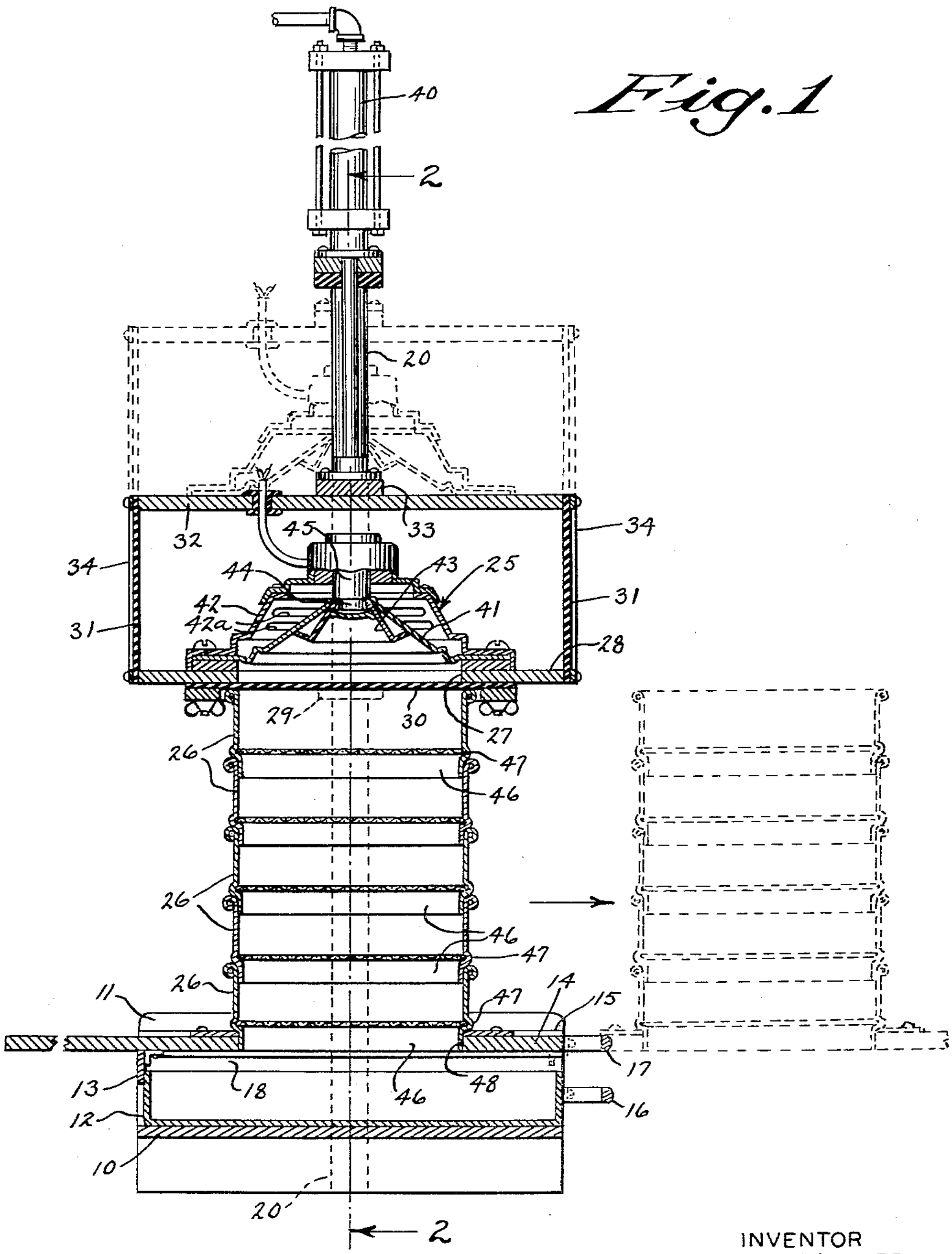
July 24, 1962 C. W. WARD 3,045,817

METHOD AND APPARATUS FOR SIFTING

Filed Nov. 4, 1959 4 Sheets-Sheet 1



INVENTOR
CHARLES W. WARD

BY Arnold J. Ericsen

ATTORNEY

July 24, 1962 C. W. WARD 3,045,817

METHOD AND APPARATUS FOR SIFTING

Filed Nov. 4, 1959 4 Sheets-Sheet 2

Fig. 2

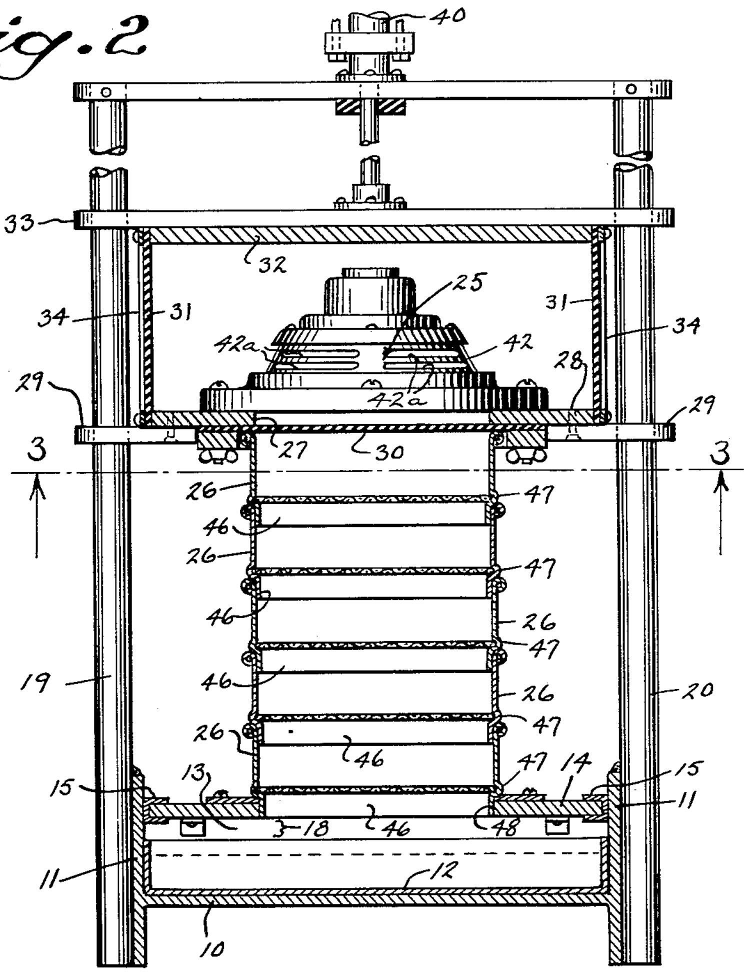
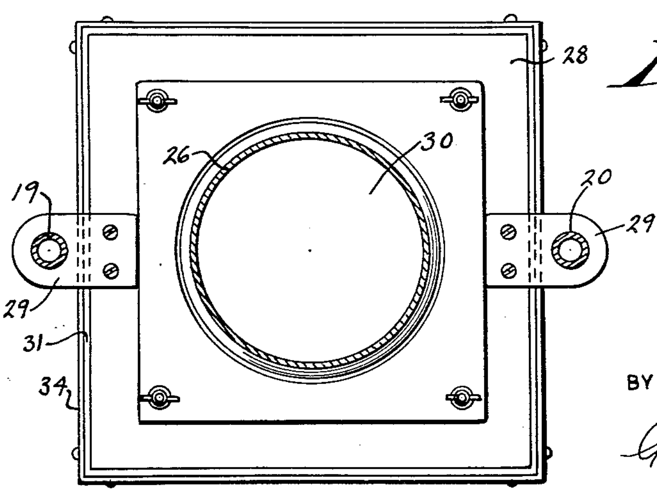


Fig. 3



INVENTOR
CHARLES W. WARD

BY

ATTORNEY

July 24, 1962 C. W. WARD 3,045,817

METHOD AND APPARATUS FOR SIFTING

Filed Nov. 4, 1959 4 Sheets-Sheet 3

Fig. 4

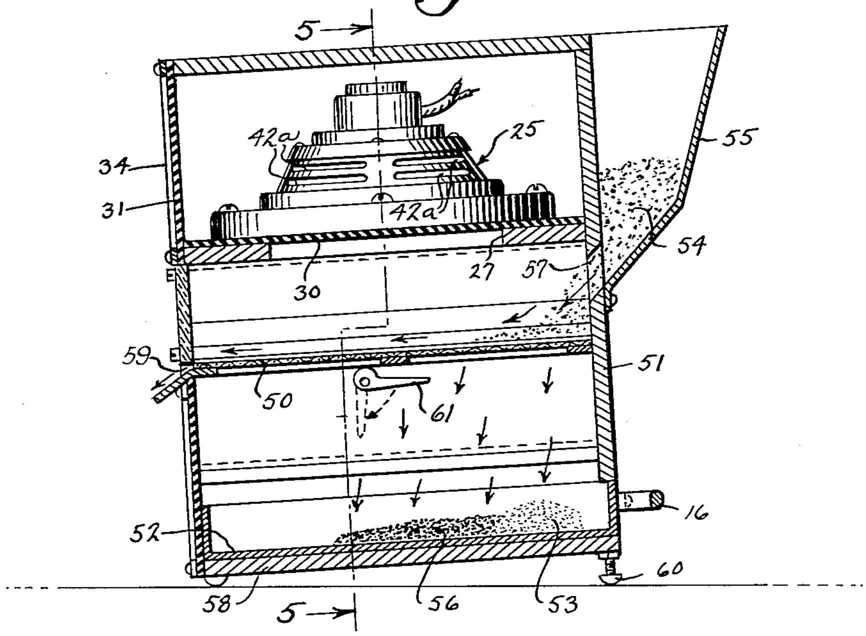


Fig. 5

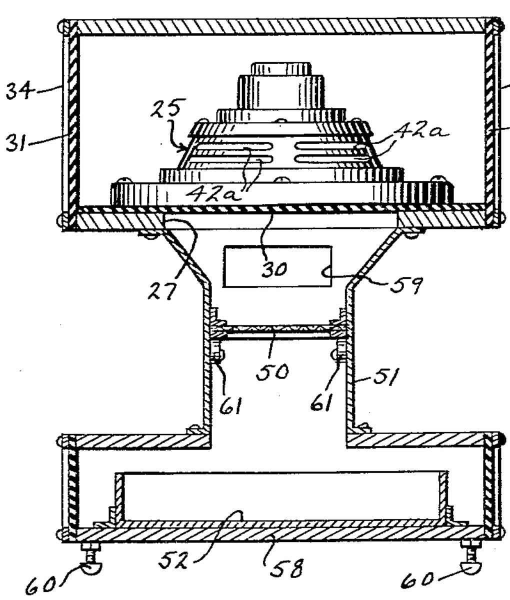
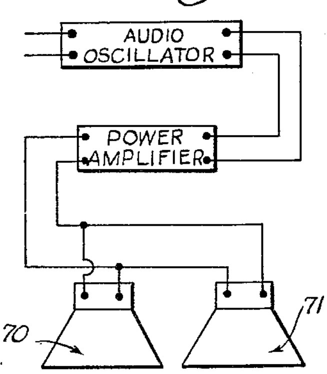


Fig. 8



INVENTOR
CHARLES W. WARD

BY

ATTORNEY

METHOD AND APPARATUS FOR SIFTING

Filed Nov. 4, 1959

Fig. 6

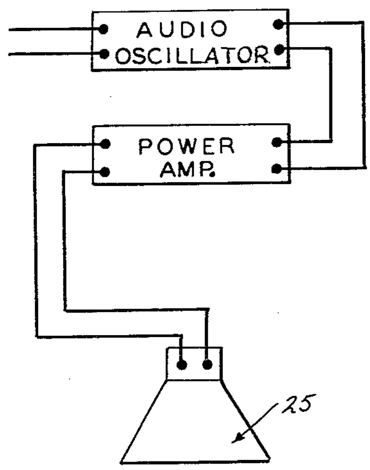
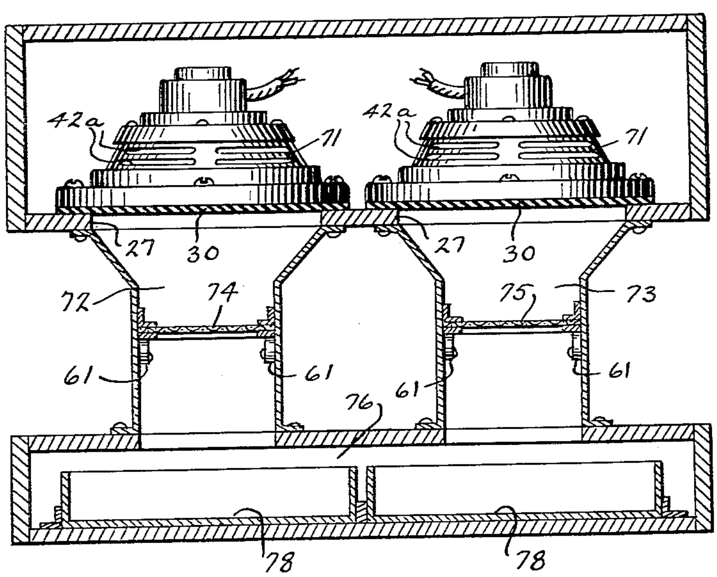


Fig. 7



INVENTOR
CHARLES W. WARD

BY
Arnold J. Ericsen
ATTORNEY

3,045,817

METHOD AND APPARATUS FOR SIFTING

Charles W. Ward, 1014 S. 23rd St., Milwaukee, Wis.

Filed Nov. 4, 1959, Ser. No. 850,865
7 Claims. (Cl. 209—21)

The present invention relates to a sifting method and an apparatus therefor, and in which the apparatus may embody one or more screens or sieves for separating a particulate material into selected size gradations and which screen or screens are disposed in a chamber communicating with an oscillatory diaphragm arranged to cause a corresponding oscillating air motion at the vicinity of the relatively stationary screen or screens to impart movement to particles being sifted, whereby sifting is accomplished by means of a cyclic motion of the particles.

In many of the process industries satisfactory production is dependent upon proper selection of particle size of various ingredients used as raw materials. This requires careful selection and grading by screening or sifting processes, and consequently, the sifting process step or steps provide a very important factor in calculating cost of preparation, because of the time and equipment involved, in addition to equipment replacement costs. Size control is particularly important in the preparation of ceramic materials, and particularly those wherein electrical dielectric characteristics are critical. Particular emphasis is placed upon size control of raw materials in the newly developing field of ferromagnetic compositions known as "ferrites" and in other sintered materials involving semiconductor application. Sifting becomes a particularly burdensome problem in processes using materials such as spray-dry powders which tend to cling to the screen, and in processes wherein the materials include considerable quantities of "fines" after they have been crushed. Fines are difficult to remove from the particles and they also tend to clog the meshes of the sieves.

Various efforts have been made in the past to reduce the time for sifting without impairing the desired results. Sifting on a commercial scale has had several unsatisfactory aspects which cause it to be a relatively inefficient operation. In certain installations stationary screens have been used without additional auxiliary apparatus for promoting sifting. These are quite low in efficiency and capacity in the finer sizes of screens, with a great tendency to bind and require a large amount of head room for their operation. Stationary screens do have the advantage of low initial and repair costs and ease and speed of installation. Although the present invention contemplates the use of stationary screens, it utilizes their advantages, and at the same time, circumvents the above-mentioned disadvantages.

In an effort to increase the efficiency of screening or sifting techniques, sifting devices have been provided which impart a relative motion to the screen or other separating element. These devices have included revolving screens, such as simple, compound and conical, and prismatic trommels have been provided, which have particular application in flour mills. The revolving screens later were improved by oscillating screens which afforded higher capacity, and by shaking the screens which were fairly efficient in sizes coarser than one-half inch, but in finer sizes the capacity was low if high efficiency was desired. The chief disadvantage of shaking the screen is high cost of maintenance both of the screen and the supporting structure.

Where large capacity and high efficiency were desired in the past, the use of vibrating and oscillating screens was standard practice. The capacity, especially in the finer sizes was much greater than other screens and materially reduced the grinding effect. However, there was considerable wear of the screen material, the supporting structure and of the various parts providing the oscillation or vibration to the screens. In fact, where it is desired to provide exacting size control, it becomes particularly important to replace vibrating screens quite often to insure exact mesh size.

In the case of testing or control wherein the specifications call for definite sizes of material, it has been the conventional practice to use devices which consist of a receptacle to hold a series of superimposed sieves of standard mesh size and a motor driven shaker which imparts to the sieves both a circular and a tapping motion. The tapping motion is imparted to a cover placed over the series of sieves and there is a tendency to cause the superimposed sieves to stick to one another, necessitating considerable time for their separation, and very often causing damage to the sieves by the use of tools for prying them apart. Sifting devices of this nature also have been found to actually force particles through the meshes by the tapping action, and have permitted particles to pass through a particular screen size which ordinarily would not pass a stationary screen unless forced therethrough. In certain cases relatively elongated particles have also been found to pass through these sieves which obviously tend to negative the results when used for standardization purposes. This has been verified from the use of glass beads which were supplied as standards to be used for control purposes. A number of the beads, upon resifting in a device of the present invention, were found to have been fused together, providing a relatively elongated structure, which, in a particular size range, would ordinarily not have passed through the sieve of a particular size unless forced therethrough. Thus, standardization control samples which were supplied for purposes of standardization were found not to be a true standard when closely examined, whereas the apparatus of the present invention has successfully provided sample after sample of standard size particles, without any indication of weight variation of graded sample amounts between siftings.

The present invention contemplates the use of one or more screens or sieves disposed with their respective mesh openings transversely of an oscillating column of air passing therethrough. The screen or screens are preferably stationarily mounted relative to their support and are not caused to vibrate, oscillate or rotate in any manner relative to the stream or the sifted particles. The air column is preferably provided by means such as a conventional audio speaker driven by a power amplifier and an audio oscillator circuit of conventional construction. The circuits may be of fixed power and oscillation for production purposes wherein the sifted materials are always to be of the same composition and are to be sifted to the same size. However, for broadest operation, it is desirable to provide variable power amplifiers and audio oscillators to permit greater versatility.

It is an object of the present invention to provide an improved method of sifting particulate material, wherein the material is spread uniformly over the surface of a sieve, subjecting the material and sieve to a transversely disposed column of reciprocably moving air at desired cyclic intervals and with sufficient energy to raise the material from the sieve as the air moves towards the material from below the sieve and then to urge the material in a direction towards the screen as the direction of air movement is reversed.

It is another object of the present invention to provide an improved sifting apparatus including a sieve or sieves for screening or sifting a particulate material by means of subjecting the material to be screened to the action of an oscillating air column transversely of the sieve or sieves.

It is a further object of the present invention to provide a sifting apparatus which includes a sieve or sieves disposed in a chamber communicating with an oscillating diaphragm arranged to cause a corresponding oscillating air motion at the vicinity of the relatively stationary sieve or sieves to impart movement to particles being sifted and which includes means for providing cyclic motion to the oscillating diaphragm.

It is a more specific object of the present invention to provide an improved sifting apparatus comprising a sieve or series of superimposed sieves disposed in a chamber communicating at one end with an oscillatory diaphragm and an electromagnetic vibrator operatively associated with the diaphragm to impart oscillatory motion thereto, and to thereby impart cyclic motion to air or other gas residing in said column to impart a cyclic motion to the particulate material to be sifted.

It is another specific object of the present invention to provide a specific embodiment of the sifting apparatus which includes a pair of electromagnetic vibrators supplied from a common energy source comprising a conventional audio oscillator and power amplifier and with the respective polarity of the core of each vibrator adjusted to provide alternate reciprocal motion to the oscillatory diaphragms respectively driven thereby, wherein the apparatus may be adapted for simultaneous sifting of material into two size gradations and wherein the chamber may be sealed from atmosphere and contain a gas which is inert to reaction with the sifting material.

The apparatus of the present invention is adaptable to a production sifting mechanism, wherein a single screen is used to provide a desired size range, and also for use in a standardizing or separating apparatus for providing the separation of a given amount of material of conglomerate size mixture into various sieve sizes by means of conventional superimposed sieves, each having a standard mesh, the largest mesh being uppermost relative to sieves of lesser mesh size.

With reference to the drawings:

FIG. 1 is a side elevational view, partially in section, of an apparatus embodying the present invention, wherein a series of superimposed sieves of varying mesh are used for separation of a particulate material into various size gradations;

FIG. 2 is a vertical sectional view taken on lines 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view of the apparatus taken in the plane of lines 3—3 of FIG. 2 and particularly illustrating the preferred relationship of the speaker cone with the series of superimposed sieves;

FIG. 4 is a side elevational view of a production type embodiment of the present invention;

FIG. 5 is a vertical sectional view taken along lines 5—5 of FIG. 4;

FIG. 6 is a schematic circuit diagram illustrating the supply circuit for the air column vibrating mechanism;

FIG. 7 is a sectional view taken on a plane comparable to the plane of FIG. 5 of still another embodiment of the present invention;

FIG. 8 is a schematic circuit diagram illustrating a supply circuit for the embodiment of FIG. 7.

Referring in particular to the embodiment of FIGS. 1–3, it will be apparent that the apparatus of the present invention may be adapted for use in conjunction with a stack of superimposed cylindrical sieves to provide an improved separatory grading and sifting device. The stacked sieves may be removably disposed in the apparatus for lateral withdrawal and replacement, without requiring separate hand removal operations of fastening nuts, bolts or other clamping means. As illustrated, the apparatus includes a supporting base comprising a base plate **10** secured at each side to vertically disposed panels **11** to provide opposed open ends. The upwardly projecting side panels **11** and the base plate **10** provide support for a removable drawer member **12** resting, as shown in FIG. 1, against a rear stop member **13**. The upwardly projecting portions of the panels **11** further support a laterally slidable sieve supporting member **14**, by means of opposed channel members **15**. Handles or drawer pulls **16** and **17** are respectively provided for the drawer **12** and the sliding sieve support **14**. It is to be noted that the present construction provides a gap or air space **18** between the drawer **12** and the member **14** for purposes hereinafter described.

As shown in FIG. 2, tubular upright members **19** and **20** are oppositely disposed from one another at either side of the base plate **10**, and are fastened by means of welding or other suitable means to the side panels **11**. The members **19** and **20** extend upwardly of the base to provide a slidable support for a conventional electromagnetic speaker **25**, such as those conventionally used in the audio circuit of radio and television receivers. The speaker **25** is supported for axial movement relative to a stack of superimposed sieves **26**. Thus, the speaker may be moved in opposed vertical directions to be seated directly upon one or more of the superimposed sieves **26**, and may be raised to permit lateral withdrawal of the sieves by means of the slidable sieve support member **14**, as shown in phantom position in the view of FIG. 1.

The speaker **25** is mounted coaxially to a similarly configured opening **27** in a speaker support member **28**, which member may be of plywood or the like. The member **28** is slidably fastened to the tubular support members **19** and **20** by means of laterally extending guide members **29**. The opening **27** is preferably covered at the bottom of the support **28** by means of a flexible membrane **30**, which may be rubber or similar material. The membrane is principally used for protection of the components of the speaker **25** from contact with dust or fines evolved during the screening and separating process, as hereinafter described. It is preferable to totally enclose the speaker as shown, by means of flexible side panels **31**, in order to prevent dust from entering into the components of the speaker. The side panels **31** are supported between the lower support member **28** and an upper support member **32**, which may also be slidably fastened to the upright support members **19** and **20** by means of laterally extending guide member **33**. The entire enclosure is held in spaced relationship by means of the corner straps **34**. Supported from the top of the vertical uprights **19** and **20** is an air cylinder **40** having a reciprocating plunger (not shown) and attached to a conventional valve (not shown) arranged for communication with an air supply to provide a means of alternatively raising and lowering the speaker unit from and to the position shown in phantom lines of FIG. 1. The unit may be moved between the respective ends of the upright support members **19** and **20** to be disposed at any desired position therebetween.

The speaker **25** is of conventional design, and provides an oscillatory conical diaphragm **41** mounted in a protective support **42**, including spaced openings **42*a***, and may include a reinforcing inner diaphragm portion **43**. The conical diaphragm is secured at its inner end to the armature **44** associated with an electromagnetic core **45**. The conventional moving coil and magnetizing coil are not specifically illustrated, but complete the usual operating circuit components of the speaker unit in a conventional manner.

The sieves **26** of the present embodiment are of conventional construction and are placed in the usual manner with the sieve of larger mesh opening being placed uppermost of the stack. Such arrangement permits separation of the material into lesser sizes downwardly relative thereto. These sieves are disposed substantially coaxial of an opening **48** in the sieve support member **14** by inserting the ring **46** of the lowermost sieve member **26** inwardly of the opening **48** and supporting the same by means of the radially extending flange **47**, and then stacking the desired number of sieves in superimposed telescoped relation thereon.

In order to sift, the slidable sieve support **14** is moved laterally outwardly to the phantom position of FIG. 1

and the particulate material to be sifted is spread evenly over the surface of the screen of the uppermost sieve **26** to take full advantage of the area provided and to provide full effect of the air acting thereon. The member **14** may then be moved inwardly while the speaker unit is in its upper (phantom view) position. The speaker cone **25** is then brought into the solid line position, with its membrane **30** resting upon the upper edge of the uppermost sieve **26** of the stack. The membrane **30** will also act as a sealing gasket between the uppermost sieve and the speaker **25**. The speaker **25** is electrically connected to a conventional audio oscillator and power amplifier as illustrated diagrammatically in FIG. 6. The oscillator and power circuits are energized from their respective power supply and tuned to the desired frequency and amplitude.

It will be apparent that after the cone, or diaphragm **41** of the speaker **25** is set into vibration that it will cause the column of air existing in the chamber enclosed by the diaphragm to be reciprocably moved. The air gap **18** is provided as a means of permitting air to be moved inwardly and outwardly and to prevent dampening of the speaker caused by an entirely closed column. The screens or sieves **26** remain relatively stationary with respect to the air column movement and the only action provided to encourage sifting is caused by the movement of the air induced by the properly tuned vibration of the speaker. It has been found to be quite satisfactory in the case of sifting glass beads between 30 and 100 mesh screen size to provide a power input of 25 watts to the speaker **25**, at a frequency range of between 25 and 50 cycles per second. A screen diameter of 8 inches and a standard 12 inch speaker was used to completely sift 200 grams of material into 40 grams each of 30, 40, 60, 80 and 100 standard mesh glass bead size in 30 seconds. Whereas, the same amount took almost five minutes to provide equivalent sifting in a conventional rotating sieve subjected to periodic tapping.

If the frequency is increased beyond the desired frequency of 45 cycles per second, a granular material tends to cake and obstruct at least certain portions of the sieve. Too low a frequency may permit air to pass through the interstices between the particles and not provide sufficient motion to lift the particles from the screen, although in many instances, lower frequencies have proved satisfactory, depending upon the material to be sifted.

To most graphically illustrate the successful operation of the device, a sample of ordinary wheat flour was sifted through a 325 mesh screen, in which the mesh opening is 0.0017 inches, whereas flour has not heretofore been effectively sifted by the usual circulating or oscillating screens, even with the tapping feature.

To illustrate the effectiveness and accuracy of sifting by the present apparatus, standard glass beads specified as U.S. Standard Sieve Size, or Tyler equivalent, were purchased in No. 30, No. 40, No. 60, No. 80 and No. 100 sieve sizes for purposes of evaluation. The glass beads provide a satisfactory standard as they do not have the usual difficulties associated with materials having fines and a tendency to cling to one another, as in the case of crushed clay, talc or the like. Forty grams each of the respective bead sizes were thoroughly mixed together and placed in a conventional rotating and tapping device.

As a comparison, a standards evaluation was made of the present embodiment using glass beads of standard size, which the supplier stated were prepared in accordance with U.S. Bureau of Standards accepted techniques. Beads of the various standard sizes were accurately weighed into 40 gram samples of each size and were thoroughly mixed and spread evenly over the surface of the uppermost sieve. The speaker used included a 10½ inch diameter cone, and was provided with a 25 watt input at a frequency of 32 cycles per second. The Table I, hereinbelow, sets forth the respective weights sifted for 30 second and 1 minute operations, with and without the rubber membrane **30** on the speaker **25**. It will be apparent from the results that the membrane has little or no effect on the operation of the device, but merely acts as a dust protector for the speaker components.

TABLE I

Standards Evaluation

Standard Sieve Size	Without Rubber Membrane		With Rubber Membrane	
	30 Seconds Operation, gms.	1.0 Minute Operation, gms.	30 Second Operation, gms.	1.0 Minute Operation, gms.
30 mesh	40.7	40.6	40.3	40.2
40 mesh	41.5	40.7	40.8	40.5
60 mesh	38.3	38.7	39.1	39.3
80 mesh	40.3	40.0	40.4	40.0
100 mesh	38.5	39.3	38.7	39.3
Dust	.3	.3	.3	.3
Total	199.6	199.6	199.6	199.6

It will be observed from Table I that the variation between the 30 second operation and 1 minute is negligible in amount sifted. Similar tests made on conventional apparatus in accordance with the technique set out in the U.S. Bureau of Standard Procedures Powder Sifting, as outlined in the Chemical Engineer's Handbook, 1952 edition, pages 962–964, took five minutes or more to obtain results not nearly as consistent. It was also found that the beads, which were supplied as being standard, were not, in fact, of uniform size, as there were a number of elongated particles which appeared to be the result of fusing together two or more glass particles. The elongated particles pass through the standard sieves under the conventional test techniques and apparatus, but were segregated by the apparatus of the present invention, to provide a true control standard.

High speed, magnified movies taken at the rate of 2000 frames per second for about 1.5 second period clearly illustrated, when projected at normal speed, that sifting was substantially completed of a pre-weighed amount of 80 mesh size material mixed with larger sized material through an 80 mesh screen within this short period. The air column tended to lift the particles from the screen and alternatively permit the appropriate size to pass through the mesh opening without visible vibration of the screen.

The apparatus and sifting method in accordance with the present invention is especially useful for the separation and screening of compositions having relatively large amounts of fines caused by crushing and other preparatory operations, such as raw materials for ceramic and ferrite production. The usual sifting techniques in these industries require batch handling in devices having vibrating screens, which are replaceable at relatively short intervals, and which techniques are also very time consuming.

To illustrate another important application of the present method and apparatus, at times it becomes important to screen or sift particulate matter having properties not conducive to conventional screening techniques. For instance, in certain applications of epoxy resins sizing of particles becomes important. Heretofore, certain of the epoxys could not be satisfactorily screened as it becomes tacky at room temperature under even slightly humid conditions. In addition, the material exhibits a "balling" or "rolling" effect upon the surface of conventional rotating screens. What little material does go through the mesh openings, tends to clog the openings because of its "sticky nature."

The method and apparatus of the present invention provide a very convenient means of sifting materials even of the nature of the above-mentioned epoxy resins. The resin was sifted in the apparatus of the embodiment of FIGS. 1, 2 and 3, using a series of screens comprising Nos. 30, 40, 60, 80 and 100 mesh screens. A 400 gram sample was sifted through this stack in 30 seconds or less.

Another embodiment of the apparatus of this invention, suitable for production purposes, is illustrated in FIGS. 4 and 5, wherein a removable sieve **50** is mounted in a housing **51** and adapted to be interchangeable with sieves of different mesh size. Like reference numerals denote like parts throughout the several embodiments. In production facilities, it is the usual practice to sift the material through a single desired screen size, as it is recovered for a specific purpose. The housing **51** includes a slidable product drawer **52** for removal of the sifted material of desired size. Another very important aspect discovered during investigation and trial of the present device, is that as the speaker **25** moves the air column in reciprocal fashion, the fines denoted by the reference numeral **53**, appear to be separated at the very beginning of operation. This provides immediate separation of the fines **53** from the unsifted raw material **54** almost simultaneously with its entry from the hopper **55**. Thus, two separate piles of sifted material are formed for added ease in separation—a pile of fines **53** directly below the entrance opening **57** and a pile of sifted material **56**. The screen **50** is preferably placed at an angle to permit the oversize particles to run off at the exit opening **59** under the influence of gravity. A satisfactory means for tilting the apparatus for this purpose is provided by adjustable legs **60**. The screen **50**, as aforementioned, is adapted for replacement and interchangeability, and lock into position by means of the cammed surface clamping members **61** rotatably mounted on the housing **51** and arranged for frictionally gripping the screen **50**.

In certain cases it has been found to be more efficient to provide twin speaker cones **70** and **71** as shown in the embodiment of FIGS. 7 and 8, the action of which may be arranged to permit a sealed housing, if desired. The speakers **70** and **71** are each connected to a power amplifier and audio oscillator, as in the case of a single speaker installation, and as specifically illustrated in FIG. 8. The polarity of each speaker is adjusted for alternating cyclic operation. The material to be sifted is fed through the separate housing portions **72** and **73** respectively including sieves **74** and **75**. The sieves may be of the same or different mesh size.

The present embodiment provides a versatile unit of increased capacity from the twin speakers acting upon air or other gas in the chambers **72** and **73**. The present structure may be totally enclosed as there is no necessity for air to be permitted access and egress, as it will merely be shuttled back and forth between the opposed chambers **72** and **73** through the chamber **76**. Sliding drawers **77** and **78** are disposed in the chamber **76** to receive sifted material in the same manner as the drawers of the previously described embodiments. The present embodiment thus permits an entirely enclosed structure in cases where a dust-free atmosphere is essential to ancillary operations or procedures. In addition, the enclosure may be filled with inert gases, in cases where air might affect the particular material to be sifted.

In each of the illustrated embodiments the power and frequency may be varied to suit the sifting material, according to its size and weight. From the aforementioned high speed moving pictures, it appears that only power sufficient to motivate the particular particles and to raise them above the screen level for purposes of permitting smaller particles to pass therethrough. The smaller particles appear to pass through the screen mesh due to a combination of gravitational action and action of the reciprocating air flow as it is moved in a direction towards the screen. It is also apparent that a steady stream of air in one direction does not effectively provide the desired operation. The air should be supplied in reciprocal or oscillating motion, in order to permit the lighter particles to fall through the mesh, rather than to be forced upwardly under fluid pressure in a steady stream. The period of reverse flow, or at least intermittent flow permits the particles to have access through the openings, the larger particles being forcibly moved upwardly away therefrom.

In most conventional sifting devices it is necessary to clean the screens by means of a wire or other brush to remove particles which have become lodged in the mesh openings. Very often the particles are securely wedged because of being subjected to pounding action, causing undue wear and abrasion by brushing of relatively fine mesh screens. The screens, when used in the present apparatus, may be cleaned in most cases by simply inverting them and gently tapping the supporting edges upon a stationary object. Rarely has it been found that particles have become so tightly wedged in the meshes that brushing was necessary to dislodge them.

Investigation has further established that the speaker may be transversely disposed at either the top or bottom end of the housing, oppositely spaced from the screen or sieve, and work effectively. It will be apparent, however, that when disposed under the screen (not shown), provision must be made for either protecting the speaker diaphragm or the protective membrane, or both, from an accumulation of sifted particles settling thereon. Such accumulation tends to dampen the vibration and adversely effect the operating efficiency of the vibrating member.

It is to be understood that the term "air" as used throughout the description and claims of the present invention is to be considered in its broadest sense to include any gaseous atmosphere capable of providing the results obtained by a reciprocably moving column of air. For instance, in cases where atmospheric air may have an adverse effect upon the material to be sifted, the terminology would equally apply to the substitution therefor of an inert gas to provide the desired sifting function.

I claim:

1. In a sifting apparatus the combination comprising a gas-containing chamber; a sifting screen placed across the chamber; an electrically responsive speaker providing a closure for one end of said chamber and including a vibratory diaphragm arranged to impart an oscillating motion to the gaseous column in said chamber; and an electrical oscillator connected to the speaker for imparting oscillations of desired frequency to said vibratory diaphragm.

2. In a sifting apparatus the combination comprising an air chamber; a sifting screen disposed within the chamber; a flexible protective membrane placed across and sealing off one end of the chamber; and an electrically responsive speaker positioned outside said membrane and including a flexible, oscillatory diaphragm disposed across the end of the chamber, whereby oscillations of the diaphragm create an oscillating air column within said chamber that is transmitted through said membrane.

3. In a sifting apparatus the combination comprising a pair of enclosed, communicating gas-containing chambers; a sifting screen disposed within each of the respective chambers; a pair of flexible diaphragms respectively disposed to enclose one end of each member of said pair of chambers; electromagnetic vibratory means arranged to oscillate each of said respective diaphragms in alternate phase relationship; whereby oscillations of each diaphragm alternately create an oscillating gas column within each of said chambers.

4. In a sifting apparatus the combination comprising a pair of enclosed communicating gas-containing chambers; a sifting screen disposed within each of the respective chambers; a pair of electrically responsive speakers each including a flexible diaphragm disposed to enclose one end of each of said pair of chambers and each including electromagnetic vibratory means arranged to oscillate each of said respective diaphragms; a common electrical circuit for said speakers, said electromagnetic means arranged in said circuit for alternate relative oscillation of the respective diaphragms; whereby oscillations of each diaphragm alternately create an oscillating gaseous column within each of said chambers.

5. In a sifting apparatus the combination comprising a pair of substantially parallel air chambers; a sifting screen disposed within each of the respective chambers; a transversely arranged air chamber communicating with one end of a respective one of said pair of air chambers to provide an enclosed continuous chamber therewith; a pair of flexible diaphragms respectively disposed to enclose the opposite ends of each member of said pair of air chambers; electromagnetic vibratory means arranged to oscillate each of said respective diaphragms in alternate phase relationship; whereby oscillations of each diaphragm alternately create an oscillating air column within the enclosed system provided by said pair of chambers and said communicating air chamber.

6. In a sifting apparatus the combination comprising a pair of substantially parallel air chambers; a sifting screen disposed within each of the respective chambers; a transversely arranged air chamber communicating with one end of a respective one of said pair of air chambers to provide an enclosed continuous chamber therewith; a pair of electrically responsive speakers each providing a closure for the opposite end of a respective chamber and each including a vibratory diaphragm and electromagnetic means arranged to oscillate each of said respective diaphragms; a common electrical circuit for said speakers, said electromagnetic means arranged in said circuit for alternate relative oscillation of the respective diaphragms; whereby oscillations of each diaphragm alternately create an oscillating air column within the enclosed system provided by said pair of chambers and said communicating air chamber.

7. In a sifting apparatus the combination comprising: a gas containing chamber; a sifting screen placed across the chamber to intercept and have gas vibrating longitudinally within said chamber pass back and forth through such screen; a vibratory diaphragm enclosing an end of said chamber whereby oscillations of the diaphragm will create longitudinal vibrations of gas in said chamber that are of a width substantially coextensive with that of the diaphragm; and electrical vibratory means associated with said diaphragm to oscillate the same in response to the vibratory means at frequencies greater than 25 cycles per second.

References Cited in the file of this patent

UNITED STATES PATENTS

796,553	Baugh	Aug. 8, 1905
1,729,579	Hayes	Sept. 24, 1929
2,283,051	Fuller	May 12, 1942
2,312,712	Hartline	Mar. 2, 1943
2,787,444	Skarstrom	Apr. 2, 1957

FOREIGN PATENTS

475,352	Great Britain	Nov. 20, 1936