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EUROPEAN PATENT APPLICATION

21 Application number: **88107171.6**

51 Int. Cl.4: **H01Q 13/06**

22 Date of filing: **04.05.88**

The title of the invention has been amended
(Guidelines for Examination in the EPO, A-III,
7.3).

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30 Priority: **11.06.87 IT 2178687 U**

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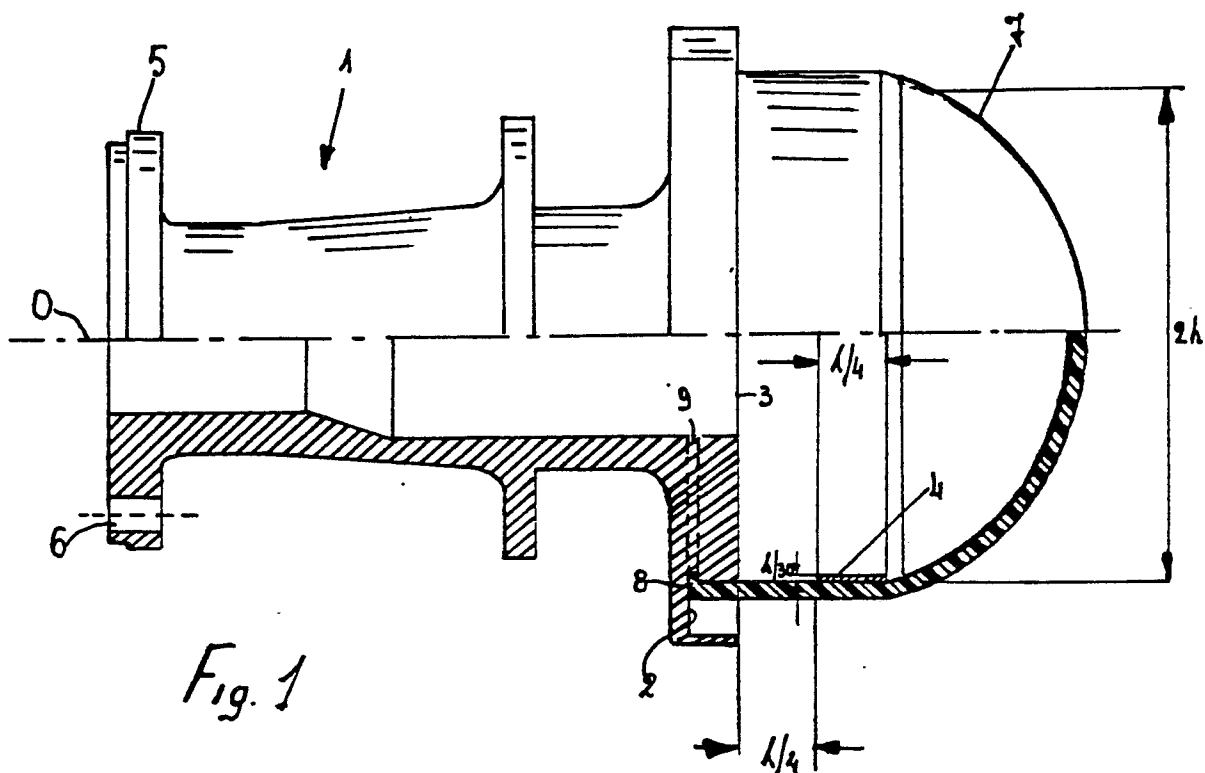
43 Date of publication of application:
15.02.89 Bulletin 89/07

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84 Designated Contracting States:
AT BE CH DE ES FR GB GR LI NL SE

54 **Horn antenna.**

57 The horn illuminator for reflector antennas with rectangular radiation pattern is provided with a ring (4) of electrically conductive material coaxially placed before the horn mouth (3) a distance of $\lambda/4$ therefrom and in a plane parallel to that of said mouth (3). The electrically conductive ring (4) is supported by a cap of polytetrafluoroethylene material acting as a protection therefor.



EP 0 303 001 A2

"HORN ILLUMINATOR FOR REFLECTOR ANTENNAS WITH RECTANGULAR RADIATION PATTERN"

This invention generally relates to antennas and, more particularly, to a horn illuminator for reflector antennas operating in all the spectrum of microwave frequencies, namely at frequencies ranging from 300 MHz to 60 GHz.

It is known that an elemental antenna for microwaves, which is normally called "primary source" is a horn having a rectangular or circular section and fed by a rectangular or circular waveguide.

In the former case the excitation fundamental mode will be the TE 10-mode and, in the latter case, it will be the TE 11-mode. Under excitation fundamental mode it is meant the mode in which the electromagnetic field is radiated in the free space from the primary source.

Normally, a primary source is used for "illuminating" one or more passive mirrors for forming a geometry based on the optics laws. The antenna array is highly directional and, according to the types of used mirrors, the final antenna takes different denominations: "prime focus, cassegrain, off-set etc".

The ideal primary source for illuminating a passive mirror (generally with a parabolic shape), should have a rectangular radiation pattern in order to deliver a constant power both in amplitude and in phase between 0° and the illumination angle included by the passive mirror. In this case there would be the dual purpose of attaining the optimal value for the illumination efficiency together with the minimum spill-over, i.e. the maximum gain with the minimum noise temperature.

Another very important characteristic for a good primary source, as already said, is that radiation patterns on the E plane (horizontal) and H plane (vertical) are as identical as possible, which is a warranty that the antenna in its whole has optimal values with respect to the cross polarisation.

Therefore, the objet of the present invention is to provide a horn illuminator or primary source capable of emitting a substantially rectangular radiation patterns both on the E plane and on the H plane.

Another objet of the present invention is to provide a horn illuminator or primary source having such a structure as to make the series production as inexpensive as possible.

More particularly, the horn illuminator for reflector antennas according to the present invention is characterized in that it is provided with a ring of electrically conductive material, coaxially placed before the horn mouth a distance of $\lambda/4$ therefrom and in a plane parallel to that of said mouth.

Advantageously, the electrically conductive ring is supported by a cap of a plastic material exhibiting good electrical properties which simultaneously acts as a protection therefor.

Preferably, the electrically conductive ring is embedded in the cap of plastic material so as to make the horn capable of being pressurized.

Suitably, the plastic material forming the cap is a polytetrafluoroethylene.

The present invention will be now illustrated in more detail in connection with the accompanying drawings, wherein:

Fig.1 is a side elevation view, partially in a diametral section and partially in a side view of the horn illuminator for reflector antennas according to the present invention;

Fig.2 shows a primary radiation pattern measured on the E plane at frequencies of 10,9 - 11,3 - 11,7 GHz, respectively;

Fig.3 shows a radiation pattern similar to that of Fig.2, however measured on the H plane;

Figs.4 and 5 show in a plot the curves relating to the efficiency and the spill-over in the center band as a function of the illumination angle of the horn illuminator.

Referring now to the drawings and particularly to Fig.1, there is shown a horn illuminator exhibiting a radiation pattern rectangular in shape on the H plane and E plane, obtained in accordance with the teachings of the present invention. The horn illuminator is provided with a flange 5 having holes 6 for the attachment to the waveguide which feeds the horn. The design of this illuminator, generally indicated by 1, is arisen from the requirement of having a maximum efficiency near the unit value at the illumination angle desired by the parabolic mirror and for this purpose there is used a horn of circular section provided with a cylindrical mouth 3 and with one choke 2 only, placed a distance of one wavelength (λ) from the O-axis of the horn 1, and this in order not to resort to the use of various chokes which would make the horn configuration too complex and expensive.

This structure alone is not sufficient to generate the HE 11-balanced hybrid mode (the hybrid modes are linear compositions of a TE-mode and TM-mode. The excitation of a balanced hybrid mode permits radiation pattern to be obtained having a nearly circular symmetry about the radiation principal axis).

In the present case the radiation patterns in the H plane and E plane are quite different. In particular, while the radiation pattern in the H plane was sufficiently near to the design requirements, the radiation pattern in the E plane appeared to be nearer to a pattern of triangular type than of rectangular type, so as to

compromise any possibility of use of the horn without resorting to further approaches.

In order to overcome this drawback the horn illuminator 1 according to the invention is provided, before the mouth 3 having a circular cross-section, with a circular ring 4 of electrically conductive material placed a distance of $\lambda/4$ from the mouth and parallel to the plane thereof. The ring 4 of electrically conductive material has an outer diameter of 2λ and a thickness of about $\lambda/30$.

The ring 4 of electrically conductive material is mechanically supported in the desired position by embedding it in a cap of a plastic material exhibiting a low dielectric constant and a low dissipation factor, such as a polytetrafluoroethylene sold under Trademark "Teflon", which simultaneously acts as a protection for the horn, thereby making it capable of being pressurized. The Teflon cap 7 has an inwardly extending end flange 8 intended to be inserted in a groove 9 provided about the choke 2 so as to permit a firm and sure fastening thereof.

The physical dimensions of the above mentioned ring as well as the optimal positioning before the primary source have been experimentally determined. This determination has demonstrated that, by employing the solution according to the invention it was possible not only to modify the radiation pattern on the E plane, but also to obtain a discrete symmetry on both planes.

The dual expedient (choke 2 + ring 4) has been proved efficient, thereby allowing all the foreseen results to be obtained.

For this measurement, the horn 1 according to the present invention has been applied for illuminating a parabola being of 1 m in diameter and having a focus of 420 mm and an illumination angle of $61,5^\circ$.

From an examination of the primary radiation pattern measured on the H plane and on the E plane at frequencies of 10,9-11,3-11,7 GHz (Figs. 2 and 3) by employing the relations:

$$1) \quad \eta_o = \cot^2 \frac{\theta}{2} \left[\int_0^{\theta} \sqrt{\gamma(\theta)} \operatorname{tg} \frac{\theta}{2} d\theta \right]^2$$

$$2) \quad \eta_s = 1 - \frac{\int_0^{\theta} \gamma(\theta) \operatorname{sen} \theta d\theta}{\int_0^{\pi} \gamma(\theta) \operatorname{sen} \theta d\theta}$$

wherein

η_o = illumination efficiency

η_s = spill-over efficiency

an average efficiency of about 88% with an illumination angle of 55° has been determined with a corresponding spillover which is largely lower than 0,1% (about 0,07-0,08%).

The efficiency and spill-over curves in the center band as a function of the illumination angle are plotted in the Figs 4 and 5, in which the ordinates show the efficiency values and the abscissas show the degrees of the illumination angle. As can be seen from Fig. 4 at 55° there is a maximum of efficiency corresponding to 88,9% (curve A) with a minimum of spill-over (curve B) while in the Fig. 5 there is a maximum of efficiency corresponding to 89,24% at $57,5^\circ$ with corresponding minimum of spill-over.

Starting from the radiation patterns on the E and H planes shown in Fig. 2 and 3 the gain has been evaluated and the obtained value (40,1 db/ISO at 11,3 GHz) has given a total efficiency of 73%, which value is quite good for a prime focus structure.

From the foregoing it is easily apparent that the horn illuminator according to the present invention exhibits radiation patterns nearly rectangular in the H plane and E plane with a horn structure very simple which permits therefore the horn illuminator to be manufactured at relatively low costs.

Claims

1) Horn illuminator for reflector antennas capable of emitting radiation patterns in the H and E planes substantially rectangular in shape, characterized in that it is provided with a ring (4) of electrically conductive material, coaxially placed before the horn mouth (3) a distance of $\lambda/4$ therefrom and in a plane parallel to that of said mouth (3).

2) Horn illuminator according to claim 1, characterized in that said electrically conductive ring (4) is supported by a cap (7) of plastic material exhibiting good electrical properties which simultaneously acts as a protection therefor.

3) Horn illuminator according to claim 2, characterized in that said electrically conductive ring (4) is
5 embedded in the cap of plastic material so as to make the horn capable of being pressurized.

4) Horn illuminator according to the preceeding claims, characterized in that said ring (4) of electrically conductive material has an outer diameter of 2λ , a height of $\lambda/4$ and a thickness of about $\lambda/30$.

5) Horn illuminator according to claims 2 and 3, characterized in that the plastic material forming the cap is a polytetrafluoroethylene such as Teflon.

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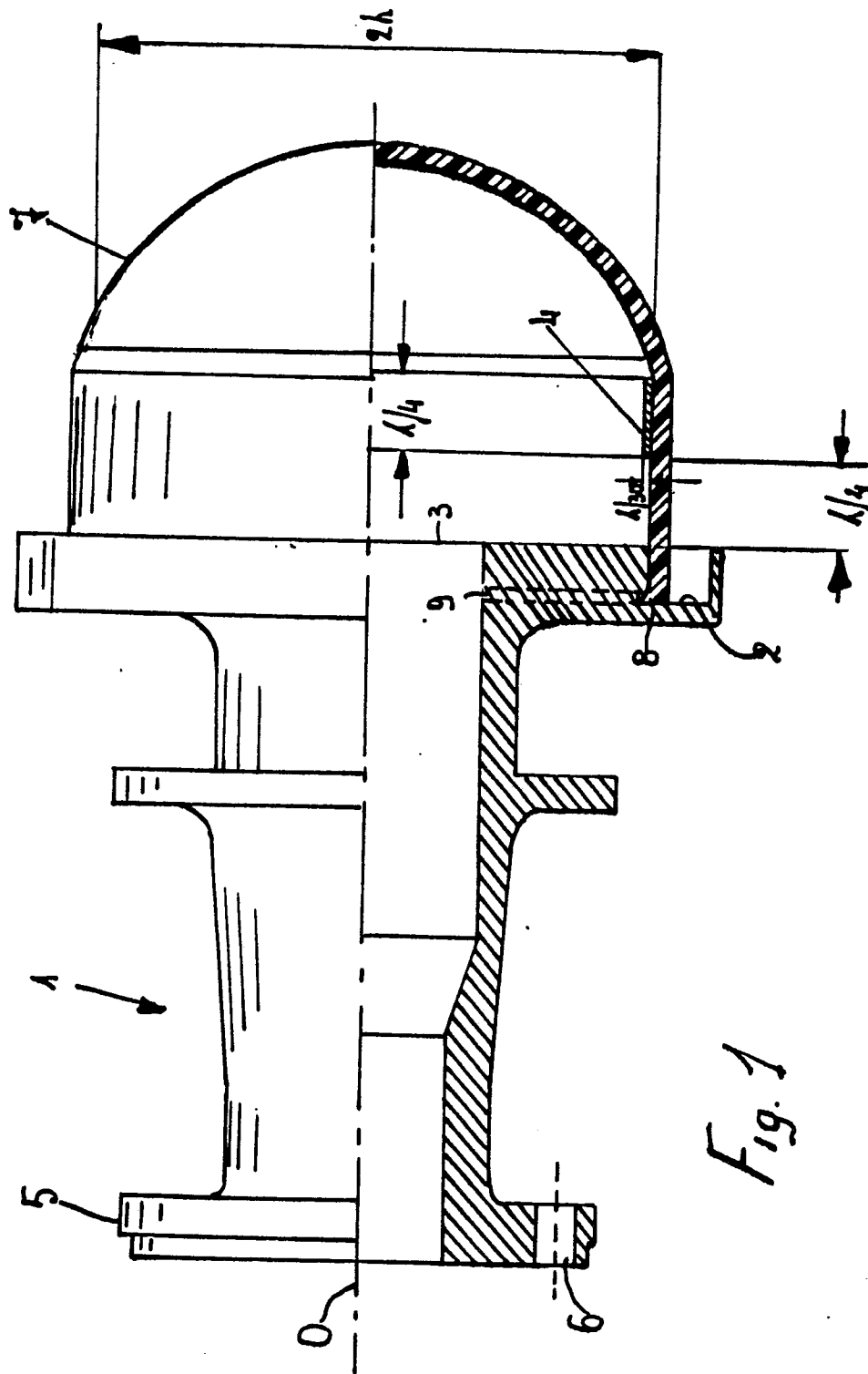
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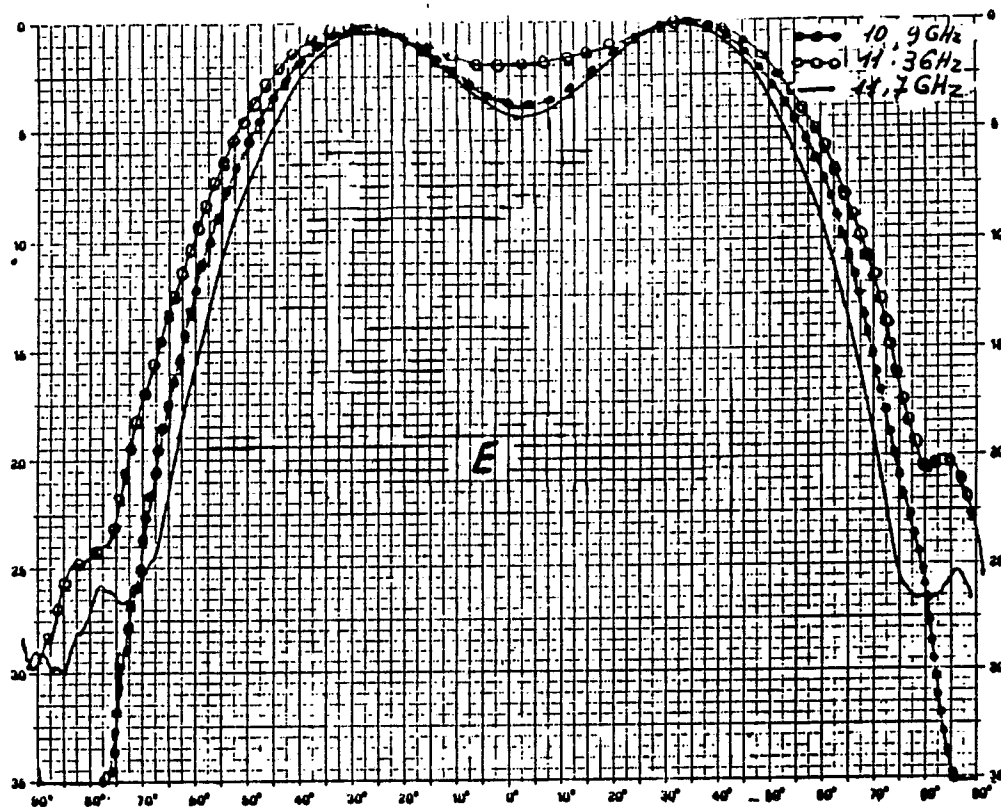


Fig 2

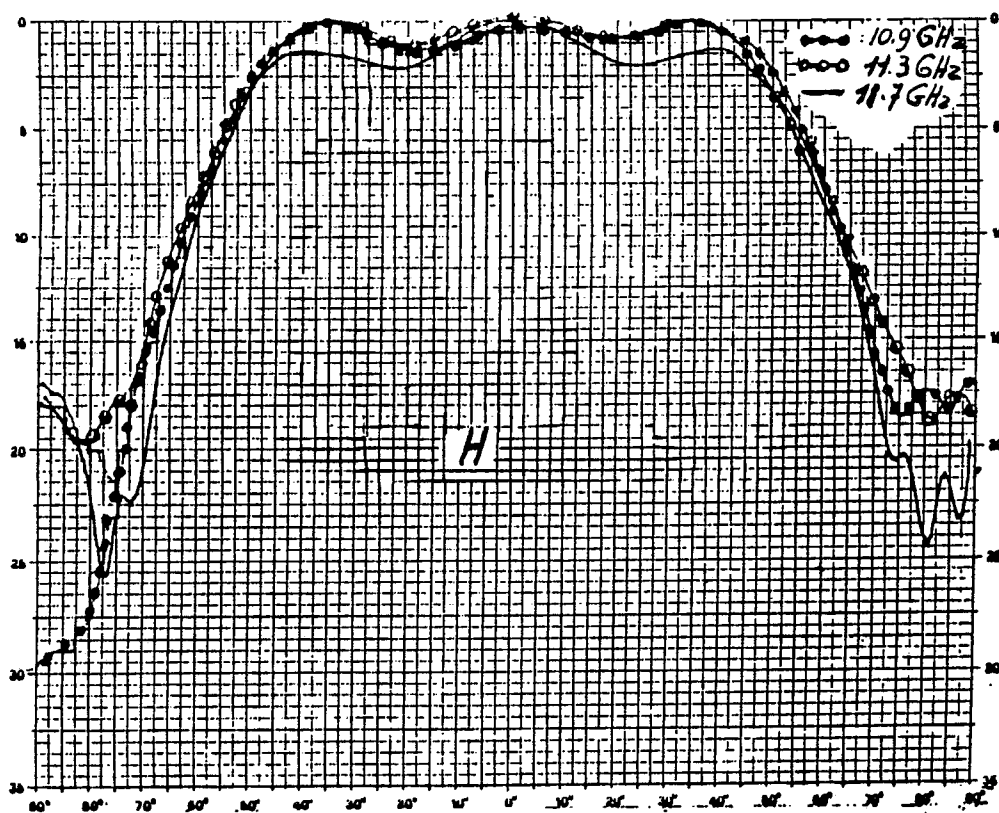


Fig 3

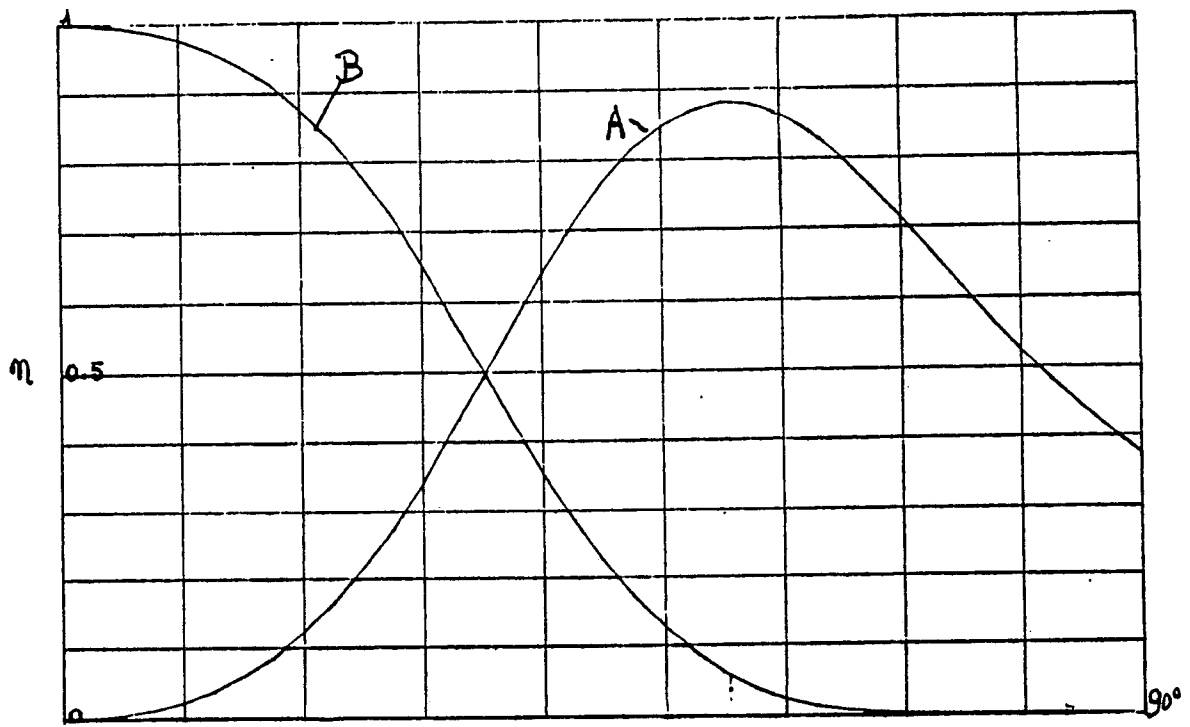


Fig. 4

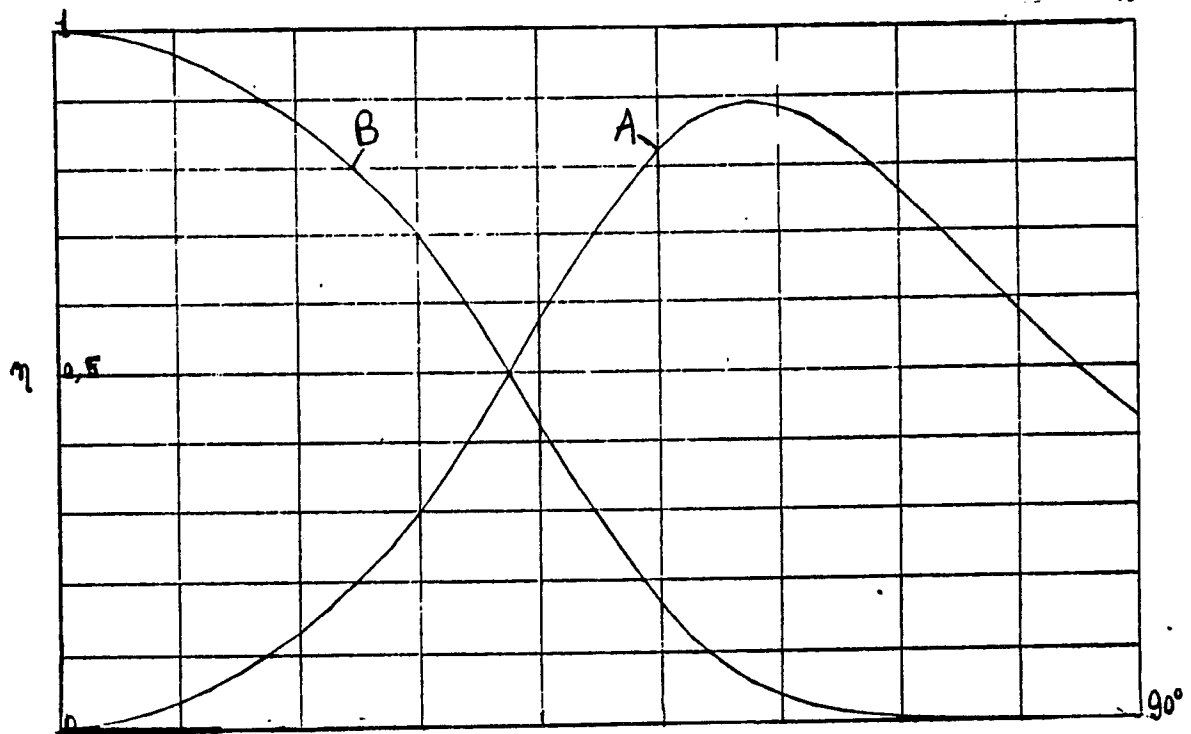


Fig. 5