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PATENT OFFICE TWENTY DOLLARS

LODGED AT SUB-OFFICE 12 FEB 1988 Melbourne

CONVENTION APPLICATION FOR A PATENT

LODGED AT SUB-OFFICE
12 FEB 1988
Melbourne

(1) Here insert (in full) Name or Names of Applicant or Applicants, followed by Address (es).

~~I~~ We (1) HENNSON INTERNATIONAL

of Chateau de Malissol, Vienne, Isere, France

FEE STAMP TO VALUE OF $320 ATTACHED
MAIL OFFICER

(2) Here insert Title of Invention.

hereby apply for the grant of a Patent for an invention entitled: (2)

PROCESS FOR TAKING A MEDICAL CAST AND DEVICE FOR ITS IMPLEMENTATION

(3) Here insert number(s) of basic application(s)

which is described in the accompanying complete specification. This application is a Convention application and is based on the application numbered (3)

87 02339

(4) Here insert Name of basic Country or Countries, and basic date or dates

for a patent or similar protection made in (4) France

on 13th February 1987

APPLICATION ACCEPTED AND AMENDMENTS

ALLOWED 14 · 12 · 90

~~My~~ Our address for service is Messrs. Edwd. Waters & Sons, Patent Attorneys, 50 Queen Street, Melbourne, Victoria, Australia.

DATED this 11th day of February 1988

(5) Signature (s) of Applicant (s) or Seal of Company and Signatures of its Officers as prescribed by its Articles of Association.

(5) HENNSON INTERNATIONAL

by

L. J. Dyson

Registered Patent Attorney

To:

Australie Form 8 (+1)

(CONVENTION. One or more persons.)

COMMONWEALTH OF AUSTRALIA

Patents Act 1952-1962

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT OR PATENT OF ADDITION

(1) Here insert (in full) Name or Names of Applicant or Applicants

In support of the Convention Application made by(1) HENNSON INTERNATIONAL

(2) Here insert title of Invention.

for a patent for an invention entitled:(2) PROCESS FOR TAKING A MEDICAL CAST AND DEVICE FOR ITS IMPLEMENTATION.

I / ~~We~~ (1) GILLES DECHELETTE, Managing Director

of(3) Chateau de Malissol, Vienne, Isere, France

(3) Here insert (in full) Address or Addresses

do solemnly and sincerely declare as follows;

1. I am authorized by / ~~We are~~ the applicant for the patent. to make this declaration.

2. The basic application as defined by Section 141 of the Act was

(4) Here insert basic Country or Countries followed by date or dates and basic Applicant or Applicants.

made in(4) France on the 13th day of February 1987, by HENNSON INTERNATIONAL

on the .... day of .... 19...., by

3. ~~I am~~ / ~~We are~~ ~~the actual inventor of the invention referred to in the basic application~~. or

(5) Here insert full Name(s) and Address(es) of actual Inventor(s) if other than Applicant(s).

4. (5) FRANCOIS DURET of Rue Paul Claudel, 38690 Le Grand Lemps, France and JEAN-LOUIS BLOUIN of Chateau de Malissol, Vienne, Isere, France.

the actual inventors of the invention and the facts upon which ~~I am~~ / ~~We are~~ the applicant is entitled to make the application, are as follow:

~~I am~~ / ~~We are~~ The applicant is the assignee of the said(6) inventors

(6) Full Name of actual Inventor or Inventors.

4. The basic application referred to in paragraph 2 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application.

DECLARED at France

this 19th day of October 1990

(12) PATENT ABRIDGMENT (11) Document No. AU-B-11666/88
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 607739

(54) Title
PROCESS AND APPARATUS FOR TAKING A MEDICAL CAST

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(56) Prior Art Documents
US 4070683
FR 2562236

(57) Claim

1. A process for capturing ~~taking~~ medical casts, characterised in that it consists in projecting, onto the part of the body the cast of which is to be obtained, a grid with a sinusoidal profile, then in repeating this projection at least twice, for a very brief period of time, with a phase shift between two successive projections of a value equal to $2\pi/n$, where n is the number of projections, in reading each image projected optically, in memorising each of these images, then correlating them, while observing the variations in intensity resulting from the variations of the phase shift, in each point of the object, and allowing the determination by calculation of the depth of each point in relation to a reference plane, the other two dimensions being defined, in relation to the optical system used, in the plane of the detector.

607739

Form 10

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-69

COMPLETE SPECIFICATION

(ORIGINAL)

Class Int. Class

Application Number:
Lodged:

Complete Specification Lodged:
Accepted:
Published:

Priority :

Related Art :

Name of Applicant : HENNSON INTERNATIONAL

This document contains the amendments made under Section 49 and is correct for printing

Address of Applicant : Chateau de Malissol, Vienne, Isere, France

Actual Inventor: FRANCOIS DURET and JEAN-LOUIS BLOUIN

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50 QUEEN STREET, MELBOURNE, AUSTRALIA, 3000.

Complete Specification for the invention entitled:

PROCESS FOR TAKING A MEDICAL CAST AND DEVICE FOR ITS IMPLEMENTATION

The following statement is a full description of this invention, including the best method of performing it known to us

PROCESS FOR TAKING A MEDICAL CAST AND DEVICE FOR ITS IMPLEMENTATION

The object of the present invention is a process for taking a medical cast and a device to implement it.

The field of application of this process encompasses the capture of the shapes of the implanting site of a dental prosthesis whether fixed or mobile and of its environment in order to make a prosthesis, through the volume analysis for a diagnostic of part of the mouth, through the analysis of any part of the human body whose diagnostic and/or the associated therapy require its visualisation as computerised images, as well as the capture of any shape with a view to making a prosthesis such as a hip, auricular, occular, knee, finger and other joint prosthesis.

The capture of medical impressions are known to be made by means of a paste in dentistry, open surgery blood imprint, in the medical field, by micro-palpatation, or by tridimensional optical methods implementing for example, ionising radiations (scanner, tridimensional tomography), non ionising raditions (photogrammetry, steroscopy of interferential methods such as holography) or by the receipt of messages (NMR or ultrasounds).

Methods implementing the capture of an impression by means of pastes are long and require great skill from the operator. Techniques such as photogrammetry, are not sufficiently precise. Other techniques such as holograhy, are very complex and costly to implement, and sometimes provide performances which are higher than those strictly necessary.

The present invention aims at ovecoming these disadvantages by providing a process for capturing a medical cast, simple in concept and offering a three dimensional image with good precision.

For this purpose, the process which it concerns consists in projecting, on the part of the body, the impression of which is to be captured, a grid of sinusoidal profile, then in repeating this projection at least twice, for a very brief time, with a phase shift between two successive projections equal in value to 2 π/n, where n is the number of projections, in carrying out an optical reading of each projected image, in memorising each of these images, then in correlating them, while observing the variations in intensity resulting from the variations of the phase shifts, at each point of the object, and allowing the determination by calculation of the depth of each point in relation to a reference plane, the two other dimensions being defined, in relation to the optical system used, in the detector's plane.

The main advantage of this system results from its great sensitivity which, for the z datum line corresponding to the depth, is of the order of P/100, where P is the pitch of the grid projected. It is possible, therefore, to work with low spatial frequencies hence with a minimum loss of contrast due to the transfer functions of the optics and of the objects whose form is to be captured.

On the other hand, the measurement principle requires relatively simpler calculations than those necessary in the usual Moire techniques. Finally, this system is insensitive to the differences in reflectivity of the object and allows an unambiguous determination of the direction of the deformations (hollows or humps), which is particularly useful for taking dental casts.

According to a first method of implementation, the sinusoidal profile grid is projected according to a beam of parallel rays.

According to another method of implementation, the sinusoidal profile grid is projected according to a divergent beam of rays and the reference plane is perpendicular to the axis of projection.

Advantageously, this process consists in using jointly a complementary projection of a second system of fringes, in order to obtain a very precise phase difference with an indetermination of 2π with the first system, and a rough phase difference although without indetermination of 2π with the second, and the correlation of the two results gives a very precise phase difference without indetermination of 2π at any point. In this case, the second system of fringes is provided by a single projection without any shift and, in this case, the calculation of the phase difference is carried out by a method of sub-sampling or a FOURIER method o any other equivalent method of phase analysis.

According to a preferred method of implementation, this process consists in analysing the variations of the coding phase deformed by the object in the two directions (x,y) defined in the plane of the detector, while taking into account the rate of modulation and reflectivity of the object to produce a binary coded image 1 if the phase exists and is contiunuous, and coded 0 if the phase does not exist or is discontinuous, then in considering the set of images thus obtained, in regrouping the images of the same value, and in defining their frontier by methods of dilation-erosion and of skeletisation of the binary objects.

In order to obtain a good precision of the measurement while using simple calculations, the number of projections of images of the grid on the part of the body to be observed is at least equal to three.

Moreover, this process consists in arranging, over the part of the body to be observed, a plurality of reference points visible in each of the positions of image acquisition, in carrying out several viewings under different angles, in detecting in each of the viewings the (x,y) position of each point, then through interpolation onto the relief, the z value of the latter, then by association of the physically identical reference points in gathering together the whole of the surfaces of each view into the same relief the coordinates of which are defined in relation to a one and only common reference code.

Advantageously, the process consists in calculating the position of each reference point in x or y of the image of reflectivity, through the analysis of the histogram of the levels of grey, then in selecting the black spots of a suitable size, and finally in providing the centre of gravity weighted by the levels of grey inside these microspots.

It should be noted that the reference points can be provided by characteristic points of the part of the body to be examined such as groove, cusp, face of the stump, streaks or points carried by objects laid on the body to be examined such as clamps in a dental application or still by reference points deposited by projections of ink or similar on the part of the body to be examined.

In any case, the invention will be well understood by means of the description which follows, by reference to the diagrammatic drawing attached representing as non limitative examples, several forms of implementation of the device for the implementation of this process:

Figure 1 is a general view of the main elements composing this device;

Figure 2 is a very diagrammatic view of the probe;

Figure 3 is a block diagram of the main components forming the device;

Figure 4 is a view in perspective of a sub-assembly allowing the creation of a coding;

Figure 5 is a side view of a phase modulation system;

Figure 6 is a side view of a first dephasing system;

Figure 7 is a side view of a second dephasing system;

Figure 8 is a block diagram showing the treatment system;

Figure 9 is a view of a block diagram showing the video processing card;

Figure 10 is a block diagram showing the processing card;

Figure 11 is a block diagram showing the image memory card.

As shown in Figure 1, this device comprises an optical probe 2 connected, on the one hand, to a light source 3 and, on the other hand to a processing system 4.

The choice of the source conditions, in a large measure, the characteristics of the system, the source chosen taking into account:

- an optimisation of the emission spectrum of the source and of the bandpass of the system,
- the power suitable to ensure a sufficient illumination of the detector as a function of the transmission of the system,
- the minimum overall measurements for a given power.

When the source cannot be placed in the probe for reasons of overall size, it is necessary to guide the light between the source and probe, which may be done by means of an optical fibre. In this case, the light is collimated by means of coupling optics from the centre of which the extremity of an optical fibre is seen under an angle α, such that α is smaller or equal to P/4D, where P is the pitch of the grid and D is the maximum field depth corresponding to a correct modulation of the projected grid.

The wavelength of the projected light can be lower than 520 μm, the light source emitting in the blue of the ultra-violet, or the light can be made of a solid state device with a semiconductor of the laser diode type.

As shown in Figure 2, the optical probe 2 appears in the shape of a casing of reduced dimensions comprising a body 5 as well as a part 6 suitable for holding in the hand of the practitioner, prolonged by a nose-piece 7 allowing the coding projections and image retrieval. If the light source is formed by a laser diode or another component of the same type, it can be lodged in the body 5. In the other cases, the light source is external and the light beam is guided through an optical fibre which may, for example, be associated to the cable 8, ensuring the transfer of the electronic signals between the probe proper and the processing system.

The optical probe comprises a projection channel for the coding designated in Figure 3 by the general reference 9, and one channel for viewing the image 10, the object whose form is to be captured being defined on the same figure by the reference 12.

The projection channel of the coding comprises collimation optics 13, and a grating 14 fitted with its dephasing system 15, and an imaging optical system comprising an optical relay 16, an image transfer optic 17 and a projection lens 18. On this same figure, the light source is designated by the reference 3, and the fibre for the transfer of the light beam bears the reference 19.

The principle of the method of profilometry by phase coding assumes the creation of a coding of sinusoidal type and phase modulated. The creation of the coding comprises two coupled elements:

- the grating, and
- the phase modulator.

In the form of implementation shown in Figure 4, the transmission system comprises a Wollastron prism 20 formed by two similar wedges 22 cut in a birefringent material, for example quartz, the fast and slow axes of which are opposed. This prism is lighted by a monochromatic light wave, and placed between two polarisers 23 and 24, the axes of which are crossed or parallel and make a 45° angle with those of the prism, the value P of the pitch of the fringes created at the interface with the prism being given by the formula

$$P = \frac{\lambda}{2\Delta n \ tg\Theta}$$

where λ is the wavelength of the light source,
where Θ is the angle of each of the birefringent prisms forming the Wallaston prism, and
Δn is the difference between the ordinary and extraordinary indices of the material.

The fundamental advantage of this system is the complete compensation of the thermal and mechanical effects, since the beams follow the same path. The pitch of the grating is to be chosen as a function of the size of the object, of the magnification of the optical system and of the depth of the field D.

One of the advantages of the method of profilometry by phase analysis is that the uncertainty in z is of the order of P/100, which is advantageous for the precise study of small objects, such as is the case in dental application, since we would recall that classical Moire or interferential processes only provide a precision lower than or equal to P/10.

For the application to the dental field, a pitch of the grating between 1 and 1.5 mm at the level of the reference plane can advantageously be selected.

The phase modulation corresponds in practice to M optical translations of the grating by a quantity nP/M, if M images are taken, where P is the pitch of the grating and n a whole number comprised between O and M, M being generally equal to 3 or 4 for reasons of ease of calculation.

These translations can be obtained through a mechanical shifting of the grating, through an optical process or through an electro-optic modulator.

By operating as shown in Figure 5, revolving a glass plate 25 of index n and of thickness e in parallel beam, a lateral displacement of this beam of a value S is caused such as

$$S = e \frac{\sin(i-r)}{\cos(r)}$$

where i is the angle of incidence of the beam on the plate, and r is the refracted angle, these angles being linked together by the relation

$$\sin i = n \sin r$$

In polarised light, it is possible to use phase plates to create the desired modulation.

As shown in Figure 6, known dephasing plates 26 are successively introduced between the polariser 23 and the Wollaston prism 22. A dephasing of the grating is thus created of a dephasing value of the phase plate. The different plates 26 can be mounted on a motorised wheel 27 the rotation of which is synchronised with the image acquisition.

According to another possiblity, shown on Figure 7, a quarter wave plate 28 is placed behind the Wallaston prism, its axis being parallel to the axis of the polariser. By revolving the analyser 24 by 180°, a dephasing value between 0 and 2π is selected in a continuous manner.

To revolve the plates, it is possible to use a stepping motor, or a direct current motor. In the case of the stepping motor, the position of the blades is known by step counting from a 0 position

This position can be determined by using a split disk presenting an opening which is perpendicular to it, and fixed on the shaft of the motor or or the wheel. A photodiode lights up the disk on one side and a photoelectric cell observes on the other side. When the hole or the slit passes in front of the photodiode, the cell is activated and emits a signal towards the processing system.

In the case of a direct current motor, it is preferable to mount a resistive potentiometer at the tip of the wheel's shaft, the measurement of the resistivity of the potentiometer permitting the position of the motor shaft to be known continuously. The set is controlled by electronic slaving which is situated in the processing system. The rotation of the plates is ensured either directly at the tip of the shaft, or by rack wheel or racked pulleys, this last solution being preferred in the case of a direct current motor.

As shown in Figure 3, the viewing channel comprises essentially an image acquisition lens 29, an image transfer system 30 and an image detector 32. The image detector is advantageiously a detector of the C.C.D. type coupled to synchronisation electronics 33 and to a numerical or video output channel 34.

Advantageously, the probe is also equipped as to be able to blow a compressed air jet 35 onto the object, in a direction parallel to the axis of projection and of observation. The object of this jet is to clean the observed surface from its impurities and, in the case of an endobuccal cast, it enables the gum to be pushed aside and to give access to deep zones for example at the level of the gum sulcus.

It is also advantageous to equip the probe with a device to prevent the formation of vapour. This device comprises means of heating up to a temperature at least equal to 30°C, these means of heating operating when the probe is in the observation position or when it is in the resting position on its support.

These means of heating can be formed by a heating resistance supplied by a low voltage current or by a film of hot air sent under low pressure.

In practice, the practitioner deposits, by means of a suitable marking pen, a few points on the tooth or on the stump or on any other area the relief of which has to be determined. After the introduction of the nose-piece of the probe in the patient's mouth, in the case of an endobuccal shape cast, direct viewing, without coding of the site to be examined is made.

The practitioner then positions the probe according to the viewing angle which seems most appropriate to him, then activates the acquisition of the first view. At this moment, the system synchronises the acquisition of the images with the dephasing of the grating and, eventually, with the stroboscopy of the light source.

Once the images have been acquired, the practitioner can withdraw the probe and check his capture of the cast by selecting three types of information:

- the image without coding of the area acquired,
- a three dimensional graphic representation of the calculated area,
- indicators of the quality of the relief corresponding to the precision of the measurement and a function of the response to coding.

After validation, this view serves as a reference for the whole of the subsequent views for which the practitioner proceeds according to the same principle along different angles. From the second acquisition of a view and of the detection of the reference points, the system can deliver on the screen a graphic image showing the reconstructed relief based on the correlated surfaces.

As shown in Figure 8, the calculator comprises six electronic modules linked by three buses, the modules being formed by a central unit card 36, a random calculation memory card 37, a specialised interfaces card 38, a card for processing the video signal 39, and image memory card 40 and a specialised calculation processing card 42, these modules being connected between one another by a digital video bus 43, a processing but 44 and a systems bus 45.

Figure 9 shows the card for processing the video signal serving as an interface between the camera set in the probe on the one hand, the viewing screen and the calculator on the other hand. This card receives at its input 46, an analog signal of the images originating from the probe which, on the one hand, is processed in 47 and injected into a digitiser 48 formed by an analog-digital converter over at least eight bits, this digitised signal being then sent over the video bus and, on the other hand, sent to the viewing screen through a viewing module.

It should be noted that the card for the processing of the video signal receives, at its input, an image of at least eight bits digital signal originating from the video bus, which is injected after its passage in a conversion table programmable from the bus system into a ditigal analog converter 49, and mixes this analog signal with, firstly, a graphic image originating from at least one graphic bit of the video bus, secondly alpha-numeric characters originating from the bus system 45 and, thirdly, a cursor of any shape originating from a sub-module 52 generator of a cursor associated to a position control register.

The resulting signal is sent to the viewing screen, the image thus formed being decomposed into distinct parts or superimposed parts, namely:

- a part representing one of the image memory planes or the image originating from the probe in which it appears, in overbrilliance or in a different colour, the state of the bit or bits origiinating from the planes of the selected graphic memories,
- a part which forms a display zone of alphanumeric text, and
- a cursor of any shape which can be activated and which can address any point of the screen.

Figure 10 shows the processing card. This module enables quick processing of the images and is associated with local working memories which are of four types : programmes memories, input data memories, output data memories and internal registers.

On Figure 10, the fast treatment processor is designated by reference 53, the local programme memory by reference 54, the input data memories by references 55a and 55b, the output data memories by references 56a and 56b, switches being provided between the processing bus 44, the input memories, the output memories and the fast treatment processor by references 57, 58 and 59. The processing card receives simultaneously at the input a flood of numerical data from at least two images originating through the processing bus 44 from images memory card 40, processes this flood of data, pixel for pixel, according to programmes preloaded by the bus system 45 and delivers onto this processing bus 44, the results of the calculations in a digital form.

Figure 11 shows the image memory card. This image memory card contains at least four digitised images of eight bits each, in the planes 60, 61, 62 and 63, and a graphic plane 64 of four bits and is provided with a sub-module 65 programmable by the bus system 45 which allows the images and graphic planes at the input or at the output to be multiplexed and switched towards the three bus system 45, video 43 and processor 44.

According to another characteristic of the invention, the specialised interfaces card 38 has electronic means available allowing synchronisation of the acquisition of the images originating from the probe with the memory card and the means of driving the plates in rotation, these electronic means being triggered externally by the user.

Advantageously, the six electronic modules of the calculator are contained on the same card, the card being divided in six overlapping parts.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A process for capturing ~~taking~~ medical casts, characterised in that it consists in projecting, onto the part of the body the cast of which is to be obtained, a grid with a sinusoidal profile, then in repeating this projection at least twice, for a very brief period of time, with a phase shift between two successive projections of a value equal to $2\pi/n$, where n is the number of projections, in reading each image projected optically, in memorising each of these images, then correlating them, while observing the variations in intensity resulting from the variations of the phase shift, in each point of the object, and allowing the determination by calculation of the depth of each point in relation to a reference plane, the other two dimensions being defined, in relation to the optical system used, in the plane of the detector.

2. A process according to claim 1, characterised in that the grid with a sinusoidal profile is projected according to a beam of parallel rays.

3. A process according to claim 1, characterised in that the grid with a sinusoidal profile is projected according to a beam of divergent rays and in that the reference plane is perpendicular to the axis of projection.

4. A process according to any one of claims 1 to 3, characterised in that it consists in using jointly a complementary projection of a second system of fringes, in order to obtain a very precise phase difference with an indetermination of 2π with the first system, and a rough phase difference of 2π, although without indetermination, with the second, and in that the correlation of the two results gives a very precise phase difference of 2π in all points without indetermination.

5. A process according to claim 4, characterised in that the second system of fringes is made by a single projection without any shift and in that, in this case, the calculation of the phase difference is made by a sub-sampling method or a FOURIER method or of any other equivalent method of phase analysis.

6. A process according to any one of claims 1 to 3, characterised in that it consists in analysing the phase variations of the coding deformed by the object in the two directions (x,y) defined in the plane of the detector, taking into account the rate of modulation and the reflectivity of the object, to produce a binary image coded 1 if the phase exist and is continuous, and coded 0 if the phase does not exist or is discontinuous, then in considering the whole of the images thus obtained, in regrouping the images of the same value, and in defining their border by methods of dilation-erosion and of skeletisation of binary objects.

7. A process according to any one of the claims 1 to 6, chracterised in that the number of image projections of the grid onto the part of the body to be observed is higher than or equal to 3.

8. A process according to any one of the claims 1 to 7, characterised in that it consists inlaying on the part of the body to be observed a plurality of reference points visible in each of the position of shooting the images, in taking several shots under different angles, in detecting in each of the shots the (x,y) position of each point, then by interpolation on the relief, the z value of the latter, then by association of the physically identical reference points in gathering the whole of the surfaces of each shot in the same relief the coordinates of which are defined in relation to a single common reference datum.

9. A process according to claim 8, characterised in that it consists in calculating the position of each reference point in x and y on the image of reflectivity, through the analysis of the histogram of the levels of grey, then in selecting the black spots of a suitable size, and finally in giving the centre of gravity weighted by the levels of grey inside these micro-spots.

10. A process according to any one of the claims 8 or 9, characterised in that the reference points are provided by characteristic points of the part of the body to be examined, such as grooves, cusp, stump face, scratches or points carried by objects added onto the body to be examined such as clamps, in the case of a dental application.

11. A process according to any one of the claims 8 and 9, characteried in that the reference points are deposited, by projection of ink or similar, on the part of the body to be examined.

12. A device used in the implementation of the process as claimed in any of Claims 1 to 11, wherein it comprises an optical probe constituted by a projection channel of a coding on the part of the body to be analysed, an observation channel of the body thus coded, said optical probe being connected to a light source, separate or not, and connected to a calculator comprising six electronic ~~packages~~ modules connected by three buses, and allowing synchronization of ~~the~~ operations, acquisition of the images, their visualization and processing to extract the relief measure according to the three dimensions.

13. A device according to claim 12, characterised in that, in the case where the light source is distinct from the probe, the light is collimated by means of coupling optics, from the centre of which the extremity of an optical fibre is seen under an angle α, such that α is smaller than or equal to P/4D, where P is the pitch of the grid and D is the maximum field depth corresponding to a correct modulation of the projected grid.

14. A device according to any one of the claims 12 and 13, characterised in that the wavelength of the light projected is lower than 520 μm, and that the light source emits in the blue or the ultraviolet.

15. A device according to any one of the claims 12 and 13, characterised in that the light source is a solid state device with a semiconductor of the laser diode type.

16. A device according to claim 12, characterised in that the projection channel for the coding comprises collimation optics, a grating fitted with its dephasing system and an optical imaging system comprising an optical relay an image transfer optic and a projection lens.

17. A device according to claim 16, characterised in that the transmission grating comprises a Wollaston prism constituted by two similar wedges cut in a birefringent material (for example quartz the fast and slow axes of which are opposed), lighted by a monochromatic light wave, placed between two polarisers, the axes of which are crossed or parallel and make a 45° angle with those of the prism, the value of the pitch p of the fringes created at the interface of the prism being given by the formula

$$p = \frac{\lambda}{2\Delta n \ \mathrm{tg}\Theta}$$

where λ is the wavelength of the light source, where Θ is the angle of each of the birefringent prisms forming the Wollaston prism, Δn is the difference between the ordinary and extraordinary indices of the material.

18. A device according to any one of the claims 16 and 17, characterised in that the dephasing system comprises a motorised wheel comprising several crystalline plates for known dephasing, so as to introduce them sequentially or in synchronisation with the shooting of the image.

19. A device according to any one of the claims 16 and 17, characterised in that a quarter wave plate is placed behind the Wollaston prism, with its fast and slow axes at 45° with the axes of the prism and in that the analyser revolves over itself allowing a dephasing value between 0 and 2π to be selected continually.

20. A device according to any one of the claims 16 and 17, characterised in that the phase modulation system comprises a glass plate of index n and of thickness e mounted pivoting to cause a lateral shift of the beam by a value S such as:

$$S = 3 \frac{\sin(i-r)}{\cos(r)}$$

where i is the angle of incidence of the beam on the plate and r the refracted angle, the said angles being linked by the relation:

$$\sin i = n \sin r$$

21. A device according to any one of the claims 18 and 19, characterised in that the means of driving the plates in rotation are provided by a stepping motor, the position of the plates being known by counting the steps from a

reference position determined by using a split or holed disk fitted on the wheel or on the driving shaft, on the one side of which is fitted a photodiode lighting the disk and on the other side of which is fitted a photoelectric cell which, when activated by the photodiode, emits a signal towards the processing system.

22. A device according to any one of the claims 18 and 19, characterised in that the means of driving the plates in rotation are provided by a direct current motor, the control means of which comprise a resistive potentiometer mounted at the extremity of the plate holding wheel shaft, the measurement of the resistivity of the potentiometer allowing the position of the motor shaft to be known continuously.

23. A device according to any one of the claims 12 to 22, characterised in that the probe is fitted with a blowing system for a compressed air jet onto the object to be observed, at the end of the nose-piece and in the direction of observation.

24. A device according to any one of claims 12 to 22, characterised in that the probe is equipped with a system avoiding the formation of vapour, comprising means of heating to a temperature at least equal to 30°C, these heating means operating when the probe is in the observation position or when it is in the resting position on a holder.

25. A device according to any one of the claims 12 to 24, wherein the ~~characterised in that a~~ calculator comprising six electronic modules linked by three buses, has modules being formed by a central unit card, a random access memory for calculation, a specialised interfaces card, a video signal

processing card, an images memory card and a specialised processing card for calculation, these modules being linked to one another by a video-digital bus, a processing bus anda bus system.

26. A device according to claim 25, characterised in that the processing card for the video signal serving as an interface between a camera arranged in the probe on the one hand, the viewing screen and the calculator on the other hand, receives at the input an analog signal of the images originating from the probe which, on the one hand is processed and injected into the input of a digitiser formed by an analog-digital converter over at least eight bits, the said signal so digitised is then sent over the video bus and on the other hand sent to the video screen through a viewing sub-module.

27. A device according to claim 25, characterised in that the video signal processing card serving as an interface between the camera set in the probe on the one hand, the viewing screen and the calculator on the other hand, receives at the input a digital signal of eight bits originating from the video bus which are injected, after passing through a conversion table programmable from the bus system, into a digital analog converter, and mixes this analog signal with, first, a graphic image originating from at least one graphic bit of the video bus, secondly, with alphanumeric characters originating from a sub-module allowing these said characters to be generated from the bus system and, thirdly, with a cursor of any shape originating from a sub-module generating a cursor associated with a position control register and finally, sends the resulting signal to the viewing screen, the image thus formed on the screen being broken down in distinct or superimposed parts:

- one part representing one of the image memory planes or the image originating in the probe over whichappears, in overbrilliance or in different colours, the state of the bit or bits originating from selected graphic memory planes,

- a part which constitutes a display zone of alphanumeric text,

- a cursor of any shape which may be activated and which can address and point of the screen.

28. A device according to claim 25, characterised in that the processing card receives simultaneously at its input, a flood of digital data of at least two images originating through the processing bus, from the image memory card, processes this flood of data, pixel by pixel, according to calculation programmes preloaded by the bus system and delivers, over the same processing bus, the results of the said calculations in digital form.

29. A device according to claim 25, characterised in that the image memory card contains at least four digitised images or eight bits each, a graphic plane of four bits, and is provided with a sub-module programmable by means of the bus system which allow the said images and graphic plans to be multiplexed or switched either to the input or to the output of the three bus, video and processor systems.

30. A device according to the claim 25, characterised in that the specialised interfaces card has electronic means available to synchronise the acquisition of the images originating from the probe with the memory card, and with the means of driving the plates in rotation, these electronic means being triggered externally by the user.

31. A device according to claim 25, characterised in that the calculator comprises six electronic modulescontained on the same card, the card being divided in six overlapping parts, formed by a central unit, a random access memory for calculation, a specialised interface, video signal processing electronics, an image memory and a specialised calculation processor, linked to one another by a video-digital bus, a processing bus and a bus system.

DATED this 19th day of October, 1990.

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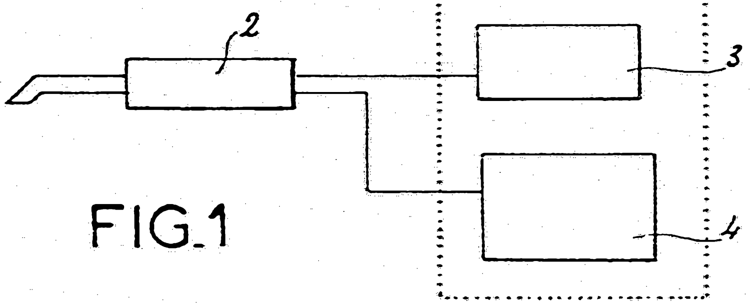

FIG.1

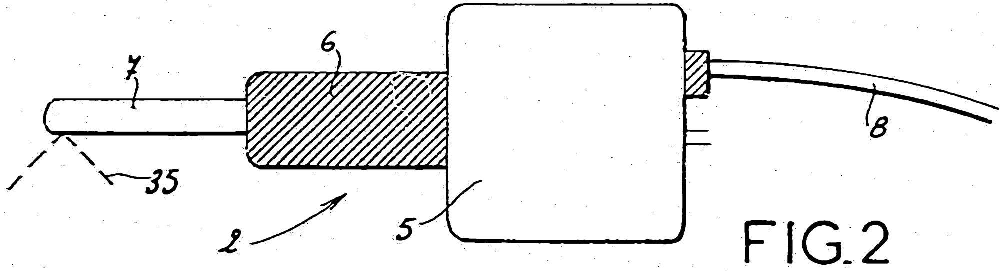

FIG.2

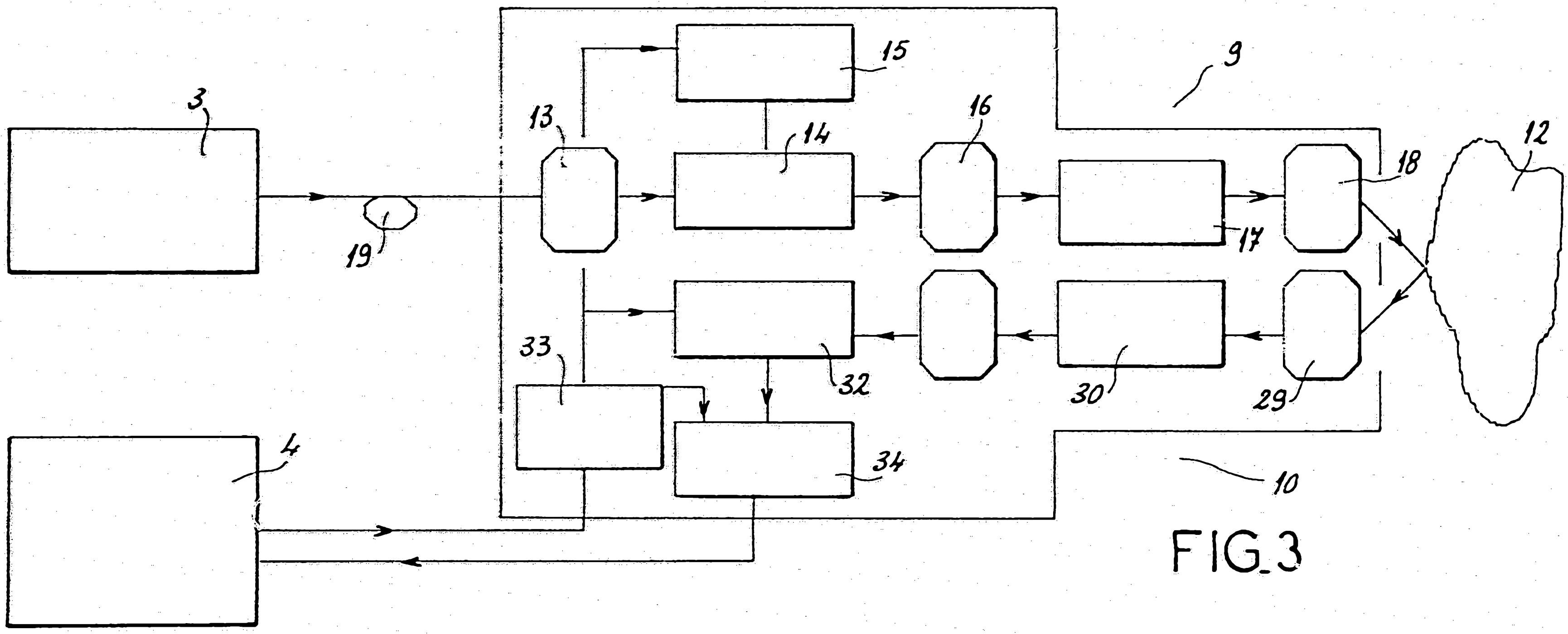

FIG.3

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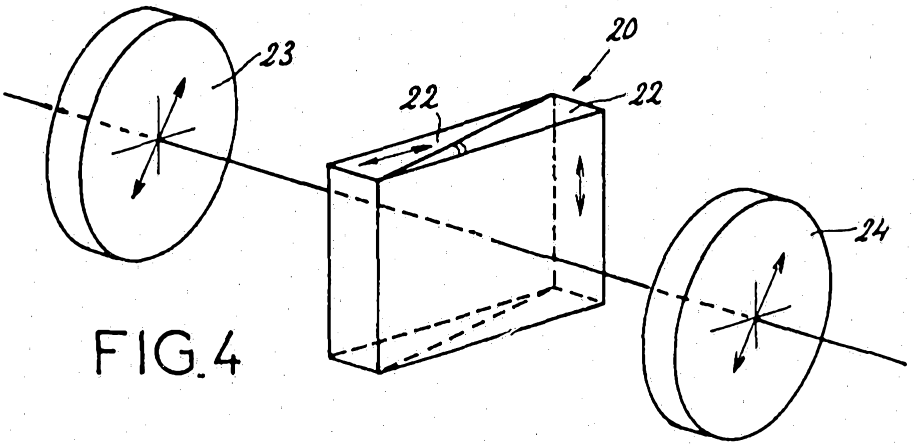

FIG.4

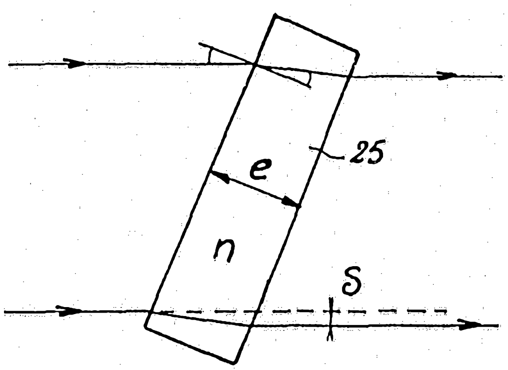

FIG.5

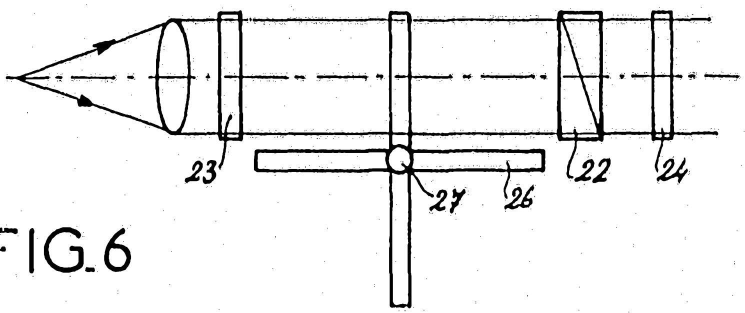

FIG.6

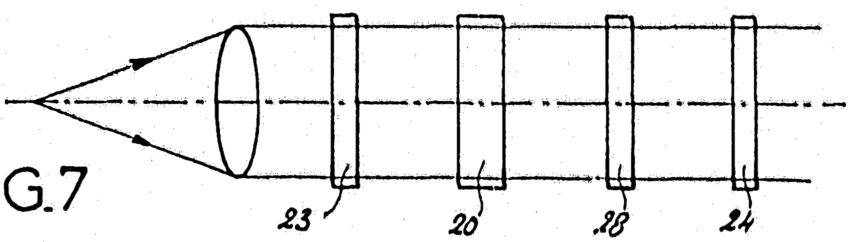

FIG.7

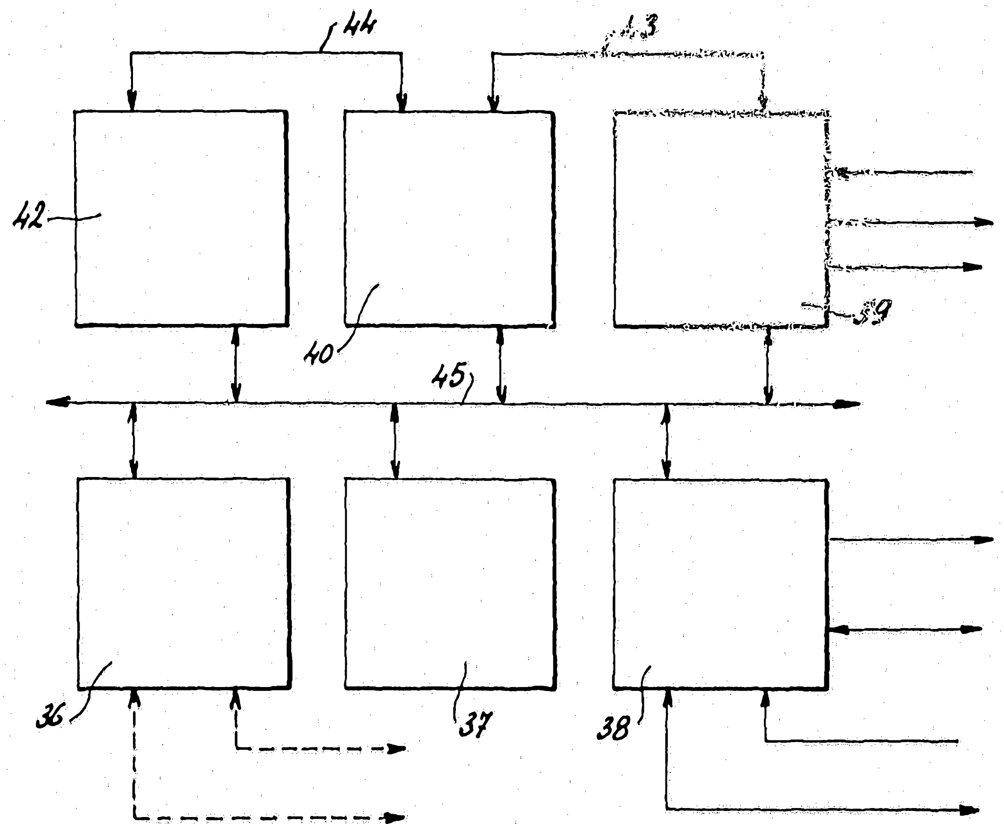

FIG.8

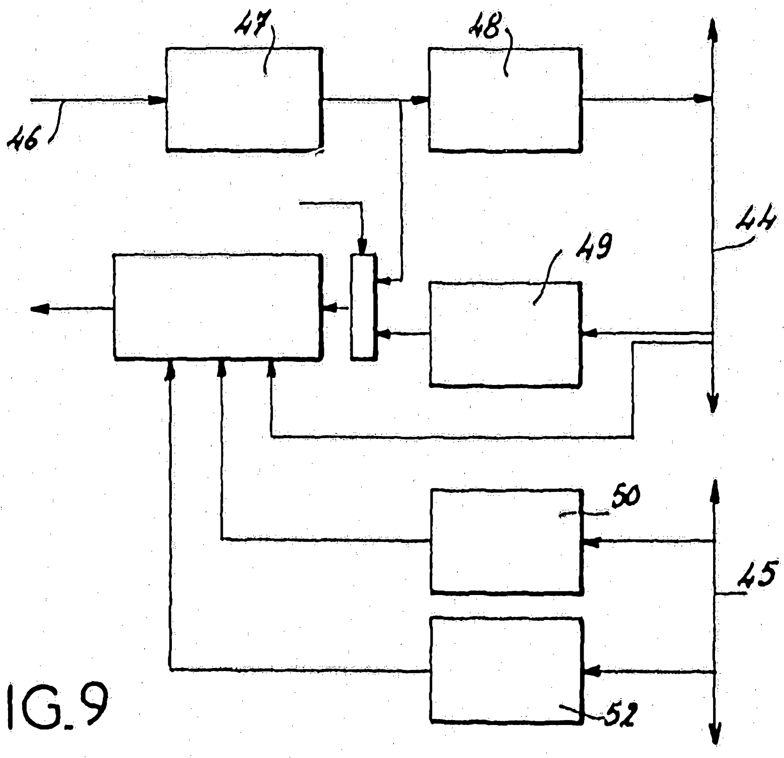

FIG.9

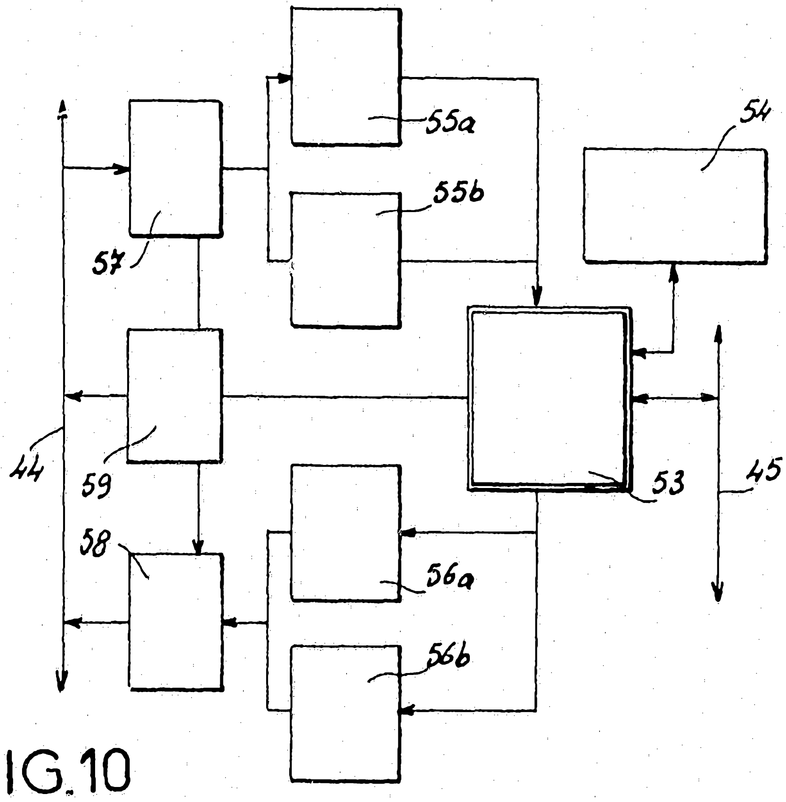

FIG.10

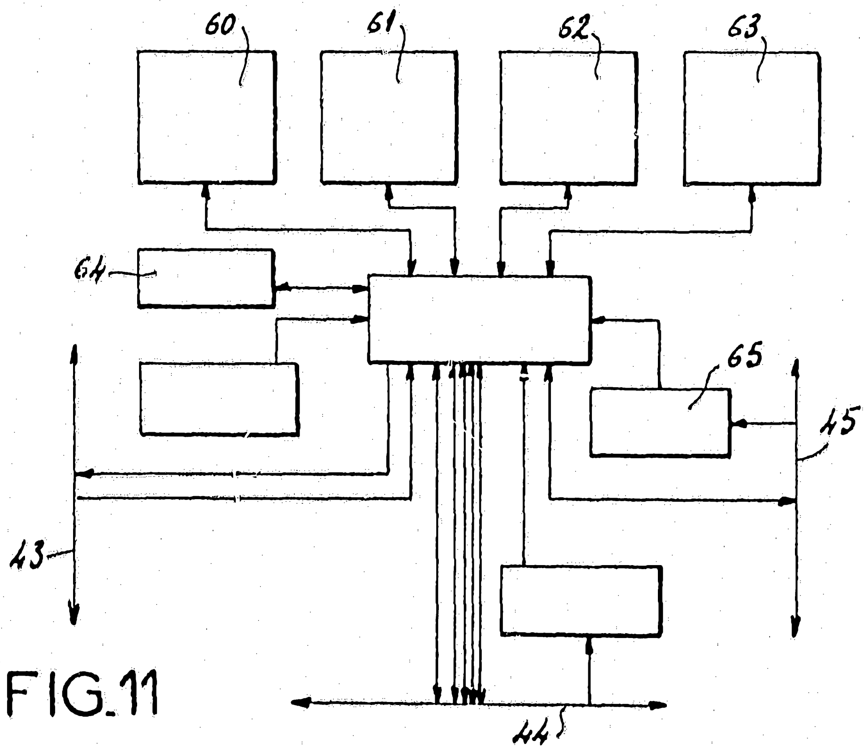

FIG.11