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MATERIAL FOR MAKING RESILIENT LIGHT PIPES TO BE MOUNTED WITHOUT SILICON GREASE

by

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1965

Joint Nuclear Research Center
Ispra Establishment - Italy
Reactor Physics Department

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For a special neutron scintillation counter a light pipe material was required which could replace Plexiglas or Lucite. This material had to be elastic in order to make a good fit between a scintillation crystal and photomultiplier even when mechanical dimensions (distance, parallelism) were somewhat undefined. Furthermore, the use of silicon grease for making an optical seal was to be avoided. Silicoloid 201, an embedding compound for electronic components and circuits, fulfills these requirements. It has a refractive index of 1.408 and a reasonable transmission for scintillation light wavelengths. In addition, it is easy to mold into any shape and it adheres well to glass, forming stable but removable seals without grease.

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Material for Making Resilient Light Pipes to be Mounted Without Silicon Grease

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For a special neutron scintillation counter a light pipe material was required which could replace Plexiglas or Lucite. This material had to be elastic in order to make a good fit between a scintillation crystal and photomultiplier even when mechanical dimensions (distance, parallelism) were somewhat undefined. Furthermore, the use of silicon grease for making an optical seal was to be avoided. Silicoloid 201, an embedding compound for electronic components and circuits, fulfills these requirements. It has a refractive index of 1.408 and a reasonable transmission for scintillation light wavelengths. In addition, it is easy to mold into any shape and it adheres well to glass, forming stable but removable seals without grease.

INTRODUCTION

FOR a special application we have constructed a large-surface neutron counter, using 20 photomultipliers of 7.6-cm cathode diameter (Du Mont 6363), together with 20 ^{6}LiI(Eu) crystals, 2 mm thick and 7.6 cm in diameter.

Because of the small thickness of the crystals and the considerable nonuniformity of photocathode sensitivity, conical Plexiglas light pipes were used to diffuse the scintillation light before it arrived at the phototubes (Fig. 1).

Optical coupling between crystal, pipe, and photocathode was provided by silicon grease, following the well-known techniques. It proved to be rather difficult, however, to obtain perfect optical seals, for the following reasons:

The scintillation assemblies were to be mounted so close to each other that it became impossible to observe visually whether the silicon seal was free of air inclusions.

There was a non-negligible difference of length (±3mm) and of cathode parallelism from one phototube to another, and this led us to use a somewhat cumbersome ring assembly (Fig. 1) in which the different parts were held together by springs. The mechanical stress produced by these springs sometimes caused instabilities of the optical coupling with time and with temperature.

Although the large-surface counter was built and used successfully, we decided later to try to fabricate improved light pipes using Silicoloid 201, a new transparent potting and embedding compound for electrical and electronic circuits which has been developed recently by ICI.[1] This compound is supplied as a solventless liquid which, upon the addition of a special curing agent, quickly cures at room temperature to a completely stable and resilient solid with very good light transparency and electrical insulation properties.

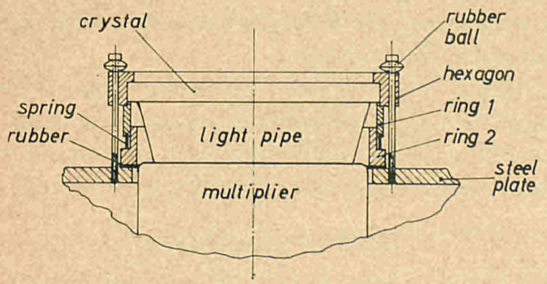

Fig. 1. Sectional view of a 7.6-cm-diam ^{6}LiI(Eu) crystal mounted on a Du Mont 6363 multiplier using a conical Plexiglas light pipe in a light-tight housing.

For our purposes the use of Silicoloid presents the following advantages: Silicoloid 201 can be molded into any desirable shape (no machining or polishing is necessary). The cured compound is elastic like a soft rubber, and it can thus be made to match other components having mechanical dimensions which are not subject to very close tolerances. Pieces of Silicoloid 201 show a good adhesion (air-tight fit) to glass and other clean dry surfaces, which makes the use of silicon grease for optical couplings unnecessary. In spite of this adhesion power, the pieces can be removed without a special releasing agent and reset simply by applying them under slight pressure.

OPTICAL PROPERTIES OF SILICOLOID 201

Silicoloid 201 has a refractive index of 1.408, which is nearly the same index as Plexiglas.

The most important property for our purposes is, of course, the ability of Silicoloid 201 to transmit scintillation

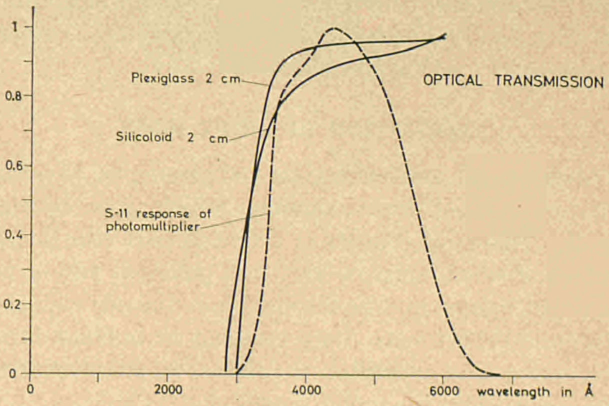

Fig. 2. Optical transmission versus wavelength, measured for 2-cm-thick samples of Plexiglas and Silicoloid 201. Dashed line shows typical S-11 response curve of a photocathode.

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[1] Imperial Chemical Industries Ltd., Nobel Division, Silicones Department, Stevenson, Ayrshire, Scotland.

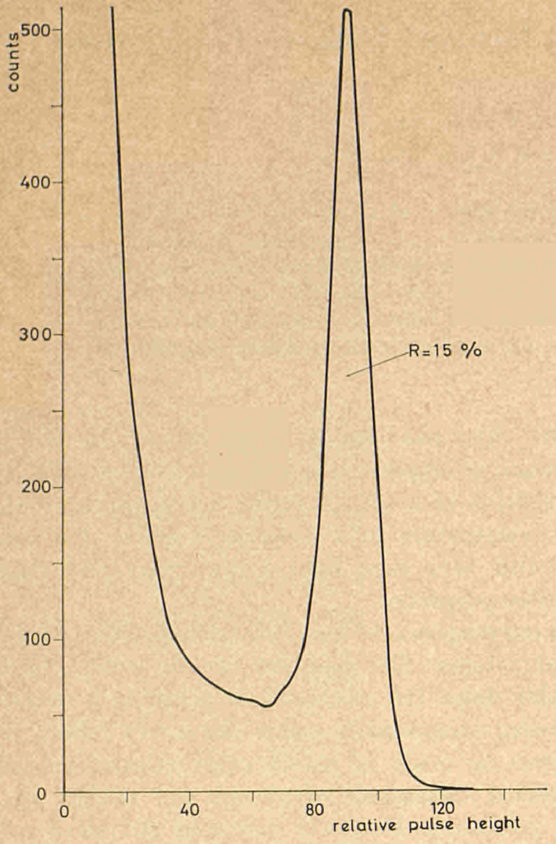

FIG. 3. Amplitude spectrum obtained with thermal neutrons irradiating a 7.6-cm-diam and 2-mm-thick ^{6}LiI(Eu) crystal, coupled to a Du Mont 6363 multiplier with one of the conical Silicoloid 201 light pipes. Peak width is 15%.

light without prohibitive attenuation. As such data were not available, the light transmission was measured for some representative samples with a Zeiss refractometer. The results for 2-cm-thick samples of Plexiglas and of Silicoloid 201, plotted together with a classical S-11 photomultiplier response curve[2] of a Du Mont 6363 tube, are shown in Fig. 2.

From these results it can be seen that the difference in light transmission between Plexiglas and Silicoloid 201 is not very significant for the sample thicknesses (2 cm) and wavelengths (~4500 Å) considered.

FABRICATION OF LIGHT PIPES

After several trials with glass and plastic, we have constructed a mold with aluminum which gave excellent results. This mold consists of a central part (the interior surface of which must be very well polished) and of two rings which serve to close the mold from the side with glass disks and rubber seals. Since escaping air bubbles during evacuation tend to expand the liquid, a conical reservoir was mounted on the top of the evacuation hole.

The fabrication of a light pipe involves the following steps: (1) Mixing of the required quantity of Silicoloid 201 and of curing agent (0.25–0.5%) in a glass cup. (2) Air removal by evacuation in a desiccator with a water pump. (3) Filling of the mold. The mold must be absolutely clean and dry. (4) Air removal as above. This must be achieved before the liquid loses its flow characteristics, otherwise some air bubbles will remain in the mold. (5) Curing at ambient temperature for at least two and, preferably, three days. We have observed that heating the mold in order to accelerate curing sometimes leads to destruction of the glass disks. This is due to the expansion of Silicoloid 201 while curing. (6) Opening of the mold and releasing of the glass disks. This requires a certain skill and patience. Breaking of glass disks causes traces on the light pipe surface.

In order to become familiar with the techniques, we have also tried to mold other shapes than the one suitable for our light pipes.

A rod of about 2 cm in diameter and 20 cm long was made, using as a mold a glass tube the inner surface of which was clad with an aluminium foil. To allow for expansion during curing, the mold was first filled to a level about 1 cm less than the desired length of the rod. The last centimeter of liquid was added after two days in order to obtain a flat top surface.

After curing, the glass tube was destroyed, and thus the rod could be released from the aluminum foil very easily. There was no evidence of the molding in two steps.

RESULTS OBTAINED WITH A CONICAL LIGHT PIPE

We have compared several conical light pipes made of Silicoloid 201 with similar light pipes made of Plexiglas. The pipes were placed between a LiI(Eu) crystal and a Du Mont 6363 multiplier. Silicon seals were used with the Plexiglas, while the Silicoloid pipes were set up without grease. In the latter case, we observed that only a slight mechanical pressure was necessary for removing all air inclusions. After applying the pressure for some minutes, the Silicoloid 201 cones remained in place and gave a good optical coupling after the mechanical pressure had been removed. The seals remained unaltered after several months of use in a portable scintillation probe.

Figure 3 shows the pulse-height spectrum obtained with thermal neutrons and a 7.6-cm-diam, 2-mm-thick LiI(Eu) crystal coupled to the multiplier with one of the Silicoloid light pipes. The peak width is 15%, which represents an improvement over the 18% width measured with the same crystal and a Plexiglas pipe.

We think that further interesting applications of Silicoloid light pipes are possible, especially in cases other than scintillation counting where light intensity is higher and where attenuation may, therefore, be tolerated.

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[2] See photomultiplier manuals of Du Mont or RCA.

To disseminate knowledge is to disseminate prosperity — I mean general prosperity and not individual riches — and with prosperity disappears the greater part of the evil which is our heritage from darker times.

Alfred Nobel

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