Science Seminar,
Period 8

Joe Andrade,
May 28, 1959

PROJECT REPORT

Problem: To determine the effects, if any, of 45 mc. Co-60 Radiation on the strength of a permanent magnet.

Object: Obvious.

Background: There are three principle types of radiations: alpha, beta, and gamma (neurtons can also be considered a principle radiation). These various radiations are affected in various ways by a magnetic field. In other words, the magnetic field has an effect on the radiation. The question is, does the radiation itself have an effect on the magnet or the magnetic field? This was what I attempted to find out. As there has been practically no work done on this problem (and what there is is classified), nearly all research had to be original.

Apparatus:

1. Magnet.-- common horseshoe magnet.
2. Magnet adjuster.-- an apparatus for holding and adjusting the magnet.
3. Balance.-- a standard triple-beam balance.
4. Balance light assembly.-- Several penlight cells and a flashlight bulb, all mounted on the moveable arm of the balance.
5. Kymograph.-- This apparatus provides the means of recording and observing the experiments. It contains a spool of photo paper that is evenly moved by a small one rpm motor. The smoothly running paper passes very near the point of the light assembly, almost touching.
6. Radiation.-- A Co-60 45 mc. source obtained from the Calif. Disaster Office, Walnut Creek.
7. Misc.-- Processing chemicals and supplies, etc.

Method: The desired magnet is placed in the magnet adjuster and placed in the proper position beneath the pan of the balance. The magnet now creates a "pull" on the balance, thereby unbalancing it. The balance is the adjusted to compensate for magnetic pull. New batteries having already been placed in the light assembly and turned on, the knymograf is "loaded" and turned on. Now we have the recording apparatus in operation and our method of detection is in order. The radiation is then placed under the magnet. An increase in magnetic strength would show by an increase in magnetic pull, thereby pulling the pan down and, therefore, making the other end of the balance go up. As the ligt assembly is mounted on this moveable arm, any movement could be seen on the developed photo strip. No variation would mean no movement of the balance. Decreased strength, the pan would go up and the pointer down.

Joe Andrade
May 28, '59.

PROJECT REPORT (P-2)

Experimentation, Data, and Observations: IN exp. one, we can see that the line of exposure remains constant, although the density of exposure slowly decreases and then ceases. Examining the batteries after the exp. showed that they were nearly dead.

Exp. 2 was similair in that there was no exposure variation. However, the density variation was somewhat different: The density remained fairly constant up to a point and then stopped in a matter of several minutes.

Exp. 3 shows no variation in the line of exposure, but again there is a different density effect. The density remains fairly dark for a long period and then quickly drops to a lower but very clear density. This second density continues for about three of four minutes and then abruptly, without any gradualness whatsoever, ceases.

New batteries were used in all exp. except no. one. All exp., except for batteries, were carried out under identical conditions.

The "dead" batteries were checked several days later and found to be as good as new.

Conclusions: From the above we can conclude that A 45 MC.CO-60 RADIATION SOURCE HAS NO NOTICEABLE EFFECT ON THE ~~STRENGTH~~OF A WEAK HORSESHOE MAGNET. This conclusion is vvery tentaive as it is based on only three experiments.

In regards to the variation in density, a conclusion can be reached that this variation was due entirley to the batteries involved. Perhaps this is the typical action of a dry cell under prolonged use. It is possible, however, although the previous explanation is more probable, that the radiation itself had an effect on the cells. But they were checked several days later and found to be in good shape. The suggestion of radiation effect is worthy of further research.

PROJECT REPORT

By Joe Andrade

Washington Union High School, April, 1959

TABLE OF CONTENTS

MAGNETIC FACTS, THEORY, AND PROJECT THEORY

In practically every physics text there is a diagram showing the theorized manner in which a magnetic circuit completes itself. The diagram shows many particles, each an individual, very tiny, magnet; all of these particles in a magnetized material are uniformly aligned. Their paths of alignment are called <u>lines of force</u>; the number of lines of force per unit area determine the <u>flux</u>, which is directly proportional to magnetic <u>strength</u>.

The above-mentioned particles are referred to as magnetic <u>domains</u>. Magnetic domains are very puxxling but interesting to physicists. Recent research on the subject has shown that a domain is a crystal composed of somewhere in the neighborhood of ten thousand atoms, very neatly arranged. When all or most of these domains are aligned in such a way that their atoms are aligned, the substance exhibits magnetic properties. In good permanent magnet materials the domains are long and thin and, when magnetized, line themselves parallel to each other.

The alignment of these domains is dependent on the material, the strength of the external magnetizing force used, the jarring the magnet has received, and the influence of other domains. There are many domains in a ferromagnetic substance which are not aligned, even in a very strong magnet; they are, however, influenced by their neighboring domains. If we have an "unbalanced" domain, i.e., one that is not in alignment in a magnetic substance but is feeling the influence of its neighbors, the smallest force will usually "tip" it into alignment.

Doing some quick, rough calculations, we find that in a very small magnet (about $\frac{1}{2}$ x $\frac{1}{2}$ x 1 inch) a gamma particle will "hit" a domain once every second. If we leave the source exposed for about fifteen minutes, each domain is "hit" by a total of 900 gamma rays. Taking into account the increased size of the magnet used (which is about twenty-two times the size of the magnet mentioned in the calculations), we find that each domain is "bombarded" by about forty gamma rays. Assuming that there are about ten thousand atoms in a domain (this is believed to be a reliable figure), we find that only one in every two hundred fifty (250) atoms are hit. This means that only about 2/5 (.4) of one per cent of the atoms in the magnet are actually "feeling" any external source. This figure leads one to believe that very few domains will be affected to a point of alignment. At least a few should experience some sort of change in position or otherwise due to the radiation. For this reason alone the project is worthwhile.

The observer is probably wondering why only neutral radiation was and is considered. The use of charged particles was given thought; however, in a letter from Mr. Lovberg of the Los Alamos Scientific Laboratory, a discussion is given regarding the use of charged particles as a means of increasing magnetic strength. After carefully studying said letter, the author decided not to use this type od radiation as it would be very impracticle (see first letter in Appendix, please).

Eliminating charged particles, this left only neutral radiation. Eliminating the use of neurtons, as a reactor is needed to provide a large source of them, this left only gamma radiation.

I was fortunate enough to obtain a 45 millicurie Cobalt-60 source under the supervision of Mr. James Armstrong, science instructor at Washington Union High School, Fr mont, California, for my experiments from Mr. Loren D. Fields of the California Disaster Office, Walnut Creek, California.

RADIATION FACTS, THEORY, AND PROTECTION

As has been previously mentioned, the radiation source used was a 45 millicurie source of Co^{60}. The source was surrounded by a heavy lead container; The source and shielding were encased in a steel jacket.

An individual can be exposed to no more than ⁄ 0.075 roentgens per hour. The accumulative total is 300 milliroentgens per week or 0.3 r./week. One can calculate the dose rate (D.R.) of the source by the formula D.R. equals kc/d^2, where k is the "k-factor of the isotope", c is the activity in millicuries, and d is the distance from the source. It was found that one could come as close as three feet to the source, at that distance receiving nearly the maximum permissible dose (m.p.d.). This calculation did not take intonaccount any shielding, etc., that might be involved. As the souce was shielded on al, areas except the top, one could come up to three feet and still be relatively safe.

Gamma rays are known for their high penetration and their ability to "strip" electrons (Co-60 also gives off beta radiation, but it was absorbed before even reaching the magnet and is not considered).
As a gamma ray goes careening through a substance and meets with an atom, it usually "strips" an electron from the atom, producing a free electron (the "free" electron usually finds its way back to an atom that needs an electron). This "hitting" of the ray with an electron produces energy, which disturbs the balance of forces within the domain. This disturbance <u>may</u> have an effect on the domain.

R E S E A R C H

The San Jose State library was the largest consulted; however, all local libraries were visited. No data at all could be found on the irradiation of magnets. Not being able to find any published data, I turned to letters.

The only data I received which even suggested that thought had been given to the irradiation of magnets was in a letter from Mr. Lovberg of the Los Alamos Lab. (see "Letters in Regards to Project"). This method could not be considered for reasons that become obvious upon reading said letter. Practically all letters received suggested that I consult Bozorth's Ferromagnetism. The work was consulted but included no data on magnetic irradiation.

Discussing the problem with Drs. Kerr and Russel of G.E.'s Vallecitos Atomic Lab., they suggested I write to Bell Telephone. They also said that my theories may or may not be correct, as no known research had been done on this subject. They also suggested I go ahead with the experiments and report any logical conclusions.

Bell Telephone Labs., were consulted; they to didn't know.

Note: For the letters mentioned and others, see "Letters in Regards to Project".

METHOD

1.--All apparatus placed in proper positions and checked.

2.--New batteries inserted in the light assembly.

3.--Balance is balanced out as accurate as possible.

4.--Magnet adjuster, with magnet, is placed in position.

5.--Magnet is adjusted to proper height by means of adjuster. The magnet now produces a "pull" on the balance, creating an unbalancing force.

6.--Balance is re-balanced as accurate as possible; compensate for magnetic pull.

7.

7.--Photographic paper placed on recording apparatus.

8.--Motor turned on.

9.--Light assembly turned on.

10.-Apparatus observed; if functioning correctly, experiment continues; if not, the mal-functioning part must be corrected.

11.-Radiation source opened and placed in position.

12.-After the proper time has elapsed (20 to 30 minutes), radiation is covered and removed.

13.-Motor and light assembly turned off.

14.-Unused paper put away.

15.-Used paper processed.

16.-Results observed and studied.

NOTE: The entire experiment is carried out in a darkroom under red safelights.

Explanation:

As has been mentioned before, the magnet creates a "pull" on the pan of the balance. This is compensated for by scale adjustment, etc. Now we have a balance affected by magnetic strength, but still balanced. Radiation is then introduced by placing the source underneath the magnet's center. If the result is an increase in magnetic strength, the pan will be attracted downward and the opposite end of the balance will rise, including the light assembly. If the magnet's strength is decreased, then the opposite is the result. If there is no change, everything remains the same.

In any event, any variation could be observed on the photographic paper. For example, if the strength increased, the light assembly would move upward and, therefore, the exposed part of the paper would be at a higher elevation. The opposite is true for a decrease, etc..

APPARATUS

I. Magnet: The first and primary piece of equipment is a common horseshoe magnet. I picked a fairly large one so that any results would be easier to observe. The magnet used was one of weak strength, as too great a strength might damage the balance.

II. Magnet Adjuster: This is the apparatus that adjusts and holds the magnet. It is a simple gear assembly mounted on a base. An old-type burette clamp is mounted on this gear system and a magnet holder has been attached to it (the clamp). A dial has been included for recording purposes.

III. Balance: This is a standard triple-beam balance, accurate to better than 1/10 of a gram. The material directly under the pan is an alloy containing a ferromagnetic substance, susceptible to magnetic attraction. The magnet "pulls" the pan down.

IV. Balance Light Assembly: A set of batteries attached to a flash-light bulb in a tube is the basis of this piece of equipment. The tube is taped up and a pinhole is poked through the front to provide a fine light beam. If the balance's pan goes down, the pointer and light assembly will rise, etc. The weight of the light assembly is compensated for by a 50 gram weight on the pan and by minor adjustments.

V. Kymograph: The kymograph's purpose is to provide a permanent record and a method of "viewing" or observing the experiment without having to be near it. This was necessary due to the high energy of the radiation involved; one could not come within three feet of the exposed source.

V. Kymograph (cont.):

The apparatus consists of a one r.p.m. motor on which is mounted a 35 mm. cartridge film spool. The motor provides a source of power to fairly evenly move the roll of paper (photographic) from the spool (A), around the nail (B) (which serves to keep the moving paper near the light at all times), and pass the cartridge (C). The pressure roller assembly (D), suggested by Jules Moritz, places a pressure on the cartridge, the friction involved forcing the paper to flow.

VI. Radiation: The source is a 45 millicurie source of Cobalt ^{60}, provided by Radiological Defense, California Disaster Office.

VII. Processing Pans: The pan with the rollers was constructed to easily and efficiently develop the experiment paper. The other is merely for the fixer (hypo).

VIII. Solutions: These are merely the developing and fixing solutions used.

XI.

CONCLUSIONS

All three experiments resulted in a conclusion of no variation in the line of exposure. From this data (explained in Chapter X), the following conclusion can be made:

<u>A 45 MILLICURIE COBALT-60 SOURCE HAS NO NOTICEABLE EFFECT (WITH THE APPARATUS USED) ON THE STRENGTH OF A WEAK HORSESHOE MAGNET.</u>

This conclusion is tentative as it is based on only three experiments. Many more experiments must be conducted before a definite conclusion can be made (the reason more were not performed is that the radiation sources are on a tight schedule and it is difficult to obtain sources).

<u>In Regards to the Variation in Exposure:</u>

The variation in exposure is due to light intensity. The bulb was checked before and after each experiment and found to be in good operating order at all times; therefore, the variation must be due to battery depletion.

The observation regarding light intensity was completely unexpected. As all three observations were somewhat different from each other in regard to light intensity, one cannot conclude anything from them without performing more experimentation.

An explanation for the variation may be that this is the normal action of a dry cell under prolonged use (it doesn't have time to recharge itself). It is <u>possible</u>, however, that the radiation itself may have had an effect on dry cell life. When the cells were checked several days later, however, they were found to be as good as new. Apparently they had recharged themselves. The suggestion of radiation effect is one worthy of further research and, perhaps, experimentation; the author plans to study it further.

XII

A MORE ACCURATE METHOD

The apparatus and method previously described ~~is~~ are fairly crude as it would take a substantial percentage increase or decrease (probably 15-20% or more) in magnetic strength to produce any noticeable variation in the position of the balance's pointer. This means that a variation of smaller magnitude could not be detected. For this reason, a more accurate method must be perfected.

I have decided to employ the phemoema phenomena of induction and the oscilloscope to bring about increased accuracy.

A coil of many turns (100 plus) is placed between the poles of a magnet and put in motion (the coil is) to induce an electric current. The coil's leads are wound around the outside of the motor's shaft to a pair of brass washers. A pair of brass "take-up" terminals will be placed touching the washers so as to pick up the current. The circuit continues to a microammeter (to measure the amount of current), ~~and~~ then to a resistor (in the neighborhood of from 5 kilo-ohms to one megaohm; its function is to resist the current and thus amplify the voltage), and finally to an oscilloscope. In other words, the voltage induced by the magnet and stepped up by the resistance will be fed to the external vertical input terminal of an oscilloscope, where a faily constant pattern should be seen. Setting the vertical attenuator and its most sensitive setting, any tiny variation in voltage will produce a noticeable change in the displayed pattern. Thus, when radiation is "shot" through the magnet, any effect it may have will be shown on the oscilloscope screen. The variation, if any, in magnetic flux will directly vary the amount of current and the voltage being graphed on the 'scope screen.

With this method, it is possible to detect variations much more accurately; however, this is still inaccurate apparatus for an experiment of this nature.

The author will attempt to continue his research using the method discussed above.

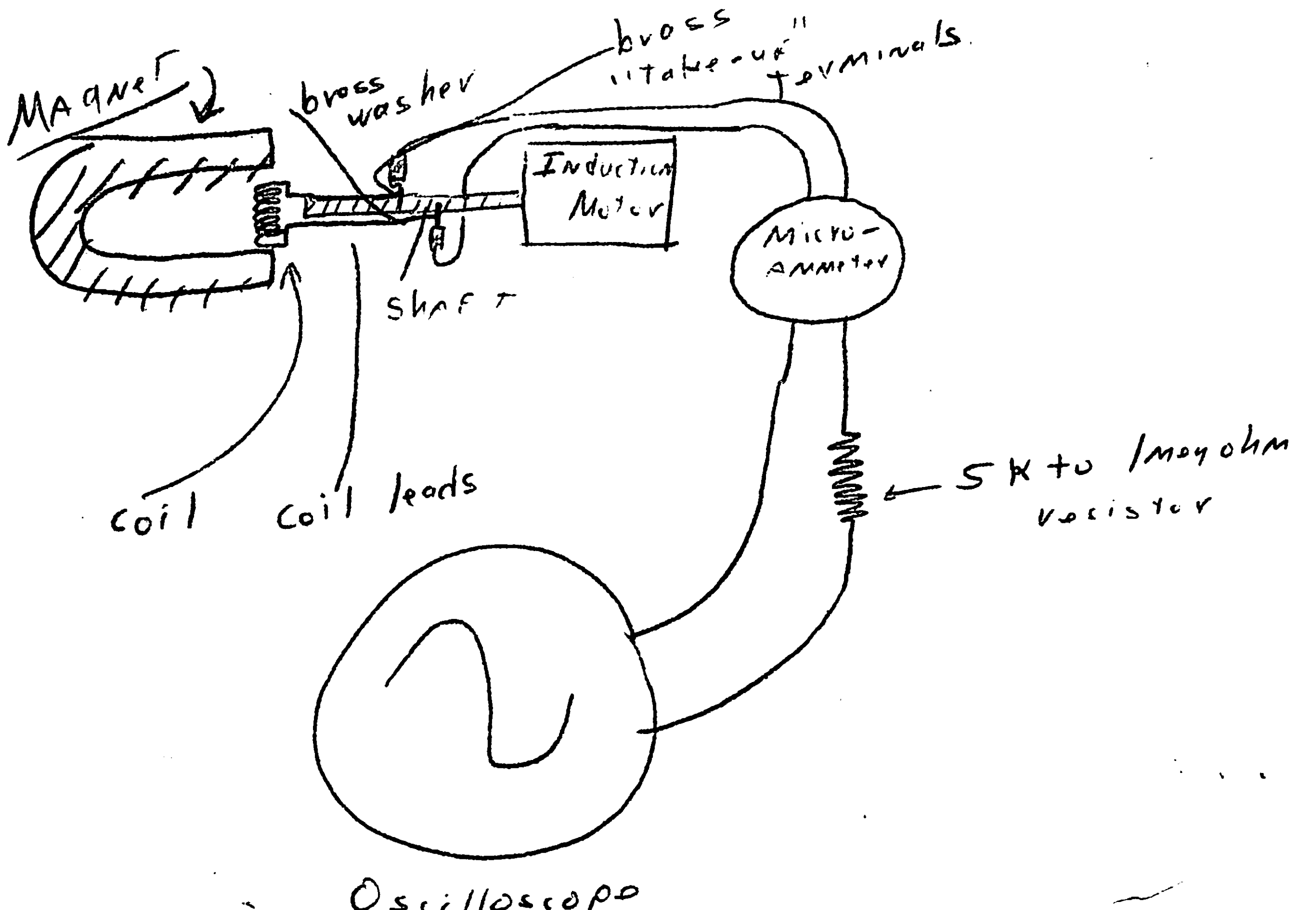

Diagram of Apparatus and circuit used in the second method described, this method being much more accurate than the "balance & light" method.

APPENDIX

Aknowledgements:

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APPENDIX

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