

The field of the invention is that of magnifying optical lenses and, more precisely, binocular optical systems intended to be inserted into the night channel of an observation system, between a light intensifier tube
5 and an observer's eyes.

The invention finds special application in observation apparatuses for armoured vehicles and, especially, periscopes for battle tanks.

However, the optical system of the invention
10 finds application whenever there is an optical context similar to the one detailed below.

In the particular case of armoured vehicles, the commander generally has available, for day vision, at least one conventional optical periscope, called day
15 channel, comprising an entry reflector receiving the light rays and an exit reflector outputting the light rays to the commander. Depending on the type of periscope, the path of the light rays between the two reflectors may be direct or may undergo one or more reflections.
20

The day channel provides optimum vision as long as the lighting is sufficient. However, this channel does not allow control by night. In fact, it is not possible, at least in a combat position, to use lighting means
25 built into the vehicle. It is therefore necessary to use an electronic night channel comprising, for example, an objective, a light intensifier tube and a binocular device, this channel outputting a visible image of the landscape to the commander.

However, the size of the known periscopes is too
30 great for them to be fitted into day/night equipment. Apart from the major drawback of presenting the tank commander with a lower-level image than that provided by the day periscopes, they use all the space available
35 between the commander's eye [sic] and the armour, thus preventing interposition of a day channel.

Because a periscope needs to be easily replaceable by another one, for example in the event of deterioration or malfunction, or else quite simply in order to

carry out maintenance adjustments, it is generally in the form of a compact assembly comprising all its constituent elements (optical-ray deflecting reflector, mechanical frame for the night channel, objectives, light intensifier tube, day-channel reflectors, etc.).

Various mechanisms may be used so as to make the dimensions of such a periscope as small as possible.

One mechanism that allows change from vision using a day channel to vision using a night channel is, for example, described in the French Patent Application No. 90/07838 relating to an "articulated mechanical frame, especially for periscopes, and a periscope mounted in such a frame". The change from one viewing channel to the other is performed, requiring a minimum amount of space, by means of a compact mechanism for controlling the tilting of a reflector directing the light rays selectively towards one channel or the other.

With the same aim in mind, it also turns out to be advantageous to consider reducing the size of the binocular devices with which periscopes are equipped. The reason for this is that, in a periscope, the binocular device is placed facing the user and thus occupies a relatively large space. The overall size constraint may thus force the optical system to include an angled part allowing the light rays emerging vertically from the intensifier tube to be deflected horizontally towards the user's eyes.

Apart from the overall size constraint, the design of a binocular device for a periscope is required to be compatible with the other elements in the optical chain. Thus, for reasons of modularity and economy, it should be possible for the binocular devices to be matched with the dimensions of existing intensifier tubes, and especially with the dimensions of the periscopes which equip the battle tanks of the Leclerc, AMX 30 or T ("trade" names) types.

The design of an optical system for the night channel of a periscope therefore requires the choice of an intensifier tube/binocular device pair.

Binocular devices are thus known for night channels for periscopes coupled to 20/30 mm intensifier tubes, for example the PHILIPS XX1380 (registered trademark) intensifier tube.

5 However, the field of view provided by these binocular devices is not wide enough to allow satisfactory comfort when driving an armoured vehicle, and especially a tank.

10 Arrangements of binocular devices are also known which are matched to the widely-used 25/25 mm intensifier tubes of the MX 9644/UV type, where the coupling between the intensifier tube and the binocular device is achieved using an assembly of 25/46 mm magnifying fibres.

15 The main drawback of this type of binocular device is that the magnification ratio necessary to bring the image to a sufficient diameter is 1.6, this leading to a reduction in the aperture of the exit fibre incompatible with a wide aperture of the binocular device. This results in a darkening of the central part of the
20 field for a nominal position of the observer's eyes and a loss of contrast due to the fibres. In addition, this solution is too bulky for most day/night applications.

 A third type of arrangement of binocular device matched to periscopes finds application in 25/40 mm tubes
25 of the THOMSON TH 9311 (registered trademark) type. These tubes are well adapted to the overall-size and image-quality criteria, but have the drawback of having a high cost.

 Moreover, the document of United States Patent
30 No. 3,922,072 by ROGERS is known, this document relating to optical combinations for night vision devices, the image being formed on a "phosphor" screen, typically an intensifier tube, and amplified by lenses. The optical combinations described are of a type comprising three
35 groups of lenses, all convergent. The first group, called front group, is characterized by a focal length lying between 3F and 12F, where F is the focal length of the combination in question, the second group, called central group, has a focal length lying between 1.6F and 2F and

the third group, called rear group, has a focal length lying between $1F$ and $1.75F$. The third group is formed by a frontwardly convex positive meniscus, the rear face of which may have an infinite radius, i.e. it may be plane.

5 However, the combinations produced do not allow a sufficiently small f-number to be obtained, so that the observer must position his eyes in a restricted region in space.

10 Furthermore, it is necessary to devise a radically novel optical arrangement because of the fact that the range of efficiency of the existing arrangements cannot be extended indefinitely simply by quantitative modification. The reason for this is that, for a given optical combination, the operating limit is reached as
15 soon as a limiting size of lens is reached.

 The object of the present invention is to alleviate these drawbacks.

 More precisely, a first object of the present invention is to provide a novel binocular optical
20 arrangement that can be used especially in a night channel for periscopes, in order to transmit images from the screen output of a light intensifier tube right up to the user's eyes.

 Another object of the present invention is to
25 provide a binocular optical arrangement which is both a wide-field and a wide-aperture one.

 An additional object of the present invention is to provide a binocular device taking up little space. In addition, the binocular device must be able to present an
30 angled glass whose function is to deflect the vertical rays coming from the light intensifier tube to the eyeglass whose axis is substantially horizontal.

 A complementary object of the present invention is to obtain an optical arrangement corresponding to a
35 nominal position of the observer's eyes at approximately 100 mm from the eyeglass. In this way, the pupils are some distance away from the first dioptric interface so as to allow the presence of a retractable reflector allowing the image from one of the channels (the day

channel for example) to be sent on when this channel is selected.

The object of the present invention is also to provide a binocular optical arrangement for a night
5 channel, meeting the following specifications:

- entry field greater than or equal to 45° ;
- magnification greater than or equal to 0.9;
- sufficiently large aperture of the binocular device, of the order of 100 mm, so as to avoid the
10 impression of looking through a loophole (it being possible, for example, to estimate the standard distance between the eyes as being of the order of 64 mm);

- the focal length must be of the order of 40 mm (for a 30 mm diameter screen), this requiring a very
15 small f-number in order to satisfy the value of the entrance-pupil diameter;

- the overlap field must be of high quality and wide, at least equal to 15° , in the user's viewing plane. In order for the observer's brain to be able to recon-
20 struct the image in binocular vision, it is necessary for the image in each eye to be roughly identical. The overlap field must therefore cover a significant percentage of the field in the central portion of the image;

- the presence of an angled glass must allow the
25 rays emerging from the intensifier tube to be deflected, for example through 90° , towards the user's eyes. Such an angled component takes up additional space and introduces off-axis aberrations.

These objects, as well as others appearing below,
30 are achieved by means of a binocular optical arrangement, of the type formed by two groups, a front group and a rear group, the said front grouping being formed by a front part and a rear part, the front part being formed by a biconvex lens and a frontwardly concave meniscus and
35 the said rear group being formed by a bonded doublet with a plane rear face comprising a convergent convex lens bonded to a divergent lens, the said lenses of the said bonded doublet having different and complementary disper-
sions to compensate for the chromatism, the focal length

of the said doublet lying between $0.85 F$ and $1.05 F$, where F is the focal length of the said binocular device.

This essential configuration of the invention makes it possible to let the rays pass into the overlap
5 field without introducing on-axis aberration.

Preferably, the centre of curvature of the front face of the said convergent lens of the said doublet is positioned on the optical axis so as to be approximately centred in the plane of formation of the image, in this
10 case on the screen.

According to one embodiment of the invention, the indices of the convergent convex lens and of the divergent lens lie between 1.75 and 1.95 approximately.

According to an advantageous embodiment of the present invention, the said rear part is formed by a
15 biconvex lens.

Preferably, the said convergent biconvex lens and the said concave meniscus of the said front part are separated by a layer of air.

According to another embodiment, the said convergent biconvex lens and the said concave meniscus of the said front part are bonded so as to form a doublet.
20

Advantageously, the said biconvex lens of the said rear part has a plane rear face.

According to another embodiment, the said rear part is a glass plate with plane and parallel faces that is combined with a frontwardly convex meniscus located between the said front part and the said glass plate.
25

Preferably, the said rear part is angled.

The presence of an angled component in the optical system according to the invention allows the light rays entering the binocular device to be deflected, especially if these light rays should reach the binocular device vertically and have to be deflected in order to
30 appear horizontally. This case is typically the one encountered in a periscope, where the commander gets a horizontal view of the light rays emerging vertically from a light intensifier tube.

Advantageously, the optical system according to

the invention is applied to an intensifier tube for a night channel of a periscope, the optical link between the screen output of the said light intensifier tube and the said system being provided by a fibre wafer at the
5 output of the intensifier tube, to which wafer the said rear doublet is bonded.

The fact of bonding the doublet avoids having a layer of air of index 1 which would cause total refraction of the mid-incidence rays and therefore a smaller
10 overlap field. The bonding therefore allows the aperture of the fibres to be artificially increased.

According to one embodiment of the invention, the spreads in the focal lengths of the said front and rear groups respectively lie between 1.75 F and 2.5 F and
15 between 0.85 F and 1.05 F approximately.

Advantageously, the optical system according to the present invention applies to a periscope, especially for an armoured vehicle.

Other features and advantages of the present
20 invention will emerge on reading the following description of a preferred embodiment of the present invention, given by way of non-limiting illustration, and from the appended drawings in which:

- Figure 1 is a diagram of a vertical section of
25 a periscope comprising a day channel and a night channel using an optical system according to the present invention;

- Figure 2 is a diagram of an optical chain for a night channel of a periscope;

30 - Figure 3 represents a first embodiment of an optical arrangement according to the present invention;

- Figure 4 represents a second embodiment of an optical arrangement according to the present invention, constituting a variant of the arrangement of Figure 3;

35 - Figure 5 represents a variant of the optical arrangement represented in Figure 4;

- Figure 6 represents the astigmatism focal lines of the optical arrangement 2 [sic] of Figure 4.

Figure 1 is a diagram of a vertical section of a

periscope comprising a day channel and a night channel using an optical system according to the present invention.

5 A periscope 1 passes through the armour 2 of a vehicle. The periscope 1 comprises two juxtaposed, independent periscopic devices 3 and 4.

10 The light rays received by the upper part of the periscope 1 are directed either towards the device 3, called the night channel, or towards the device 4, called the day channel, depending on the position of a retractable reflector 5. This reflector may, especially, be a mirror or a triangular prism.

15 When the light rays have a sufficient intensity, the retractable reflector 5 is folded down in such a way that the light rays pass directly into the day channel 4.

According to a particular embodiment, the first device 4 may comprise two reflectors 6 and 7 that reflect the light signals entering the periscope towards an observer 8, typically a commander of an armoured vehicle.

20 The light signals coming from the outside are reflected by the reflector 6 towards the reflector 7 which sends them on to the observer 8.

25 When the periscope operates in day mode, that is to say when the rays are admitted into the device 4, the periscope is prevented from moving rotationally. It is not necessary to be able to rotate the day channel in bearing, since known armoured vehicles generally have two lateral day periscopes.

30 The change from the day channel 4 to the night channel 3 is performed by tilting the retractable reflector 5 above the night channel 3. Thus, the light rays admitted into the periscope are directed towards the second processing device 3 and no longer reach the day channel 4.

35 The night channel 3 is formed, in the configuration of Figure 1, by an objective 9, a light intensifier tube 10 and a binocular device 11. The binocular device 11 makes it possible to obtain an image that can be seen by both eyes at the output of the binocular device 11. It

includes an angled component part 30 which allows the light rays to be sent on along a substantially horizontal axis 31 towards the observer's eyes. The construction of the binocular device is detailed below.

5 The light rays coming from the outside are deflected by the retractable reflector 5 towards the objective 9, amplified electronically by the light intensifier 10, penetrate the binocular device 11 and emerge from the binocular device 11 to be seen by the
10 observer 8.

 The night channel 3 may also be formed by CCD or other infrared sensors or by light-signal processing devices. For example, the intensifier tube 10 may be replaced with a camera sensor and a display screen which
15 may or may not be followed by an optical pick-up device.

 When the periscope 1 according to the present invention is in the night position, that is to say when the retractable reflector 5 is in active position (deflection of the light rays towards the channel 3), the
20 observer 8 can slew the night channel, that is to say it can be rotated about a vertical axis. It should be noted that, in the event of pivoting in bearing, the objective 9 and the intensifier tube 10 advantageously remain immobilized, only the retractable reflector 5 and the
25 binocular device 11 being free to rotate. This allows the overall size of the periscope to be reduced.

 Figure 2 is a diagram of an optical chain for the night channel 3 of a periscope.

 The light rays enter the optical chain of the
30 night channel 3 along the direction 12 and pass through an entrance pupil 13 of aperture angle 2θ towards the objective 9 of focal length f . The objective 9 of focal length f forms an image of the landscape on the photocathode 14 of the intensifier tube 10 with a diam-
35 eter ϕ . The focal length f , the field 2θ and the diameter ϕ of the photocathode 14 satisfy the equation:

$$\phi = 2 f \tan \theta \quad (1)$$

 At its output, the intensifier tube 10 includes a screen 15 on which is formed the image whose luminance

has been amplified. The diameter of the screen 15 is $2y$. The binocular device 11 of focal length f forms an image of the screen 15 of the intensifier tube 10 at a distance D from an exit pupil 16. The size of this image is $2y'$ and can be seen in the plane of the exit pupil 16 at an angle $2\theta'$. The following equation is satisfied:

$$y' = D \cdot \tan \theta' \quad (2)$$

The magnification G of the night channel is defined by:

$$G = \tan \theta' / \tan \theta \quad (3)$$

The binocular device 11 is characterized by:

$$- \text{its magnification } g_y = y' / y \quad (4)$$

- the diameter of its exit pupil ϕ_{ep}

- the angle $2\theta'$ at which the image is seen

- its focal length F defined to a good approximation, for $D \gg 1$ by

$$F \approx y / \tan \theta' \quad (5)$$

- its f-number, equal to F / ϕ_{ep}

The value of y depends on the intensifier tube 10 used.

One particular application of the invention consists in using an intensifier tube 10 whose photocathode diameter is equal to 20 mm and $2y$ is equal to 30 mm (20/30 tube).

The specification of the night channel determines the values of the magnification G , the field 2θ and the diameter of the pupil ϕ_{ep} .

A preferred embodiment of the present invention consists in taking the following values:

$$G = 0.9$$

$$\theta > 45^\circ$$

$$\phi_{ep} = 95 \text{ mm}$$

In addition, D is chosen to be close to 2 m since the magnification G is less sensitive to variations in D for a longitudinal shift of the eyes of the observer 8:

$$\text{If } D \text{ is large, } G = f \times \text{tube magnification} \times g_y / D.$$

The calculation for the above optical system is carried out using the equations given:

- equation (3) allows θ' to be obtained from G

and θ :

- equation (2) allows y' to be obtained from D and θ' ;

5 and y' ;

- equation (4) allows g_y to be obtained from y

- equation (5) gives F from y and θ' .

In addition, the equation $N = F/\phi_{ep}$ (6) allows the f-number N to be obtained from the focal length F of the binocular device 11 and from the diameter ϕ_{ep} of its pupil.

10

These values are to be compared with those commonly used in the case of night channels for periscopes:

- $2y$ lying between 40 and 46 mm;
- 15 - G lying between 0.9 and 1;
- $\theta = 45^\circ$;
- $\phi_{ep} = 85$ mm.

Equation (6) gives:

$$N = F/\phi_{ep} = y/\tan\theta' \cdot \phi_{ep} = y/G \cdot \tan\theta \cdot \phi_{ep}$$

20 Thus, according to the specification, N is 20% smaller than is commonly achieved, hence the difficulty of combining the above characteristics and, at the same time, providing an image of excellent quality.

When there is distortion, equation (1) becomes:

25 $\phi_{ep} = 2 f \tan\theta (1 + X)$ where X is the percentage of distortion.

For $X < 0$, for a given ϕ_{ep} , the product $f \cdot \tan\theta$ is higher, this allowing the field θ to be artificially increased without correspondingly decreasing the focal length. It is then advantageous to introduce a distortion of opposite sign into the binocular device 11 in order not to obtain too distorted a final image at the output of the binocular device 11.

30

By way of indication, a very low overall distortion (objective + tube + binocular device) of the order of 0.85%, is obtained.

35

Figure 3 represents a first embodiment of an optical arrangement according to the present invention.

The arrangement represented, called arrangement

1, is formed by two groups of lenses:

- a front group formed by a front part and a rear part.

The front part is located on the side on which the observer 8 is and it consists of a convergent biconvex lens 20 and a frontwardly concave meniscus 21. The "front" is defined as being the side on which the observer 8 is and the "rear" the side on which the light rays enter. The biconvex lens 20 possesses a front radius R_1 and a rear radius R_2 , the front and rear radii of the meniscus 21 being respectively R_3 and R_4 and centred on the axis 26.

The rear part of the front group is formed by a biconvex thick lens 22. The front and rear radii of the biconvex lens 22 are respectively R_5 and R_6 .

- a rear group composed of a doublet 23,24 bonded to the plane rear face.

The front radius of the rear group is R_7 and the central radius, forming the separation between the two elements 23, 24 of the doublet, is R_8 .

Table 1 specifies the values of the thicknesses following each radius represented, the values of the various radii, and the material which follows each radius for the arrangement 1.

In this embodiment, the convergent biconvex lens 20 is separated from the frontwardly concave meniscus 21 by a layer of air.

As specified in the table, the rear radius R_6 may also be infinite, that is to say that the rear face of the lens 22 may be plane (shown as a solid line in Figure 3).

Figure 4 represents a variant of the arrangement 1 of Figure 2, corresponding to a preferred embodiment of the present invention, called arrangement 2.

The arrangement 2 consists in bonding the convergent biconvex lens 20 to the frontwardly concave meniscus 21. A biconvex bonded doublet is thus formed. It should be noted that the rear face of the biconvex bonded doublet may be plane. The bonded meniscus 21 may have a

plane rear face, as represented by the dotted line. The lens 22 and the doublet 23, 24 remain similar to those of Figure 1, only the dimensions of the radii and of the thicknesses being modified.

5 Table 2 specifies the thicknesses and the materials used in the arrangement 2, according to a preferred embodiment of the present invention.

Table 1

	Surface	Following thick- ness (mm)	Radius (mm)	Following material
10	20,R1	27.873	91.676	BK7
	20,R2	0.734	-93.116	Air
	21,R3	3.410	-91.154	SF6
	21,R4	0.836	1581.437	Air
	22,R5	57.927	74.086	SF6
15	22,R6	0.294	∞	Air
	23,R7	18.201	30.337	LaSFN30
	23,24,R8	16.274	-53.147	SF57

Table 2

	Surface	Following thick- ness (mm)	Radius (mm)	Following material
20	20,R1	31.002	77.535	BK7
	20,21,R2	3.388	-93.087	SF6
	21,R3	0.692	747.621	Air
	22,R4	56.647	81.223	SF6
	22,R5	0.447	∞	Air
25	23,R6	17.641	29.104	LaSFN30
	23,24,R7	16.181	-100.461	SF57

Figure 5 represents a variant of the arrangement

2 represented in Figure 4.

The front part of the front group and the rear group remain identical to those represented in arrangement 2 of Figure 4, only the dimensions of the lenses being different.

The variant consists in using a frontwardly convex meniscus 51 and a glass plate 52 with plane and parallel faces in order to form the rear part 22 of the front group.

Tables 3 and 4 below give examples of optical arrangements corresponding to the geometry of Figure 5, these being called respectively arrangement 3 and arrangement 4.

Table 3

Surface	Following thickness (mm)	Radius (mm)	Following material
20,R1	31.474	81.226	BK7
20,21 R2	3.400	-86.352	SF6
21,R3	0.716	1147.70	Air
22,R4	15.066	92.924	SF6
22,R5	0.689	-709.581	Air
22,R6	42.430	∞	SF6
22,R7	0.464	∞	Air
23,R9	18.487	29.013	LaSFN30
23,24,R9	16.079	-164.431	SF57

Table 4

	Surface	Following thickness (mm)	Radius (mm)	Following material
	20,R1	24.970	151.561	BK7
	20,21 R2	3.394	-77.005	SF6
5	21,R3	0.578	-352.297	Air
	22,R4	19.747	70.928	LaSF9
	22,R5	1.685	1192.327	Air
	22,R6	42.456	∞	SF6
	22,R7	0.493	∞	Air
10	23,R8	18.571	30.910	LaSFN30
	23,24,R9	14.258	-42.799	SF57

The bonded meniscus 21 may have a plane rear face, as represented by the dotted line.

15 It should be noted that the arrangements 1,2,3 and 4 do not constitute an exhaustive list of the configurational possibilities of a binocular device according to the present invention, and that other arrangements will easily be apparent to those skilled in the art without going beyond the scope of the invention.

20 In the case of the use of an arrangement according to the invention in a night channel for periscopes, it is advantageous to make use of an angled lens among those forming the binocular device. The function of such an angled lens is to deflect the light rays emerging
25 vertically from a light intensifier tube towards the user's eyes.

One advantageous embodiment of the present invention consists in making an angled component in the rear part of the front group of the binocular device.
30 Thus, the rear group is on the axis of the intensifier

tube, the rear part of the front group deflects the light rays through 90° and directs them towards the front part of the front group, that is to say towards the user. Thus it would be the lens 22 which would be angled in Figures 3 and 4 and the glass plate 52 in Figure 5.

The main characteristic of the present invention is that the rear group is formed by a bonded doublet of two materials having very high refractive indices and different and complementary dispersions to compensate for the chromatism, for example a flint-type glass and a crown-type glass (the dispersion being defined as being characteristic of the variation in refractive index as a function of wavelength).

The focal length of the doublet 23, 24 lies between $0.85F$ and $1.05F$, where F is the focal length of the lens combination of the optical arrangement.

The refractive indices of the two lenses of the doublet lie between 1.5 and 1.95 and preferably between 1.75 and 1.95.

The purpose of the rear doublet is to let through the rays into the overlap field without introducing on-axis aberration.

One advantageous embodiment of the present invention thus consists in locating the convergent lens on the optical axis so as substantially to centre the convex rear face of the convergent lens of the doublet in the plane of the image.

The biconvex lens 24 of the doublet 23, 24 advantageously has a plane rear face so as to be able to be easily coupled to a fibre assembly.

The light rays entering the binocular device may especially come from a light intensifier tube placed substantially perpendicular to an axis passing through the binocular device. This configuration of the linkage between an intensifier tube and the binocular device leads, however, to a smaller overlap field since it does not allow the rays with too grazing an incidence to be taken into account. This drawback is partly compensated for by the bonding of the fibre [sic] to the doublet,

especially to the biconvex lens 24 of the doublet, thereby artificially increasing the aperture of the fibre. The reason for this is that the presence of an air layer, of refractive index 1, between the fibre and the doublet would lead to total refraction of the mid-incidence rays and therefore to the overlap field closing in. According to this embodiment, the fibres, which may especially be magnifying fibres, are also coupled to the intensifier tube by bonding.

As described previously, in a periscope, the night channel is generally free to rotate and only the pivoting reflector 5 and the binocular device 11 are able to rotate about a vertical axis. In this case, the rear group (23,24) is fixed and the front group (20,21,22) is free to rotate about the axis passing through the intensifier tube.

It should be noted that it is also possible to interpose a simple glass instead of the fibre wafer between the intensifier tube and the binocular device according to the present invention.

Table 5 below gives the values and spreads of the focal lengths of each of the lenses 20 to 24 for the four arrangement examples represented.

Table 5

	Arrange- ment 1	Arrange- ment 2	Arrange- ment 3	Arrange- ment 4	Spread
25	20 2.34F	2.17F	2.16F	2.55F	2.16F/2.55F
	21 -2.63 F	-2.53 F	-2.46F	-3.03F	-2.46F/-3.03F
	22 2.27F	2.49F	2.54F	2.17F	2.17F/2.54 F
	23 0.66F	0.74F	0.80F	0.62F	0.62F/0.80 F
	24 -1.54F	-2.92F	-4.79F	-1.24F	-4.79F/-1.24F

Table 6 below gives the values and spreads of the focal lengths of each of the front and rear groups, depending on the arrangement adopted.

Table 6

		Arrange- ment 1	Arrange- ment 2	Arrange- ment 3	Arrange- ment 4	Spread
5	Front group	2.09F	2.16F	2.23F	1.94F	1.94F/2.23F
	Rear group	0.96F	0.91F	0.9F	0.99F	0.9F/0.99F

10 It should be noted that, in Tables 5 and 6, the spreads of each lens correspond respectively to the values of the focal lengths of these lenses in the arrangements 3 and 4.

15 Table 7 below gives the ranges of variation in the refractive indices and in the constringences of each of the lenses 20 to 24 for the spectral band of the "phosphor" P_{20} . The "phosphor" P_{20} is used on the output screens of some intensifier tubes.

Table 7

20	Lens	20	21	22	23	24
	Index	1.48 to 1.75	1.75 to 1.85	1.75 to 1.95	1.75 to 1.95	1.75 to 1.95
	Constr- ingence	40 to 70	20 to 30	20 to 50	30 to 50	20 to 30

25 The following values were used for the four above arrangements:

- $\phi_{op} > = 96$ mm
- $F \approx 40$ mm

for an F/0.42 aperture.

30 Pin-cushion distortion has been deliberately introduced into the above arrangements to compensate for that of the objective of the night channel and the

binocular field is greater than or equal to 41.5° (for D substantially equal to 2 m).

One of the main aims of the present invention is to correct the aberrations of the system, especially
5 astigmatism and curvature. Curvature is defined as being the mean of two, sagittal and tangential, astigmatism curves. Astigmatism occurs when the focal distance is different for the horizontal (sagittal) or vertical (tangential) directions.

10 Astigmatism is generally controlled by means of a pattern consisting of a meshwork of vertical or horizontal bars.

Figure 6 represents the astigmatism focal lines of the arrangement 2 for an inter-pupil separation of 64
15 mm.

The reference frame represented comprises, as abscissa, the focal distance in dioptres of the arrangement studied and, as ordinate, the height of the object point in question.

20 Curve 60 corresponds to the sagittal astigmatism focal line and curve 61 to the tangential astigmatism curve. The interval 63 corresponds to the zone of binocular vision (the field zone seen simultaneously by both eyes or the overlapping field).

25 Over this portion of the field, the astigmatism is much less than 0.5 dioptres, thereby allowing the observer to merge the images seen by each of his eyes without any difficulty.

The image exhibits no or very little curvature so
30 that it is seen in one plane. Nevertheless, it is possible to develop variants with greater curvature so as to give the system the degree of freedom necessary to reduce the field-edge astigmatism.

The focal length of an optical system according
35 to the present invention is very short, of the order of 40 mm.

The power distribution is as follows for each of the groups:

- front group: 1.75F/2.5F with front part: 6F/13F
rear part: 2F/3.5F
- rear group: 0.85F/1.05F.

5 The present invention is especially intended to
be used in night-channel periscopes for armoured
vehicles, but this application is not limiting, it being
possible for the optical system according to the inven-
tion also to be used in other fields where binocular
devices are needed to allow observation.



CLAIMS

1. Binocular optical system, of the type formed by two groups, a front group (20,21,22) and a rear group (23,24), "front" designating the side on which the observer (8) is and "rear" the side on which the light rays enter, characterized in that the said front group is formed by a front part (20,21) and a rear part (22), the front part being formed by a convergent biconvex lens (20) and a frontwardly concave meniscus (21), and in that the said rear group (23,24) is formed by a bonded doublet (23,24) with a plane rear face comprising a convergent convex lens bonded to a divergent lens, the said lenses of the said bonded doublet (23,24) having different and complementary dispersions to compensate for the chromatism, the focal length of the said doublet (23,24) lying between $0.85F$ and $1.05F$, where F is the focal length of the said binocular device.
2. Optical system according to Claim 1, characterized in that the centre of curvature of the front face of the said doublet is positioned on the optical axis (26) so as to be approximately centered in the plane of formation of the image.
3. Optical system according to either one of Claims 1 and 2, characterized in that the indices of the convergent convex lens (23) and of the divergent lens (24) lie between 1.75 and 1.95 approximately.
4. Optical system according to Claim 4 [sic], characterized in that the said rear part (22) is formed by a biconvex lens (22).
5. Optical system according to Claim 4, characterized in that the said convergent biconvex lens (20) and the said concave meniscus (21) of the said front part are separated by a layer of air.
6. Optical system according to Claim 4, characterized in that the said convergent biconvex lens (20) and the said concave meniscus (21) of the said front part are bonded so as to form a doublet.
7. Optical system according to Claim 1,



characterized in that the said rear part (22) is formed by a plano-convex lens (22), the rear face of which is plane.

8. Optical system according to Claim 1, characterized in that the said rear part (22) is formed by a glass plate (52) with plane and parallel faces that is combined with a frontwardly convex meniscus (51) located between the said front part (20,21) and the said glass plate (52).
9. Optical system according to any one of Claims 1 to 8, characterized in that the said rear part (22) is angled.
10. Optical system according to any one of Claims 1 to 9, applied to an intensifier tube (10) for a night channel of a periscope, in which an optical link between the screen output (15) of the said light intensifier tube and the said system is provided by a fibre wafer bonded to the said doublet (23,24) and to the screen of the said intensifier tube (10).
11. Optical system according to any one of Claims 1 to 10, characterized in that the spreads of the focal lengths of the said front (20,21,22) and rear (23,24) groups respectively lie between $1.75F$ and $2.5F$ and between $0.85F$ and $1.05F$ approximately.
12. Periscope equipped with an optical system according to any one of Claims 1 to 11.