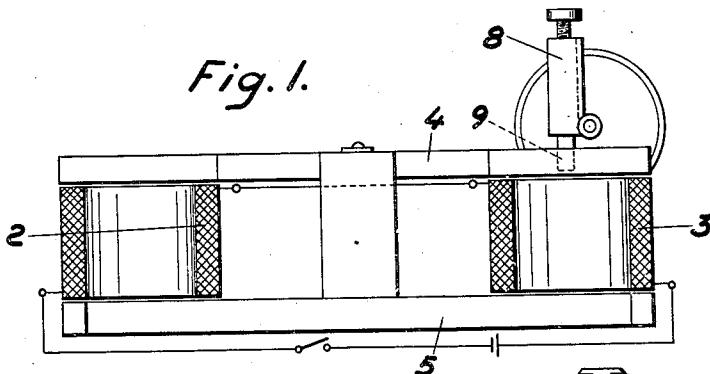
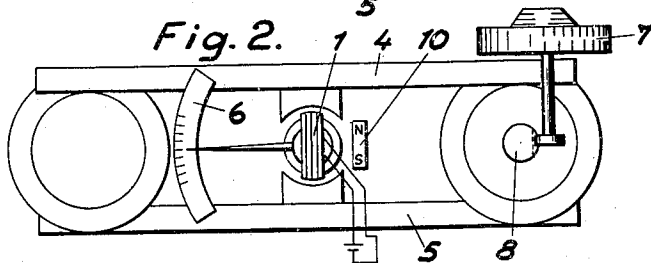
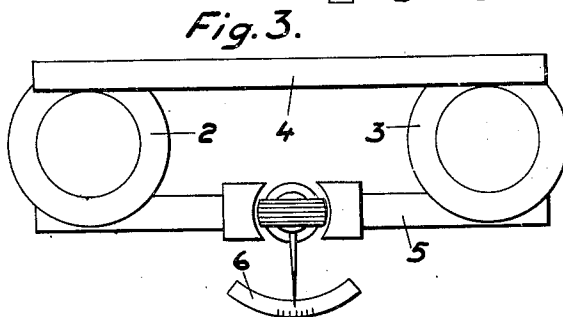
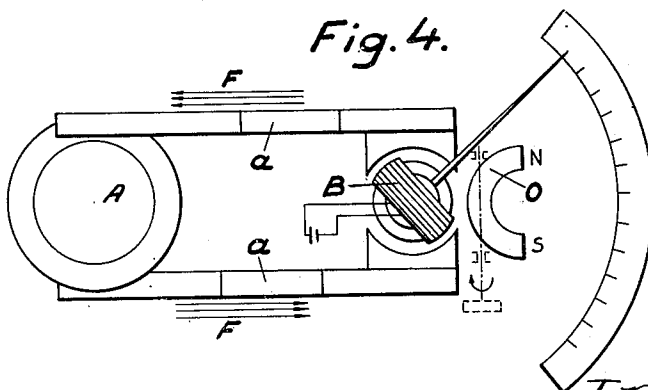


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2 Sheets-Sheet 1



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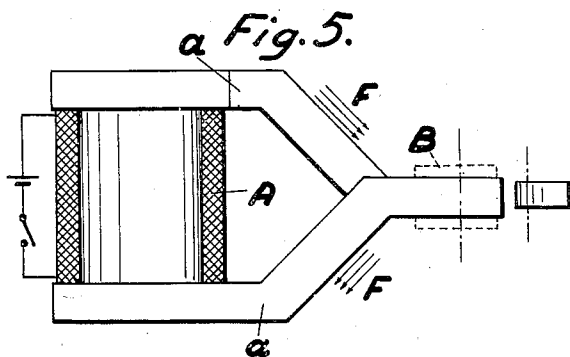
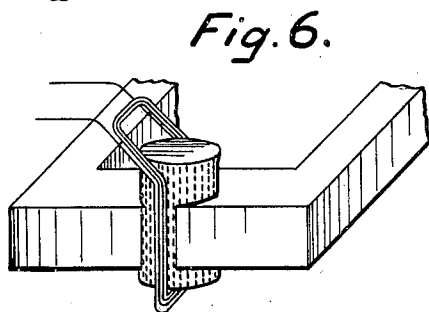
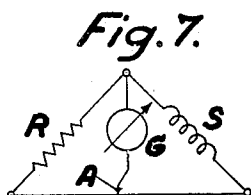
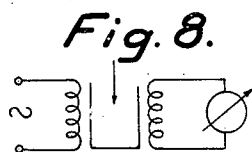
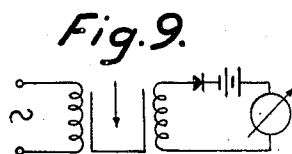
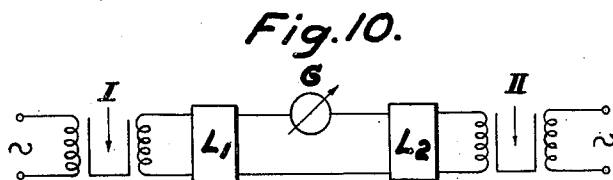
Nov. 22, 1949

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DETERMINATION OF THE CONTENT OF
A MINERAL IN ORES AND THE LIKE

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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DETERMINATION OF THE CONTENT OF A
MINERAL IN ORES AND THE LIKERasmüs Christian Østraat Wiig,
Svarstad, NorwayApplication October 3, 1945, Serial No. 620,072
In Norway September 29, 1941Section 1, Public Law 690, August 8, 1946
Patent expires September 29, 1961

2 Claims. (Cl. 175—183)

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The present invention relates to a method and a device by which it is possible to quickly and readily determine the mineral content of ores, for example the respective Fe or iron, content of ore concentrates, and waste samples, from concentration machines. The invention is substantially characterized by the fact that samples of the ore are inserted as a core in a magnetic field, and that the increase of the magnetic field thus obtained is measured and gives a measure of the mineral content.

It is of particular importance to undertake such measurement when dealing with magnetic concentration of iron ore sources in which iron is also present in slightly magnetic or non-magnetic condition. This fact will appear from the following statement.

Magnetite sources almost always contain some iron in slightly magnetic or non-magnetic condition, in the form of Fe_2O_3 or ferric oxide, for example. When the Fe content of the source is too low to be utilized it must be concentrated. This is usually done by magnetic concentration. The concentration machine works on the principle that the magnetic material of the crushed ore is attracted by magnets and is transported to one place, while the non-magnetic material leaves as waste. Therefore it is necessary that as little as possible of the material that contains iron, which can be attracted by magnets, be lost with the waste, and thus it is necessary to control the waste through analyses. In the known methods it has been necessary to determine the Fe content chemically, perhaps preferably through so-called HCl or hydrochloric acid analyses. As mentioned above, the magnetite seldom occurs by itself and the ore source usually includes hematite or other more or less slightly magnetic iron compounds together with the magnetite. Even if the former constitutes a small part of the iron quantity in the ore source it might, however, constitute an essential part of the waste during the different concentration stages. In determining the iron content of the waste material through HCl-analyses, in order to use the same as a basis for judging the working condition of the machines, the size of the iron loss is indicated, but the analyses give an incorrect view of the working capacity and condition of the machines. As a matter of fact, the HCl-

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analyses indicate the presence of non-magnetic iron which is soluble in hydrochloric acid. According to the mode of operation of the machines the said iron must be separated together with the waste. The misjudgment caused hereby is clear from the following example:

A raw ore contains 45% Fe, 0.5–1% of which is in the form of Fe_2O_3 . This ore is of course concentrated magnetically. During the first concentration stage about 20 percent by weight is separated as waste. The said waste contains particles in the form of small pure grains, poor grains, and large portions of the non-magnetic Fe_2O_3 . The waste might here contain up to 2.5% Fe in the form of Fe_2O_3 (at 0.5% of the raw ore) or up to 5% Fe in the form of Fe_2O_3 (at 1% of the raw ore). If the concentration machine is all right, the waste will, according to experience, contain about 0.5% Fe of a suitable charge of ore containing exclusively magnetite, and the HCl-analyses will show about 0.5% Fe. Moreover, the analyses will show varying quantities of Fe, between 2.5 and 5%, according to the quantity of hematite in the ore supplied. Thus no HCl-analyses indicating between about 1 and 5.5% Fe will to a certainty indicate whether the Fe-content of the waste is due to the fact that the concentration machine is working improperly or whether the supplied ore has contained hematite or other iron compounds soluble in hydrochloric acid. Moreover, it is rather impossible to correct the result by a calculation of probabilities because the hematite content might vary from one place to the other in the mine. Also, since the material to be concentrated is not sufficiently mixed before distribution to the various systems in the concentration plant any comparison between the material leaving the various machines would be of no avail. It is generally known that the exact difference between the total Fe content in the waste and the Fe content in the form of Fe_2O_3 or ferro-soferric oxide, must be obtained. The known methods for this determination have either taken too long a time or have been so troublesome that it has been extremely difficult to test more than a very few samples a day. In order to obtain the best results in concentration it is of the greatest importance that the Fe_2O_3 content of the waste and of the concentrate be determined as quickly

as possible both during the daily operation as well as during tests conducted to improve results earlier obtained. By the present method and apparatus any person, without chemical training, will be able to immediately establish the working condition of the concentration machines. Further anyone can make hundreds of tests a day with a single apparatus and without the use of chemicals.

There are also other occasions when iron of different magnetic properties is present in various compounds. It is usual to employ machines, the mode of operation of which is based on the magnetic properties of the magnetite when the iron occurs as magnetite. This is usual whether the magnetite occurs as ore worth breaking or as an impurity in other ores or products worth breaking. Also in this case a quick and reliable control of the machines is of the greatest importance. The concentration of titanium ore may be mentioned as an example. Magnetite as well as ilmenite may here occur in breakable quantities but they must be separated from one another. In the concentration of the magnetite the presence of ilmenite inconveniences the control of the machine. The slightly magnetic ilmenite leaves the machine with the waste material containing the magnetite and thus gives the waste an iron content which is not characteristic for the working condition of the machine, unless checked by undertaking other analyses. In the concentration of ilmenite the use of the present apparatus enhances the control of the machines. If, in operation, Fe occurs in the form of Fe_2O_3 the present method is not only much quicker than the chemical one but it also provides a safer basis for judging the machines,

The susceptibility of magnetite is constant within wide limits in powder form and therefore a sample containing magnetite together with other non-magnetic or slightly magnetic compounds will change its susceptibility in relation to the concentration of magnetite. Tests have proved that exact measurements can be made very quickly and that the same are only dependent on the magnetic properties of the samples and therefore practically independent of the size and compaction of the grains.

In the determination of a magnetite content for example, the method is carried into effect in the following way. In making exact determinations a dried sample is placed in a suitable container and packed sufficiently. The size of the sample is without importance. The principal thing is that the container be more than half filled. Thereafter the container is inserted as a core in a magnet field in an apparatus which by deflection of a pointer directly indicates the percentage of Fe in the form of magnetite. A single person can make the whole determination in a few seconds.

The total time required for this determination is only dependent on the time required for the sample to dry. In the control of concentration machines it is often unnecessary to make this exact determination, and thus if the sample is in a wet state it is only necessary to mix it after it has had an opportunity of sinking. This is of great importance when it is necessary to quickly control a concentration machine.

As mentioned above, magnetite occurs as impurity, and it might be of interest to be able to quickly determine the quantity of this impurity in a slightly magnetic or nonmagnetic material,

in ilmenite or in raw materials used by the glass industry for example.

Having generally set forth the invention the same is illustrated on the accompanying drawings in which:

Figs. 1 and 2 are diagrammatic side and top views, respectively, of one embodiment of the invention,

Fig. 3 illustrates a modification thereof,

Figs. 4 and 5 are diagrammatic top and side views of another modification, and

Figs. 6 to 10 illustrate still further modifications.

In Figs. 1 and 2 iron members 4 and 5 are placed symmetrically about the movable coil 1 of a moving coil instrument. These members are made of laminated iron and have a small remanence. The hollow coils 2 and 3 are connected in such a way that the magnetic fields obtained, when the current is closed through them, counteract one another so that no magnetic lines of force cross the magnetic lines of force generated by the movable coil 1 when the current has been closed through the same. The pointer of the movable coil instrument will then point to zero on the scale 6. Thus when a sample containing iron ore in the form of magnetite is inserted in the space of the coil 2, the pointer will make a deflection which can be read on the scale 6 in percentage by weight of Fe. Also the iron armature 9 can by means of rack 8 be pushed into the coil 3 until the pointer points to zero again. The percentage by weight of Fe can then be read on the scale 7 which is empirically graduated.

In measuring apparatus which are to register very small iron contents a compensator in the form of a permanent magnet 10 should be utilized. This magnet should be mounted in such a way that it is adjustable and can be adjusted so that its magnetic field counteracts the residual magnetism acting on the coil 1.

In Fig. 3 a somewhat modified embodiment of the invention is shown wherein the movable coil is mounted in a gap between the ends of the arm member 5 so that the scale 6 can be disposed at the side of the device. The compensation device 10 used in the form shown in Figs. 1 and 2 may be used in this arrangement.

In the modification shown in Figs. 4 and 5 the magnetic circuit of a solenoid A having a core of air has been closed through the iron parts of the apparatus, namely, the solenoid cylinders and the iron arms a.

The magnetic field which is indicated by the arrows F is generated either by a permanent magnet or an electromagnet, and is chosen as large as and directed opposite to the field generated by the solenoid A. The lines of force in the moving coil instrument B are not in this case crossed by any flux and the pointer of the instrument adjusts itself to zero.

By filling the core of the solenoid A with a sample containing permeable material there is generated a field which causes the pointer of the moving coil instrument to be deflected.

An adjustable magnet O is mounted in such a way that its field can counteract the action of the residual magnetism of the iron construction relative to the moving coil instrument B.

When the sample is allowed to sink it becomes uneven because the material settles in the form of layers. This can have a disturbing effect when the sample is not mixed and the lines of force extend through the sample in the longitudinal direction. Therefore, the embodiment shown in

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Fig. 6 is better because the lines of force extend through the sample in the transverse direction since the coil is disposed vertically.

When alternating current of suitable frequency is used the bridge connection shown in Fig. 7 can be employed.

The galvanometer G is provided with a rectifier. The sample is inserted in the coil S. The movable contact A which is adjusted along the bridge so that it becomes without current, moves along an empirically graduated scale, and the percent of Fe can be read directly when the galvanometer G is pointing to zero.

In Fig. 8 is shown a transformer with two windings, alternating current being sent through its primary winding and the secondary tension is measured.

The secondary tension becomes dependent on the sample placed in the transformer core. As the tension change becomes small when it is the question of poor samples one should compensate the secondary tension which is obtained with air only as transformer core so that the measuring instrument is pointing to zero prior to inserting the sample. This has proved to be difficult if one does not use a rectifier and compensates with continuous-current, as shown in Fig. 9.

In the modification shown in Fig. 10 exactly equal transformers I and II and rectifiers L₁ and L₂ are utilized. The galvanometer G is a moving coil instrument which is graduated on both sides of the zero point. When the current is closed through the two primary windings the galvanometer G will point to zero. In the same way it will point to zero when samples with the same magnetic properties are inserted in the transformers I and II. If one of the said samples is known the other is thus determined. Therefore, standard samples can be placed in the core II to determine the samples inserted in the core I.

In order to easily and quickly read the percentage directly by weight of Fe, an iron armature is mounted for insertion as a core in the transformer II. This insertion can be made with a rack and a toothed wheel, similar to the arrangement of Fig. 1, in such a way that one can read the position of the iron armature in the coil on a scale. This scale can be graduated empirically in percent of Fe, and in this way one can thus

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determine the samples inserted in the transformer I.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In apparatus for determining the mineral content of ore, two spaced hollow coils connected to provide opposed magnetic fields, at least one of said coils having an open internal space for freely accommodating the material to be tested, a magnetic member bridging ends of the coils, a magnetic member bridging the other ends of the coils, a movable coil mounted between said members adapted to be influenced by lines of flux between said members, a pointer carried by said movable coil, and magnetic means for counteracting residual magnetism acting on said coil.

2. In apparatus for determining the mineral content of ore, two spaced hollow coils connected to provide opposed magnetic fields, at least one of said coils having an open internal space for freely accommodating the material to be tested, a magnetic member bridging ends of the coils, a magnetic member bridging the other ends of the coils, a movable coil mounted between said members adapted to be influenced by lines of flux between said members, a pointer carried by said movable coil, and means including an indicator for varying the permeability of one of said hollow coils.

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