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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
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Letter
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MAGNETIC ANALYSIS.

This letter circular has been prepared in answer to numerous requests received by the Bureau of Standards for information regarding the use of magnetic analysis for the non-destructive testing of iron and steel and their products.

It has been well established that any treatment (such as heat treatment or mechanical working for instance) which alters the mechanical properties of a given piece of steel to a measurable degree at the same time produces a corresponding change in its magnetic properties. It is upon this simple fact that the hope is based that it may be possible to utilize the results of magnetic tests, which do not injure or alter the sample in any way, for the estimation of mechanical properties. With this end in view, many experiments have been made, especially during the past ten years, for the purpose of determining the laws of correlation between the two sets of properties. Up to the present time, however, no law has been discovered connecting the magnetic characteristics of any material with any other physical property.

Failing the establishment of direct laws of correlation, the next possibility would be to compare the magnetic properties of samples to be tested with those of a similar sample known to possess the desired mechanical characteristics and which therefore could be taken as a standard of quality. This method has proved to be of some value in a limited way in cases where safety is of paramount importance and the rejection of a certain percentage of good material is a secondary consideration. In most, if not all, of the cases in which this method has been tried it has been found that influences having a negligible effect on the mechanical properties may modify the magnetic properties to a marked degree. For general application, therefore, this method in its present stage of development fails from the standpoint of reliability.

One phase of magnetic analysis which has received a considerable amount of attention is the detection of flaws and hidden defects. It has been found that flaws within a material give rise to magnetic irregularities which are generally easy to discover. Much time and effort has been put upon this development, because the commercial value of a reliable non-destructive method for the detection of hidden flaws in otherwise satisfactory material would be very great. Experiments along this line have been so far unsuccessful, however, for the reason that variations in magnetic properties generally existing in material free from flaws are often times of greater

magnitude than the variations due to flaws. One possible exception to this general statement may be the method which has been found useful in a number of cases for detecting the presence of incipient cracks which do not reach the surface. This method consists of immersing the piece in oil in which very fine iron dust is held in suspension. When the piece is strongly magnetized there will be a concentration of the iron particles along the lines where the cracks are. Cracks as far beneath the surface as an eighth of an inch have been detected in this way.

Another phase of magnetic analysis which deserves mention may be termed thermomagnetic analysis. Various constituents of steel lose their magnetic properties at definite temperatures. It is possible, therefore, to learn many things about the constitution of alloy steels by observations of the variations in magnetic properties on heating or cooling. Such experiments require special technique and have not been made to any large extent in this country. Elsewhere they have been developed to a greater extent, notably in Japan. This is an important line of research which should not be neglected.

Altho investigations up to the present time have not led in many cases to practical applications of commercial value, the evidence at hand is not conclusive that such applications are not possible. The magnetic properties of iron and steel depend upon a very complicated set of conditions, which fact makes experimentation in this field particularly difficult. A great many points remain to be investigated and it will be necessary to collect and correlate a large mass of data before the full realization of the possibilities of magnetic analysis can reasonably be expected. However, the benefits to be derived from developments leading to practical applications give ample justification for much more research in this field.

A more detailed treatment of this subject is given in a paper by T. Spooner in the Electric Journal, Vol.22, p-113, 1925. A paper by R. L. Sanford entitled "The Present Status of Magnetic Analysis" Transactions, American Society for Steel Treating, Vol.5, p-577, 1924, also gives an extensive bibliography.

Bureau of Standards,
Washington, D. C.