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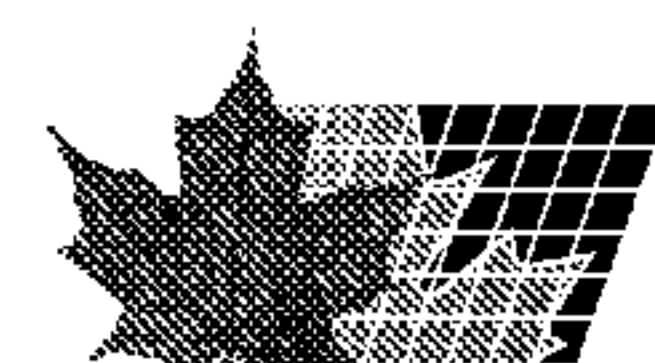
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(54) Titre : DISPOSITIF DE TERMINAISON EN POINTE POUR FIBRES OPTIQUES

(54) Title: TERMINATOR BY TAPERING FIBER OPTIC

(57) **Abrégé/Abstract:**

Fiber optic terminator for application in Electro-Optics industry is designed based on matching gel, polymer filling or complex design to succeed in eliminating the back reflection (e.g. when guided optical signal encounters air gap) at the last connector which terminates an optical fiber link. With the Terminator by Tapering Fiber Optic (herein after named TermTaper), the incoming optical signal (e.g. from source) goes thru a perpendicular cleaved short piece of fiber at one end, guided for a few centimeters and then, is trapped at the opposite end by a taper. In the TermTaper, all components, fiber optic and connector parts, are commercially available. There is no need for a specific fabricating method neither tools nor chemical product. The invention is suited for telecom wavelength range 1260 -1650 nanometer.



TERMINATOR BY TAPERING FIBER OPTIC

ABSTRACT

Fiber optic terminator for application in Electro-Optics industry is designed based on matching gel, polymer filling or complex design to succeed in eliminating the back reflection (e.g. when guided optical signal encounters air gap) at the last connector which terminates an optical fiber link. With the Terminator by Tapering Fiber Optic (herein after named TermTaper), the incoming optical signal (e.g. from source) goes thru a perpendicular cleaved short piece of fiber at one end, guided for a few centimeters and then, is trapped at the opposite end by a taper. In the TermTaper, all components, fiber optic and connector parts, are commercially available. There is no need for a specific fabricating method neither tools nor chemical product. The invention is suited for telecom wavelength range 1260 – 1650 nanometer.

TERMINATOR BY TAPERING FIBER OPTIC

FIELD OF THE INVENTION

This invention relates to optical communication devices, and more particularly to a termination for an optical fiber.

BACKGROUND OF THE INVENTION

A few years ago, it has been suggested to represent the graphic result of an optical time domain reflectometer (OTDR) fiber optic measurement (e.g. loss and integrity of fiber light path) as a digital fixed image or <Signature>, store in a database, said, right at the time of the project acceptance date. The objective was to monitor change, over time, for fiber and connections, and facilitate break location when accidental damage occurs by comparing the latest trace with records. This trace <Signature> shows characteristics of a fiber light path and thus is unique for each case.

However, that project could not be implemented as planned because of missing information, the status of the last connector on which any "ready for service" fiber light path terminate. It is known that the benefit of unidirectional fiber light path testing with OTDR, has some drawbacks and one of these, is the lack of showing the status of last connector in which the end face acts as a mirror when slightly guided light crosses the boundary glass/air. In fact, the unmatched refractive index of both mediums glass (~1.5) and air (~1.0) causes a reflection of around 4% (e.g. depend of the value of refractive index for doped fiber region (core) which is slightly lower than this one for pure glass) of the incoming optical power back to the source. More drawbacks could occur for this back reflection such as noise for optical system on fiber link.

In order to characterize the last connection for validate the data of a trace "Signature" for a fiber light path, the termination shall provide an event "return loss" of at least 30 dB. This is a rule of thumb value to insure fiber optic monitoring system using OTDR can detect an opened condition (e.g. for surveillance mode) at the far end of the light path. The opened condition is hereafter described as the reading of the event "return loss" for incoming signal when reflected at the boundary of mediums glass-air of connector cleaved end face. OTDRs on market provide a reading of 14-15 dB for this condition.

For monitoring degradation at the far end connection, the event "return loss" shall range in the 40 dB figure and higher. In order to achieve accurate event "return loss" readings, the OTDR shall launch a LASER pulse 100 nanosecond width, at both wavelengths 1310 and 1550 nanometer as a minimum requirement.

SUMMARY OF THE INVENTION

This invention provides a Fiber Optic Terminator fabricated with components commercially available, tools as well, without any matching gel or polymer kind of product.

Also, this invention provides a device suited for the wavelength range 1260 – 1650 nanometers, with an optimized refractive index matching as accurate as SMF can provide so in the range of one part in ten thousands (0.0001), and a termination quality of 40 dB for event "return loss" when using bare fiber adaptor connector as holder, either type ST, SC or FC.

The above description shows that the invention relates only on a well known mean to modify glass shape so heating. However, this has a tremendous impact when glass is optical fiber. The light guiding property changes and presents new applications. In this case, an optical termination is made. A comparison with other similar products shows that the difficulty to match fiber refractive index is completely eliminated because the terminator is a fiber piece itself. Thus, the matching accuracy rises at one part in one thousand instead of one hundred for existing patents. In addition, the "return loss" (e.g. RL) calculated is not a concern either because the taper "traps" all the incoming optical power (e.g. from optical source) so the RL is only related to the quality of connector end face (e.g. ferrule) polishing in which the terminator is inserted. Then, the matter for terminator RL rating behaves on the existing manner to terminate optical fiber itself. One could ever request super polished connector (SPC), ultra polished connector (UPC) or angle polished connector (APC) depending the requirement of RL criteria for the application. There is no limitation for the invention to fit within the existing terminating components market for optical fiber.

In addition, usefulness relies to Fiber Optic Supplier, as the preferred embodiment is:

- Well suited for use in any kind of fiber patch panel and distribution frame on the market

- Designed to reduce manufacturing cost

Benefit economy of volume for commercial components

- Designed to cut down production cost

Working people with hands on skills

- Designed to have short time to market

Use of already tested components will speed up the tests to meet technical requirements for Telco Outside Plant Engineering or those by Telcordia

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view with dimensions of a piece of a rolled SMF optical fiber use to make the optical terminator;

FIG. 2 is a perspective view with dimensions of the optical fiber of FIG. 1 with one half of coating removed;

FIG. 3 is a perspective view with dimensions of the optical fiber of FIG. 1 and 2 once tapered; the taper zone is shown by streaked lines

FIG. 4 is a perspective view with dimension of the optical fiber of FIG. 1, 2 and 3 once tapered, cut the taper side end and perpendicularly cleaved at the opposite end of taper, resulting in the Terminator by Tapering Fiber Optic

FIG. 5 is a perspective view of the optical fiber of FIG. 4, said Terminator with indications of longitudinal and cross views;

FIG. 6 is the longitudinal view A-A as per FIG. 4, said the Terminator; the drawing is not scaled;

FIG. 7 is the cross-section view B-B as per FIG. 4, said the Terminator; the drawing is not scaled.

FIG. 8 shows the Terminator mounted in a SC type connector;

FIG. 9 shows the Terminator of FIG. 1 mated with sleeve to a terminated fiber cable;

FIG. 10 shows OTDR event "return loss" measurement when the Terminator is in the condition of FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The "Terminator by Tapering Fiber Optic" (e.g. TermTaper) resembles to an assembled fiber optic connector without the fiber cable. It includes and uses all of regular connector components as boot, crimp ring, ferrule mount, connector body and coupling. Some of these may vary in shape accordingly the required connector type, FC, SC, or ST.

FIG. 1 shows the embodiment 1 as a 15 cm (e.g. to facilitate handling) piece cut from a rolled single mode fiber (SMF), such as CORNING SMF-28e.

FIG. 2 shows the piece of fiber 1 with one half stripped from its coating 3, 11, 15; this work exposes 7-8 cm of bare fiber 2 which is cleaned with appropriated wipes and alcohol.

For the guided optic aspect, the optical wave guide (e.g. optical fiber) is modified by tapering one end. This action is made with a fusion set. It could be done by another way (e.g. micro burner) without impacting the functionality of the embodiment.

Here is some background why the taper modify so much the optical guiding property of fiber. The guiding property of fiber is demonstrated by mathematic formula when resolving Maxwell's equations in circular coordinates. For fiber optic, the solutions are Bessel functions J and W. These provide a representation for the optical power distribution (e.g. fundamental mode transverse electrical (TE₀₀)) in the wave guide. The J function applies for the core when W is for the cladding. The conditions at the refractive index boundary core/cladding are demonstrated using proper limit values for integration. If one changes the physical shape (e.g. straight cylinder) of fiber, the guidance property is then modified. For example, if one bend the fiber and performs an end-to-end lost test at the 1550nm wavelength, it would be noticed an important loss of the launched optical signal. Now, if the fiber is bent around a 1 cm diameter mandrel and wind three times, performing the same test will result at a complete attenuation of optical signal.

In the case of tapering the cylindrical shape, the fiber offers various guided signal behaviors that could be used for as many as applications. In this invention, the taper allows optical power to vanish from the core to a "sacrifice" core/cladding. There is no light coming back to source once it has gone thru this kind of shape, said taper. This is the main requirement for a termination. The tapering process is detailed in the following paragraphs.

Using a fusion set, such as CORNING COMPACT™ FUSION SET #CFS-XSM-T-P (herein after named set), the device coated end is put in place between the opened left latches, aligned in order bare fiber section is exposed in the fusion spot area, then, the latches are closed. This manual operation leaves the bare fiber half free, laying on the right opened latches support. Then, the camera mobile arm holder is pushed in locked position and the set turns on. The bare fiber which lay down in fusion spot area is shown at the LCD monitor screen.

As this time, the fusion set is ready for a fusion alike; simultaneously pressing the "pre-fuse" button while holding the bare fiber end with fingers in order to pull on the device. These two actions are coordinated in observing the image of fiber. Once the deformation occurs, just upon the fused of electric arc (e.g. bright flash at the screen), one shall relax on the traction.

FIG. 3 shows the embodiment with the taper 4 for which the length is in the range of 100 - 125 micron. The enlargement/reduction taper ratio of a sample is typically 1:5. This means that the diameter at the "waist" 5, 10 and 13 is approximately 1/5 of the optical fiber diameter 14.

It was experimented a taper 4 ratio up to 1:7 which revealed as to be properly terminating a fiber light path. Although, it was not tested if a greater ratio than 1:5 (e.g. 1:3) would still perform as a Terminator.

FIG. 4 shows the other operations on the optical fiber. The bare fiber exceeding the taper is cut 6, 11 at around half centimeter passed the taper zone 4; this is not critical. As a handy mean to work with the embodiment (and also avoiding the taper from break 5, 10), an appropriate thermal shrink sleeve (~1 cm long) is slid, centered on the taper and heated (flame of a candle) until it stays in place (e.g. tight enough so one can hold safely the device). During the work, the appropriate cleaning was done as many times as the bare fiber 2 was in contact with fingers.

Referring again to FIG. 4, the embodiment has the opposite side of the taper partially stripped 8; then, the tip end 7, 9 is perpendicularly cleaved using a fiber cleaver or a scribe tool. Thus a sample has an overall length of ~4.5 cm or less compare to 5.5 cm for the assembled connector. This demonstrates that the Terminator fits well within the dimension of commercially available assembled connector.

FIG. 5, 6 and 7 show respectively a representation of the Terminator, its longitudinal and cross-section views.

Then, the embodiment is placed in a bare fiber adapter or a pre-assembled connector for verification of its functionality and performance. As a measurement result with an optical time domain reflectometer set for 1550 nanometer wavelength and pulse width at 100 nanosecond, a sample typically allows a 40 dB event "return loss" when mated to the last connector of a fiber link. "Terminator by Tapering Fiber Optic" on the market, for example a type SC, would be done accordingly factory SC connector termination procedure on a cable.

FIG. 8, 9 and 10 show respectively a Terminator in a holding SC type connector, then when it is mated with sleeve and connected to a terminated fiber cable, and finally, a typical OTDR event "return loss" measurement for it.

CLAIMS:

- 1. A low-reflectance Fiber Optic Terminator for making end-to-end contact with an optical fiber whose end portion is held within a cylindrical ferrule and the cylindrical ferrule is held within an optical connector, said Fiber Optic Terminator comprising a short piece of an optical fiber whose one end is perpendicularly cleaved and the opposite end tapered and so held within an identical cylindrical ferrule and optical connector, and whose refractive index is in the same order than the refractive index of optical fiber, said Fiber Optic Terminator having a length that fit within dimension of an assembled optical connector; the event "return loss" by said Fiber Optic Terminator being determined by the polishing technique of connector end face.**
- 2. A Fiber Optic Terminator as defined in claim 1 wherein suited for the wavelength range 1260 – 1650 nanometer.**
- 3. A Fiber Optic Terminator as defined in claim 1 that has an optimized matching refractive index as accurate as optical fiber can provide so in the range of one part in ten thousands (0.0001).**
- 4. A Fiber Optic Terminator as defined in claim 1 that has a termination quality of 40 dB for event “return loss” when using bare fiber adaptor connector, either type ST, SC or FC, this quality rating being set as required when using factory assembled mounting connector (e.g. polishing end face enhances the contact with the other fiber) for the said type.**
- 5. A Fiber Optic Terminator as in claim 1 is fully compatible with technique to improve transmission of optical signal at connection as SPC, UPC or APC.**
- 6. A Fiber Optic Terminator as in claim 1 is fabricated with components commercially available, tools as well, without any need for index refraction matching gel or polymer kind of product.**
- 7. A method to fabricate Fiber Optic Terminator as defined in claim 1, comprising: training for field technician to use fusion set to taper an optical fiber right at the premise, as cable vault, manhole, and fiber distributed interface or pole mount terminal, said taper, terminating temporally unused fiber part of installation of wavelength division multiplex device so avoiding back reflection to working digital transmission system on feeding fiber.**

Application number/numéro de demande: 2488005

Figures: (1-2-3-4), (5), (8-9-10)

Pages: _____

DRW-IP

Unscannable items
received with this application
(Request original documents in File Prep. Section on the 10th Floor)

Documents reçus avec cette demande ne pouvant être balayés
(Commander les documents originaux dans la section de préparation des dossiers au
10ième étage)

Figure 5

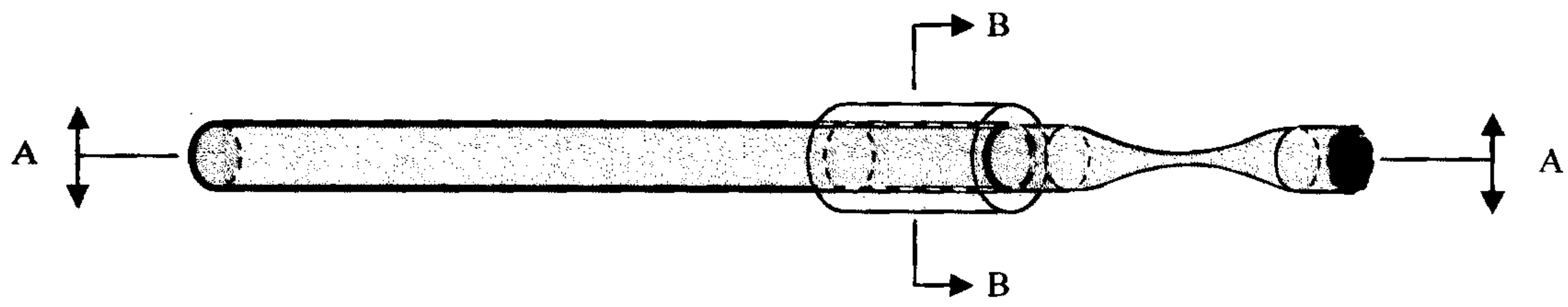


Figure 6

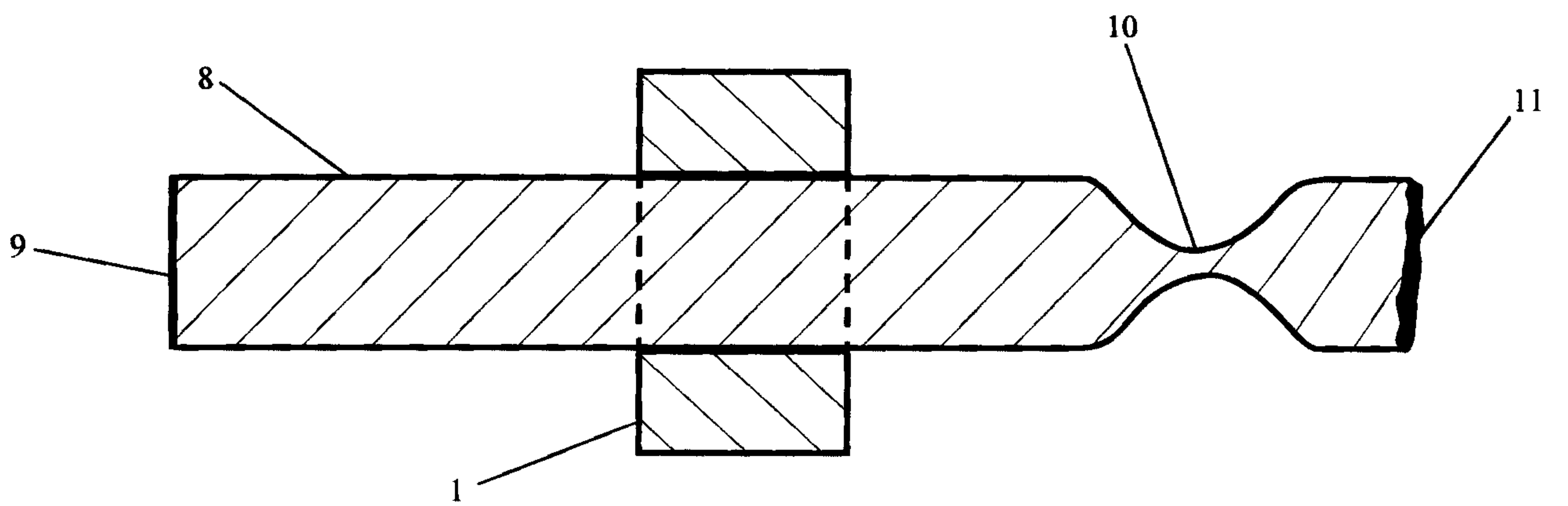


Figure 7

