MAGNETIC INTERFERENCE - THE ENEMY OF TOP PRODUCT PERFORMANCE

Magnetic shielding has become indispensable for optimum product performance as the trend to ever smaller layouts crowds components even closer to each other. This, of course, dramatically increases susceptibility to electromagnetic interaction even in the best engineered layouts.

To shield out a magnetic field, its source must first be determined. Usually, this is not difficult, but sometimes the source seems to elude discovery. For example, interfering magnetic fields are several times greater in modern, low-ceilinged concrete structures than in older, higher ceilinged buildings of different construction. This can be immensely perplexing, until the realization dawns that numerous reinforcing steel beams are incorporated into concrete construction and that low ceilings bring the resulting steel beams' extraneous magnetic interference much closer to sensitive equipment than in higher ceilinged rooms of different construction.

Once the unwelcome field's source is discovered, consideration is given whether to shield the source or the affected components. When practical, it is preferable to shield the affected component or components.

Other factors to consider in specifying the optimum shield are the strength of the field, the number of shielding layers required, whether to use high or low permeability alloy or a combination thereof, the shape of the shield and the accessibility of the component to be shielded. It is vital that the shielding alloys selected do not saturate when properly used, do not suffer excessive permeability loss from shock, display minimum retentivity, and exhibit relatively stable permeability characteristics after final anneal, avoiding the expense and inconvenience of regularly repeated annealings.

In accordance with the time tested "ounce of prevention," the shield should be incorporated at the equipment manufacturing stage whenever possible. CRTs are a good example. Retrofitting the optimum shield is often expensive and sometimes impossible if the tube designer hasn't allowed sufficient neck area. If the shield is designed into the tube at the very beginning, optimum shielding is attained easily.

Shield shapes range from a simple box, conical or cylindrical configurations to more complex shapes and sometimes conform to the glass bottle or the CRT. In complex applications, shields are tailored to fit exactly and can consist of many unusual configurations.

PM Tube Shielding in High Magnetic Environments

Selecting shielding for photomultiplier tubes is simplified because shielding manufacturers have fabricated shields already tooled up for most PM tube sizes. It is only necessary to inform one's shielding source of the PM tube manufacturer's name and the tube's type number to obtain the correct shielding shape. The strength of the magnetic field is the other factor involved.

Figure 1 shows a photomultiplier tube used in relatively high magnetic field environments commonly encountered in physics research set-ups and similar applications. There are five shielding layers to provide maximum flux diversion in such environments. In addition to its adaptability to many experimental applications, variations of this shield design finds use in specialized laboratory equipment production.

The outermost layer is heavy-gauge, low-permeability alloy. For mounting convenience, a stainless steel flange is heliarc welded near one end. An interface of .050 non-magnetic stainless steel is next, followed by another heavy-gauge, low-permeability shielding alloy layer enclosed in a .020 non-magnetic stainless steel cylinder. The innermost layer is .025 high permeability shielding alloy.

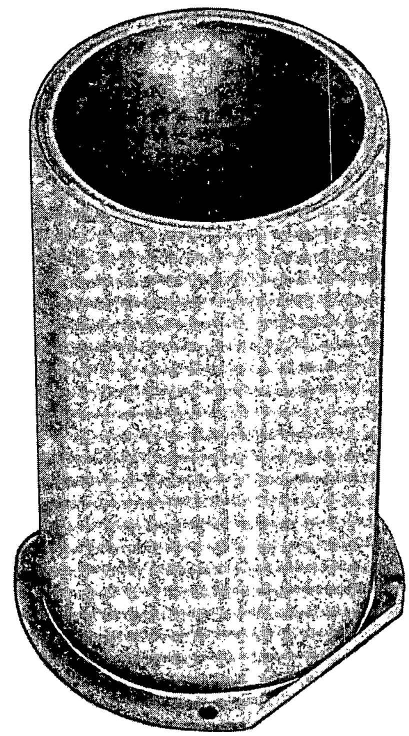

Figure 1.

To maximize shielding effectiveness, the ferromagnetic layers were individually heat treated. The two low permeability layers were then coated with rust inhibiting oil for oxidation protection in average environments. The high permeability layer was not oil coated as it is relatively inert to normal environmental attack.

Immobile Shielding Room vs. Mobile Shielded Chamber

Figure 2 illustrates a very large economical mobile multi-layer controlled magnetic environment chamber for determining response characteristics, sensitivity and orientation direction of magnetic sensor devices used for signature recognition, proximity sensing, etc. in a wide variety of industrial, military and commercial security applications. It diverts most of the external fields present.

The cost is far less than for an immobile shielded room. Two parallel 1″ x 4″ aluminum sections attached to the cradle's front and rear enable a forklift to move the entire 800 lb. structure easily, achieving desired field mobility.

The chamber's 36″ OD and 34″ ID x 40″ L dimensions contain a Helmholtz structure of required size without its suffering severe anomaly distortions caused by proximity of the shielding structure. Of course, larger or smaller shields can be constructed to meet any specific dimensional requirement.

The initial residual field level within the shield is established by incorporating a degaussing winding structure into the shield, located to produce its principal reaction on the inner shield. With the shield's axis parallel to the earth's plane, the degaussing cycle is continued until a minimum residual field of approximately one milligauss is reached. The degaussing operation is then terminated. The object is to reach a repeatable level rather than a low minimum. Once the internal ambient level has been normalized, a desired field level generated by the Helmholtz system can be established.

Physically, the shield consists of two concentrically located cylinders of .062″ high permeability alloy, each with welded bottom and removable cover top having a 5″ overlap flange minimizing external field entry possibility. Convenient handles on the outside cover simplify manual cover installation and removal.

Ten 1″ x 1″ bar stock aluminum spacers, the length of the cylinders symmetrically spaced, are attached to the inside of the outer cylinder. The two covers are installed simultaneously because they are spaced 1″ apart in all directions and made into an integrated assembly. The entire structure is mounted on a ¼″ thick aluminum cradle. Both cradle and shield are securely anchored to each other by ¼″ thick aluminum bands welded to the cradle structure and extending around the outer perimeter to a point beyond the shield midline.

Prior to final assembly, the shield and covers were subjected to a proper high temperature anneal. To optimize magnetic properties, the vacuum furnace was held at high termperature for an adequate soak time. Cooling rate was carefully controlled to give permeability optimization. Accordingly, the shielding alloys display stable permeability, will not saturate when properly used, will not suffer excessive permeability degradation from shock, and do not require periodic annealings.

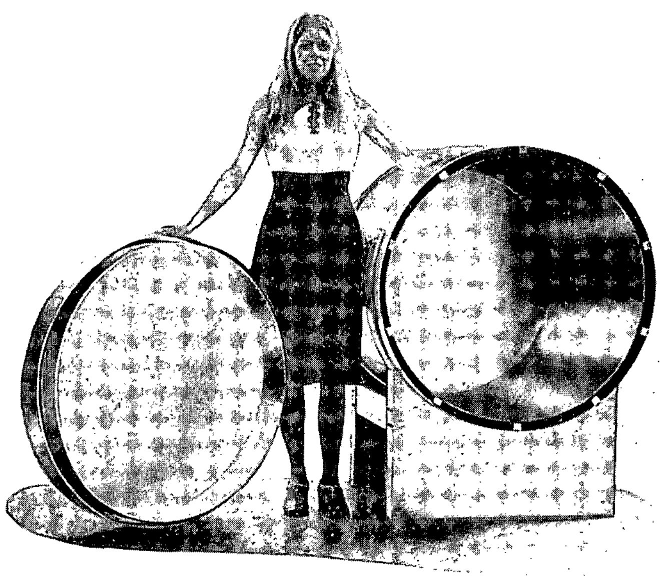

Figure 2.

Shock And Vibration Protection

Figure 3 depicts a customized very large high performance magnetic shield for a complex radar system in a series of consoles using either 16″ conventional CRTs or memory type tubes. It is used in areas subjected to shock and vibration and still delivers top performance shielding.

Maximum protection against mechanical shock and vibration even in rough sea or mobile ground applications is provided by potting the tube in a resilient material within the shock mounted rugged dual layer shield. Convenient access for periodic yoke adjustments is achieved through four rectangular holes 90° apart cut at the narrow end of the square to round transition. When operational, these holes are shielded by a removable, conformally formed cover, positioned and secured by tightening two screw clamps.

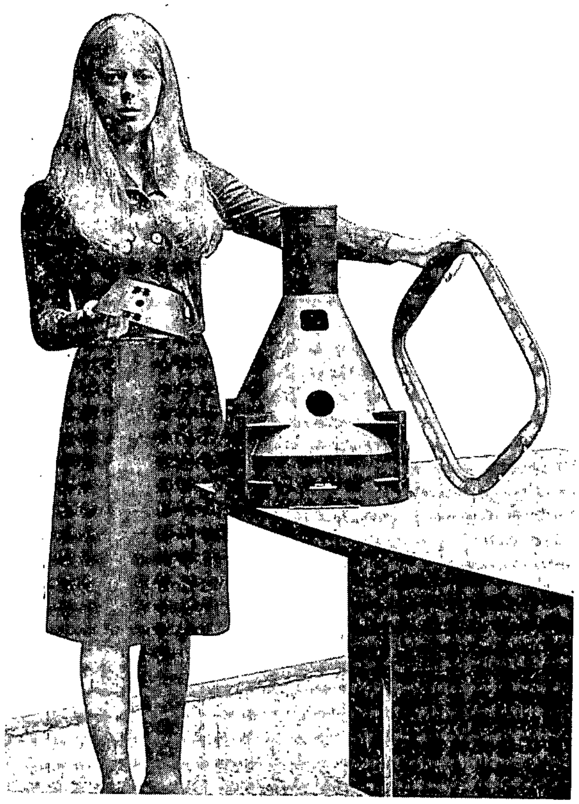

Figure 3.

Despite exposure to wide variations in external magnetic environments, control tests determine that 55dB minimum attenuation was held with approximately 5 gauss impinging on the shield plane. Operationally, widely varying exposure includes degaussing fields and radiating fields from close by associated electronic equipment, such as power supplies, power carrying service ducts, etc., aboard ship.

For quality control purposes, a single point source test of effective attenuation was used. A directional field from a soft iron core solenoid excited by a 60 Hz source was directed normal to the shield's axis. A calibrated AC magnetic field probe was positioned inside the shield and oriented to display maximum pickup from the radiating source. Of course, more elaborate test procedures, such as large Helmholtz field generating structures, could be used. However, it was determined that a point source test is extremely reliable in establishing that the shielding alloys have responded properly to heat treatment.

Figure 3 shows the main shield on the table, the conformal cover in the model's right hand and the aluminum bezel in her left hand. The 3⅝″ wide forward section of the basic rectangular shield has a high permeability inner shielding layer .040″ thick and a high permeability outside overlay .050″ thick. This assembly is fusion heliarc welded per MIL-W-8611 to the transition section which terminates cylindrically to mate with the neck section. This section uses high permeability .062″ thick shielding material. The final neck section uses high permeability .090″ thick shielding material.

Four shock mount plates made of U-shaped nonmagnetic stainless steel channels are positioned at each radius corner parallel to the shield's axis and vertical to the plane of the open end. These plates are heliarc welded per MIL-W-8611 to the shield itself in addition to using fitted reinforcing gussets mating with the shield's tapered section. Four flanges formed at right angles extend outward from the shield's open end to facilitate attachment of the aluminum bezel. Bracketry is ⅛″ nonmagnetic stainless steel. The complete unit was formed over solid aluminum plugs.

After complete fabrication and fitting, the entire shield, except for the aluminum bezel, was given an anhydrous hydrogen anneal to maximize the high permeability alloy's magnetic properties. The shield and tube assembly was then mounted inside the console by attaching to the shock mounts.

These three examples typify the versatility and effectiveness of magnetic shielding tailored to a precise application. Note that only enough shielding is used in each application to divert offending magnetic fields which prevent optimum product functioning. When more than sufficient shielding is ordered, it adds unnecessarily to cost.

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