604995

COMMONWEALTH of AUSTRALIA
Patents Act 1952

APPLICATION FOR A STANDARD PATENT

I/We

Krone Aktiengesellschaft

of

Beeskowdamm 3-11, D-1000 Berlin 37, Federal Republic of Germany

hereby apply for the grant of a Standard Patent for an invention entitled:

Optical component for fiber-optic transmission systems

which is described in the accompanying complete specification.

Details of basic application(s):-

Number	Convention Country	Date
P 38 04 822.1	Federal Republic of Germany	12 February 1988

The address for service is care of DAVIES & COLLISON, Patent Attorneys, of 1 Little Collins Street, Melbourne, in the State of Victoria, Commonwealth of Australia.

DATED this THIRTIETH day of NOVEMBER 1988

To: THE COMMISSIONER OF PATENTS

Keith Leslie
....
a member of the firm of DAVIES & COLLISON for and on behalf of the applicant(s)

M004811 30/11/88

Davies & Collison, Melbourne

APPLICATION ACCEPTED AND AMENDMENTS
ALLOWED 26 - 9 - 90

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

DECLARATION IN SUPPORT OF CONVENTION OR NON–CONVENTION APPLICATION FOR A PATENT

Insert title of invention.

In support of the Application made for a patent for an invention entitled: "OPTICAL COMPONENT FOR FIBER-OPTIC TRANSMISSION SYSTEMS"

Insert full name(s) and address(es) of declarant(s) being the applicant(s) or person(s) authorized to sign on behalf of an applicant company.

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Cross out whichever of paragraphs 1(a) or 1(b) does not apply

1(a) relates to application made by individual(s)

1(b) relates to application made by company; insert name of applicant company.

do solemnly and sincerely declare as follows :–

1. (a)

or (b) I am authorized by

Krone Aktiengesellschaft

the applicant............. for the patent to make this declaration on its behalf.

Cross out whichever of paragraphs 2(a) or 2(b) does not apply

2(a) relates to application made by inventor(s)

2(b) relates to application made by company(s) or person(s) who are not inventor(s); insert full name(s) and address(es) of inventors.

2. (a)

or (b)

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4790 Paderborn
Federal Republic of Germany

is the actual inventor........... of the invention and the facts upon which the applicant........... is entitled to make the application are as follows :–

State manner in which applicant(s) derive title from inventor(s)

The applicant would, if a patent were granted on an application made by the said actual inventor, be entitled to have the patent assigned to it.

Cross out paragraphs 3 and 4 for non-convention applications. For convention applications, insert basic country(s) followed by date(s) and basic applicant(s).

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

in Federal Republic of Germany on the 12 February 1988

by Krone Aktiengesellschaft

in .... on the ....

by ....

in .... on the ....

by ....

4. The basic application......... referred to in paragraph 3 of this Declaration was the first application......... made in a Convention country in respect of the invention the subject of the application

Insert place and date of signature.

Declared at Melbourne this 18th day of January 1989.

Signature of declarant(s) (no attestation required)

Note Initial all alterations.

Keith Leslie

DAVIES & COLLISON, MELBOURNE and CANBERRA.

(12) PATENT ABRIDGMENT (11) Document No. AU-B-26428/88
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OPTICAL COMPONENT FOR FIBER-OPTIC TRANSMISSION SYSTEMS

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(56) Prior Art Documents
AU 515326 35812/78 G02B 6/06
US 4505539

(57) Claim

1. An optical component for two or more optical fibers, comprising at least two supports for the fibers and a guide space formed between said supports for an adjusting member movable therebetween, said supports providing guide means for said adjusting member, and the component further comprising electrode surfaces arranged to provide an electric field in the guide space, said surfaces being connectable to an adjustable voltage supply to provide said electric field, the field being for moving the adjusting member in the guide space,

wherein the adjusting member is formed as an adjustment plate guided between the supports by said guide means, said adjustment plate being made from a dielectric material, the position of the plate in relation to the supports affecting the optical path between fibers supported by said supports in use of the component, and

wherein the electrode surfaces are provided as a plurality of spaced electrode strips provided with terminals and connected to a control system for

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switching the voltage between the individual electrode strips, so as to generate a controllably repositionable electric field in the guide space for linear displacement of the adjustment plate into any of a plurality of positions so as to control the character of said optical path.

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COMPLETE SPECIFICATION

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COMPLETE SPECIFICATION FOR THE INVENTION ENTITLED:

Optical component for fiber-optic transmission systems

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

The invention relates to an optical component for fiber-optic transmission systems. Known optical components comprise for instance attenuation elements, filters, power dividers or the like, and may have a construction comprising at least two supports for fibers and an adjusting member movable therebetween.

There is known, e.g., an optical attenuation element consisting of a box-type housing, in the opposed side walls of which supports in form of couplings for the optical fibers are provided. Thereto, optical imaging systems in the form of spherical lenses are assigned on the inner sides of the housing for light beam expansion. Within the interior, a circular disk is borne by axle journals in the side walls of the housing, the optical axis of the fiber being arranged spaced to the rotation axis of the disk. The disk carries as filter magazine various filter disks, to which one stop location each is assigned. By turning the filter disk, it can be turned into different stop locations, such that different attenuation values are adjustable. It is disadvantageous, here, that the adjustment of the different filters each has to be effected manually directly at the optical attenuation element. Remote actuation is not possible. Corresponding disadvantages are existing, too, for other optical components of similar construction in form of filters, power dividers or the like.

It is an object of the present invention to provide an optical component which can be adjusted by remote actuation, such that adjustment directly at the optical component is not necessary.

According to the present invention, there is provided an optical component for two or more optical fibers, comprising at least two supports for the fibers and a guide space formed between said supports for an adjusting member movable therebetween, said supports providing guide means for said adjusting member, and the component further comprising electrode surfaces arranged to provide an electric field in the guide space, said surfaces being connectable to an adjustable voltage supply to provide said electric field, the field being for moving the adjusting member in the guide space,

wherein the adjusting member is formed as an adjustment plate guided between the supports by said guide means, said adjustment plate being made from a dielectric material, the position of the plate in relation to the supports affecting the optical path between fibers supported by said supports in use of the component, and

wherein the electrode surfaces are provided as a plurality of spaced electrode strips provided with terminals and connected to a control system for switching the voltage between the individual electrode strips, so as to generate a controllably repositionable electric field in the guide space for linear displacement of the adjustment plate into any of a plurality of positions so as to control the character of said optical path.

An optical component according to an embodiment of the invention allows remote adjustment as per the following principle: Based on a defined input signal, a control system provides for local displacement of the electrical field between the guide plates, being, simultaneously, support or carrier, resp., of the optical fibers, if applicable, together with their optical imaging systems. With the electrical field, the adjustment plate having different optical properties is displaced between the fibers such that different attenuation values, filter curves, power dividers or the like are possible. The optical component according to the invention can also be used as electrically controllable optical switch commutator.

Further advantageous embodiments of the invention result from the subclaims.

In the following, embodiments of the invention are described in more detail, by way of example only, with reference to the drawings, which are:

Fig. 1 the physical principle of the optical component,

Fig. 2 the first embodiment of the optical component in a vertical section,

Fig. 3 the optical component according to Fig. 2 in a turned vertical section,

Fig. 4 a horizontal section through the second embodiment of the optical component,

Fig. 5 a horizontal section through the third embodiment of the optical component,

Fig. 6 a horizontal section through the fourth embodiment of the optical component,

Fig. 7 a horizontal section through the fifth embodiment of the optical component,

Fig. 8 a vertical section through the optical component in the fifth embodiment,

Fig. 9 a fundamental representation of an optical imaging system,

Fig. 10 a fundamental representation of the sixth embodiment of the optical component as electrically adjustable optical power divider,

Fig. 11 the seventh embodiment of the optical component as electrically adjustable optical power divider,

Fig. 12 a horizontal section through the eighth embodiment of the optical component as electrically adjustable optical filter,

Fig. 13 the fundamental curve of the transmitted power of the optical filter according to Fig. 12 as a function of the wavelength and the adjustment of the adjustment plate, and

Fig. 14 the ninth embodiment of the optical component as electrically controllable optical commutator switch.

The physical basis of the optical component according to the invention is the fact that a movable dielectric 1 in the field of a plate condenser 2 is attracted into the latter, if, according to Fig. 1, the dielectric is first partially outside the action of the electric field (transition partially into the state of minimum energy). The force F acting on the dielectric 1 is with constant charge Q on the condenser plates 2

$$F_Q = \frac{1}{2} \cdot \frac{\varepsilon - \varepsilon_0}{[\varepsilon_0 a + (\varepsilon - \varepsilon_0) x]^2} \cdot \frac{d}{h} Q^2$$

wherein: $x < a$,

ε_0 being the dielectric constant of the ambient space, ε the dielectric constant of the dielectric 1, and h the dimension of the system vertically to the drawing plane. The remaining values will be introduced as per Fig. 1.

For a constant voltage U, this force is

$$F_U = \frac{1}{2} \cdot (\varepsilon - \varepsilon_0) \cdot U^2 \cdot \frac{h}{d}$$

wherein: $x < a$.

On this fundamental physical principle, the optical component according to the invention is based, according to which the dielectric 1 can accurately be positioned in distinct positions with an electric field between the condenser plates 2.

Figs. 2 and 3 show the first embodiment of the optical component consisting of two parallel guide plates 10, 11 in a distance d and of an adjustment plate 12 movable therebetween. Into the guide plates 10, 11, the optical fibers 13, 14 with their optical imaging systems 19 are inserted such that their free front faces are arranged opposed to the movable adjustment plate 12. The guide plates 10, 11 and the adjustment plate 12 consist of dielectric material, e.g. glass panes. On each inner side of the guide plates 10, 11, parallel rows of conductive electrode strips 15, 16 are disposed. They may consist of vaporized transparent material. The individual electrode strips 15, 16 of each guide plate 10, 11 are provided with terminals 18 being connected to a control system not shown here, said control system effecting the commutation of voltage between the individual electrode strips 15, 16.

The complete optical component consisting of the guide plates 10, 11 and of the adjustment plate 12 is arranged within a hermetically sealed housing being filled with a liquid having an appropriate index.

By application of the voltage to the electrodes 15, 16 or their terminals 18, resp., identified by the letters Bi to Bj, and by disconnection of the voltage at the electrodes 15, 15 or their terminals 18, resp., identified by the letters Ai to Ak, the electric field moves. Because of the fundamental physical principle mentioned above, the dielectric adjustment plate 12 moves to new positions and can, depending on number, distance and size of the electrodes 15, 16, occupy a plurality of distinct positions. Friction is kept extremely low by adding the liquid of appropriate index.

Application of the voltage to the electrode strips 15, 16 of the two guide plates 10, 11 can be achieved such that the necessary commutations are effected by solid-state components being designed in chip-on-glass technology on one of the guide plates 10, 11. This is a conventional technology for LCD components. Then, only the voltages for building-up the electric field at one point and the necessary control signals have to be supplied to the solid-state components.

Power consumption is extremely low, as the energy required for moving the adjustment plate 12 to a new position is very low. Only partial capacities have to be charged. The periods of time for a new fixation of the adjustment plate 12, said periods of time being determined thereby and by the inertia of the adjustment plate 12, are of the order of ms.

In a technical embodiment, because of the desired movement in only one straight-line coordinate, the adjustment plate 12 must be fixed either by the field itself or by a groove or spacer pieces, resp. As it is useful to maintain the fixation even for the case of disconnected voltage, a mechanical fixation is advantageous.

The position of origin has to be effected by inertialization electrically or by mechanical means, e.g. by a traveling electric field over the complete range of movement, and then by distinct movement into a defined position of origin.

In the second embodiment according to Fig. 4, an optical component is represented, consisting of two guide plates 20, 21 and an adjustment plate 22 guided in a guide space 27 left free in the guide plate 21. The electrode strips 25, 26 are arranged on the surfaces of the two guide plates 20, 21, resp., in the area of the adjustment plate 22. To the fibers 23, 24, optical imaging systems 29 are assigned.

In Fig. 5, the third embodiment is shown, said embodiment being particularly advantageous for simple manufacture. Here, to the fibers 33, 34, resp., optical imaging systems 39 are assigned. Only one dilectric guide plate 31 leaving free the guide space 37 for the adjustment plate 32 is vaporized with two rows of electrode strips 35, 36 being arranged on either side of the guide space 37 for the adjustment plate 32. In equal way, the guide plate 31 could, instead of the electrode strips 35, 36, be provided with solid-state components in chip-on-glass technology. The necessary voltage for achieving the same action of force as in the two first embodiments is, however, larger.

The fourth embodiment shown in Fig. 6 consists of a plane guide plate 40, of the second guide plate 41 provided with the guide space 47 for the adjustment plate 42, into said guide plate 41 the optical fibers 43, 44 being inserted by means of optical imaging systems 49, and of two rows of electrode strips 45, 46 being disposed on the two border areas of the guide space 47 of the guide plate 41. This embodiment can be used, e.g., as electrically adjustable optical attenuation element.

In the fifth embodiment of an optical component shown in Figs. 7 and 8, the guide groove 57 for the adjustment plate 52 is, in contrast to the fourth embodiment, arranged uniformly in both guide plates 50, 51. The electrode strips 55, 56 are each disposed on the outer sides of the guide plates 50, 51 in the area of the guide space 57 or of the adjustment plate 56 guided movably therein. The fibers 53, 54 terminate in optical imaging systems 59 being inserted into the guide plates 50, 51.

Fig. 9 shows an optical imaging system 59 between a fiber 53 as collimated bundle and the fiber end of the other fiber 54.

In the following, special optical components are described in more detail, said optical components basing on the fundamental physical principle explained above and applying the embodiments of Figs. 2 to 7 for fixing the adjustment plate or for building-up the electric field, resp., said components serving as examples only, as, in principle, all embodiments are always possible.

On optical transmission paths, the path attenuation must be adjusted to a desired value and be held constant over long periods of time. Depending on the receiving level, a telemetry signalcan be transmitted to the transmitter, and an optical attenuation member can be adjusted by a control signal such that the deviation of the attenuation from the desired value remains under a predetermined theshold. For achieving these functions serves, e.g., the fifth embodiment according to Figs. 7 and 8 as electrically adjustable optical attenuation member. Therein, the adjustment plate 52, i.e. a dielectric disk with a transmission variable in longitudinal direction is moved between the front faces of the optical fibers 53, 54 because of the fundamental physical principle described above. Depending on the position of the adjustment plate 52, the attenuation can be adjusted in fixed steps between a maximum and a minimum value, and depending on the number of electrode strips 55, 56 and of the continuous variation of the transmision of the adjustment plate 52. Herein, the guide space 57 has a depth corresponding to the width of the adjustment plate 52.

Figs. 10 and 11 show in fundamental representations the sixth and seventh embodiment, resp., of the optical component as optical power divider with electrically adjustable division ratio. In communication networks with optical transmission, coupling-out of a defined portion of the optical power from the transmission path is an important function.

In the optical components of an electrically controllable power divider shown in fundamental manner in Figs. 10 and 11, an adjustment plate 62 or 72, resp., from interference filters sectionally different is brought according to the embodiments of an optical component described above into the optical path between input fiber 60, 70 and two output fibers 61, 61' or 71, 71', resp. By electrical control signals, the guide plate 62, 72 is brought in steps of distinct size into selected positions between the non-shown guide plates carrying the electrode strips also not shown. Hereby, filters of variable transmission or reflexion, resp., become effective in the optical beam path, said filters being formed by the adjustment plates 62 or 72, resp. The reflected optical power portion is coupled-out over a semi-transparent mirror 68 into an output fiber 61' (Fig. 10).

Fig. 12 shows the eighth embodiment of an optical component as electrically adjustable optical filter. In wavelength multiplex transmission systems, a filter must be used at the end of the path for selection of the signal having a specified wavelength. With a tunable filter, signals having different wavelengths can easily be separated. Herein, the adjustment plate 82 is the filter, the position of which is electrically controllable. The filter is movable between the guide plates 80, 81 according to the aforementioned principle between the front sides of the input fiber 83 and the output fiber 84.

Fig. 13 shows the fundamental curves of the coupled-out optical power for different wavelengths λ and movement of the adjustment plate 82 in direction of arrow A (curve A) or in direction of arrow B (curve B).

Finally, in Fig. 14, an electrically controllable optical commutator switch is shown as ninth embodiment of the optical component. In networks with optical transmission, it is reasonable to activate replacement paths in case of a failure of individual components or networks branches, e.g. in local networks with ring-type structure. For this, optical commutator switches are necessary coupling the signal of a fiber, the input fiber 93, into one of two possible output fibers 94, 94'. Known switches make use, for this, of a direct mechanical or piezo-electrically controlled movement of the fiber. With the arrangement of adjustment plate 92 between two guide plates 90, 91 consisting each of dielectric material, a simple commutation can be achieved with the transparent dielectric adjustment plate 92, if its refractive index n2 is suitably selected in contrast to the refractive index n1 of all other materials. Therewith, optical matrices can be built up, too, in optical exchange networks.

Optical switches can be also be formed with an arrangement identical to the fifth embodiment of the optical component shown in Figs. 7 and 8, if the adjustment plate 52 is replaced by a non-transparent adjustment plate moved in a liquid of an appropriate index. Such switches can, even with very large diameters of the fiber core, be applied as optical switches in display systems with fiber-optic light guiding and replace, there, other, less effective switches. It is useful, here, to arrange switch arrays, the dimension of which is oriented at the sizes of symbols or images.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An optical component for two or more optical fibers, comprising at least two supports for the fibers and a guide space formed between said supports for an adjusting member movable therebetween, said supports providing guide means for said adjusting member, and the component further comprising electrode surfaces arranged to provide an electric field in the guide space, said surfaces being connectable to an adjustable voltage supply to provide said electric field, the field being for moving the adjusting member in the guide space,

wherein the adjusting member is formed as an adjustment plate guided between the supports by said guide means, said adjustment plate being made from a dielectric material, the position of the plate in relation to the supports affecting the optical path between fibers supported by said supports in use of the component, and

wherein the electrode surfaces are provided as a plurality of spaced electrode strips provided with terminals and connected to a control system for switching the voltage between the individual electrode strips, so as to generate a controllably repositionable electric field in the guide space for linear displacement of the adjustment plate into any of a plurality of positions so as to control the character of said optical path.

2. An optical component according to claim 1, wherein the dielectric material is glass.

3. An optical component according to either one of the preceding claims, wherein the electrode strips comprise conductive, transparent material.

4. An optical component according to any one of the preceding claims, wherein the electrode strips are formed by vaporisation onto surfaces of the guide means.

5. An optical component according to any one of the preceding claims wherein said guide means comprises at least one guide plate.

6. An optical component according to claim 5 wherein the guide space for the adjustment plate is provided by a recess in said at least one guide plate.

7. An optical component according to any one of claims 1 to 6, characterized by that the electrode strips are provided in arrays of parallel strips on surfaces of the guide means.

8. An optical component according to claim 7, wherein the arrays of electrode strips are provided on surfaces of the guide means which define the guide space.

9. An optical component according to any one of the preceding claims wherein the electrode surfaces are provided on surfaces of the guide means which are lateral with respect to the guide space.

10. An optical component according to any one of claims 1 to 8 wherein the electrode surfaces are provided on surfaces of the guide means which are transverse to the longitudinal direction of optical fibers supported by said at least two supports.

11. An optical component according to any one of the preceding claims where the thickness of the adjustment plate substantially determines the depth of the guide space in the longitudinal direction of optical fibers supported by said at least two supports.

12. An optical component according to any one of the preceding claims wherein the width of the adjustment plate substantially determines the dimension of the guide space in a direction transverse to the longitudinal direction of optical fibers supported by said at least two supports.

13. An optical component according to any one of the preceding claims wherein the adjustment plate substantially fills the guide space.

14. An optical component according to any one of the preceding claims wherein the guide space is provided by recesses in a surface of each of two guide plates providing said guide means.

15. An optical component according to any one of claims 1 to 7 or 9 to 14, wherein the electrode strips are provided on outer surfaces of the guide means, so as to be separated from the guide space itself by material of the guide means.

16. An optical component according to any one of the preceding claims, comprising a component selected from the group comprising an alternation element, a filter, a power divider and a switch.

17. An optical component for two or more optical fibers substantially as hereinbefore described with reference to the accompanying drawings.

DATED THIS 6th day of SEPTEMBER 1990.

KRONE AKTIENGESELLSCHAFT
by DAVIES & COLLISON
Patent Attorneys for the applicant(s)

FIG.1

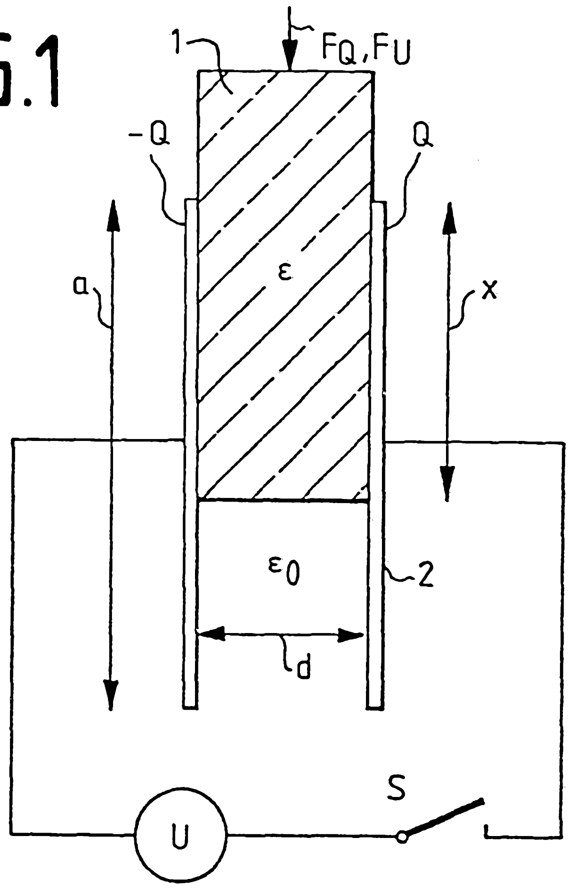

FIG.2

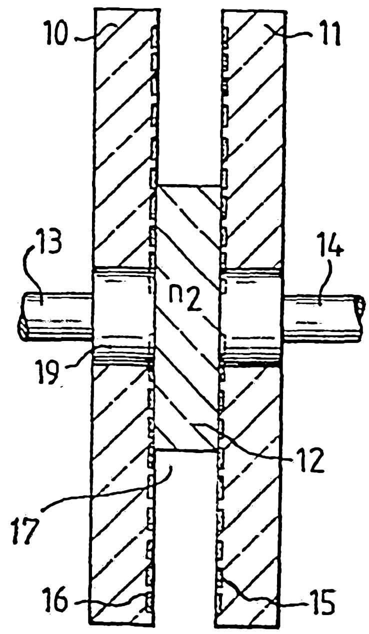

FIG.3

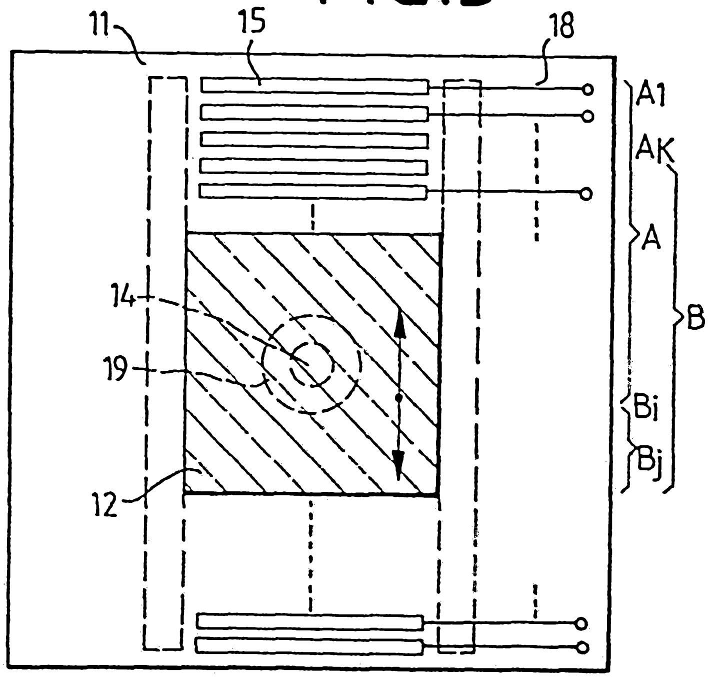

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FIG.4

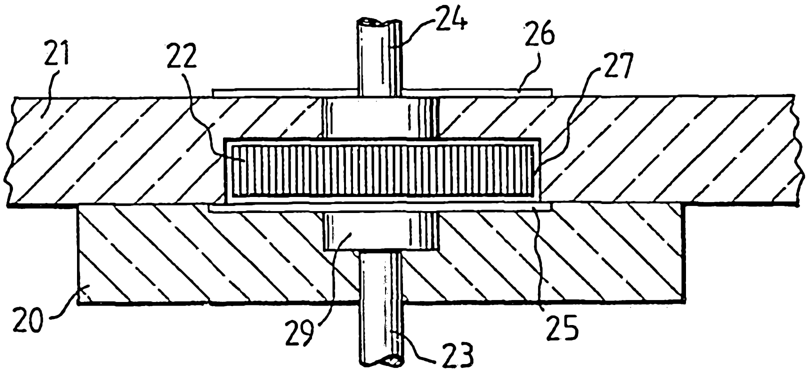


FIG.5

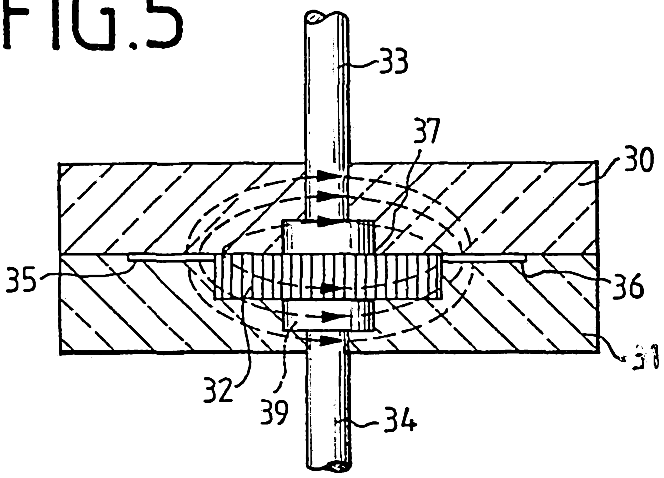


FIG.6

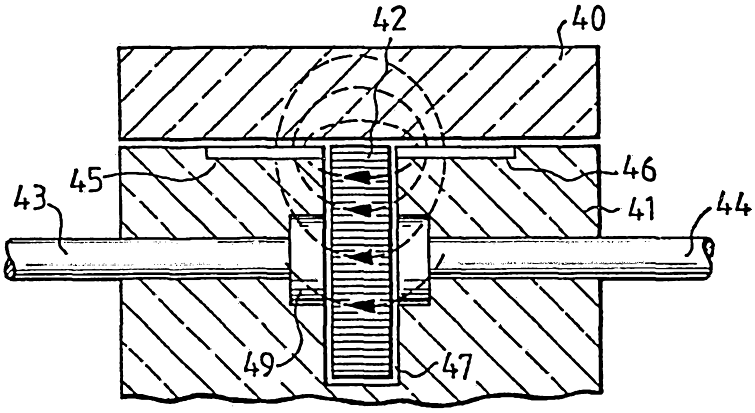


FIG.7

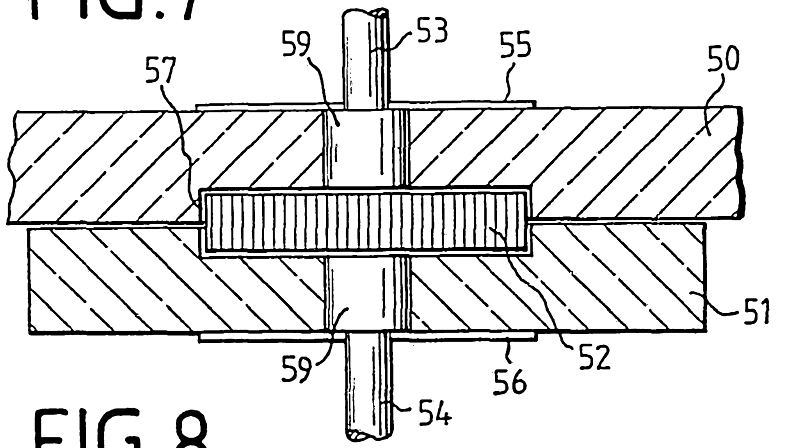


FIG.8

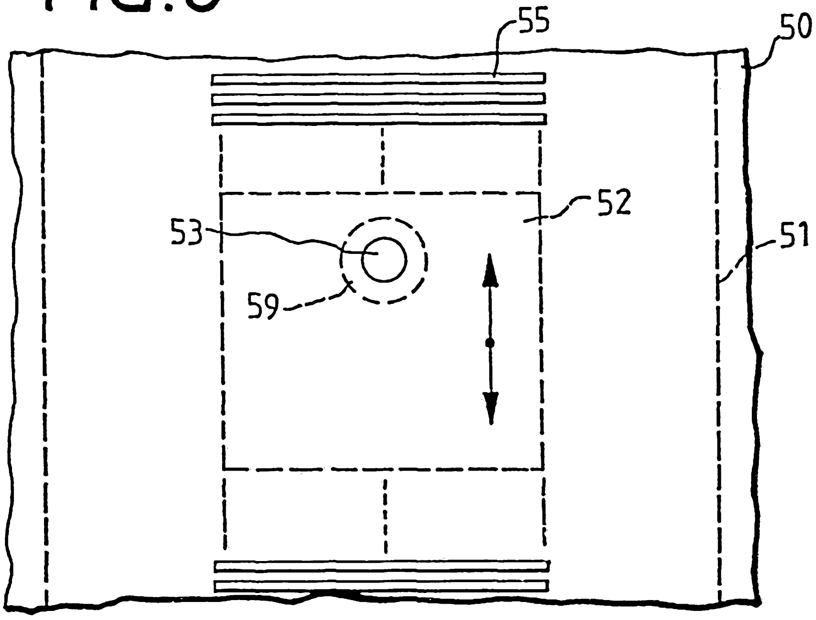


FIG.9

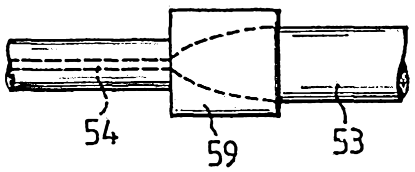


FIG.10

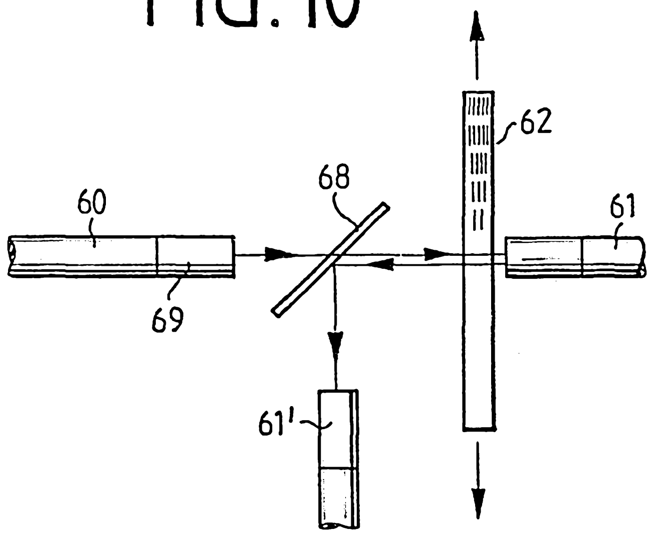


FIG.11

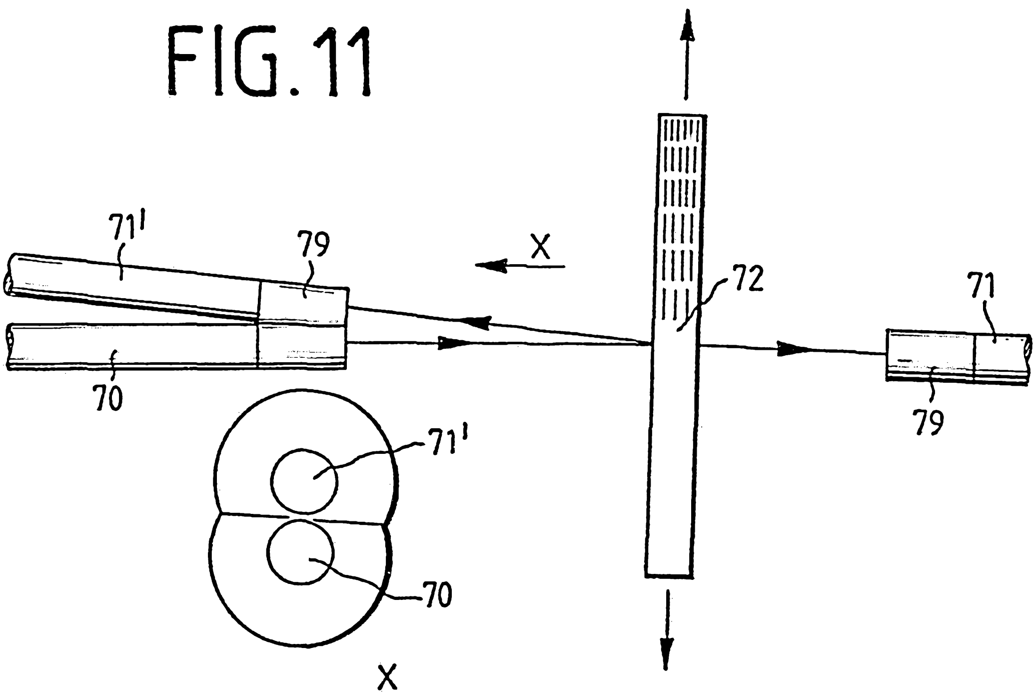
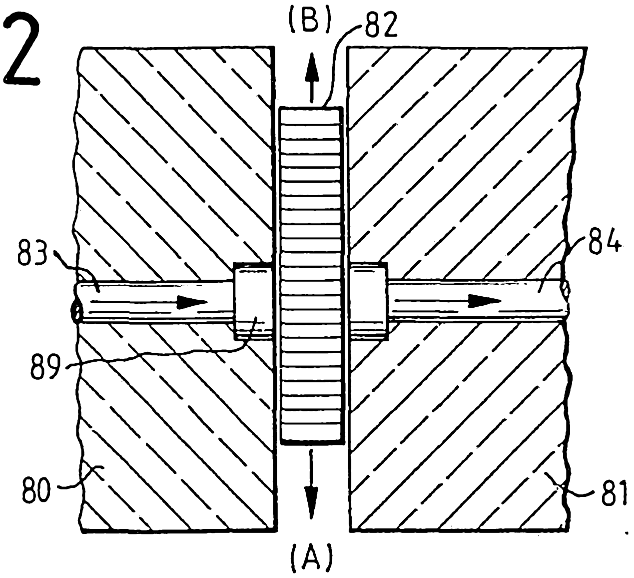


FIG.12



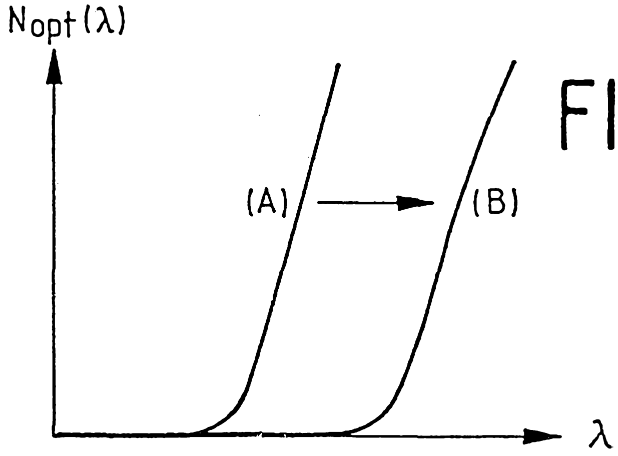


FIG.13

FIG.14