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Eye Protection in Radar Fields

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Tests on animals indicate that eyes exposed to microwave radiation may develop cataracts. The design of protective goggles, utilizing transparent microwave shielding, is discussed.

MANY TYPES of electronic equipment are susceptible to interference from microwave fields resulting from rectification effects at the input of electrometer tubes or d-c amplifiers or from multi[illegible]ator triggering. Frequently a meter window in the equipment permits easy entry of the radar waves. It is desirable to prevent this entry by means of an optically transparent material which is opaque to microwaves.

Such material could be used in protective goggles to protect the eyes of personnel subjected to radar fields since it is known that microwave fields can produce cataract of the eye in dogs[1] and rabbits.[2,3] Further work[4,5,6] emphasizes caution when exposing the eyes to microwave radiation. The use of copper or bronze screen wire has been suggested as a protective measure[7]. This personnel hazard becomes particularly important where clo[illegible] contact with high-power radars exists as on ships, te[illegible]acilities, tanks, aircraft,[8] and from forward-scatter propagation transmitters.[8,9]

OPTICAL AND MICROWAVE PROPERTY MEASUREMENTS

MEASUREMENTS WERE MADE of the optical and microwave properties of various materials. The optical property, measured with a spectrophotometer, was the per-cent transmission of visible light corrected for visual response. The microwave property was the per-cent transmission of three microwave frequencies (5.9, 9.7, and 18.8 kmc), measured by determining the insertion loss [illegible]n the material being investigated was inserted between the coupling flanges of two wave guide sections. The test flanges were located just prior to a tuner section terminated in a tuned bolometer section, with both sections adjusted to make the voltage standing-wave ratio unity. The power absorbed by the bolometer was measured at 1,000 cps by a Hewlett-Packard model *415A* bolometer bridge unit. A 1,000-cps modulated klystron produced the microwave power, which was fed through an attenuator section, an absorption wave meter, and a slotted line, with the flange on the load side being used for tests. The TE_{10} mode was used for all measurements. [illegible]e guide types *RG-50/U*, *RG-51/U*, and *RG-56/U* were used for frequencies of 5.9, 9.7, and 18.8 kmc resp[illegible]ely.

The results of the measurements are shown in Table I. As expected, good electrical conductivity is essential to microwave shielding, whereas this characteristic is not generally compatible with high light transmission and other psychological and physiological factors to be considered in the application to protective goggles. Table I also shows that the microwave results are rather critically dependent on frequency and the thickness of the material used. At the higher frequencies, the shielding effects of the film coatings are generally better. The greater the film thickness, the better the shielding because the film conductivity is greater. In general, thin films do not have the same volume resistivity or the same shielding properties as the bulk metal because of surface effects. It should be noted that the microwave attenuation is the result of both reflection and absorption of microwave energy by the various materials. Thus, the attenuation measured is, in part, a function of the mismatch between the impedance of the wave guide (Table I, last line) and the surface impedance of the conducting film. The d-c values of the surface film resistivity are specified as a guide to judging the relation to reflection properties. Inasmuch as the intrinsic impedance of free space is 377 ohms, the attenuation of the various materials in free space will be comparable with the values given in Table I.

CONSTRUCTION OF PROTECTIVE GOGGLES

IN CONSTRUCTING PROTECTIVE GOGGLES, the frame of the lenses must be such as to be nonresonant in the range of required effectiveness. Wire mesh has a limited microwave attenuation and causes a bad optical effect in front of the eyes. Also, the attenuation is poorer at higher frequencies. Lead glass used for X-ray protection has low microwave attenuation. The Corning heating panel glass did not permit clear vision because of the unevenness of the surface, although its microwave shielding and measured optical transmittance were favorable. The most feasible method found was the use of an evaporated gold film. Transmittance curves for two gold films are shown in Fig. 1. A pair of suitable goggles would have the gold film on the lenses and protective wire mesh on the sides. The 3.2 per-cent transmission is not too low for outdoor work and is permissible for indoor work in well-lighted rooms, provided the greenish-blue tinge of the gold film can be tolerated.

For particular instrumental applications where visual acuity is less important, wire mesh or the Corning heating panel glass may be more suitable.

Various types of semiconductive plastics were considered,[10,11,12,13] but the transparent plastics had extremely low conductivity, whereas the good conductors were not

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transparent. Various types of undercured plastics are conductive, but most are unstable and usually opaque. Where conductivity in plastics is produced by an additive, the transparency is, in general, adversely affected. The type of shielding to be used depends upon the applicat[illegible] The us[illegible] of an evaporated gold film for radar prot[illegible]ve goggl[illegible]s appears to be a feasible method of applying attenuation to lenses of various curvatures. The conductive coating on meter faces also serves as an antistatic coating.

Table I. Microwave and Optical Properties of Materials

Material	Microwave Transmittance, Per Cent			Optical Transmittance, Per Cent
	at 5.9 kmc	at 9.7 kmc	at 18.8 kmc	
Gold film about 11 mμ thick on plastic (300 ohms per square)	23	10	0.8	49
Gold [illegible]out 30 mμ [illegible]k on plastic (12 ohms per square)	0.16	0.1	0.01	21
Gold film about 75 mμ thick on glass (1.5 ohms per square)	0.04	0.01	0.004	3.2
Copper mesh (20 per inch)	0.1	0.2	0.2	50
Copper mesh (6 per inch)	1.0	1.3	2.5	60
Lead glass (X-ray protective, ¼-inch thick)	30	25	16	85
Lucite (3/16-inch thick)	80	50	25	92
Libby-Owens-Ford Electrap[illegible]ass, with co[illegible]ve coating about 150 mμ thick (120 ohms per square)	16	16	16	85
Libby-Owens-Ford Electrapane glass, with conductive coating about 300 mμ thick (70 ohms per square)	9	10	8	80
Corning heating panel glass, with conductive coating about 1.5 μ thick (15 ohms per square)	1.6	1.2	0.08	45
Waveg[illegible] imped-ance [illegible]	554	448	568	—

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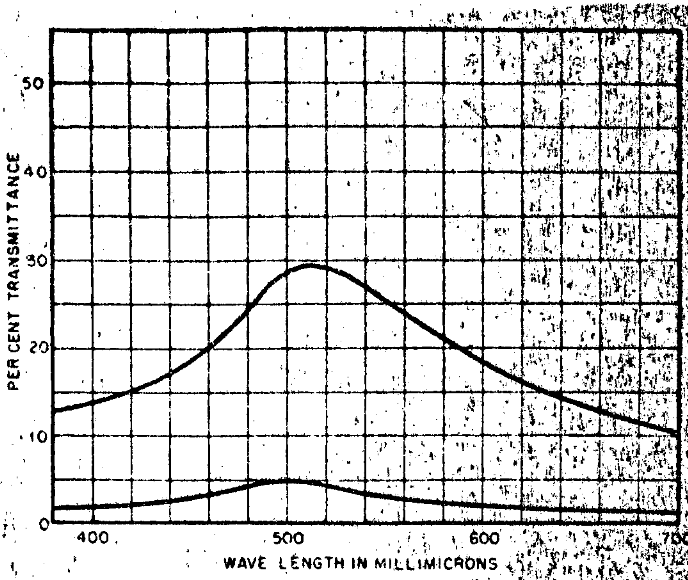

Fig. 1. Spectrophotometric curves. The upper curve is for 30mμ evaporated gold film on plastic, 24 per cent transmittance, corrected for visual response; the lower curve is for 75mμ evaporated gold film on glass spectacle lens, 3.2 per cent transmittance, corrected for visual response.

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Fuel Injection for Autos

Gasoline fuel injection for automobiles is an innovation that may well "revolutionize" the American car within the near future. The West German firm, Robert Bosch GmbH, has extensive experience in this field, having produced its 2,000,000th diesel fuel injection pump in Stuttgart last year. This fact indicates the fuel injection principle is a sound, efficient, and economical engine feature of the present and the future in the automotive transportation field. In the gasoline fuel injection system, individual cylinders are supplied with identical amounts of fuel, evenly and quickly. Gasoline from the tank goes to a pump, then is forced directly and evenly into the combustion chambers of the cylinders through tiny nozzles which are fed by tubes connected with the pump. The actual mixing of the fuel and air takes place in the combustion chamber. Thus, the clumsy carburetor is eliminated. Robert Bosch GmbH has adapted these injection systems for many years to such fields as passenger car gasoline engines, passenger car diesel engines, diesel trucks, diesel buses, tractors locomotive engines, marine engines, and utility engines.