good illumination on the range may indicate a slightly smaller aperture than that given say a *2.9 mm (be cautious, it is better to err larger than smaller).* Similarly, a cloudy and overcast day may require a larger size of 3.1 mm. Other ranges and other rifles may be calculated in advance, and a log can be kept for each rifle. Thus a selection may be made in advance for the front sight apertures, and the appropriate insert installed before going to the firing point.

It may be seen that the calculations are not difficult, and will provide the shooter with the selection of apertures for the front sight based upon known scientific principles.

Sight Focus and Eyesight

For purposes of this discussion, it will be assumed that vision either is, or has been corrected to 20/20 by means of suitable corrective lenses. Thus both farsighted and nearsighted shooters will wear corrective glasses to bring them to normal of 20/20 vision.

People whose age is less than 45 will have eyes with lenses which are normally soft and flexible. The contraction of the ciliary muscle of the eye can change the power of the lens very quickly by changing the thickness of the lens. After the age of 45 to 50 years, the lens of the eye, which up to this point has been supple and flexible, becomes stiff and noncompliant. The ciliary muscle has lo work harder to get it to move the required amount.

As the shooter becomes older, the lens becomes even stiffer, so that even when the ciliary muscle contracts to its utmost, it can cause the lens to change only a small amount.

A normal eye is focused at infinity when it is at rest. The contraction of the ciliary muscle and the thickening of the lens are necessary to focus at a shorter distance, such as the front sight at a distance of approximately one meter. When the lens becomes stiffer with age, it becomes increasingly difficult to focus at a shorter distance. The usual and customary solution is to go to bifocals, where the top half of the lens has the proper prescription to give good vision at distance, or infinity, and the lower half gives good vision at normal reading distance, which is about 16 or 17 inches for most people. A trifocal, if used, has a middle lens, which has a prescription, which will give vision acuity at 3 to 5 feet .

When a person obtains bifocals, the lower or close lens will normally be +1.5 to +2.0 diopters more powerful than the distance, or infinity grind. Neither the infinity nor the bifocal lens is correct, either for location of lenses, or for power. The infinity grind does not allow the eye to focus upon the front sight, and the bifocal is too powerful. In addition, both lenses will not allow proper position of head and eye at the rear sight.

When using target aperture sights, it is necessary to look through the center of the rear aperture, while placing the target in the exact center of the front sight aperture. The front sight aperture must have greatest clarity, without making the target unacceptably blurred. This then becomes the statement of the problem, which must be faced. It is capable of solution, however the solution is neither simple, nor inexpensive.

The proper focal length of one’s shooting glasses is that length at which the front sight is clear and sharp, but at which the target as only slightly blurred. It is not essential to see the target with absolute clarity, but it is absolutely necessary to do so for the front sight. For emphasis, it is more important to see the front sight

The solution can be found in the use of a separate dedicated pair of glasses used only for shooting. Special glasses, such as the Knobloch, and others, consist of a frame to which special lenses can be fitted, These lenses are provided by means of the mounting construction, with an arrangement by which they can be rotated, or moved both vertically and horizontally within the frames to accommodate the wearer. This movement will allow the shooter, when in position at the firing point, to adjust the lens of the shooting to be exactly perpendicular to the line of sight, and aligned with the center of the lens. The hardest part will be that of obtaining a proper prescription capable of meeting the preceding criteria.

It should be noted that the lenses of the shooting glasses are further from the eye than conventional glasses. It is not possible to obtain this prescription from the optometrist by conventional means. Calculation based on the normal lenses has not always proven to be satisfactory in this case. One can start with the normal distance, or infinity correction in a trial lens, and then tape to it various lenses or combinations of +0.25, +0.50, and +1.0 diopter, while looking through the rifle sights. It should be noted that the lenses are additive algebraically, that is, a +0.25 lens, with a +0.50 becomes a +0.75 lens. When the combination of lenses together give the desired results, the prescription may be determined. Fortunately, there are optometrists who are also shooters, and such professionals are able and willing to help. A shooter, looking for optical help, is given every consideration.

When the prescription for the shooting glasses is obtained, the lenses should be hardened, so that in the event of a blow-by, or of a cartridge case splitting, the eye is protected.

The use of the Knobloch Universal shooting glasses will also allow various accessories to be mounted. Thus additional elements, such as filters and auxiliary lenses can be mounted. In the interests of simplicity, one should not add to the shooting glasses when used for shooting high power, since recoil could be a factor.

The human eye is so constituted that the maximum sensitivity of vision occurs in the optical wave length from 500 to 600 nanometers. Light at wavelengths less than 400 nanometers constitutes the ultraviolet spectrum, which contributes to haze and loss of visual acuity outdoors. Optical glass is currently available which filters out light below 400 nanometers, and this may be specified in the lenses of the shooting glasses.

Optical eyepieces which can be screwed into the rear sight, such as the Redfield VARD, add the Walter Gehmann Model 530, both contain an arrangement of lenses which can be moved horizontally in order to change one's focus. When installed in the receiver sight, they will allow lens movement to allow the front sight to be in sharp focus, while allowing the target to be slightly blurred. These eyepieces also incorporate a variable diopter as well, and when stopped down, will increase further visual acuity of the front sight and target.

It should be noted that the optical eyepiece is not permitted in matches sponsored by The International Shooting Union, but is permitted in National Matches by both the DCRA and NRA.

The Stewart eyepiece has been used extensively in Great Britain. This unit permits the use of various combinations of colored filters and fixed lenses to be mounted near the sight aperture.

In conclusion, it must be stated that one cannot hit what one cannot see. For this reason, the ultimate selection is very personal, and remains with the individual.

Aiming Techniques

A long period of shooting using a consistent rhythm does not tire the eye as much as one overly prolonged shot. During one minute of time of aiming without blinking, visual acuity is diminished by one half. Strained aiming causes eye fatigue, which results in a temporary loss of individual sectors of the field of vision. In this regard, shooters should especially avoid prolonged aiming under bright illumination for it causes the rapid development of blind spots. The blind spots will require 5 to 10 minutes of time for their complete disappearance after such aiming ceases.

Prolonged aiming is detrimental to aiming precision. After 15 to 20 seconds, the eye no longed notices errors in the sight picture. By aiming for such long periods, the shooter can make gross errors, which he does not perceive. The aiming process begins when vision is first concentrated upon the circular front sight aperture and ends with the execution of the shot. This process should not exceed 5 to 8 seconds. In between shots, the eyes should be rested, if possible.

Equalization of the seeing task may be carried out by using the non-aiming eye for spotting of the shot in the target.

Conclusion

From the preceding discussion the following points have become obvious:

1. Superior scores can be made in competition using iron, or metallic sights by the application of sound scientific principles, in harmony with the physiology of the human eye.

2. And further, these higher scores can be made by shooters whose vision has been corrected, and as a result there are no limitations due to chronological age alone.

Table 5.1 (revised)

Distance Eye to Front Sight		32	33	34	35	36	37	38	39	40	41	42
						True M.O.A. of Aperture						
Aperture Size												
Decimal	mm											
0.055	1.40	5.92	5.74	5.57	5.41	5.26	5.12	4.99	4.86	4.74	4.62	4.51
0.059	1.50	6.34	6.15	5.97	5.80	5.64	5.49	5.34	5.21	5.08	4.95	4.83
0.063	1.60	6.77	6.56	6.37	6.19	6.02	5.85	5.70	5.55	5.41	5.28	5.16
0.067	1.70	7.19	6.97	6.77	6.57	6.39	6.22	6.05	5.90	5.75	5.61	5.48
0.071	1.80	7.61	7.38	7.17	6.96	6.77	6.58	6.41	6.25	6.09	5.94	5.80
0.075	1.90	8.04	7.79	7.56	7.35	7.14	6.95	6.77	6.59	6.43	6.27	6.12
0.079	2.00	8.46	8.20	7.96	7.73	7.52	7.32	7.12	6.94	6.77	6.60	6.44
0.083	2.10	8.88	8.61	8.36	8.12	7.90	7.68	7.48	7.29	7.11	6.93	6.77
0.087	2.20	9.30	9.02	8.76	8.51	8.27	8.05	7.84	7.63	7.44	7.26	7.09
0.091	2.30	9.73	9.43	9.16	8.89	8.65	8.41	8.19	7.98	7.78	7.59	7.41
0.094	2.40	10.15	9.84	9.55	9.28	9.02	8.78	8.55	8.33	8.12	7.92	7.73
0.098	2.50	10.57	10.25	9.95	9.67	9.40	9.14	8.90	8.68	8.46	8.25	8.06
0.102	2.60	11.00	10.66	10.35	10.05	9.77	9.51	9.26	9.02	8.80	8.58	8.38
0.106	2.70	11.42	11.07	10.75	10.44	10.15	9.88	9.62	9.37	9.14	8.91	8.70
0.110	2.80	11.84	11.48	11.15	10.83	10.53	10.24	9.97	9.72	9.47	9.24	9.02
0.114	2.90	12.27	11.89	11.54	11.21	10.90	10.61	10.33	10.06	9.81	9.57	9.35
0.118	3.00	12.69	12.30	11.94	11.60	11.28	10.97	10.69	10.41	10.15	9.90	9.67
0.122	3.10	13.11	12.71	12.34	11.99	11.65	11.34	11.04	10.76	10.49	10.23	9.99
0.126	3.20	13.53	13.12	12.74	12.37	12.03	11.71	11.40	11.11	10.83	10.56	10.31
0.130	3.30	13.96	13.53	13.14	12.76	12.41	12.07	11.75	11.45	11.17	10.89	10.63
0.134	3.40	14.38	13.94	13.53	13.15	12.78	12.44	12.11	11.80	11.50	11.22	10.96
0.138	3.50	14.80	14.35	13.93	13.53	13.16	12.80	12.47	12.15	11.84	11.55	11.28
0.142	3.60	15.23	14.76	14.33	13.92	13.53	13.17	12.82	12.49	12.18	11.88	11.60
0.146	3.70	15.65	15.17	14.73	14.31	13.91	13.53	13.18	12.84	12.52	12.21	11.92
0.150	3.80	16.07	15.59	15.13	14.69	14.29	13.90	13.53	13.19	12.86	12.54	12.25
0.154	3.90	16.50	16.00	15.52	15.08	14.66	14.27	13.89	13.53	13.20	12.87	12.57
0.157	4.00	16.92	16.41	15.92	15.47	15.04	14.63	14.25	13.88	13.53	13.20	12.89

Table 5.2 (revised)

U.S. TARGETS

Target (yards)	Aiming Mark (inches)	True MOA	Min. Aperture Size (MOA)
200	13	6.21	12.21
300	19	6.05	12.05
500	24	4.58	10.58
600	36	5.73	11.73
800	44	5.25	11.25
900	44	4.67	10.67
1000	44	4.20	10.20

SMALLBORE TARGETS

Target (yards)	Aiming Mark (inches)	True MOA	Min. Aperture Size (MOA)
50	3.89	7.43	13.43
100	8	7.64	13.64

CANADIAN/BRITISH TARGETS

Target (yards)	Aiming Mark (inches)	True MOA	Min. Aperture Size (MOA)
300	22	7.00	13.00
500	39	7.45	13.45
600	39	6.21	12.21
800	48	5.73	11.73
900	48	5.09	11.09
1000	48	4.58	10.58
(meters)			
300	22	6.40	12.40
500	39	6.81	12.81
700	48	5.99	11.99
800	48	5.24	11.24
900	48	4.66	10.66