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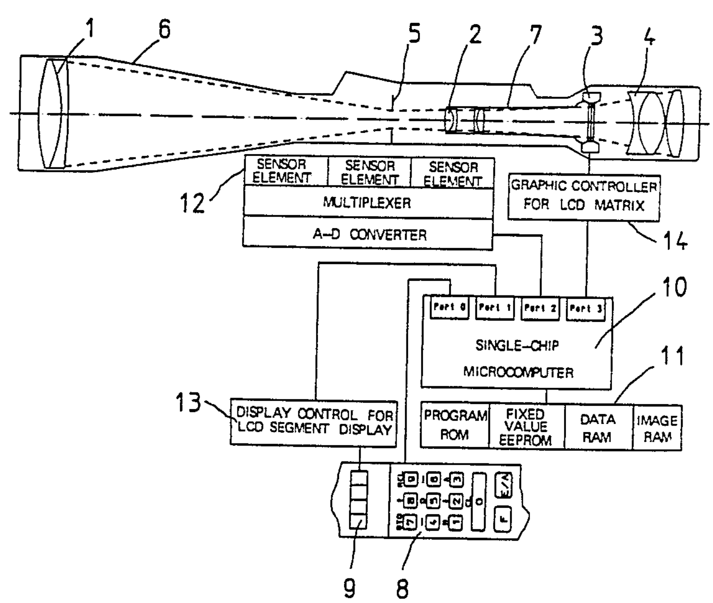
(54) **Telescope sight**

(57) A telescope sight for handguns, in particular for hunting and for military purposes, wherein an LCD matrix 3 is disposed in one of the device image planes and is connected by way of a control unit 14 to a computer 10. In order to enable a marksman to take consideration of the factors influencing the ballistics of the projectile in a simple and optimum manner and to achieve a high degree of accuracy, sensing elements 12 are provided to detect factors influencing the ballistics of the projectile, which are connected by way of A-D converters to the computer, a keyboard 8 being provided for keying in data which are selectable by the marksman. The computer memory 11 contains the working programs and fixed data which are input by the manufacturer and the gunsmith.

Fig. 1



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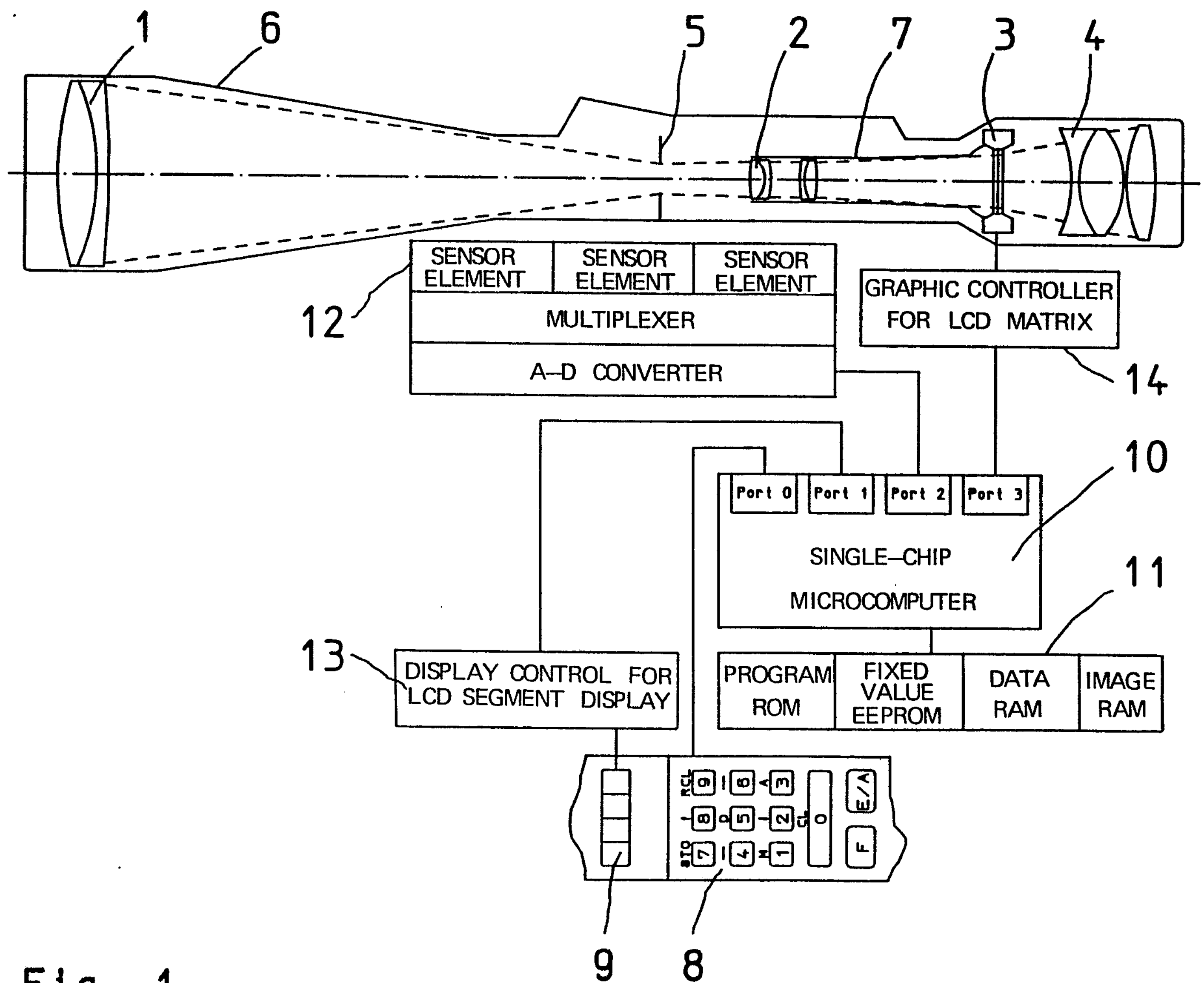
1
6
5
2
7
3
4
SENSOR ELEMENT
SENSOR ELEMENT
SENSOR ELEMENT
MULTIPLEXER
A–D CONVERTER
12
GRAPHIC CONTROLLER FOR LCD MATRIX
14
10
Port 0
Port 1
Port 2
Port 3
SINGLE–CHIP MICROCOMPUTER
11
PROGRAM ROM
FIXED VALUE EEPROM
DATA RAM
IMAGE RAM
13
DISPLAY CONTROL FOR LCD SEGMENT DISPLAY
RCL
STO
E/A
F
9
8

Fig. 1

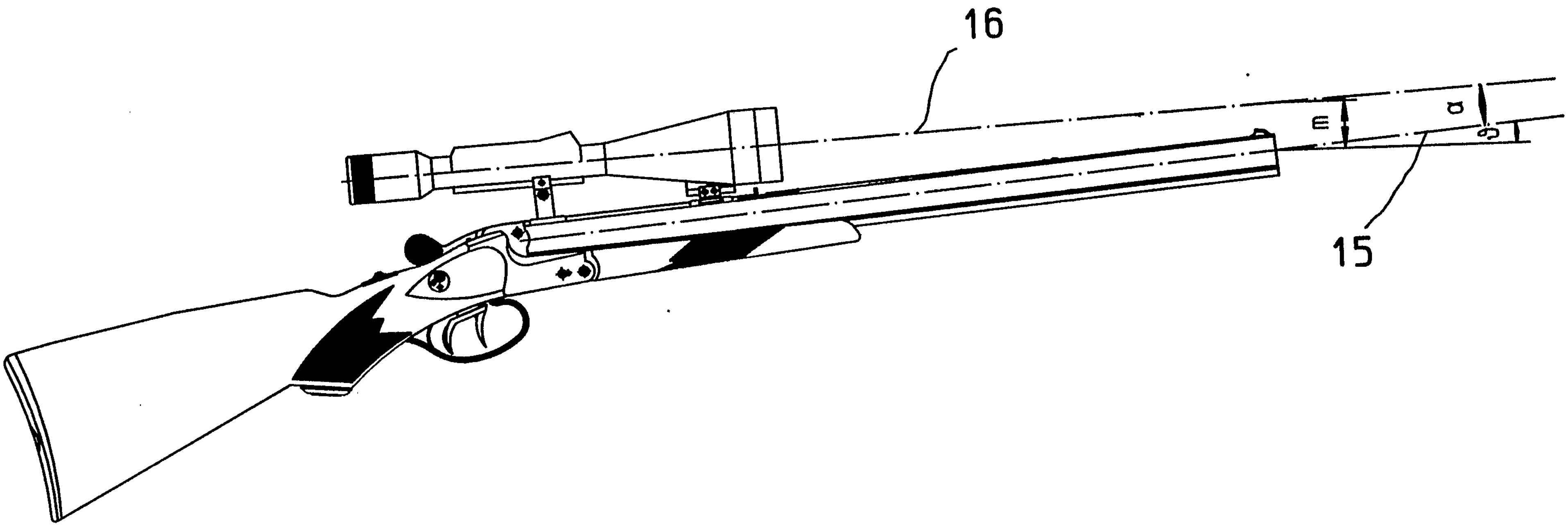

Fig. 2

DESCRIPTION

TELESCOPE SIGHT

The invention relates to a telescope sight for use with handguns, in particular for hunting or in the military field.

Telescope sights are usually mounted on the gun and are ranged, i.e. set up, with it. This is based on certain premises. The weapon is ranged at a horizontal angle of departure and a fixed range, for example 50 m or 100 m, using typical ammunition for the weapon and under real atmospheric conditions. In practice, deviations from these conditions occur and are reflected in a change in the ballistics. Where possible, the marksman corrects these variations subjectively, and possibly with a high degree of error, by holding the graticule on the target.

When actually shooting, a large number of factors affect the ballistics to a greater or lesser degree. These include, in particular:

canting of the gun,

an angled shot upwards or downwards,

the initial velocity and the drag coefficient of the projectile,

air pressure, determined by the difference between the height at which the weapon was ranged and the height at which it is used, and meteorological changes, air temperature,

irregularities in the form of the projectile,

the occurrence of oscillations in the barrel,

rotation of the projectile about its longitudinal axis (Magnus effect),

rotation of the projectile about its centre of mass (precision and notation movement), and

the rotation of the earth.

As a result of canting of the gun, there is a deviation from the target both vertically as well as laterally.

Errors occurring in the event of an angular shot are caused by the different directions of gravity and by the movement of the projectile. The initial velocity and drag coefficient are determined by the force of the propelling charge and by the type, form and dimensions of the projectile.

Given the same calibre, a greater initial velocity and higher mass will produce greater flatness, that is, the trajectory will be less curved.

The actual air pressure prevailing at the shooting location is significant, because if there is lower air pressure, there is less air resistance to the bullet, and vice versa. In addition to meteorological influences, another systematic error is the difference in height between the location at which the weapon was ranged, and the location at which it is used. Air temperature, and variations therein, influence firstly the density of the air itself and secondly the burning of the projectile propelling charge. At low temperatures, a larger angle of sight must be used when shooting, and vice versa. Irregularities in the form of the projectile such as, for example, grooves, lead to the additional formation of whirls on the projectile and hence to increased air resistance.

The barrel oscillations, comprising transverse, longitudinal and torsional oscillations, result from pressing the projectile into the barrel and from the effective gas pressure, and cause the mouth of the barrel to describe a somewhat elliptically formed curve. Because of the mass inertia of the barrel, the actual oscillation does not begin until shortly before the projectile reaches the mouth. This is the so-called departure error angle which is influenced by the following factors:

the clamping of the gun

heating of the barrel

fluctuations in gas pressure

fluctuations in projectile velocity

fluctuations in projectile dimensions from shot to shot.

Because of the rotation of the projectile about its own longitudinal axis, which is caused by a rifled barrel, the projectile undergoes a lift. This is known as the Magnus effect. Rotation of the projectile about its centre of mass, which is represented by a precision and nutation movement, causes a wobbling movement. This produces deviations, which produce a circle of confusion over a large number of shots.

As a result of the Coriolis force, the rotation of the earth causes a lateral displacement of the point of impact. This error occurs to its full extent when the direction of shooting is along a meridian. The latter influences, caused by irregularity in the form of the projectile, oscillations, the Magnus effect, precision and nutation movement and by the rotation of the earth, are largely negligible in ranges of up to 300 m, which are conventional in hunting. The marksman should note the following: influences caused by canting, angled shots, ammunition, air pressure and air temperature. Side drift of the projectile caused by wind should also be taken into account.

Corresponding technical aids are available to the marksman to aid and facilitate the aiming operation.

The state of the art at the moment is such that telescope sights have height and side adjustment.

These types of adjustment may be designed in such a way that the height adjustment curve follows the ballistics of a particular type of ammunition and that the influence of the wind may be compensated by a lateral adjustment.

DAS 2357544 "Sighting device for firearms", describes a device which can be adapted to different types of ammunition using different exchangeable setting scales.

A device for compensating an angled shot and the pressure of the air is described in DAS 1946972, "Sighting device, in particular a telescope sight". Deviations in angle and pressure are automatically detected and are fed to an electronic comparison circuit, where they are evaluated. Correction is carried out either by the user, or mechanically by adjusting the line of sight.

DOS 2259913, "Telescope sight", discloses a solution which relates to preventing displacements of the point of impact by canting of the weapon, angled shooting upwards or downwards and by changes in the weight of the air. According to the invention, this is achieved in that either the inversion system, the cross line, a compensating lens or a planar-parallel compensating glass plate is disposed in the beam path by way of a cardan joint. This optical component can be influenced by suitable adjusting groups, which are under the influence of gravity and which are coupled to a barometric capsule.

In all these solutions, only selected factors of influence can be taken into account, and changing over to amended starting data, for example different ammunition characteristics, involves mechanical/structural changes. The mechanical solutions selected are subjected to a shooting stress in an order of magnitude of several hundred g (acceleration due to gravity) and must be designed for this. The above-listed devices have design features which vary greatly from those of conventional telescope sights and cannot be used on every gun. To do so, it is necessary to adapt them each time to the adjusting characteristics. The selected principle of mechanical initiation of the adjusting movement is not suitable for a transportable device from the energy point of view.

It is an object of the present invention to eliminate the above-listed disadvantages of the prior art, to considerably improve the features of a telescope sight and to allow the manufacturer to adapt the telescope sight to different guns with negligible material outlay.

In accordance with the present invention, there is provided a telescope sight comprising an objective, an inversion system, an eyepiece having an objective image plane and an eyepiece image plane, an LCD matrix which is disposed in one of the image planes of the telescope sight, this matrix is connected by way of a control unit to a computer, at least one sensing element which detects factors influencing the ballistics of the projectile, at least one A/D converter which is connected to said sensing element or elements and to the computer, a keyboard for keying in data which are selectable by the marksman, and a memory which is connected to the computer and contains the working programs and the fixed data which are input by the manufacturer and the gunsmith.

It is advantageous to provide sensing elements for detecting the departure angle, canting angle, air pressure, ambient temperature and other influencing factors.

It is also advantageous to provide a range finder, which is connected to the computer, to replace manual input of the range. The computer, as a processing unit, and other components of the electronics may, for example, also be in the form of one or more ASIC circuits.

Using the invention, shooting errors caused by canting, angled shots, different ammunition, and changes in air pressure and air temperature are compensated by means of objective methods of calculation. The telescope sight can be adapted rationally to different guns without mechanical alterations. The utility value is increased still further in that different sight graticules, which are adapted to the respective hunting conditions, may be selected.

This is achieved by the invention in that a high-resolution LCD matrix, which operates in transmitted light, is disposed in the objective or eyepiece image plane. The pixels on this LCD matrix are controlled by the computer. The computer is used initially to form an image limitation (diaphragm) and a sight graticule (line image). The sight is selected by way of a keyboard entry. The keyboard is also used to input data specific to use such as calibre, initial velocity, range, projectile mass, etc. These quantities are picked up by sensors, for example for detecting the angle of departure, canting angle and air pressure, which are provided in the device, and are passed to corresponding A-D converters. The signals pass by way of the latter to the computer which carries out continuous evaluation of the automatically detected measured values in accordance with a predetermined program and evaluates corresponding displacement quantities for the cross wire of the cross-line grid. This displacement is carried out in the image store in the form of a bit manipulation. The resulting values are read out onto the LCD matrix by way of a suitable graphic controller.

By virtue of the present invention, a marksman is enabled to take account of the factors influencing the ballistics of a projectile in a simple and optimum manner and hence to achieve a high degree of accuracy.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:-

Fig.1 illustrates diagrammatically one embodiment of a telescopic sight in accordance with the present invention; and

Fig.2 shows the telescopic sight of Fig.1 mounted on a rifle.

The telescope sight shown in Fig.1 includes an optical system which comprises an objective 1, an image inversion system 2, and LCD matrix 3 and an eyepiece 4. The inversion system 2 and its focal point on the object side is disposed in the objective image plane 5. The eyepiece image plane and the LCD matrix 3 are disposed in the image-side focal point of the inversion system 2.

The optical components are integrated into a housing 6. The inversion system is held in a swing tube 7, which can be swivelled about the point of intersection of the eyepiece image plane with the optical axis, as is known from the centred sight graticule.

Furthermore, the device also has a keyboard 8 and a keyboard display 9.

Electronic components, comprising a computer 10, memory 11, sensor elements 12, control for the LCD displays 13 and a control unit for the LCD matrix 14, are integrated into the device.

Two angle sensors are disposed in the device in such a way that one detects tilting about the transverse axis (angle of incidence) and the other detects tilting about the longitudinal axis of the telescope sight (canting angle). The pressure sensor comprises a barometric gauge chamber having strips for measuring expansion for detecting the external air pressure. It would be possible to add a temperature sensor or to dispense with the pressure sensor depending on the degree of accuracy required, the desired level of comfort or the conditions of use to be taken into account.

The measurement sensor 12 is connected by way of a multiplexer to an analogue-digital converter for converting the analogue electrical signals into digitally processable electrical signals. The A-D converter has a degree of accuracy which is adapted to the object to be measured and its influence in the computing algorithm, typically an 8-bit resolution. The signals from the A-D converter pass to a port of a single-chip microcomputer.

The single-chip microcomputer operates with a data width of at least 8 bits and a high clock frequency.

The keyboard 8, which may be in the form of a flat keyboard, the display control 13 for the LCD segment display 9 and the graphic controller 14 for the LCD matrix 3 occupy further ports of the single-chip microcomputer.

The computer circuit 10 is also connected to a memory element 11, which comprises a ROM for holding the working program, an EEPROM, which contains data specific to the device, and dynamic RAM circuits which act as image and data stores. The memory may be supplemented by a static RAM which can be used to keep user data even after it has been switched off.

The LCD matrix 3 may have a grid of 512 x 512 points on an area of 20 x 20 mm^2. Of this area, a circle having a diameter of 16 mm is required for the intermediate image occurring in the eyepiece image field. The larger dimensioning of the LCD matrix 3 is justified by the achievement of the necessary adjustment range for an image field which is central with respect to the sighting mark.

In order to achieve maximum possible transmission, an effect is used in the liquid crystal matrix 3, which in principle makes it possible to do without a polarisation filter. The necessary high multiplex rates can be realised in conjunction with the ferroelectric effect.

The electronics and the computer technology are designed such that the components can be used in telescope sights having different magnification, entrance pupil diameters or applications. Since these devices are conventionally mounted on handguns, current must be supplied from an integrated energy source. In addition to the requirement for a high storage capacity, a high temperature operative range must be ensured. It is therefore recommended to use lithium batteries. In order to reduce energy requirements, the entire circuitry is executed in CMOS technology.

A computing algorithm is installed in the program memory and it determines the actual ballistics using the factors of influence to be taken into account.

The ballistic problem of the movement of a missile in the atmosphere taking into account gravity,

air resistance, and

wind

can be represented mathematically by two linear differential equations of the second order, one of which is inhomogeneous:

$$1.)\quad \frac{d}{dt}\left\{\frac{d}{dt}[x]\right\} + E * \frac{d}{dt}[x] = 0$$

$$2.)\quad \frac{d}{dt}\left\{\frac{d}{dt}[y]\right\} + E * \frac{d}{dt}[y] = -g$$

These two differential equations of the second order may be converted into four differential equations of the first order. A method developed by C. Runge and W. Kutta, together with the modifications developed by Nystrom, can be used to solve this system of differential equations of the first order.

Firstly, the theoretical point of intersection of the bore axis 15 and the sight line 16 is calculated using the mounting height m and the angle of incidence α (Fig.2).

The angle φ represents the actual angle of departure of the projectile. Subsequently, the deviation y' of the sight line 16 from the actual point of impact is determined taking into account the canting angle for the predetermined range s. This difference is calculated by way of the objective focal length f' and the scale of reproduction β of the inversion system back into the necessary displacement quantity y'' at the location of the LCD matrix 3 in the eyepiece image plane

$$y'' = \frac{y'}{s} \cdot f' \cdot \beta$$

and into the direction vector.

Taking into account the known graduation spacing of the LCD matrix 3, the necessary displacement in pixel units in the x and y directions is calculated and is carried out in the form of a bit manipulation in the image memory RAM.

The fixed value EPROM contains data which are necessary for adapting the electronics to the device specification, such as, for example:

the objective focal length f',

the scale of reproduction of the inversion system β,

the diameter of the field stop d, and

the pixel spacing on the LCD matrix.

These data are entered by the manufacturer. The gunsmith is able to introduce further data specific to the gun and the mounting, such as:

mounting height m of the telescope sight,

angle of incidence α of the sight line 16 with respect to the bore axis 15,

calibre, and

sight preselection as required by the user and preferred type of ammunition.

If these data are retained, the marksman does not have to add any special input. If a static RAM memory is provided, the actual adjustment can be stored separately and can be called up in the event of subsequent use in the complex.

The basic orientation of the sight line 16 with respect to the bore axis 15 of the gun and hence the provision of a defined angle of incidence α is guaranteed when mounting the telescope by the design of the centred sight graticule 7.

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CLAIMS

1. A telescope sight, comprising an objective, an inversion system, an eyepiece having an objective image plane and an eyepiece image plane, an LCD matrix which is disposed in one of the image planes of the telescope sight and is connected by way of a control unit to a computer, at least one sensing element which detects factors influencing the ballistics of the projectile, at least one A-D converter, which is connected to said sensing element or elements and to the computer, a keyboard for keying in data which are selectable by the marksman, and a memory which is connected to the computer and contains the working programs and fixed data which are input by the manufacturer and the gunsmith.

2. A telescope sight as claimed in claim 1, wherein sensing elements are provided for detecting the departure angle, canting angle, air pressure, ambient temperature and other influencing factors.

3. A telescope sight as claimed in claim 1 or 2, wherein a range finder is provided which is coupled to the computer.

4. A telescope sight as claimed in claim 1, wherein the computer is a procesing unit in the form of one or more ASIC circuits.

5. A telescopic sight, substantially as hereinbefore described, with reference to and as illustrated in the accompanying drawings.

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