No. 704,010. Patented July 8, 1902.

T. A. EDISON.

APPARATUS FOR CONCENTRATING MAGNETIC IRON ORES.

(Application filed May 23, 1898.)

(No Model.) 2 Sheets—Sheet 1.

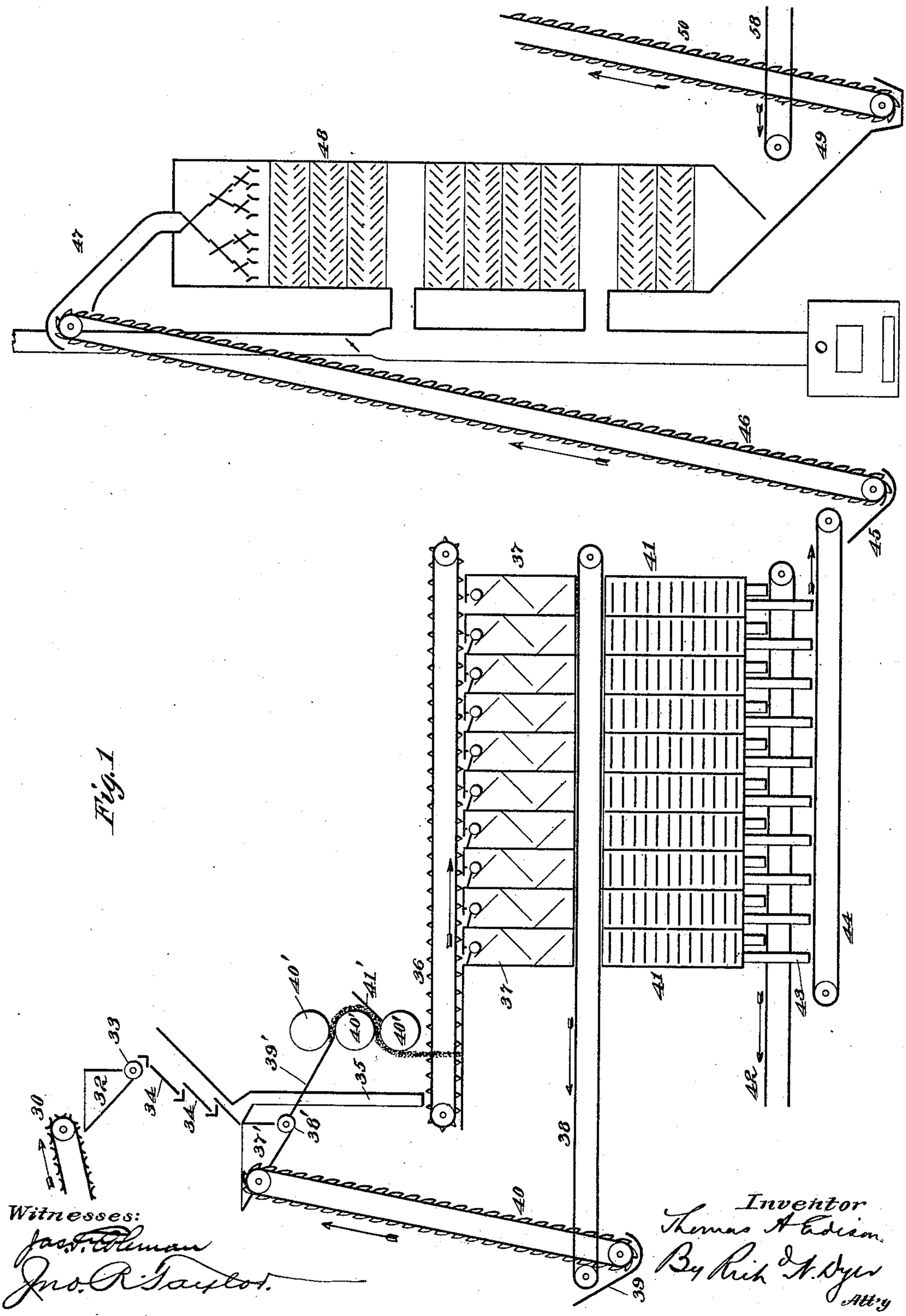

Fig. 1.

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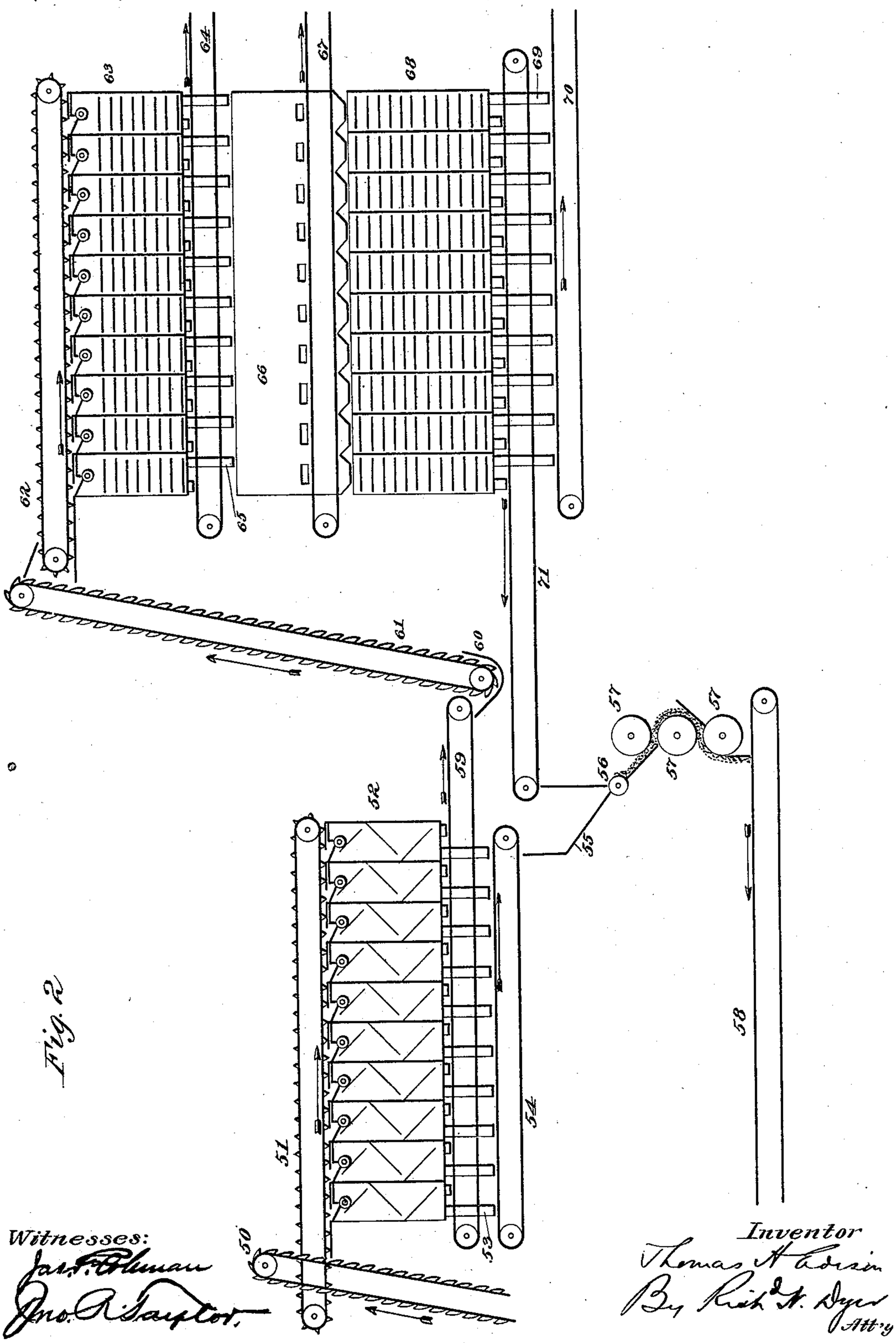

Fig. 2.

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UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF LLEWELLYN PARK, NEW JERSEY.

APPARATUS FOR CONCENTRATING MAGNETIC IRON ORES.

SPECIFICATION forming part of Letters Patent No. 704,010, dated July 8, 1902.

Application filed May 23, 1898. Serial No. 681,473. (No model.)

To all whom it may concern:

Be it known that I, THOMAS A. EDISON, a citizen of the United States, residing at Llewellyn Park, in the county of Essex and State of New Jersey, have invented a certain new and useful Improvement in Apparatus for Concentracting Magnetic Iron Ores, (Case No. 987,) of which the following is a specification.

My invention relates to an improved connected apparatus by means of which concentrates of high percentages may be obtained economically from magnetic iron ores, preferably in the form of more or less finely-ground particles.

In Letters Patent No. 672,617, dated April 22, 1901, I have described an improved apparatus by which rock, and particularly magnetic iron ore, may be reduced from the large sizes obtained from the preliminary blast to small particles in an economical manner, such apparatus comprising, essentially, one or more sets of massive rolls driven through friction connections and by which the preliminary reduction of the rock is effected and one or more sets of grinding-rolls by which the rock will be reduced to particles of the desired size, a drier being employed with such apparatus when the ore carries an objectionable amount of moisture. With the apparatus described in the aforesaid patent I am enabled to handle enormous quantities of iron ore which may be thrown out by relatively infrequent blasts of much larger cubic capacity than is at present possible and to reduce the same to small particles, which are automatically stored in a suitable stockhouse, being preferably dried after the grinding operations have been effected.

My present invention contemplates an apparatus which is designed to supplement the apparatus covered in said patent and by which the ore in small particles, resulting from the grinding, may be treated for an effective separation of the magnetic particles therein. When, therefore, my present invention is used in connection with a rock-reducing apparatus such as is covered in said patent it comprises, first, a set of, preferably three, pulverizing-rolls, by means of which the material after it has been ground may be reduced to comparative fineness. A screening apparatus is employed in connection with the said pulverizing-rolls, by means of which material of sufficient fineness will be deflected onto said pulverizing-rolls. The preferred type of pulverizing-rolls which I employ is that invented by me and described and claimed in Letters Patent dated November 21, 1899, and numbered 637,327, and which I call the "three-high rolls." Each set of three-high rolls comprises three rolls mounted vertically one above the other in suitable housings or side frames, the outside rolls being connected by a number of turns of wire rope to the loop or bight of which tension is applied, so that not only will the wire rope give an increased pressure between the rolls on the principle of a block and tackle, but since the rope moves with the rolls friction is almost entirely eliminated. Power is applied to preferably the lower roll, and the other two rolls are driven by friction. I find in practice that a pulverizing-mill of this type can be operated with but little power and that enormous quantities of material can be pulverized automatically and at low cost. The material after leaving the first three-high rolls and having been crushed therein will be deposited in the path of a scraper-conveyer, together with the fine screenings which pass through the screens referred to and which are sufficiently fine as not to require pulverization. This fine material is fed to a set of separating-screens, which with magnetite iron ore, with which I have experimented and upon which I am now operating, will be of the size of about fourteen meshes per linear inch. I find that the best results in the screening are effected when the meshes of the screens instead of being circular, as is common, are very much elongated and when devices are employed for arresting the flow of material at the top of each screen-section, so that the velocity of the material in the screening operation is much reduced, as I have described and claimed in my Letters Patent dated May 28, 1901, and numbered 675,057. The tailings from these screens are deposited on a conveyer and are returned to the first set of three-high rolls, since such tailings contain, manifestly, their full proportion of the magnetic particles. The fine screenings are fed, preferably by gravity, to a set of magnetic

separators, one located beneath each of the screens and by which a rough magnetic separation is effected. Each of these magnetic separators comprises a number of electromagnets mounted one above the other in such a way that the material will be deflected into actual contact with the magnetic pole and will accumulate thereon as a magnetic brush, the iron particles falling off therefrom by the accumulation of fresh material, such magnetic particles taking a trajectory, due to the resultant of gravitation and the lines of magnetic force, and being deflected to one side of a partition or screen, on the other side of which the non-magnetic or slightly-magnetic material falls. The first separators are designed, as stated, to effect a very rough separation, saving all of the material in which there are any magnetic particles whatever and rejecting only the absolutely non-magnetic particles. The first separator is therefore so constructed that the tailings of the material rejected by the uppermost magnets are subjected to the effect of the magnets immediately below the same, the tailings of the second magnets being subjected to the third set, and so on. In this way the material which is finally rejected by the separators is compelled to pass through all of the magnetic fields and is manifestly low in and practically free from magnetic particles. The tailings from the first set of magnetic separators and which are but slightly, if at all, magnetic, but which frequently comprise a large proportion of the bulk of the material, are directed to a suitable conveyer and are removed to the desired dump or other locality. At the very outset of the operation it will thus be seen that I have quickly and economically eliminated a large part of the mass, which does not have to be further considered and by which the subsequent and finer operations are simplified and cheapened.

I find that in order to effect a fine separation of the magnetic from the non-magnetic particles when the material is extremely finely divided it is desirable to eliminate therefrom all moisture, and the rough concentrates from the first magnetic separators are therefore preferably passed through a suitable drier by which moisture will be removed therefrom. This drier comprises an upright chamber containing a large number of inclined baffle-plates therein, by means of which the material in falling downward through the same will partake of zigzag paths, a distributing device being employed at the top of the drier for subdividing the material and evenly distributing it throughout the entire area thereof. The drier is heated in any suitable way, but preferably by hot air and products of combustion from a furnace, as I have described in my Patent No. 648,933, dated May 8, 1900. From the drier when used the dried rough concentrates are fed to a suitable conveying apparatus by which they are distributed over a set of screens of the ultimate degree of fineness. With the magnetite iron ores referred to these screens are of approximately fifty meshes per linear inch, and to obtain the best results these meshes are elongated and checking devices are employed to arrest the velocity of the material, as I have before referred to. The tailings which are rejected by the fine or fifty-mesh screens are conveyed to a second set of pulverizing-rolls, preferably three-high rolls, and are reduced thereby to the desired fineness, being then conveyed back to the screens, through which they once more pass. In this way I reject all material which is not of the required fineness; but the said rejected material is repeatedly acted upon automatically until it has been brought down to the proper size. The screenings from the fifty-mesh screens, which manifestly are of great fineness, are then conveyed to and are distributed over a set of magnetic separators, by which a careful separation is effected. The second magnetic separators are therefore so constructed that the concentrated material separated by the uppermost magnets will be subjected to the effect of the magnets immediately below the same, and the material separated by the second magnets will be successively subjected to the effect of the succeeding magnets, so that at each set of magnets an opportunity is offered for non-magnetic particles to detach themselves and which may have been carried down mechanically with the magnetic particles. The particles separated by the second set of magnets and which necessarily are very fine and slightly, if at all, magnetic are conveyed from the apparatus to a suitable sand pile or dump. I find that the concentrates from the second magnets carry considerable quantities of dust, which adheres to the magnetic particles and is not separated in the magnetic separators. It is therefore desirable in order to secure the best results that the concentrates from the second magnets should be passed through a suitable dusting apparatus, by which the dust may be removed on a large scale. I find, moreover, that by subjecting these concentrates to a dusting action a large proportion of the phosphorus may be eliminated from magnetite iron ores, such as those with which I have worked. This elimination of the phosphorus by passing the concentrates through a dusting apparatus depends upon the fact which I have discovered that the percentage of phosphorus carried by the fine dust is very much higher than that in the original run of ore. My improved dusting apparatus comprises a dusting-chamber, close to one wall of which the concentrates are allowed to fall in a wide preferably thin stream, suitable provision being made to check the material, so as to cause it to fall slowly through the dusting-chamber. The material in thus falling through the dusting-chamber will be acted upon by one or more blasts or currents of air, by which the fine dust will be blown off. Preferably the air-blast will

be strong enough to carry off not only the fine dust, but also the lighter particles of the material; but these lighter particles being of value, although they still carry with them an objectionable amount of dust, will be deposited in a hopper at the bottom of the dusting-chamber and carried to a suitable separating apparatus, by which the dust will be removed therefrom. This material may be conveniently directed to a magnetic separator of the type wherein the magnetic particles will be kept in constant agitation and by which the dust will be removed, or instead such particles may be passed through a second dusting apparatus and the dust further removed therefrom by a blast or blasts of air. The concentrates which are unaffected by the blast or blasts of air in the first instance will be found to be practically free from dust, as I have described and claimed in an application filed on even date herewith, Serial No. 681,476. The fine dust blown out of the material by the blast or blasts of air is suitable for commercial purposes, such as in the manufacture of paint, owing to its practically impalpable character. The concentrates from the second separators after having been dusted are passed to a third and final set of magnetic separators, which are preferably of the same type as the second set of separators referred to and wherein the particles separated by the uppermost set of magnets are successively subjected to the effect of the succeeding magnets. Since, however, the particles which are not separated by the third set of magnets have already been subjected to the separating action of the magnets in the second set of separators, they are necessarily rich in iron. These particles I find to a certain extent successfully withstand the effect of the magnets of the third set of separators by reason of their weight, since the magnets of the third set are of great delicacy and are designed to effect an almost, if not absolutely, complete separation. The so-called "semimagnetic" particles, for want of a better expression, which are not affected by the magnets of the third set of separators, are therefore conveyed back to the second pulverizing-rolls, where they are reground, and thence pass to the fine screens, from which they are successively directed to the second separators, the dusting apparatus, and again through the third separators. The concentrates removed by the three sets of magnetic separators comprise practically pure material with only a small percentage of non-magnetic substance, which is practically negligible. These fine concentrates are therefore in condition for bricking or for placing in any other form suitable for market.

In the accompanying drawings I illustrate diagrammatically my improved apparatus, such as I have above referred to, for concentrating magnetic iron ore, wherein—

Figure 1 represents so much of the apparatus as comprises the first set of pulverizing-rolls, preliminary or sorting screen, the first or fourteen-mesh screens, the first magnets, and the drier, and Fig. 2 showing the screens of ultimate fineness or fifty mesh, the second set of pulverizing-rolls, the second and third magnets, and the dusting apparatus.

In both of the above views corresponding parts are represented by the same numerals of reference.

30 is a suitable elevator or conveyer for removing the ground magnetic iron ore from a suitable stock-house or other point of deposit to a hopper 32, having a roller-feed 33 at its lower end.

34 34 are inclined screen-sections beneath said hopper for screening or sorting the material, said screen-sections being preferably provided with checking plates or ledges above each section, as shown, for arresting the velocity of the material and to thereby provide for a better screening action. The fine screenings which pass through the screens 34 are conveyed by a chute 35 to a conveyer 36 and are fed over a set of screens 37, each preferably having a roller-feed at its upper end. The screens 37 comprise a series of inclined screen-sections of a relatively fine mesh. In the instance under consideration these screens are approximately fourteen meshes to the linear inch. The tailings which are rejected by the screens 37 are deposited on a conveyer 38 and carried to a hopper 39, from which they are elevated by an elevator 40 to a chute or hopper 37′, having a roller-feed 38′ at its lower end. The tailings from the screens 34 are also deposited in the hopper 37′. The roller-feed 38′ removes the relatively coarse material from the hopper 37′ and directs it upon an inclined apron 39′ to the first set of pulverizing-rolls 40′ 40′ 40′, which are preferably of the type before referred to. The material passes between the upper roll and the intermediate roll and thence upon an inclined apron 41′, between the intermediate roll and the lower roll, so that the material will be finely pulverized and will be deposited upon the conveyer 36 and fed to the fourteen-mesh screens 37. The fine screenings from the screens 37 then fall by their weight through the magnetic separating apparatus 41 of the type described, by which a rough separation takes place, the non-magnetic material rejected by said separators falling upon a conveyer 42 and being carried to a suitable dump or sand pile, while the rough concentrates fall through chutes 43 and are carried by a conveyer 44 to a hopper 45, from which they are elevated by an elevator 46 to a chute 47, leading to the top of a suitable drier 48. This drier comprises an upright chamber having a large number of inclined baffle-plates therein, by which the material will be caused to descend through the drier in a series of zigzag streams over the heated baffle-plates and meeting in its descent ascending currents of hot air and products of combustion. By means of this drier

all moisture will be eliminated from the rough concentrates. From the drier 48 the rough concentrates are deposited into a hopper 49, from which they are elevated by an elevator 50 to a conveyer 51 and thence are distributed over a set of screens 52 of the ultimate fineness of mesh. In the present instance these screens are approximately fifty meshes per linear inch. The tailings from the fifty-mesh screens are deposited through chutes 53 upon a conveyer 54 and carried to a hopper 55, having a roller-feed 56 at its lower end. These roughly-concentrated tailings are directed by the roller-feed 56 through a second set of three-high or pulverizing rolls 57, by which the material will be pulverized. From these rolls the repulverized tailings are carried by conveyer 58 back to the hopper 49 and pass again through the fifty-mesh screens 52. By this cycle of operation it will be observed none of the rough concentrates in their present condition are lost, but that any material which is too coarse to pass through the screens 52 will be again concentrated and represented to such screens. The fine screenings from the fifty-mesh screens are carried by a conveyer 59 to a hopper 60, from which they are elevated by an elevator 61 to a conveyer 62, and by the latter conveyer such fine screenings are distributed over a set of magnetic separators 63 of the type referred to and by which a very careful and thorough separation takes place. The non-magnetic material rejected by the second separators is carried by a belt conveyer 64 to the sand heap, while the concentrates from this separator pass through chute 65 and fall by their weight through a dusting apparatus 66 of the type referred to and by which most, if not all, of the dust will be eliminated, thereby also removing a large part of the phosphorus in the ore. The fine dust from the dusting apparatus will be conveyed by a conveyer 67 to any suitable locality and owing to its impalpable condition is well suited for commercial purposes—as, for instance, in the manufacture of paint. The concentrates which have withstood the action of the air-blast in the dusting apparatus 66 and which are therefore practically free from dust are allowed to pass through a third set of separating-magnets 68, in which a final separation takes place, the resulting concentrates passing through the chutes 69 upon a belt conveyer 70 and being conveyed to any suitable point, where they are put in the desired commercial form—as, for instance, by being molded under enormous pressure into briquets of convenient size and shape. The material which is rejected by the third set of separators 68 is necessarily rich in iron, since it has been subjected to the effect of the magnets of the second separators. This material is therefore conveyed by a belt 71 back to the hopper 55, where after passing through the second pulverizing-rolls it is again screened by the screens 52 and further subjected to the separators 63 and 68 and the dusting apparatus 66.

With an apparatus such as I have above described the operation of handling magnetic iron ore in enormous quantities can be carried on in the most economical manner, and the resulting concentrates will be practically free from impurities.

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

1. A connected apparatus for concentrating iron ore, comprising a set of pulverizing-rolls by which the material is finely pulverized, a screen to which the finely-pulverized material is fed, a magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of said screen, a drier to which the magnetic particles are fed and by which they are dried, a fine screen to which the dried magnetic particles are fed, a second set of pulverizing-rolls for pulverizing the tailings of the fine screen, and means for returning the repulverized material to said fine screen, substantially as set forth.

2. A connected apparatus for concentrating iron ore, comprising a set of pulverizing-rolls for finely pulverizing the material, a screen to which the finely-pulverized material is fed, means for returning the tailings of said screen to said pulverizing-rolls, a magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of said screen, a drier for drying the magnetic particles removed by said separator, a fine screen to which the dried magnetic particles are fed, a second set of pulverizing-rolls for repulverizing the tailings of the fine screen, and means for returning said repulverized tailings to the fine screen, substantially as set forth.

3. A connected apparatus for concentrating iron ore, comprising a set of pulverizing-rolls by which the material is finely pulverized, a screen to which the finely-pulverized material is fed, means for returning the tailings of said screen to the pulverizing-rolls, a magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of said screen, a drier, a fine screen to which the magnetic particles are fed, a second set of pulverizing-rolls for repulverizing the tailings of said fine screen, means for returning said repulverized tailings to the fine screen, a second magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of the second screen, and means for conveying the particles rejected by the second separator to the second set of pulverizing-rolls, substantially as set forth.

4. A connected apparatus for concentrating iron ore, comprising a set of pulverizing-rolls by which the material will be pulverized, a screen to which the finely-pulverized material is fed, means for returning the tailings

of said screen to the pulverizing-rolls, a magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of said screen, a drier for drying the magnetic particles, a fine screen to which the dried magnetic particles are fed, a second set of pulverizing-rolls for repulverizing the tailings of the fine screen, means for returning said repulverized tailings to the fine screen, a second magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of the said fine screen, and a dusting apparatus for removing dust from the concentrates, substantially as set forth.

5. A connected apparatus for concentrating iron ore, comprising a set of pulverizing-rolls by which the material will be pulverized, a screen to which the finely-pulverized material is fed, means for returning the tailings of said screen to the pulverizing-rolls, a magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of said screen, a drier for drying the magnetic particles, a fine screen to which the dried magnetic particles are fed, a second set of pulverizing-rolls for repulverizing the tailings of the fine screen, means for returning said repulverized tailings to the fine screen, a second magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of the said fine screen, a dusting apparatus for removing dust from the concentrates, and a third magnetic separator for effecting a final separation of the dusted concentrates, substantially as set forth.

6. A connected apparatus for concentrating iron ore, comprising a set of pulverizing-rolls by which the material will be finely pulverized, a screen to which the finely-pulverized material is fed, means for returning the tailings of said screen to the pulverizing-rolls, a magnetic separator for separating the magnetic from the non-magnetic particles of the screenings of said screen, a drier for drying the magnetic particles, a fine screen to which the dried magnetic particles are fed, a second set of pulverizing-rolls for repulverizing the tailings of the fine screen, a second magnetic separator to which the screenings of the fine screen are fed and by which the magnetic particles will be separated from the non-magnetic particles, a dusting apparatus for dusting the magnetic particles, a third magnetic separator for effecting a final sepation of the dusted concentrates, and means for returning the particles rejected by the third separator to the repulverizing-rolls, substantially as set forth.

This specification signed and witnessed this 11th day of April, 1898.

THOMAS A. EDISON.

Witnesses:
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F. C. DEVONALD.