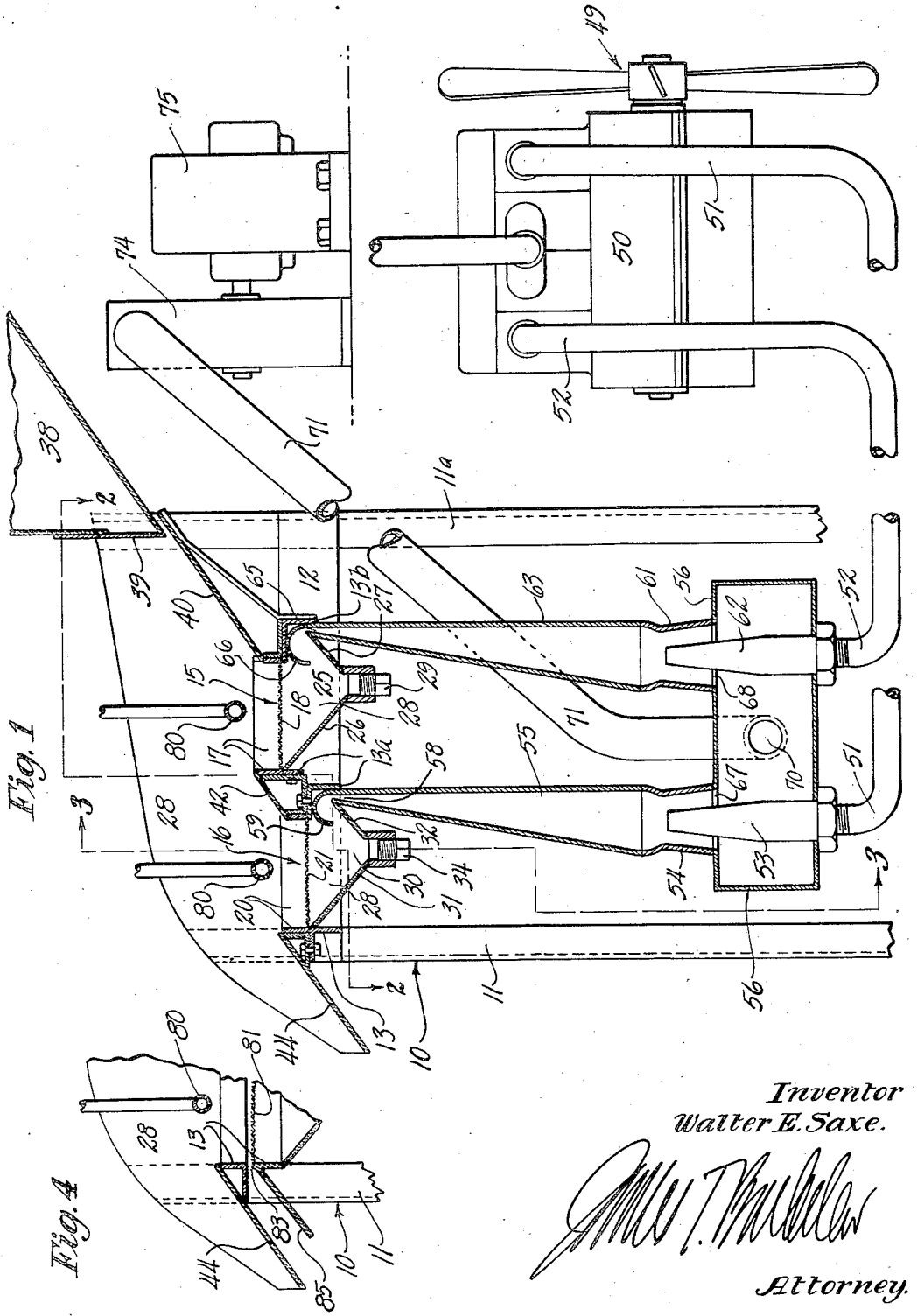
May 12, 1936. W. E. SAXE 2,040,503

MATERIAL SEPARATOR

Filed Jan. 27, 1934 3 Sheets-Sheet 1



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MATERIAL SEPARATOR

Filed Jan. 27, 1934 3 Sheets-Sheet 2

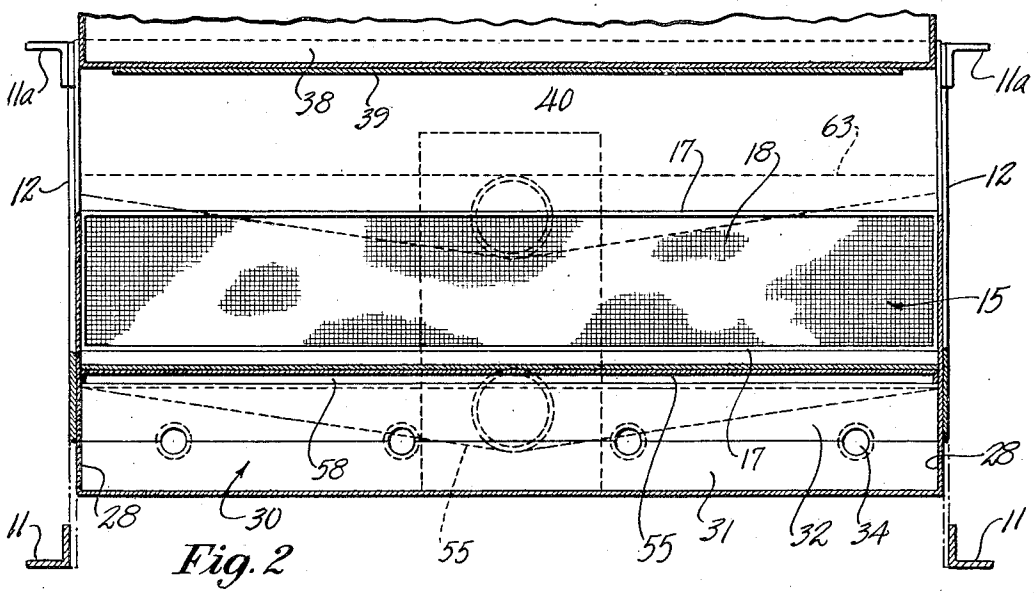


Fig. 2

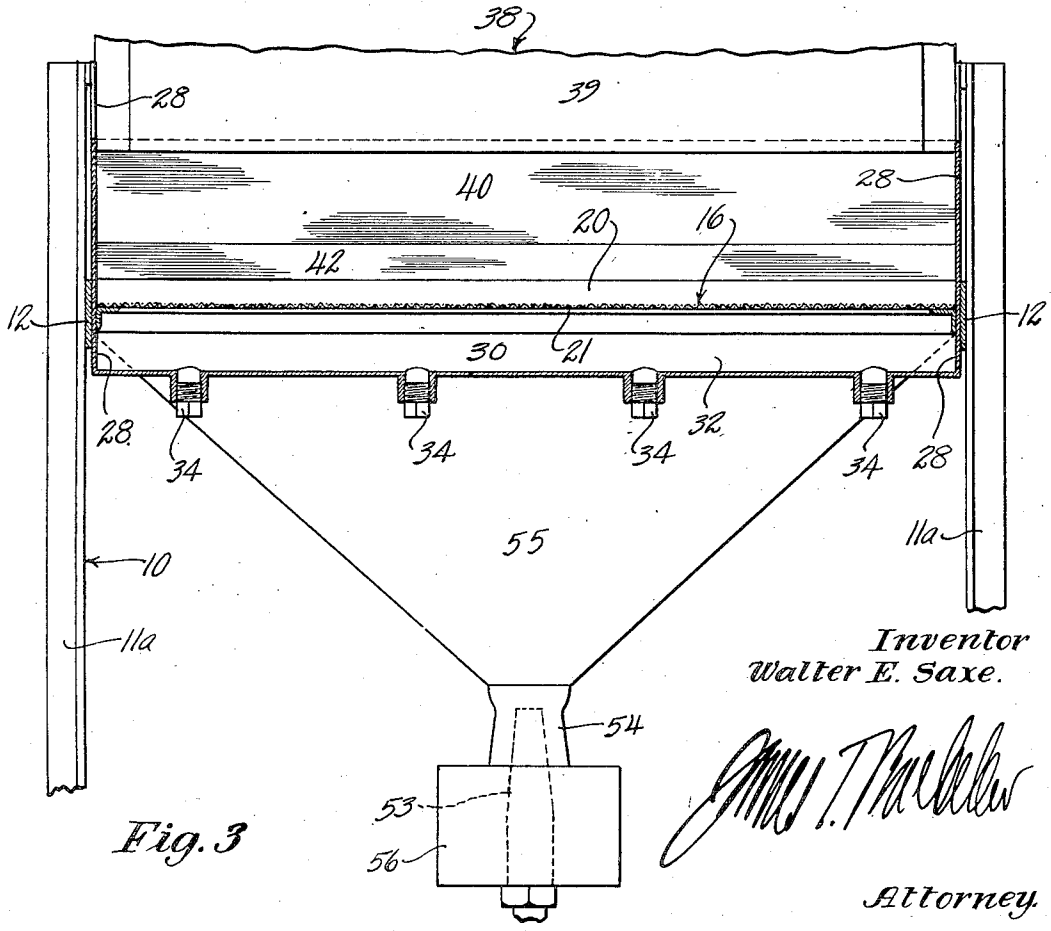


Fig. 3

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MATERIAL SEPARATOR

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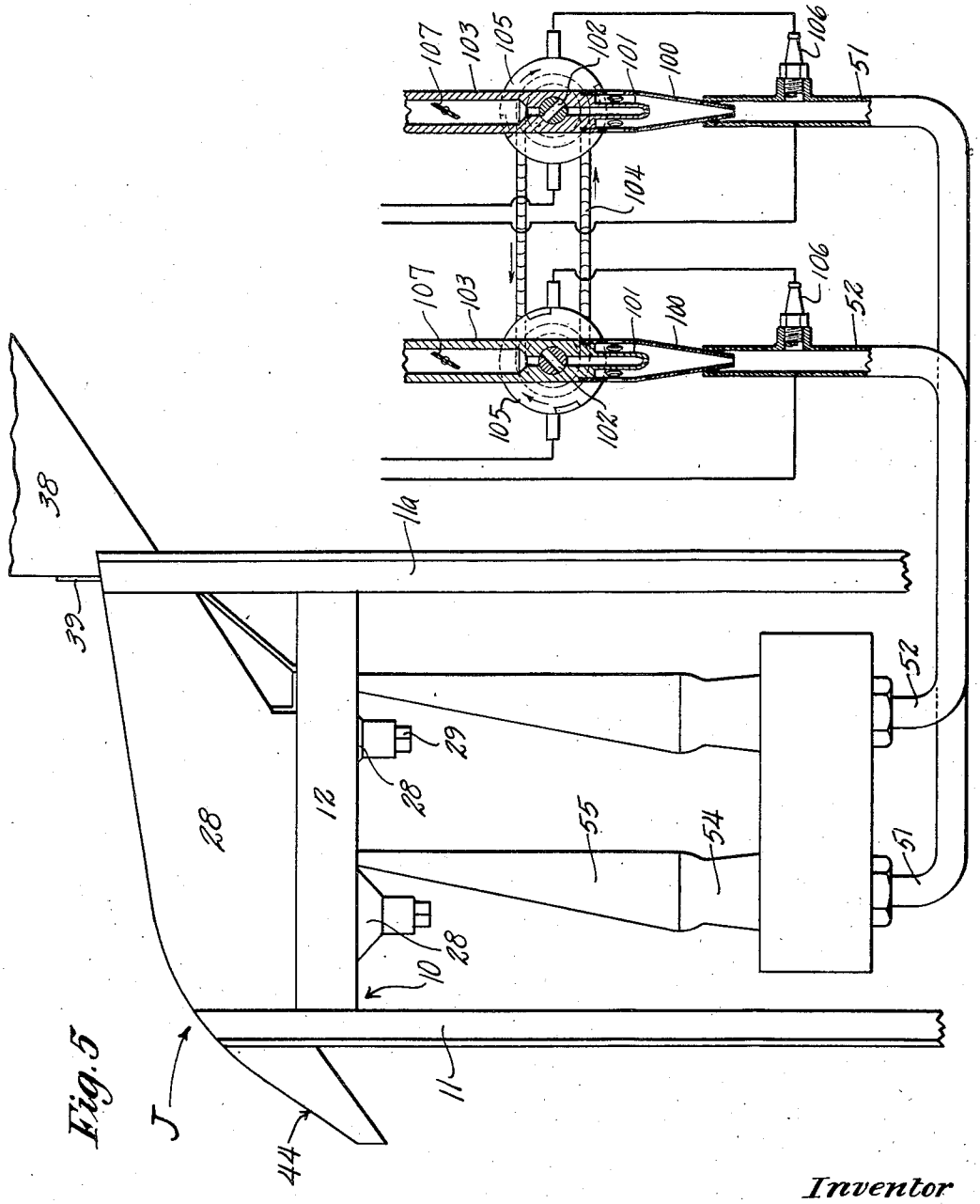


Fig. 5

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UNITED STATES PATENT OFFICE

2,040,503

MATERIAL SEPARATOR

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Application January 27, 1934, Serial No. 708,611

16 Claims. (Cl. 209—502)

The present invention relates generally to devices for dry separation or concentration of mixed dry substances, typically and more particularly to pneumatic jigs used in the concentration of ores. The invention is described as embodied in an ore jig because the apparatus has been particularly developed for that material; but such description is not intended to be a limitation on the apparatus itself or its use, for it may be used to separate or concentrate any suitable mixture and may be changed from the form shown in order to more efficiently handle a particular mixture, without departing from the spirit and scope of the invention. The improved method of dry concentration is more particularly described and claimed in application Ser. No. 706,163, entitled Material separation, filed by Walter E. Saxe on January 11, 1934.

Where possible, jigs have been generally of the hydraulic type. In many areas, however, it is not possible to obtain water for washing ores because of prior water rights annexed to all available water, an entire absence of water, restrictions on disposal of tailings, and the like, or the high cost of obtaining the water may make its use economically prohibitive in the case of ore having low recovery value.

For these reasons, jigs have been developed to use air as a concentrating fluid, and in general the theory of operation has been the same as with water jigs, there being only a change in the concentrating fluid medium used. However, the use of air in place of and in the same manner as water has disadvantages because air requires a fairly well graded feed to the jig and does not make for as close a separation. The concentration of ore in a jig or similar device using air or a gaseous medium for concentration is herein termed dry in contradistinction to wet processes carried on in a device using a liquid medium for concentration. The present invention is particularly adapted to handling normally dry substances; but it is also adapted to separation of moist or damp mixtures and, as will be mentioned later, provision is made for the addition of water to the mixture passing over the screen if such is desirable.

Concentration carried on in a hydraulic jig is based upon the different rates of settling of the ore particles in the water used as the concentrating fluid medium. By means of a piston or similar reciprocating member, the water is given a vertically reciprocatory movement through the screen and ore bed so as to impart a like motion to the particles of ore above the screen. The upward or impulse movement and the downward movement are termed "pulsion" and "suction" respectively. When there is substituted a gaseous concentrating medium, commonly air, the separation is usually carried on in a generally similar manner; and water jigs have been modified structurally to become adapted to the use of air. In this latter type of device, it is customary to impart movement to the air by means of a reciprocating or oscillating member, or by the intermittent introduction into the hutch of charges of compressed air.

All air jigs have heretofore been characterized by inability to so move the air as to impart to the ore a sharp, sudden impulse, and likewise by the lack of a sharply defined suction immediately following the pulsion. The incompressibility and weight of the body of water within a water jig causes the water to follow closely the movement of the reciprocating piston, with the result that the pulsion is relatively short and quickly followed by a suction sufficiently pronounced to cause a distinct downward fluid movement through the ore bed. But when air is used, these operating characteristics are not had because of air's inherent elasticity. During the pulsion stroke of a piston or vane, the air in front of the moving member compresses rather than moving bodily and then exhausts relatively slowly through the ore bed, so that the ore particles are subjected to pressure from the air over a relatively long period of time. During the suction stroke, the elastic expansibility of the air within the hutch makes it tend to fill the hutch rather than to draw outside air downwardly through the ore bed; and unless pressure within the hutch has been restored to substantially atmospheric before the beginning of the suction stroke, there is little likelihood that the pressure within the hutch will become sub-atmospheric during the suction stroke, as is necessary to produce a true suction or downward air movement through the ore bed. Because of the low viscosity of air, an air jig must operate at a relatively high number of pulsions per minute, and at such a high rate of operation the time between the beginning of successive pulsion strokes is not sufficient to allow the air to lose completely the energy stored by compression, with the result that the successive impulses merge and subject the ore to a substantially continuous pressure of fluctuating value without any true suction between marked impulses.

The absence of truly sharp pulsions separated by intervening suctions or low pressure periods

keeps down the efficiency of the air jigs, and prevents large capacity or close separation by this means. By making the impulses sudden and distinct, speed, efficiency, and closeness of separation can be greatly increased.

It is therefore an object of the invention to provide a dry concentrating device adapted to exert upon the ore mixture being treated, a series of sudden, sharp impacts following one another at a high rate but without loss of distinctness.

It is a further object of the invention to provide a dry concentration device capable of creating a relative drop in pressure of such magnitude and so sharply following each impact, as to produce a true suction.

These objects are accomplished in a device embodying the invention by providing a screen over a hutch in the usual manner, and providing means for introducing into the hutch successive charges of heated gas under pressure. In a typical and preferred form, this last means comprises a cylinder of an internal combustion engine and a pipe leading the exhaust from the cylinder into the hutch. An independently driven reversible fan is also provided so that a continuous stream of air may pass through the hutch for purposes of ventilation and the like if desired.

How the above and other objects and advantages of the invention are attained will be more readily apparent from the following description, wherein is described a present preferred form of the invention, and the annexed drawings in which:

Fig. 1 is a vertical median section of a jig constructed in accord with the invention, and showing somewhat diagrammatically a motor driven fan and internal combustion engine operatively connected with the jig;

Fig. 2 is a plan, partially in section, of the jig as indicated by line 2—2 in Fig. 1;

Fig. 3 is an elevation, partially in section, as indicated by line 3—3 in Fig. 1, omitting the fan and internal combustion engine;

Fig. 4 is a fragmentary vertical section of an optional discharge from a screen; and,

Fig. 5 is a diagram illustrating an optional means of supplying the hot gas charges.

The jig illustrated in the drawings is provided with two screens for reasons that will be mentioned, but any other number may be used if desired. The jig has a supporting frame generally indicated at **10** in Fig. 1, and comprising front and rear upright members **11** and **11***a* respectively, horizontal side members **12**, and transverse frame members **13**, **13***a*, and **13***b*. As may be clearly seen in Fig. 1, these three transverse frame members are each composed of several individual pieces so arranged and fastened together as to support the screens **15** and **16**. Screen **15** is formed with an open rectangular frame member **17** across which is attached, by welding or any other suitable means, a foraminous screening member such as a piece of wire cloth **18**, the frame resting on transverse frame members **13***a* and **13***b* so that the screen spans the interval between these transverse frame members. Screen **16** is formed in a similar manner with frame **20** resting on transverse members **13** and **13***a* to support wire cloth **21** in the interval between the two transverse members. Although fixed screens can be used, it is preferable that they be formed as described with individual frames so that the screens may be easily and quickly removed from the jigs for washing or for replacement.

The space beneath screen **15** is enclosed to form a trough shaped hutch **25** for receiving and collecting the particles passing through the screen above. By means of downwardly converging side plates **26** and **27** and end plates **28**, there is formed a hutch enclosure having one side formed at least in part by screen **18**. The bottom of this enclosure is provided with one or more drain openings adapted to receive a plug **29** so that the screenings accumulated within the hutch can be periodically removed.

A similar hutch **30** is likewise formed beneath screen **16** by means of the downwardly converging side plates **31** and **32** and end plates **28**. Screenings are removed from the hutch by means of drain holes at the bottom, here shown as four in number in Fig. 3, adapted to be stoppered by screw plugs **34**.

The gravel to be treated is supplied to the jig from hopper **38** (see Fig. 1) or any other suitable material handling device. The hopper is preferably provided with some means to regulate the feed, such as discharge gate **39**. After leaving the hopper, the gravel passes down feed apron **40** to screen **15** and thence over a second feed apron **42** to screen **16**, the tailings finally leaving the jig by means of discharge apron **44**. End plates **28** extend upwardly above the screens as illustrated to properly confine the ore in its passage over the jig.

For the purpose of introducing into the hutch intermittent charges of hot gas under pressure to carry on the separation of the materials passed over the screen, I provide certain apparatus, a preferred form of which will now be described. Although any other suitable source of heated gas may be provided, I preferably use an internal combustion engine **50** since the exhaust from the cylinders is a readily available and economical source of the charges, and may be regulated as to quantity and frequency without expensive apparatus. It is preferable to provide the engine with an adjustable load, and this is easily done by attaching a variable pitch propeller **49** to the engine crankshaft; although it will be understood that all or a part of the power from the engine may normally be expended in operating machinery. In fact, the primary use of the engine may be for plant operation; and the engine only incidentally supply hot exhaust gases to the jig.

Each of hutches **30** and **25** is individually supplied with the exhaust from one cylinder of the engine by means of pipes **51** and **52** leading respectively to the two hutches. Considering only hutch **30** for the moment, it will be seen that the exhaust from pipe **51** passes through conical injection nozzle **53** into aspirator **54** connected at one end to mixing tube **55**. Aspirator **54** is mounted on manifold **56** and opens at its lower end **67** into the manifold. In Fig. 1 it will be seen that, beginning at a point slightly above the end of nozzle **53**, mixing tube **55** continually decreases in thickness upwardly; and in Fig. 3 it will be seen that the tube is fan shaped because it uniformly increases in width upwardly to equal the length of the hutch. In this manner all cross sections of the mixing tube are of substantially the same area so that by the time the gas leaves tube mouth **58** at the top of hutch wall **32**, the gas pressure at the tube mouth is uniform along the entire length of the hutch. Pressure over the entire screen **16** is further equalized by means of curved baffle **59**, which may conveniently be a continuation of the rear wall of tube **55**. Baffle **59** directs the incoming gas charge against wall **32** of the hutch so as

to more evenly distribute the pressure across screen 16 and avoid local concentration of the pressure. Additional baffles or gas inlets may be provided if desired.

Heated gas charges are introduced into hutch 25 in a similar manner by pipe 52 that discharges through injector nozzle 62 into aspirator 61 and mixing tube 63. Shaped similarly to tube 55, tube 63 discharges at its mouth 65 into hutch 25 and is likewise provided with a baffle 66 to divert the incoming gases.

Although under certain circumstances it may be satisfactory to directly connect the exhaust pipe to the mixing tube so that there is no gap between them, yet for reasons that will be mentioned I prefer to use the above described construction to obtain aspiration. The discharge of exhaust from nozzles 53 produces within aspirator 54 a reduction of pressure that draws into the aspirator a quantity of air through the open end 67 of the aspirator. To aid in this effect, the aspirator is made conical and concentric with discharge nozzle 53. Aspirator 61 is similarly shaped and located with reference to nozzle 62, and operates to introduce air through its open end 68. Orifices 67 and 68 may be open to the atmosphere or any other suitable supply of air.

However, orifices 67 and 68 are preferably formed as openings in the top of manifold 56 which, through orifice 70 and pipe 71, is placed in communication with fan 74, here shown as driven by a motor 75. Fan 74 is of such nature that by reversing the rotation of motor 75, the fan may be made to move air in either direction through pipe 71 and manifold 56.

Some types of ores and mixtures can be more efficiently separated if moistened. For this purpose a perforated water pipe 80 is placed over each screen to wet the mixture on the screen.

Fig. 4 shows a variational form of screen arrangement that may be used on one or both screens. In this form screen 81 may be fixed, and attached to the frame members. At one edge of the screen, the frame members are disposed to form opening 83 through which the coarse concentrates collected on the screen can continually pass to be discharged over apron 85 to receive suitable further treatment. The screen is inclined suitably to aid feed toward the discharge opening.

The process of separating various materials by means of impacts produced by successive charges of heated gas is fully described and claimed in the copending application hereinbefore referred to, so that the operation of this device need only be briefly discussed here. The products of combustion resulting from successive explosions in the cylinders of the internal combustion engine provide the successive charges of heated gas under pressure which are introduced into the hutches. Because of its temperature, the exhaust gas expands and exerts a sudden, sharp force on all particles above the screen. The rapid cooling of this gas contracts it to a much smaller volume near or below atmospheric pressure with two results: The duration of the impulse exerted is so short as to be almost infinitesimal, and a distinct low pressure or relative suction is produced between impulses. The short time of the impulse allows the use of a relatively large force, so large that were it to continue for the full time of pulsion in the usual jig processes, which is long enough to allow the particles to acquire approximately the maximum velocity of the moving fluid medium, all the material above the screen would be blown away. Thus the separation is accomplished by applying rapidly succeeding and sharply defined impacts to the material rather than by allowing the particles to settle in a fluid medium, as has been the practice in jigs heretofore. A rapid cooling of the heated gas causes a relatively low pressure period that not only sharply defines succeeding impacts but also aids in the separation of materials; and this low pressure may, depending upon the final volume when cooled, drop so far as to cause a sub-atmospheric pressure within the hutches between successive impacts, although the sub-atmospheric pressure is not essential since the drop in pressure is so swift and so great as to produce the desired suction effect.

The desired impact will vary with the materials handled, but in general will be sufficient to lift the low density particles of gangue and insufficient to lift the high density metallic particles which will consequently settle downwardly onto the screen. The finer of these latter particles will pass through the screens into the hutches from which they can be removed by taking out plugs 29 and 34; and the larger of the particles will remain upon the screens and can be collected by removing and washing the screens. The rate of flow of mixture to the jig is controlled by gate 39 of the hopper, and will be adjusted to pass the mixture at a proper rate to effect the desired separation.

Although a single screen and hutch may be sufficient to effect the desired separation in many cases, two screens and hutches are here shown in tandem as a means of increasing the total time that the material is treated. Thus successive screen and hutch units may be added which are fed by the tailings passing over discharge apron 44, or the tailings may be discharged to a suitable conveying apparatus for removing them from the place of treatment.

The character of the mixture being treated and whether coarse or fine concentrates are to be saved, will determine the magnitude and frequency of the impacts to be applied. These characteristics of the impacts may be varied in several ways. Thus the quantity of explosive charge admitted to the cylinders as determined by the throttle setting on the motor and the loading imposed by variable pitch propeller 49, or other load, will determine the quantity and frequency of exhaust from the cylinders. Generally speaking, the engine speed will determine the successive speed of the impulses; and the engine loading the impact force. If the load be a constant one, the impact force may be adjusted within limits by adjusting the timing of the exhaust valve. Again, under given operating conditions of the engine, the impact will be stronger if exhaust pipes 51 and 52 are connected directly to their respective mixing tubes 55 and 63 than if the construction here illustrated is followed. By providing openings 67 and 68, the aspiration effect mentioned draws in a considerable quantity of air and tends to lessen the force of the impacts.

The operation of fan 74 also acts in some measure to control the magnitude of the impact. Fan 74 may be operated as a blower to force a continuous stream of air upwardly through screens 15 and 16 under a suitable head; or the fan may be operated as a suction fan to move the draft of air downwardly through these two screens. The operation of the fan is thus seen to change only the magnitude of the impact

relative to atmospheric pressure, since the continuous stream of air, depending upon its direction, bodily shifts the pressure curve from the position it would occupy if the fan were not in operation and orifices **67** and **68** were exposed to the atmosphere.

Ventilation of the hutch is accomplished either by aspiration or by the fan, or by both. The air mixed with the exhaust gas is in sufficient volume to prevent condensation of the water vapor in the exhaust, and so help dry the heavy fines in the hutch.

A variational form of the device may be used in which pipe **71** and opening **70** are omitted so that manifold **56** is closed to the atmosphere. The two hutches are then interconnected through their associated mixing tubes and manifold **56**. With this construction, the aspiration caused by the discharge of exhaust gas from nozzle **53** produces a lower pressure in the manifold and mixing tube **63** that draws air downwardly through screen **15**. Likewise, at the time of impact in hutch **25**, there is a suction in hutch **30**. By selecting two cylinders of engine **50** that fire alternately at equal time intervals, each explosion may be used simultaneously to produce an impact in one hutch and a suction in the other.

Fig. 5 shows in diagram an optional arrangement for producing the hot gaseous charges. In this figure the jig as a whole is indicated at J, its structure being the same as before described. The two pipes **51** and **52** are each fed with combustible fluid and air mixture through a nozzle **100** which forms in effect a mixing tube for admixing air with gas fed through inner nozzle **101** under control of valve **102**. Gas or other combustible fluid under sufficient pressure is fed to the valve by pipe **103**. The two valves **102** may be interconnected to rotate at 90° timing from each other, as by chain drive connection indicated at **104**; and the valves may be driven by any suitable means at any desired speed.

Each valve may have attached a timing commutator **105**, which in a suitable electric circuit that may be of any type or kind and needs no description, will supply ignition current to an ignition plug **106** to fire the combustible mixture in the combustion chamber in the pipe **51** or **52**. Ignition will take place after valve **102** has closed. A throttle or other control valve **107** functions to control the volume of the combustible charges introduced to the ignition chamber in, or in connection with, the pipe **50** or **51**.

By using such an apparatus as here indicated, the hot gaseous charges may be supplied to the jig to perform the same function in the same manner as has been described. The final result is the same; but this simple apparatus allows the use of acetylene or any other gas or fluid fuel that may be convenient without the necessity of using an engine or the like.

Having illustrated and described a present preferred form of my invention, it is to be understood that the foregoing disclosure is intended to be illustrative of rather than restrictive upon the broader claims appended hereto; for various changes in arrangement, construction, and design of parts may be made without departing from the spirit and scope of the invention as set out in the following claims. Nor is my invention limited to the materials treated, since it is adapted to the screening or separation according to size of homogeneous materials.

I claim:

1. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, an internal combustion engine, and a conduit conveying the successive pulsations of hot exhaust gas from a cylinder of the engine into the enclosure.

2. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, and means for forming and delivering to the enclosure successive charges of heated gas under pressure, said means embodying a conduit chamber leading to the enclosure, means for periodically introducing a combustible metered charge to the chamber, and means for igniting the charge.

3. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, and means for forming and delivering to the enclosure successive charges of heated gas under pressure, said means embodying a conduit chamber leading to the enclosure, means for periodically introducing a combustible metered charge of gas and air to the chamber, and means for igniting the charge.

4. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, means for introducing successive charges of heated gas under pressure into the enclosure, and ventilating means adapted to pass a continuous stream of air through the enclosure and the screen.

5. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, means for introducing successive charges of heated gas under pressure into the enclosure, and ventilating means adapted to pass a continuous stream of air into the enclosure and outwardly through the screen.

6. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, means for introducing successive charges of heated gas under pressure into the enclosure, and a ventilating means adapted to remove air from the enclosure causing a continuous air stream entering the enclosure through the screen.

7. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, means for introducing successive charges of heated gas under pressure into the enclosure, said means including an aspirator adapted to mix air with the gas charge before introduction into said enclosure, and ventilating means connected to the aspirator adapted to pass a continuous stream of air through the enclosure and the screen.

8. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, an internal combustion engine, and means to introduce the successive pulsations of the hot exhaust gas from a cylinder of the engine into the enclosure, said gas introducing means including an aspirator adapted to mix air with the exhaust gas before introduction into said enclosure.

9. A mixed material separator comprising an

enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, an internal combustion engine, a conduit conveying the successive pulsations of the hot exhaust gas from a cylinder of the engine to the enclosure, and means to apply a variable load to said engine.

10. A mixed material separator comprising a pair of enclosures each having one side formed by a screen adapted to receive and carry the material on its outer face, means to form charges of heated gas under pressure and introduce successive charges of gas alternately into the two enclosures, said means including a pair of aspirators with air passages associated one with each enclosure to mix air with the gas charge before introduction into the enclosure, and a manifold interconnecting the air passages of said two aspirators.

11. A mixed material separator comprising a pair of enclosures each having one side formed by a screen adapted to receive and carry the material on its outer face, means to form charges of heated gas under pressure and introduce successive charges of gas alternately into the two enclosures, said means including a pair of aspirators associated one with each enclosure to mix air with the gas charge before introduction into the enclosure, a manifold interconnecting said two aspirators, and ventilating means connected to said manifold to pass a continuous stream of air through the enclosures and screens.

12. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, means for introducing successive charges of gas under pressure into the enclosure in such timed relation as to allow the pressure of one charge to dissipate before the next charge is introduced, and thereby to produce a pressure pulsation in the enclosure, and means independent of the pulsation producing means for constantly modifying the mean pressure in the enclosure.

13. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, an internal combustion engine, a conduit conveying the successive pulsations of the hot exhaust gas from a cylinder of the engine to the enclosure, and means for independently varying the engine load and speed, thereby to vary independently the volume and succession speed of the pulsations conveyed to the enclosure.

14. A mixed material separator comprising a pair of enclosures each having one side formed by a screen adapted to receive and carry the material on its outer face, means to form charges of heated gas under pressure and introduce successive charges of such heated gas alternately into the two enclosures in such sequence that a previously introduced charge is cooling and contracting in one chamber at the time a charge is introduced to the other chamber, aspirators with gas passages associated severally with the charge introduction means so that a relatively low pressure is induced in each aspirator gas passage when a heated gas charge passes therethrough, and means interconnecting the aspirator gas passages to communicate the induced low pressures alternately from each aspirator to the other.

15. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, an internal combustion engine, a conduit conveying the successive pulsations of the hot exhaust gas from a cylinder of the engine to the enclosure, and means to vary the engine speed thereby to vary the succession speed of the pulsations conveyed to the enclosure.

16. A mixed material separator comprising an enclosure one side of which is formed by a screen adapted to receive and carry the material on its outer face, and means for forming and delivering to the enclosure successive charges of heated gas under pressure, said means embodying a conduit chamber leading to the enclosure, means for periodically introducing a combustible metered charge to the chamber, said means being capable of operation at varying speeds to vary the periodicity of charge introduction to the enclosure, means for controllably varying the volume of the combustible charge, and means for igniting the charge.

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