

June 7, 1960

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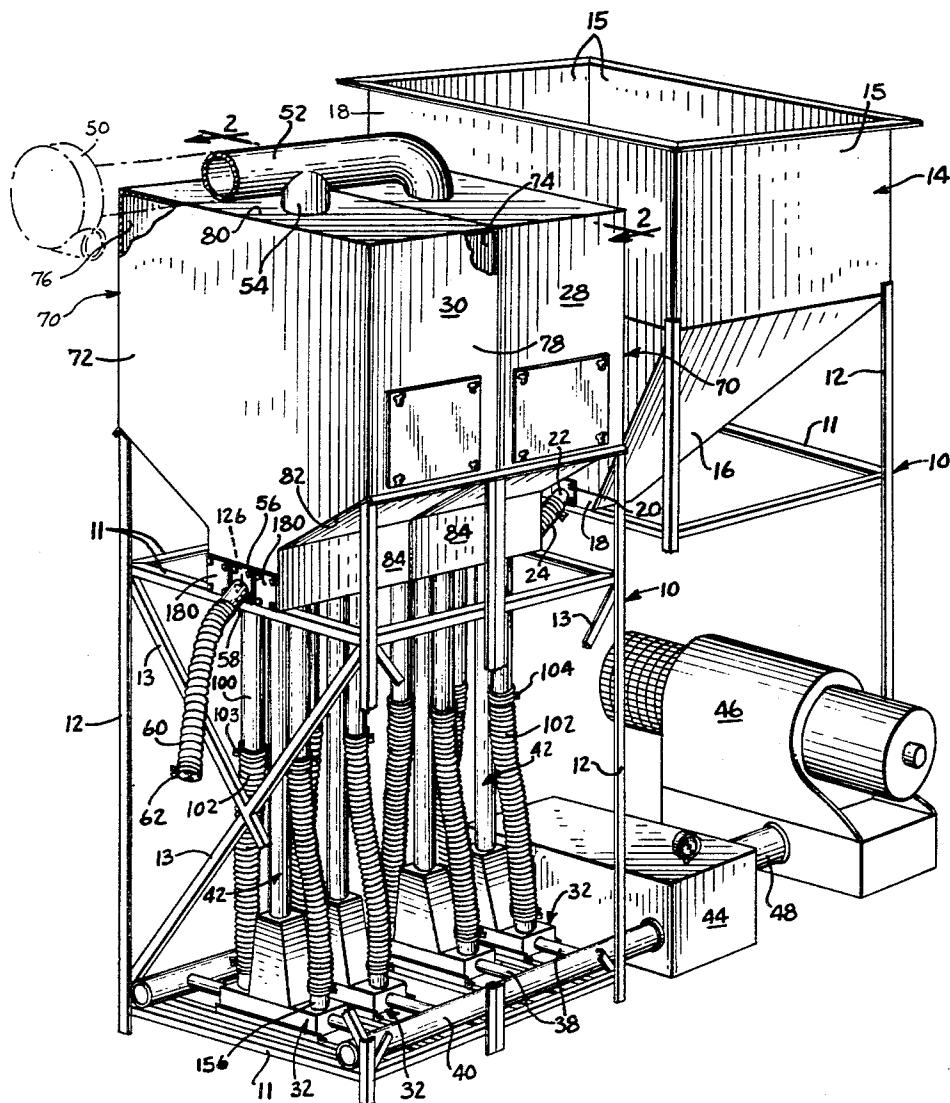
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APPARATUS FOR CLEANING FOUNDRY SAND AND THE LIKE

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5 Sheets-Sheet 1

Fig. 1



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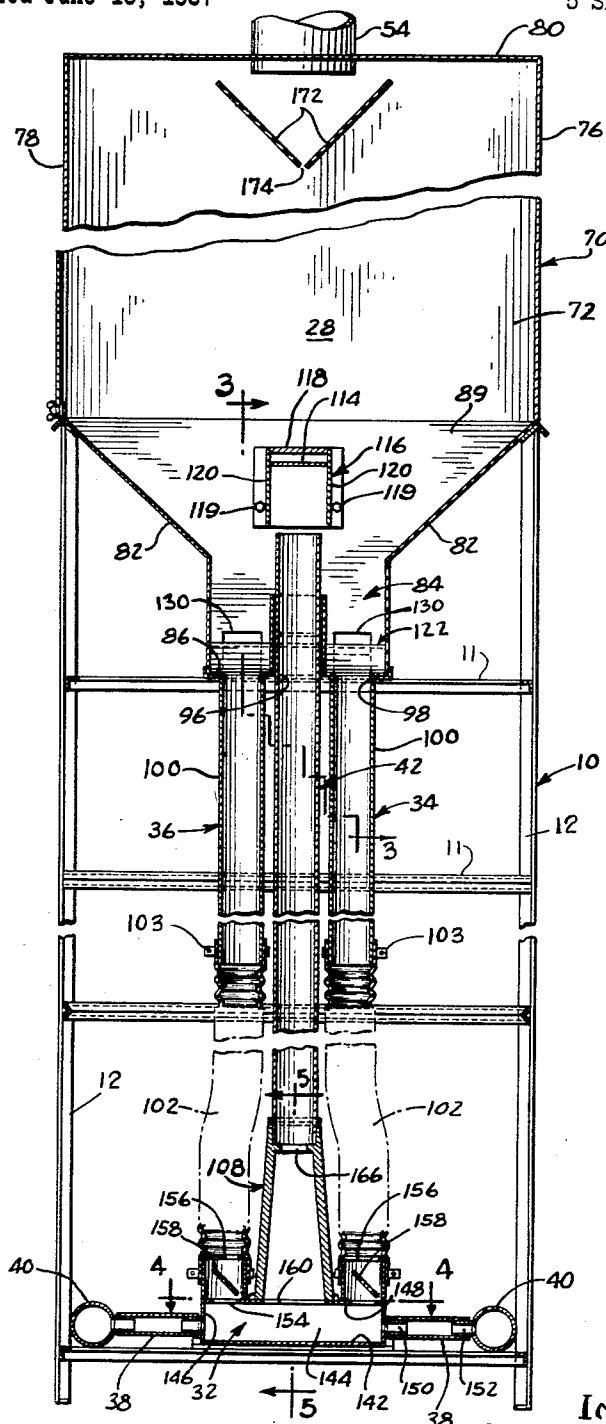
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5 Sheets-Sheet 2

Fig. 2



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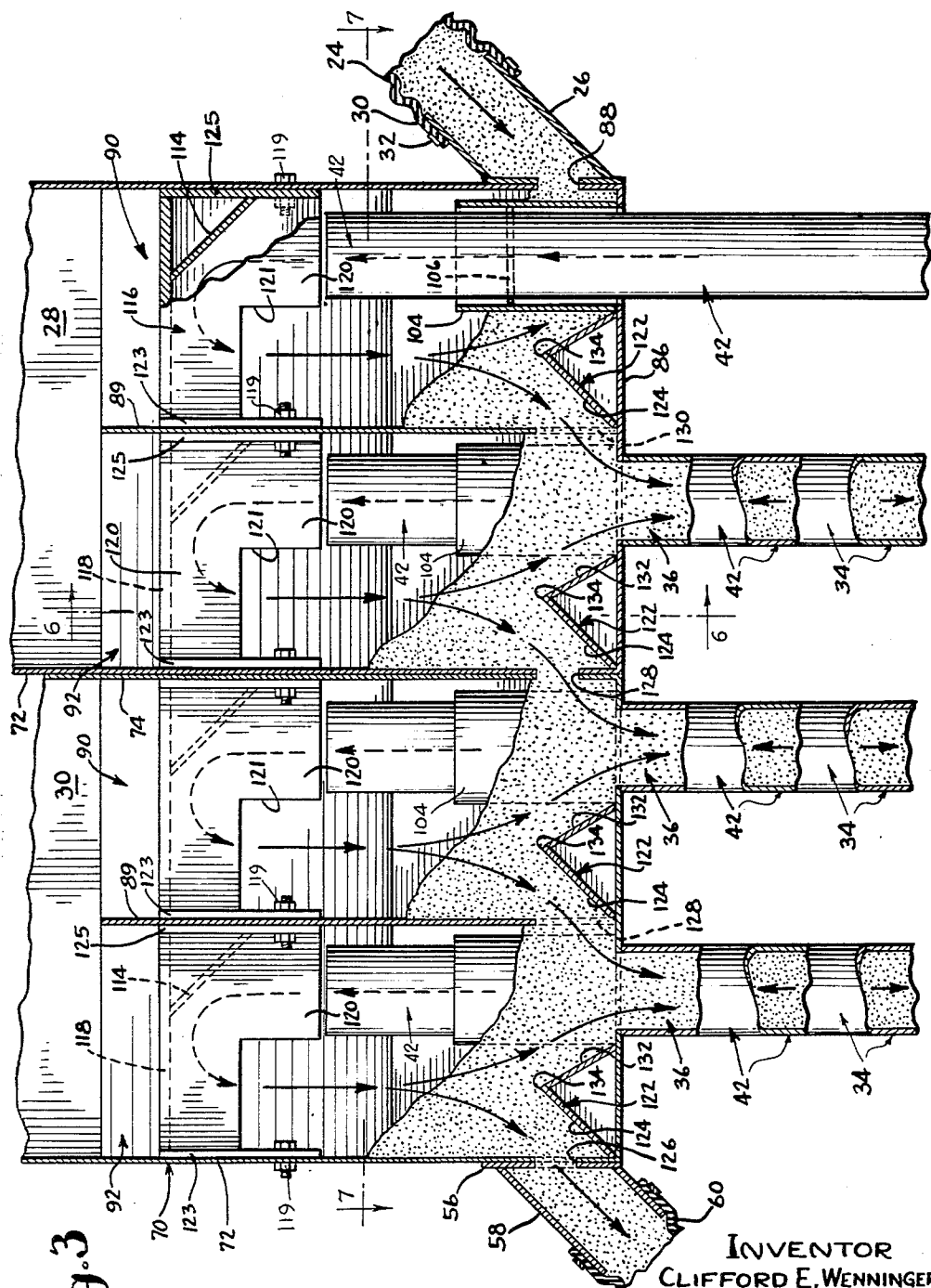
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APPARATUS FOR CLEANING FOUNDRY SAND AND THE LIKE

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Fig. 4

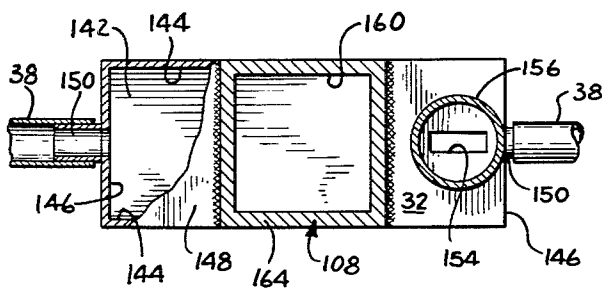


Fig. 5

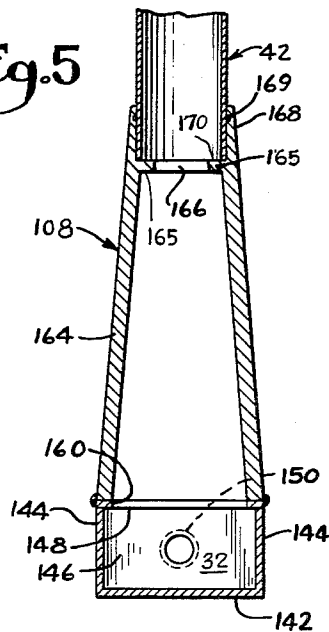
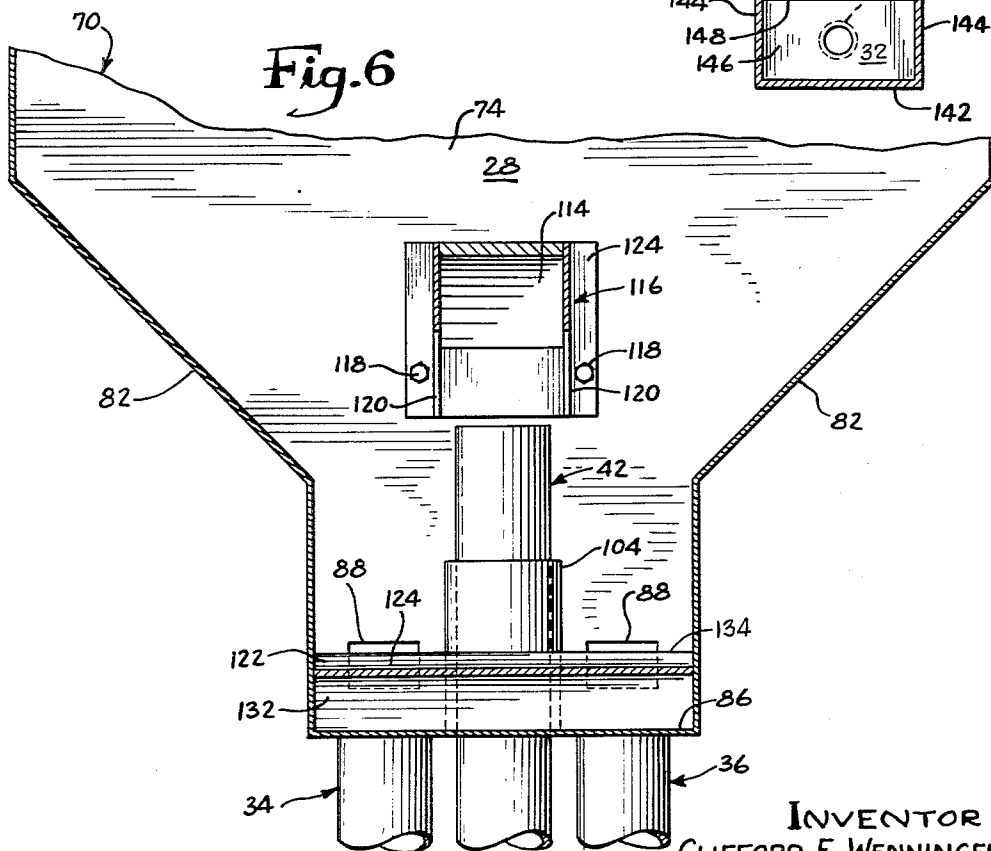


Fig. 6



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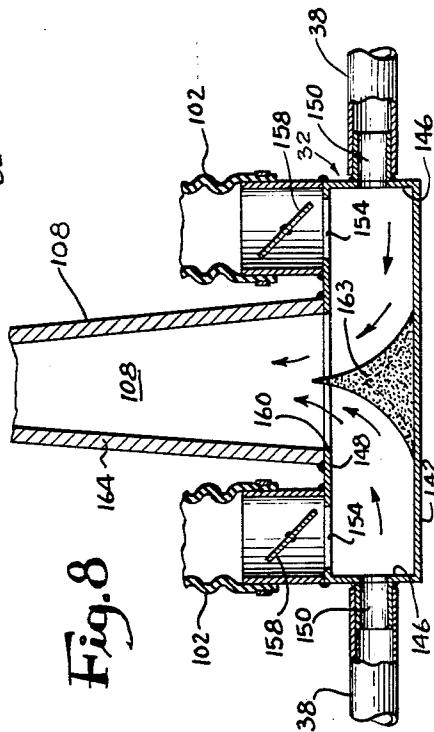
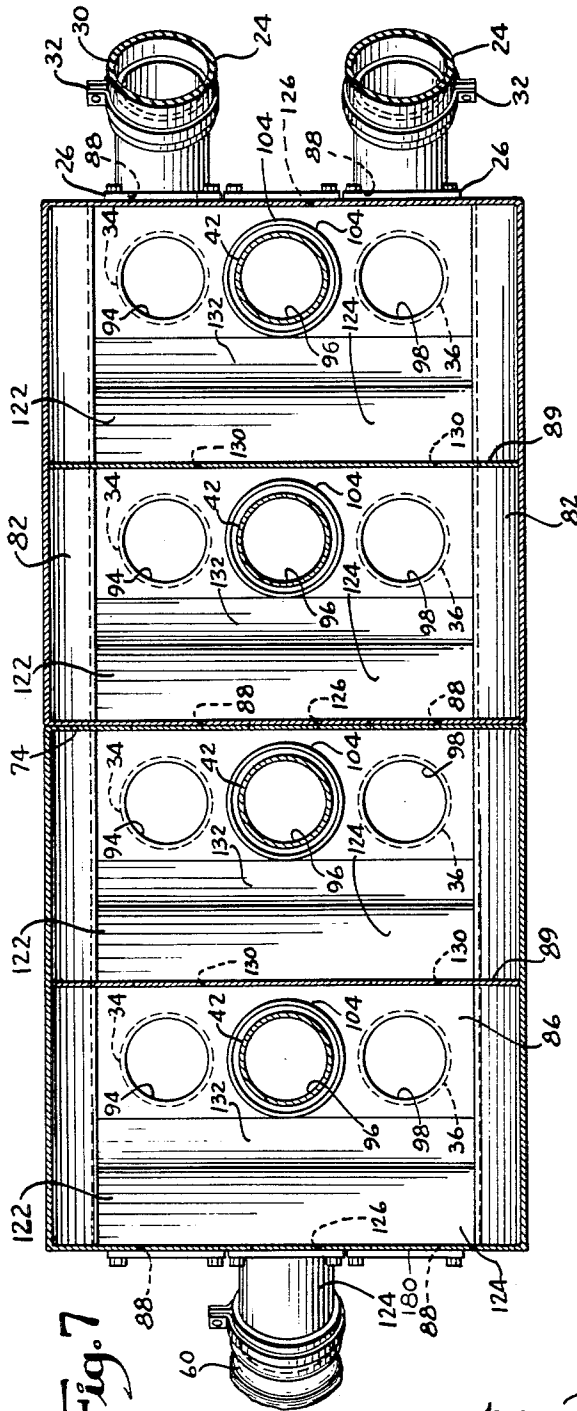
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5 Sheets-Sheet 5



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APPARATUS FOR CLEANING FOUNDRY SAND AND THE LIKE

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4 Claims. (Cl. 22—89)

The present invention relates to an apparatus for reclaiming spent and inert used materials and has particular reference to a dry reclamation system for the treatment of used materials such as spent core and molding sand resulting from foundry operations in order to free the sand from adhering foreign matter such as foreign bond substances, carbonaceous coatings, scale, and the like, as well as to separate the same from such foreign matter in its loose state, thereby restoring the sand to a useable condition so that the same may be used again in the production of good cores or molds. The invention is applicable to the treatment of ordinary molding sand which has previously been used, and it is also applicable to the treatment of original sand containing some impurities so that its quality may be improved for use, either in the making of sand cores or as molding sand. Irrespective, however, of the particular use to which the invention may be put, the essential features of the same are at all times preserved.

Broadly stated and briefly outlined, the present invention contemplates the provision of a continuous flow sand reclamation apparatus for reconditioning foundry sand utilizing a dry scrubbing process wherein the sand is subjected to high turbulence in a gaseous atmosphere with the sand being moved solely by virtue of its entrainment in the highly turbulent gaseous atmosphere with head-on, as well as tangential particle collision due to the colliding action of streams of the atmosphere taking place early in the operation; with thorough aeration of the particles at the time of and immediately after such head-on and tangential collision; with secondary collision between the particles and a fixed portion of the apparatus taking place subsequently, and with further aeration taking place during such collision and immediately thereafter to carry away the fines and impurities released during such impacting operations.

The invention further contemplates the provision of an apparatus which is of a multi-stage character in that the sand may progress successively through a series of substantially identical dry scrubbing operations or stages from a region of initial sand introduction at a given level in the first stage to a region of sand discharge at substantially the same level in the last stage with the various stages being balanced, so to speak, against one another whereby, by the simple expedient of controlling the rate of discharge of sand from the last stage in the system, the effect of such control is transmitted through the entire system so that the sand issuing from the secondary sand collision phases of operation, as outlined above, in all of the stages will automatically and collectively be regulated as between the discharge of the sand from the stage and retention of sand therein so that in any given installation the duration of sand treatment may be varied to accommodate different operating requirements.

Heretofore, in sand cleaning or scrubbing equipment of the multi-stage type wherein air is employed as the conveying, scrubbing and fines-removal medium, it has

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been deemed necessary, in order to obtain continuous flow of the sand through the apparatus from the sand inlet to the sand outlet, to rely upon the action of gravity to assist the air in moving the sand progressively from sand inlet to sand outlet. This has necessitated introducing the sand into the apparatus at a relatively high level and allowing the same to "cascade," so to speak, through the various stages with the finely cleaned sand being discharged from the apparatus at a relatively low level. In order to control the quality of clean sand issuing from such systems, the only means available is the regulation of the rate at which sand is introduced into the system. The larger the quantity of sand which is entrained in the air stream associated with any given stage, the more sluggish will be the scrubbing operation and the less effective the cleaning action. Thus, when it has been ascertained by an analysis of sand issuing at the discharge outlet that the sand is not being sufficiently cleaned, it is necessary to restrict the introduction of sand into the apparatus at the inlet. However, the effect of this control is not immediate since the entire body of sand within the apparatus must first pass through the apparatus before the effect of the change in rate of sand feed will be observed at the outlet. Furthermore, in order to vary the rate of sand feed at the sand inlet, certain control equipment must be provided, as, for example, a variable speed bucket conveyor and electrical controls therefor by means of which the quantity of sand delivered to the inlet may be varied. Still further, where installations involving a large number of sand recycling stages are concerned, the height of the equipment must be relatively great so the number of stages is limited to existing floor and building accommodations. Additionally, each particular installation must be designed as a permanent one since the addition of a recycling stage at the discharge end of the system would bring the final sand discharge outlet below operating level, while the addition of such a stage at the inlet end of the system would involve not only bringing the sand inlet to a prohibitively high elevation but would also involve a complete rearrangement of sand feeding and blower installations.

The present invention is designed to overcome the above-noted limitations that are attendant upon the construction and use of existing sand cleaning equipment of this general character and, toward this end, it contemplates the provision of an apparatus wherein the sand is impelled through the system solely by the buoyant action of air, unassisted by the action of gravity, and with the sand passing through the system horizontally along the same general level from sand inlet to sand outlet. By such an arrangement, the sand inlet for the system as a whole may be positioned at substantially the same level as the final sand outlet, thus making possible the stage-balancing operation referred to above wherein, by the simple expedient of varying the effective size of the sand discharge opening at the final sand discharge region of the system, the extent of the recycling action in all of the recycling stages may be varied. Furthermore, because so-called level flow of sand through the system is resorted to, the various units which comprise the recycling stages of the system may be of identical construction with all the corresponding components thereof such as impact members, sand diversion members, up-flow and downflow sand delivery tubes, partition walls, between-stage sand passages and the like, as will be described in detail presently, existing at the same general levels in the system.

The provision of a novel form of apparatus for accomplishing the above outlined aims being among the principal objects of the present invention, it is another important object to provide an apparatus of this sort

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which, in the preferred form thereof, is capable of being manufactured in the form of section "package type" units, each unit being of the two-stage type, which is to say that the sand is subjected to two stages of treatment with initial and secondary particle collision taking place as described above in each stage, and with the various units being capable of readily being assembled together in serially arranged fashion to produce a multi-stage apparatus which, from the standpoint of practicability, will permit the addition of new units to previously installed units without dismantling the installed units, thus permitting future expansion of any given installation to accommodate increased capacities. In connection with this last mentioned object, experience has shown that a single two-phase unit will best handle small capacities and conveniently, with moderate air pressures, allow for a wide range of recycling of the sand when such recycling is found necessary without overtaxing the system and causing undue wear. It is, however, within the scope of the invention to utilize units having more than two stages or a single stage unit, either standing alone or in combination with other serially arranged single phase units but, for purposes of illustration herein, the units disclosed are of the two-stage type.

Another important object of the invention is to provide a sand cleaning apparatus of this general character wherein each stage embodies an upper recycling chamber wherein the above mentioned secondary particle collision takes place and an associated lower initial sand and air mixing and impact chamber where the above mentioned initial particle collision takes place, the upper recycling chamber embodying a novel sand diversion member by means of which horizontal flow of a portion of the sand forwardly through the stage toward the next adjacent recycling stage in the system is effected, while at the same time another portion of the sand is retained in the recycling stage for recycling purposes.

By virtue of the novel sand diversion member briefly outlined above, the apparatus is self-emptying, which is to say, that in the event it is desired to remove all of the sand in the apparatus for the purpose of dismantling, inspection of parts, repair or the like, or for the purpose of making a new run with sand of a character different from that of a previous run, the sand may be allowed automatically to "run out" by the simple expedient of shutting off the supply of sand to the apparatus and opening the final discharge orifice whereby the sand will be completely expelled from the various treatment units including the initial sand-air mixing chambers and the recycling treatment chambers.

It is a still further object of the invention to provide a sand cleaning apparatus of the character briefly outlined above having associated therewith a novel form of sand-impacting chamber wherein substantially greater "impact-shock" is attained than has heretofore been possible utilizing conventional impact methods and apparatus employing nozzles and similar jet producing devices. In carrying out this last mentioned object, the invention contemplates the introduction of controlled quantities of sand into a pair of oppositely directed opposed air streams at regions in advance of the region of collision of the two streams so that the individual particles of sand become entrained in the respective opposing streams and are impelled thereby into a region of impact where the two streams meet in head-on fashion. The colliding particles thus make impact with one another not only under the force of their own kinetic energy but they are given further impetus due to the dynamic backing force of the impelling air behind them so that the total impact shock imparted to the colliding particles is materially increased and a more effective scrubbing action in this region of the system is attained. Furthermore, the sand-impacting chamber is so designed that the regions of juncture of the oppositely moving air streams, and consequently, the region of particle collision, takes place adjacent an un-

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opposed wall of the chamber so that the two air streams and the particles entrained thereby are constrained to move outwardly away from the unopposed wall and produce an extremely effective tangential collision of the sand particles, the resultant vectorial thrust of which is a trigonometric function of the combined velocities of the two air streams insofar as its magnitude is concerned and also insofar as its direction is concerned with the resultant direction being in the direction of expulsion of the sand from the impact chamber. By such an arrangement, the colliding sand particles are subjected to a rebound phenomena which assists the action of the flowing air stream in moving the sand from the initial impacting phase of the system to the secondary impacting phase and, therefore, greater amounts of sand may be moved utilizing lower velocity air streams.

Yet another object of the invention is to provide an apparatus of this sort wherein the parts thereof which are subjected to the abrading action of the sand undergoing treatment, particularly the various relatively high velocity sand conduits or tubes leading from the region of initial impact to the region of secondary impact are exposed to view and are accessible from the outside of the apparatus, as well as being provided with simple removable and replaceable fittings, so that worn parts may easily be replaced with a minimum of effort. A similar and related object of the invention is to provide an apparatus which thus readily lends itself to replacement of parts and which, moreover, will permit of such replacement without requiring emptying of the apparatus or draining of sand from any of the sand treatment units associated with the same, either in part or in full, or draining of the initial sand-air mixing or impact chambers.

It is an additional object of the invention to provide a multi-stage sand scrubbing apparatus involving the introduction of sand into opposed blower-impelled air streams, as previously outlined, and wherein, in each stage of the apparatus, the loading of the various air streams may be regulatably controlled whereby air inlet velocities may automatically and without disturbing the normal operation of the air blower be varied in accordance with engineering exigencies to produce a more efficient scrubbing action at the regions involved.

Another object of the invention, in a system of this character having an air inlet blower for introduction into the various scrubbing stages of sand-impelling air streams and an exhaust blower for the removal of the dislodged impurities and other fines from such stages, is to provide a novel type of "push-pull" cooperation between the two blowers whereby the load on the blower is materially decreased for any given quantity of airborne sand in the system. In carrying out this last mentioned object, it is contemplated that in each stage of operation, both the sand inlet to the stage and the sand outlet therefrom are disposed below the normal operating level of sand, i.e., below the uppermost level of the static head of sand maintained in the stage, with no direct openings from the stage to the atmosphere so that the two blowers are, in effect, in operative communication with each other.

Finally, it is a further object of the invention to provide a multi-stage sand scrubbing apparatus having sand recycling enclosures in each stage which are symmetrical in configuration and which are so designed that the movement of air therein is conducive toward the elimination of eddy currents, the tendency being for a more or less uniform flow of air upwardly in all horizontally displaced regions of the enclosures. By such an arrangement, during the elimination of fines through the top stack or stacks by an upward flow of air through the enclosure, there will be no localized up-rush of air at one region at a greater velocity than at any other region, and thus, the character of the fines which are airborne toward the stack will be uniform at all points in the enclosure.

The provision of a sand cleaning apparatus which is

extremely simple in its construction, particularly as regards its lack of complicated manual controls and which, therefore, may be manufactured at a relatively low cost; one which is completely devoid of operationally moving parts and which, therefore, is unlikely to get out of order; one which is of relatively small compact design and which is possessed of a minimum expense of sand conducting piping with no horizontal piping whatsoever; one which embodies relatively large area, high capacity baffles, considering its relatively small overall size; one which is rugged and durable and which, therefore, is possessed of a comparatively long life; one which is capable of ease of assembly and disassembly for purposes of inspection, replacement of parts or repair; one which is smooth, silent and substantially dust-free in its operation, and one which, otherwise, is well adapted to perform the services required of it, are further desirable features which have been borne in mind in the production and development of the present invention.

Numerous other objects and advantages of the invention will become more readily apparent as the following description ensues.

In the accompanying five sheets of drawings forming a part of this specification, a typical and preferred installation, constructed in accordance with the principles of the present invention, has been shown.

In these drawings:

Fig. 1 is a perspective view of a dual unit system constructed in accordance with the principles of the present invention, portions of the sand scrubbing unit framework being broken away to more clearly reveal the nature of the invention;

Fig. 2 is a sectional view taken substantially along the vertical plane indicated by the line 2—2 of Fig. 1 in the direction of the arrows;

Fig. 3 is an enlarged sectional view taken substantially along the line 3—3 of Fig. 2 with certain tubes being broken away to more clearly reveal the nature of sand flow therein;

Fig. 4 is an enlarged sectional view taken substantially along the line 4—4 of Fig. 2;

Fig. 5 is an enlarged sectional view taken substantially along the line 5—5 of Fig. 2;

Fig. 6 is an enlarged sectional view taken substantially along the line 6—6 of Fig. 3;

Fig. 7 is a sectional view taken substantially along the line 7—7 of Fig. 3; and

Fig. 8 is an enlarged longitudinal sectional view, somewhat schematic in its representation, taken centrally through one of a series of sand and air mixing and impact devices employed in connection with the invention.

Referring now to the drawings in detail, and in particular to Fig. 1, the sand cleaning apparatus comprising the present invention involves in its general organization a framework which has been designated in its entirety at 10, the design of which may vary to accommodate different installations and which, therefore, need not be described in detail except to state that it includes horizontal members 11, vertical members 12 and interconnecting strut members 13 by means of which the various operative sand treatment instrumentalities may be operatively supported from a foundry floor or other supporting surface.

Briefly, the framework-supported apparatus includes a feed hopper 14 of more or less conventional design having vertical side walls 15 which merge with inwardly sloping hopper bottom walls 16 to define a funnel portion having one vertical side 18 provided with a pair of spaced outlet fittings 20 having tubular nipples 22 adapted to be connected to the ends of a pair of flexible feed hoses 24. The other ends of the feed hoses 24 are adapted to be connected to similar fittings 26 (Fig. 3) provided at the inlet end of the first unit in a series of sand recycling and treatment units operatively supported in the upper regions

of the framework 10. While a single unit may, in certain installations, suffice for efficient sand reclamation, plural units may be arranged in series relationship, as will be described presently. For purposes of illustration herein two such units have been disclosed and these have been designated at 28 and 30, respectively, although it will be understood that a greater number of such units may be employed if desired. The units 28 and 30 are substantially identical in construction and, therefore, it is thought that a description of one will suffice for the others. Each recycling unit 28 or 30, as the case may be, is of the two-stage variety, which is to say that it is divided into two compartments, as will be described subsequently, with each compartment being operatively connected to an associated individual sand and air mixing and impact unit 32, the various units 32 being substantially identical and each being disposed immediately beneath the respective recycling unit with which it is associated and operatively supported in the lower regions of the framework 10. Each mixing unit 32 serves an individual recycling stage of one of the units 28 and 30 and thus there are two of the mixing units for each recycling unit. Each mixing unit is adapted to receive sand from the particular recycling unit with which it is associated by gravity feed from the recycling unit through a pair of downflow conduits 34 and 36, and to cause the quantity of sand received therefrom to be entrained in respective streams of air issuing from branch conduits 38 leading from a pair of manifold conduits 40. By such an arrangement, high turbulence sand-impacting will take place within the unit and subsequent discharge of the thus initially treated sand will be effected by an upward flow thereof through an axially straight upflow conduit or tube 42. The sand, now partially cleaned and freed from some of its impurities, together with such impurities in their free state, will thus be returned to the recycling stage from whence it formerly issued for further impact treatment and recycling, if desired, or for discharge thereof from that particular stage and introduction into the next succeeding stage in the same unit 28 or 30, in a succeeding serially arranged unit, or for final discharge from the apparatus, as the case may be. The manifold conduits 40 are fed with air under pressure from a surge tank 44 which is in turn fed from a conventional blower assembly 46 through a supply conduit 48. The loosened impurities and other fines are in part impelled from each unit under the influence of built-up air pressure within the unit, and in part impelled under the influence of a suction blower or fan 50 associated with an exhaust manifold conduit 52 having branch conduits or stacks 54 leading from the top walls of the units 28 and 30. The final discharge of cleaned sand is effected from the second or last recycling stage associated with the unit 30 through a discharge fitting 56 having a tubular nipple 58 connected to a flexible discharge conduit 60, the free end of which carries an adjustable orifice valve assembly or cut-off device 62.

Referring now to Figs. 2, 3 and 6, the sand treatment and recycling unit 28 is in the form of a generally rectangular box-like housing 70 having vertical front and rear end walls 72 and 74, respectively, side walls 76 and 78, and a planar horizontal top wall 80. The central regions of the side walls 76 and 78 slope downwardly and inwardly as at 82 and the lower regions of said side walls extend vertically and, in combination with the end walls 72 and 74, define a lower well portion 84 at the bottom of the housing, which well portion is provided with a planar horizontal bottom wall 86. The rear end wall 74 is formed with an inlet opening 88 in register with the previously mentioned inlet fittings 26 near the bottom region of the well 84. As shown in the drawings, the housing 70 is symmetrical in cross section and has in the top wall 80 thereof openings through which the lower ends of the branch conduits 54 extend.

As best seen in Figs. 2 and 3, the well portion 84 is

divided by a partition 89 into two sand-impacting compartments 90 and 92 representing the first and second sand treating stages associated with each of the units as previously set forth. The bottom wall 86 on the rear side of the partition 89 and in close proximity to the wall 74 is formed with a series of three spaced holes 94, 96 and 98 arranged in transverse alignment. The two outside holes 94 and 98 are in sealing registry with the upper ends of two of the downflow conduits 34 and 36, respectively, whereby these latter conduits are in communication with the compartment or stage 90. The medial hole 96 accommodates entry into the compartment 90 of one of the upflow conduits 42, the three conduits communicating with the interior of one of the sand and air mixing and impact devices or units 32 in a manner and for a purpose that will be made clear presently. As best seen in Fig. 7, the centers of the holes 94 and 98 lie in vertical planes which extend at right angles to the length of the enclosure and pass through the axes of the upflow tubes 42. In a similar manner, the bottom wall 86 on the front side of the partition, and in close proximity to the latter, is formed with a series of three holes, similarly designated, these three holes accommodating the positioning of the upper ends of two downflow conduits 34 and 36 and one upflow conduit 42 as heretofore described and leading to a sand and air mixing and impact unit 32 associated with the compartment or stage 92. It is to be noted that the holes 94 and 98, and consequently, the upper ends of the two conduits 34 and 36 are in longitudinal register and close proximity to the inlet openings 38 so that sand introduced from the feed hoses 24 under the influence of gravity from the hopper assembly 14 will spill into these vertical conduits 34 and 36 and thus flow by gravity downward into the sand and air mixing unit 32 associated therewith for initial impact treatment as will be described subsequently.

The various downflow conduits 34 and 36 are of a composite nature, each including an upper metal tube section 100 the upper rim of which may be welded to the rim of the opening 94 or 98 with which it communicates, and a lower flexible tubular section 102 which may be of the corrugated metallized rubber or other elastomer type. The upper ends of the sections 102 are connected to the lower ends of the sections 100 in telescopic relation by means of conventional split clamping hands 103. The conduits 42 are in the form of metal tubes, preferably formed of steel, and the upper ends thereof project completely through the openings 96 as shown at the right hand side of Fig. 3 and are floatingly supported within outer tubular sleeve members 104 by means of one or more O-rings 106 which may be interposed between the conduits 42 and sleeve members 104. The lower ends of the conduits 42 are removably confined in hollow frusto-pyramidal castings 108 associated with the sand and air mixing units 32. The sections 42 project outwardly, as shown in Figs. 3 and 6, an appreciable distance into the compartment 90 and 92 and underlie or are in vertical register with respective deflector or impact plates 114 commonly referred to as "heel" plates and which are preferably formed of hardened steel on account of the good wear characteristics of such material.

The heel plates 114 are inclined at an angle of approximately 45° with respect to a vertical plane and each plate is supported in position across the upper rear transverse corner of an inverted box-like structure or impact member 116 having a top wall 118, side walls 120 and front and rear end walls 123 and 125, respectively. The supporting structures 116 are bolted or otherwise secured as at 119 between the end walls of the respective compartments or stages with which they are associated and the side walls thereof are formed with cut-away portions 121 in the forward regions thereof to facilitate lateral flow of air from the structures for purposes which will become clear presently.

Supported on the bottom wall 86 of each unit 28 and 30 are a pair of rigid baffle members or divider plates 122 which are in the form of elongated angle pieces which extend transversely of the unit and substantially bridge the distance between the side walls 76 and 78. The angle pieces rest loosely on the bottom wall 86 and are immovably maintained in their seated positions between the side walls 76 and 78 and between the forward end walls of the respective compartments which, in the case of the compartment 90, is the partition member 89, and the adjacent sleeve members 104 against which these angle pieces bear. As shown in the drawings, each angle piece 122 is imperforate, extends at approximately a 45° angle with respect to the horizontal, and presents a forwardly and downwardly inclined surface 124. The latter constitutes a sand diversion member and, in the case of the compartment 92 of the unit 30, registers with or opposes an outlet or discharge opening 126 in communication with the discharge nipple 58 and, in the case of the compartment 92 of the unit 28, similarly opposes an opening 128 in the end wall 72, the opening constituting a sand discharge opening for the compartment 92 of the unit 28, as well as a sand inlet opening for the compartment 90 of the unit 30. In the case of the compartment 90 of the unit 28, the inclined face 124 of the angle piece 122 opposes an opening 130 in the partition wall 89 by means of which sand may be discharged from the compartment 90 and enter the compartment 92. Each angle piece 122 also presents a rearwardly and downwardly inclined surface 132 constituting a sand diversion member and which, in the case of all of the various stages or compartments in the system, opposes or is inclined toward the open upper ends of the downflow conduits 34 and 36 associated with the various stages. The upper transversely extending edge 134 at the intersection of the inclined faces 124 and 132 thus defines a dividing ridge whereby a portion of the sand issuing from the box-like structure 116 after impact with the heel plate 114 and top wall 118 may be directed to the downflow conduits 34 and 36 and the remaining portion of the sand directed to the discharge opening 112, 130 or 128, as the case may be, in the particular stage involved.

Referring now to Figs. 2, 4 and 8 wherein the details of the sand and air mixing and impact units 32 are best illustrated, these units are substantially identical in construction and thus a description of one of them will suffice for the others. Each unit 32 comprises a generally rectangular and relatively shallow closed elongated box-like casing including a bottom wall 142, upstanding side and end walls 144 and 146, respectively, and a top wall 148. The previously mentioned branch conduits 38 leading from the manifold conduits 40 are in the form of metal tubes which are telescopically received over nipples 150 communicating with the interior of the unit 32 through the end walls 146 and with the interior of the branch conduits 40, respectively. The top wall 148 of the unit 32 is formed adjacent its opposite ends with a pair of aligned elongated slots 154 (Fig. 4) of somewhat less width than the diameter of the air inlet nipples 150 and the two slots 154 are longitudinally aligned with the air inlet nipples 150 so that sand entering the unit 32 through the slots will be introduced into the air streams issuing from the nipples and completely enveloped thereby. Extending upwardly from the top wall 148 and embracing the slots 154 are a pair of attachment nipples 156 which receive thereover the lower ends of the flexible tubes 102 associated with the downflow conduits 36. Each nipple has mounted therein a control damper 153 which may be of the conventional stove-pipe butterfly valve type and which dampers are adapted to be manipulated to regulate the quantity of sand introduced into the air streams issuing from the branch conduits 38 to decrease or increase the loading of these streams for purposes which will shortly be made clear when the operation of the apparatus is set forth.

The medial region of the top wall 148 is formed with a

rectangular opening 160 and, supported on the wall 148 above the opening and in register therewith, is one of the previously mentioned hollow frusto-pyramidal castings 108. Each casting 108 is provided with upwardly converging side walls 164 (Figs. 4 and 5) and a top wall 165 provided with a central opening 166 surrounded by a centering boss or flange 168 providing an internal ledge portion 170 on which the lower end of the conduit 42 is adapted to be supported. A sealing member in the form of an O-ring 169 of rubber or other elastomeric material is interposed between the retaining or centering flange 168 and the wall of the conduit 42.

As best seen in Fig. 2, a pair of inclined baffles 172 extend longitudinally across the upper rectangular portion of each housing 70 from one end wall 72 thereof to the other end wall 74 and underlie the stacks 54. The baffles 172 converge downwardly and their lower edges are spaced apart a slight distance to provide an elongated slot or opening 174.

It is to be noted that in the system as a whole, the various sand diversion members 122, impact members 116, baffles 172 and other corresponding instrumentalities of the compartments 90 and 92 associated with each unit 28 and 30 are positioned at approximately the same levels so that substantially the same operating characteristics are attained in each stage of operation.

In the operation of the system illustrated herein, the supply hopper 14 may be supplied with sand to be treated by means of a suitable elevator, batch feeder or the like (not shown) and it may also have associated therewith suitable screening and magnetic devices for removing foreign bodies, oversize particles and the like so that the sand fed therefrom through the feed conduits or supply connections 24 may be of a reasonably uniform character. Upon energization of the blower 46, sand flowing by gravity through the conduits 24 and entering the lower well portion 84 of the first unit 28 in the series of two units passes into the compartment 90 and flows by gravity downwardly through the two downflow conduits 36 and passes through the rectangular slots or openings 154 in the top wall 148 of the first sand and air mixing device 32.

The sand entering the two opposed air streams issuing from the inlet nipples 150 becomes completely entrained in these streams and, since the two streams are directed toward each other in head-on fashion, some of the sand particles may collide by direct head-on impact. However, since the opposing air streams unite or meet in the vicinity of the bottom wall 142 of the unit 32, a static region of relatively high pressure will be built up as indicated at 163 in Fig. 8 wherein a mound or ridge of sand particles may build up in varying degrees depending upon the velocities of the air streams involved, the quantity of sand admitted to the unit by the control dampers 158 and other factors. Since the walls of the unit 32 prevent downward or lateral expansion of the colliding air streams, these streams are swept generally upwardly as indicated by the arrows in Fig. 8 and caused to take on tangential aspects as they enter the hollow casting 108. The particles of sand entrained in the converging air streams are thus thrown into impacting relationship whereby they collide tangentially and the resultant direction of motion of the particles will carry them upwardly into the casting 108 and conduit 42 thus relieving the air streams of some of the burden involved in displacing or impelling these particles and increasing the ability of these streams to entrain sand particles. Furthermore, because of the fact that, in addition to the kinetic energy possessed by the colliding particles, these particles also are dynamically backed by the force of air behind them, an extremely effective scrubbing action will take place in the various units 32.

The stream of air induced in the upflow conduit 42 by virtue of the union of the incoming air streams in the unit 32 and the pressure built up in this unit, together with its airborne sand, passes upwardly and issues from

the upper end of the conduit and is directed against the overlying heel plate 114 as well as against the top wall 118 of the impact member 116 so that a secondary impact operation takes place within the structure 116. The sand particles striking the plate 114 and wall 118 are thrown forwardly in the unit 70 and are swept downwardly in the form of a descending umbrella-like curtain by the reentrant stream of air which also is deflected by the heel plate 114. As the air encounters the relieved portions 120 on opposite sides of the structure 116, a certain amount of lateral expansion thereof may take place and this air flows generally laterally in the upper region of the unit and is deflected upwardly by the sloping walls 82 of the unit above the upper level of the partition wall 89 where it may commingle with air which is similarly moving upwardly from the next adjacent compartment 92. The region above the partition wall 89 is a region of comparatively low turbulence so that the lighter scrubbed particles which have not settled out by gravity from the air stream issuing from the sides of the structure 116 will at this time become detached from the air stream and fall downwardly. All sand which has settled out below or above the general level of the structure 116 will move downwardly toward the divider plates 122 wherein a portion thereof is constrained to move forwardly and pass through the discharge opening 130 and the remainder thereof is constrained to move rearwardly and pass downwardly into the downflow conduits 34 and 36 for recycling purposes where it will commingle with fresh sand introduced into the system from the supply conduit 24. If this sand which flows forwardly along the inclined surface 124 of the divider plate 122 finds ready access into the next adjacent compartment 92, a major portion of the sand which has been scrubbed in the first stage of operations both in the unit 32 and in the compartment 90 will issue from the compartment 90 and enter the compartment 92. However, as will be described in greater detail presently, if due to restriction of sand discharge from the last stage in the system, there is a "backing up" of the normal overall forward flow of sand in the system, the influence of such restriction will be reflected in all of the compartments and sand will accumulate in the vicinity of the deflector or divider plate 122 of the compartment and build up to a point of sand cut-off where all of the sand in the first scrubbing stage is retained for recycling purposes. The upward movement of air in the upper regions of the compartment 90 is the result of the pressure of oncoming air issuing from the upflow conduit 42, as well as of the suction created by the exhaust blower or suction fan 50. This air has its velocity reduced somewhat by the two baffle members 172 and, as the air passes around these members and enters the exhaust stack 54, the fines will be carried from the stage while any heavier particles will fall downwardly and be returned to the stage through the slot 174. As may be best visualized in Fig. 2, the vertical side walls 76 and 78 above the impact member 116 are smooth, while the sloping portions 82 thereof at the approximate level of the impact member are equally spaced from the impact member, thus rendering the enclosure as a whole symmetrical in cross sectional configuration. By virtue of this fact, equal flow around the opposite side of the impact member 116 will obtain so that the quality of fines which are airborne upwardly toward the stack 54 on both sides of the member 116 will be substantially the same. In other words, the screen mesh rating of the fines passing upwardly through the enclosure will not vary appreciably in different lateral regions of the same. Furthermore, this uniformity of airborne fines will be enhanced since the symmetry of the cross sectional configuration of the enclosure is not conducive to the creation of eddy or other cross currents which, if present, would cause settling out of undesirable fines and their advancement or return to adjacent treatment stages.

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The operation of each succeeding stage is substantially identical with that described in connection with the first scrubbing stage and recycling of the sand will take place in all of the various compartments which may be serially arranged in the system.

It will be understood that the dampers 158 may be employed to control the loading of the various inlet air streams entering the units 32. Generally speaking, a decreased loading will permit the blower 46 to introduce more air and establish the desired air inlet velocities compatible with efficient scrubbing. Where the air streams are overloaded, the velocity of these streams will be reduced to a point where insufficient impact will take place in the secondary impacting phase against the heel plate 114 and top wall 118. It is then necessary to adjust the control dampers 158 and reduce the quantity of sand admitted to the unit 32.

The extent of recycling operations, and consequently the duration of retention of the sand, as well as the quantity and quality of the sand discharged from the system may be regulated by the simple expedient of adjusting the cut-off device 62 carried at the end of the flexible discharge conduit 60 to thus, in effect, vary the size of the discharge opening 126. This device 62 may be of any suitable type and it has been disclosed herein as being of the rotary cut-off type wherein triangular apertures in respective cooperating cut-off plates may be moved into different positions of partial or full register. As the quantity of sand discharged from the system is decreased, the static head of sand in the last compartment 92 of the last unit 30 in the series builds up to a point where complete cut-off of the discharge opening 126 may take place and the effect of this phenomenon is reflected back through the entire system with similar cut-off actions taking place at the various discharge openings 128, 130 and 88. When a condition of complete cut-off takes place at the outlet of any particular stage, full sand retention and recycling in that stage will take place. Thus, the entire operation of the system may be controlled by operation of the single outlet valve or cut-off device 62 with regulation of the various control dampers 158 being resorted to when the character of the scrubbing action in the various stages requires alteration.

It will be observed that since the abrasive effect of sand moving downwardly by gravity in the downflow conduits 34 and 36 is relatively slight, these conduits need not be formed of abrasive resistant material such as steel, as are the upflow conduits 42. The conduits 42 which conduct high velocity airborne sand particles upwardly from the sand and air mixing and impact units 32 to the recycling compartments 90 and 92 are subjected to appreciable abrasive action and, for this reason, they are formed of steel as previously described and the floating mounting arrangement including the O-ring seals 106 makes it possible to easily remove these conduits for replacement purposes without requiring access to the interior of the compartments involved and without disturbing the associated units 32.

It is to be noted additionally that the various units 28 and 30 in the four stage system illustrated herein, or in a system having a greater number of stages, are of substantially identical basic construction from a manufacturing standpoint. Where a particular unit is to be employed for first and second stage operations, the inlet openings 88 will be operatively associated with a pair of the inlet fittings 26 which may be welded in operative position thereover. Where such unit is to be employed as an intermediate unit or as the final unit in the series, the openings 88 will be devoid of such fittings. Where a particular unit is employed for initial or intermediate stage operations in a system of any size, the discharge openings 128 will remain operative for sand discharge purposes. However, when the unit is employed for the last two stages of operation, these openings 128 will

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be sealed off by suitable imperforate closure plates such as have been shown at 180 in Figs. 1 and 7 and which may be bolted in position.

The invention is not to be limited to the exact arrangement of parts shown in the accompanying drawings or described in this specification as various changes in the details of construction may be resorted to without departing from the spirit of the invention. For example, while a flexible conduit 60 having a rotary cut-off device 62 at its discharge end is shown herein for sand flow regulation throughout the system as previously described, it is obvious that a sliding gate-type of construction emptying into a discharge chute for varying the actual size of the opening 126 may be substituted if desired. Other substitutions or modifications are contemplated within the spirit of the invention and only insofar as the invention has particularly been pointed out in the accompanying claims is the same to be limited.

This application is a continuation of my application Serial No. 665,512, filed on June 13, 1957.

Having thus described the invention what I claim as new and desire to secure by Letters Patent is:

1. A multi-stage apparatus of the level flow type, adapted primarily to condition foundry sand and comprising:
 25 a sand recycling enclosure embodying a top wall, upstanding opposed side walls, a rear end wall, a front end wall, and a planar horizontal bottom wall, and having a sand discharge opening in the front end wall for outflow of sand from the enclosure and a sand inlet opening in said rear end wall at substantially the same level as the aforesaid discharge opening in said front end wall, means providing a plurality of independent initial sand and air mixing chambers disposed an appreciable distance below the level of the bottom wall of the enclosure and arranged in longitudinal alignment and spaced apart relation beneath said bottom wall, an axially straight upflow delivery tube leading vertically and upwardly from each of said initial sand and air mixing chambers, the upper ends of the upflow sand delivery tubes communicating with the interior of the enclosure through the bottom wall thereof at longitudinally spaced regions therealong, a sand downflow conduit leading vertically and upwardly from each of said sand and air mixing chambers, the upper ends of the downflow conduits communicating with the interior of said enclosure through the bottom wall thereof through respective sand discharge openings which are formed in said bottom wall in the vicinity of said longitudinally spaced regions respectively and have the centers thereof lying in vertical planes which extend at right angles to the length of said enclosure and pass through the axes of the upflow sand delivery tubes respectively, means forming an air jet within each of said sand and air mixing chambers, means for supplying air under pressure to each of said air jets to produce an upward rush of air from its respective mixing chamber through the associated upflow sand delivery tube whereby sand issuing from the associated downflow conduit will become entrained in the air issuing from the air jet and be airborne upwardly through said upflow sand delivery tube and into the enclosure, an impact member in vertical register with the upper end of each sand upflow sand delivery tube within the enclosure, and against which the airborne sand and the air stream issuing from such sand delivery tube is adapted to impinge and be deflected, at least in part, forwardly within the enclosure over an area of the bottom wall underlying said impact member for subsequent free gravitational descent over said underlying area, and a rigid downwardly and forwardly inclined sand diversion member associated with each impact member, positioned therebeneath and in partial register with the path of sand descending from said impact member, and arranged to deflect and constrain a portion of the descending sand forwardly toward and into the next adjacent forward sand discharge opening, while at the same time allowing the

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remaining portion of the descending sand to flow to the sand discharge opening beneath said impact member for discharge therethrough into the communicating downflow conduit.

2. A multi-stage sand conditioning apparatus as set forth in claim 1 and wherein the downwardly and forwardly inclined sand diversion members are flat and imperforate and extend at approximately a 45° angle with respect to the horizontal.

3. A multi-stage sand conditioning apparatus as set forth in claim 1 and including, additionally rigid downwardly and rearwardly inclined sand diversion members which are disposed adjacent to, and have the upper edge portions thereof connected to the upper edge portions of, the downwardly and forwardly inclined sand diversion members and are arranged to deflect the remaining portions of the descending sand rearwardly towards the adjacent sand discharge openings.

4. A multi-stage apparatus as set forth in claim 1 and wherein the cross sectional configuration of the sand

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recycling enclosure is symmetrical, the side walls of the enclosures have the central regions thereof downwardly and inwardly inclined and have the lower regions substantially vertical, and the top wall of the enclosure is both horizontal and planar and has an opening therein for exhausting spent air under pressure with fines therein.

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