Magnetic Field Huyler

S 4614

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SPECIAL PROJECTS

This letter reports first on the trip to Syracuse I made September 22 with you and Mr. Howden, and then discusses magnetic aspects of the cathode ray tube test facility room and equipment.

Because of the heavy rain and the presence of a wide and deep ditch through the test room area, together with the presence of considerable metal scaffolding along the wall and a large power shovel in the immediate vicinity, no magnetic field measurements were made. It is tentatively planned to make these measurements on a Saturday as soon as possible after the ditch has been filled and the scaffolding removed, when the shovel and other equipment will not be there.

In discussion with Mr. Lee Huyler the effects of ambient magnetic fields on the tube operation were explained by Mr. Huyler, and it was tentatively agreed that the magnetic field variation along the tube test line should be no greater than ±0.05 gauss. Mr. Huyler then showed me a test in which a tube was set up in the field of a large set of Helmholtz coils. The ambient field was held to zero in the test region inside the coils. A microscope set up in front of the tube face permitted observation of the electron spot movement over a single phosphor dot as the field strength was varied. A horizontal field variation of 0.2 gauss appeared to move the electron spot from the center of the phosphor to tangency with the periphery, about 1.5 mils. The acceptable maximum allowable deflection was said to be 0.5 mils, making the maximum permissible field change about 0.067 gauss. This was considered supporting evidence for the agreed-upon limit of 0.05 gauss. Mr. Huyler will repeat the observations and confirm the 0.05 gauss limit.

In a meeting in the afternoon at which the test room construction was discussed I made recommendations as follow, relative to the magnetic considerations to be observed.

1. A magnetic shield should be hung under the mezzanine floor to form a ceiling shield against field disturbances which might be caused by equipment on the mezzanine floor. This shield may consist of two sheets of low-carbon steel 1/16 in. thick separated by 3/4 in. of non-magnetic spacer, and suspended 3/4 in. below the structural steel of the mezzanine floor by non-magnetic spacers.

2. The concrete floor may contain the usual type and amount of reinforcing steel. Care should be exercised to see that the steel is reasonably uniformly distributed.

3. The base and rails of the carrousel conveyor can be of structural steel as shown. The vertical field will be increased several per cent at the tube position, but will be the same at all test stations.

There was considerable discussion about orientation of the carrousel conveyor relative to the ambient magnetic field. The consensus at the meeting seemed to be that the tubes should be tested with their axes parallel to the direction of the horizontal component of the ambient field. This would require that the conveyor be reoriented to a position about 90 degrees from the presently shown position. The effect of such a change on the present lay-out of construction and conveyor routing was discussed at some length. The mezzanine floor would not be enlarged, but the sheet steel ceiling shield would be extended to cover the carrousel conveyor. It was pointed out that the precise field direction would not be known reliably until the steel construction is completed. However, I suggested that as soon as conditions in the area permit a magnetic compass be taken out and the present direction of the ambient field determined. This should permit approximate orientation of the carrousel on the drawings and determine the structure and lay-out of the room. Space should be provided for moving one end of the carrousel (opposite the drive end) in the plans, if necessary, before installation. I pointed out that if the orientation is correct within $\pm$ 10 deg. the cross-wise component of horizontal field will be within the 0.05 gauss tolerance. I will give further study to the effect of the sheet steel ceiling and the steel carrousel base and rails on the horizontal magnetic field. The entire question of reorientation was later rendered uncertain in discussion with Mr. W. Rublack, who felt that the tubes should be tested with tube shields in place and with the axis of the tubes at right angles to the horizontal component of the field. This would be approximately as is presently shown.

A simple calculation may be made as follows to illustrate the effect of the ambient magnetic field on the position of the electron spot at the phosphor screen. The radius of curvature of an electron orbit in a magnetic field is given by the following equation.

$$Br = \frac{1}{300}\sqrt{V^2 + 1.02V \times 10^6} \quad \text{gauss-cm.}$$

B = the magnetic field density in gausses
r = the radius of curvature of the electron path in cm.
V = the electron energy in volts.
The magnetic field, the electron path, and the radius to the center of curvature of the path are mutually perpendicular.

The length of the electron path from the electron gun to the mask before the phosphor screen was given as 14 in.

The electron energy was given as 25000 volts.

The mask location was given as 0.5 in. in front of the screen.

$$Br = \frac{1}{300}\sqrt{625 \times 10^6 + 1.02 \times 25000 \times 10^6} = 540 \text{ gauss-cm.}$$

$$r = \frac{540}{0.5} = 1080 \text{ cm.} \quad \text{in earth's field of } B = 0.5 \text{ gauss.}$$

$$\frac{14 \times 2.54}{1080} = 0.033 \text{ radians curvature of the path}$$

The deflection from an initial straight line is as follows.

$$\text{defl.} = 14 \times 0.033/2 = 0.238 \text{ in.}$$

This indicates that the beam will strike the mask about 0.24 in. to the side from a straight line tangent to the beam path at the electron gun.

The deflection of the electron spot relative to a phosphor dot on the screen depends upon the change in the angle of the beam path at the hole in the mask through which it passes. The attached sketch shows two beam paths between an electron gun and a hole in the mask, illustrating the difference in the points at which the beams strike the screen. Assume, in the sketch, that the magnetic field is uniform and perpendicular to the paper. Assume also that all the angles are small so that chords and arcs are substantially equal in length and that sines and tangents are substantially equal numerically to the angles in radians.

Assume that the magnetic field density is equal to B gausses, giving a radius of curvature of r cm.

$$r = \frac{(Br)}{B} \qquad 2\theta = \frac{c}{r} = \frac{cB}{(Br)}$$

Let the field density be increased to $B + \Delta B$ gausses. The beam which now enters the hole in the mask will be one leaving the electron gun at a somewhat greater angle, and it will enter the hole at a greater angle.

$$2(\theta + \Delta\theta) = \frac{c(B + \Delta B)}{(Br)} \qquad 2\Delta\theta = \frac{c\Delta B}{(Br)}$$

$$d = a\theta = \frac{acB}{2(Br)}$$

$$\Delta d = a\Delta\theta = \frac{ac\,\Delta B}{2(Br)}$$

$$\Delta B = \frac{2(Br)\,\Delta d}{ac}$$

$\Delta d = 0.0005$ in. $\quad a = 0.5$ in $\quad c = 14$ in. $\quad (Br) = 540$

$$\Delta B = \frac{2 \times 540 \times 0.0005}{0.5 \times 14 \times 2.54} = 0.0304 \text{ gauss}$$ (.03)

This is somewhat smaller than the tolerance of 0.05 gauss tentatively agreed upon, and apparently observed in the helmholtz coil test. The mask and its frame, being of iron, may provide a small amount of magnetic shielding. The amount of deflection calculated applies when the direction of the incremental field is perpendicular to the beam path, so that for a particular direction of field the deflection will vary greatly over the entire screen. I will continue to consider the maximum permissible field variation to be 0.05 gauss until this, or a lower value, is confirmed.

The features of the test room which relate to the magnetic field have been studied as shown in the prints supplied. The following comments and recommendations are offered.

Structural elements should be of non-magnetic material as far as possible. This applies to the posts and structure supporting the contact rails at each station. An exception is conceded for the carrousel base channel members and the conveyor rails and supports. These are below the test stations and are continuous so that they are not expected to cause variations in field strength from station to station. Gaps in the base channel members should be bridged by overlapping plates to reduce local disturbances. A rough flux map has been drawn, indicating that the vertical magnetic field may be increased 5-10% at all test stations by these magnetic members. The steel conveyor chain will be continuous and will be shielded by the conveyor rails. The steel rollers in the conveyor will be within the rails and shielded by them. The conveyor drive will be located in a pit a short distance from the conveyor at one end and covered by an iron plate to shield the area from any alternating magnetic field generated by the drive motor.

The mezzanine floor over the carrousel area will carry conveyors and test equipment of mass and other characteristics as yet unknown. It will include transformers which may generate alternating magnetic fields as well as distort the ambient field. The mezzanine floor will be of structural steel framework, covered by steel non-slip deck plates about 1/4 in. thick. A magnetic shield should be hung below this mezzanine floor structure as a ceiling over the test area, consisting of two sheets of low carbon steel, 1/16 in. thick, separated one above the other by non-magnetic spacers 3/4 in. thick. The upper sheet should be suspended about 3/4 in. below the mezzanine framework by non-magnetic spacers. The sheets should be composed of as few pieces as can be feasibly handled. Joints may be welded or screwed together. If screwed joints are used they may be either lap joints or butt joints with a strip of the same material covering the joint. Screws should be spaced closely enough to provide substantially continuous contact between the adjoining sheet edges. The material should be annealed to produce its best magnetic properties, and should be subjected to as little stress and bending as possible in hanging. A material such as B3D1A1 low carbon sheet 0.0625 in. thick, process gas annealed, is suggested.

The H beam columns shown supporting the mezzanine floor are shown no closer than 14 feet to the carrousel, and extend to the ground floor level. It is not expected that these columns will cause significant distortion of the magnetic field at the carrousel test stations. This conclusion is confirmed by measurements made at the Portsmouth facility and reported by Mr. R. F. Wood in a letter of June 24, 1966, a copy of which was given me by Mr. Huyler.

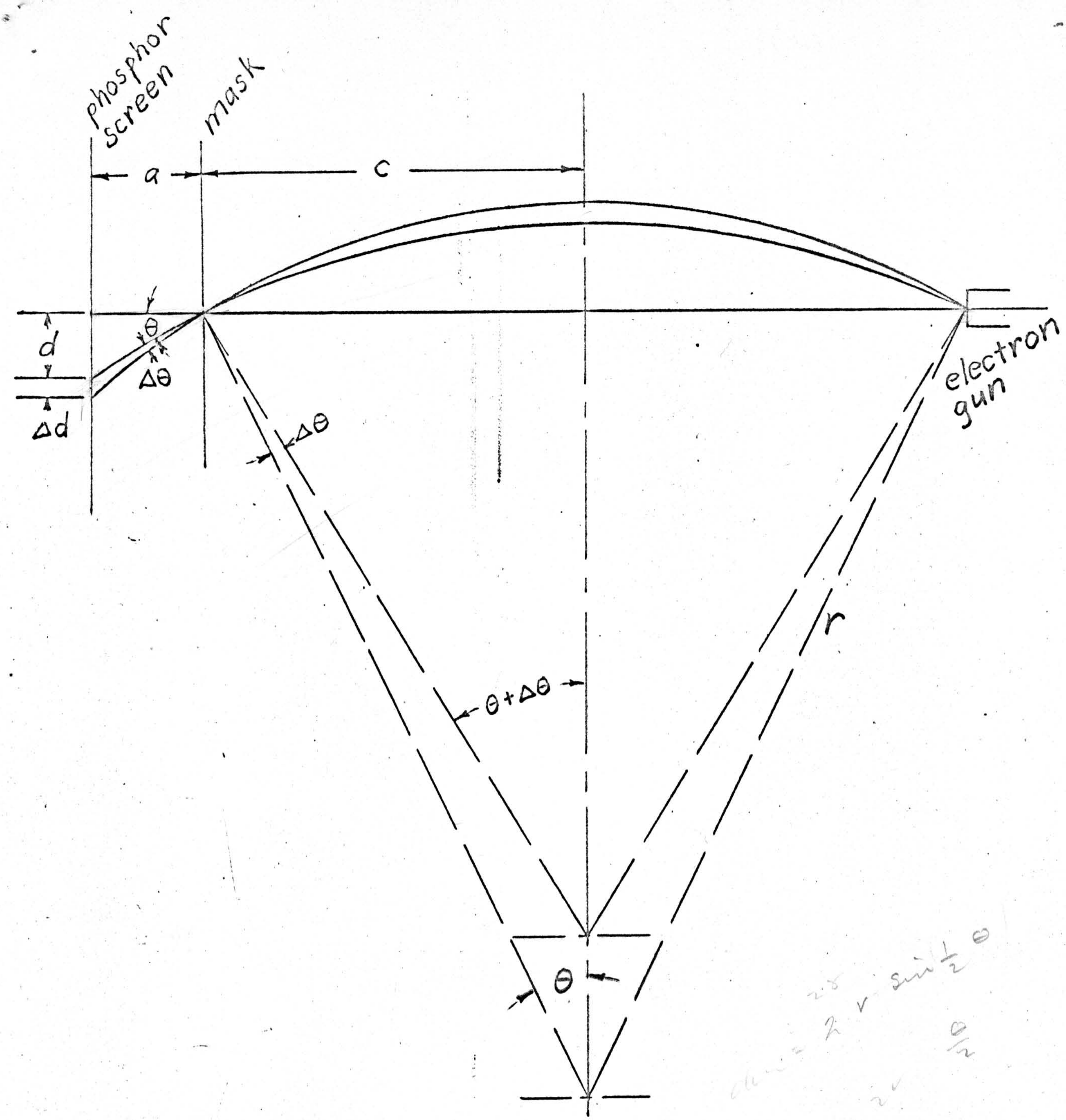
The concrete ground floor may contain reinforcing steel in the usual form and amount if care is taken to distribute it uniformly over the area. Joints between individual bars should be wired closely together. Isolated individual bars should be avoided. The best construction magnetically would be welded mesh of appropriate weight. The reinforcing steel should be checked for magnetization either before being placed or just before being covered with concrete to make sure portions have not become magnetized, as would occur if the steel were handled with a lifting magnet at some time prior to its use. If strong magnetic poles are found the portions of steel containing them should be demagnetized. Details of the measurement and demagnetizing process can be worked out when the type and amount of reinforcing steel are decided upon.

Preliminary study has been given to the in and out conveyors bringing tubes to the carrousel and taking them away. It is hoped that these can be of conventional steel construction if they are not allowed any nearer the carrousel than necessary for convenient transfer of the tubes, and then only as loops. The hangers for the loops may preferrably be of non-magnetic material. More firm decision will be made when the orientation of the carrousel is decided upon and the relative orientation of the conveyors fixed.

R. F. Edgar
Electric Power Control

RFE:pr

Attch.



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