ELECTRODE VIBRATING APPARATUS

Harry A. Wintermute, Plainfield, N. J., assignor to Research Corporation, New York, N. Y., a corporation of New York

Application December 9, 1955, Serial No. 552,151

14 Claims. (Cl. 183—7)

The present invention relates to new and useful improvements in vibrating systems for electrical gas cleaning equipment and more particularly and specifically to new and useful magnetic vibrating apparatus for the collecting plate systems of electrostatic precipitator equipment.

Conventional rapping apparatus for collecting plates of gas cleaning apparatus generally includes a positively activated rapping bar which is either rigidly connected to the collecting plates or which is provided with hammer formations for striking the collecting plates of the system. Direct acting power means are operably connected to these rapping bars to cause rapid reciprocating, or oscillating, movement of the bars which in turn vibrate the collecting plates to which they are attached, or to rapidly strike plates in the case of rapping hammers, for dislodging materials precipitated upon the plates.

It has been discovered that the use of conventional rapping apparatus which directly contacts the collecting plates of the precipitator system has decided disadvantages which reduce the efficiency and effectiveness of collecting plate cleaning. For example, rapping apparatus which includes a rapping bar in direct contact with the collecting plates of a gas cleaning system produces a dampening of the vibratory movements of the plates through the braking effect created by the rapping bar being rigidly fastened between the plates and the bar driving mechanism. This dampening of the collecting plate vibration induced by the rapping apparatus greatly reduces the effectiveness of the plate vibration in dislodging precipitated matter from the surfaces of the plates.

Further, where a single rapping bar serves to produce vibration of a plurality of plates in a collecting plate system substantial differences often occur in the degree of vibratory motion set up in different of the individual plates in the system by reason of varying tolerances and clearances, plate thicknesses, plate spacing and plate alignment within the system. The occurrence of such variations in vibratory motion between the several plates in a collecting system substantially impairs the efficiency and effectiveness of the cleaning apparatus because the deposited accumulations on the several plates are not evenly removed leaving certain of the plates less effective than others in accumulating or collecting precipitate from the gas being cleaned.

Still further disadvantages inherent in conventional rapping apparatus are occasioned by the fact that rapping bars either fixed rigidly to the collecting plates or physically striking the plates tend to establish uneven stresses and strains within the plates by reason of such localized contact therewith thereby tending to structurally weaken the system and producing conditions which require frequent maintenance and repair of the gas cleaning apparatus.

It is, therefore, a general object of the present invention to provide new and improved apparatus for gas cleaning equipment which serves to overcome and eliminate many of the disadvantages and problems inherent in prior constructions.

A primary object of this invention lies in the provision of vibrating apparatus for electrical precipitation equipment wherein heretofore objectionable fixed connections between the actuator bars of the apparatus and the collecting plates of the precipitator are eliminated.

Another object of this invention is the provision of vibrating apparatus for gas cleaning equipment which, by eliminating fixed connections between actuating bars and collecting plates, serves to substantially increase the efficiency and effectiveness of the apparatus.

A still further object of this invention resides in the provision of vibrating apparatus for the collecting plates of gas cleaning equipment which, through elimination of dampening effects in the vibration of the collecting plates, provides for substantially increased displacement of the collecting elements.

A further object of this invention is the provision of vibrating apparatus for the collecting plates of gas cleaning equipment which employs a system of magnetic fields between the vibration apparatus and the collecting plates for producing vibratory motion in the collecting plates without rigid connection or contact between the apparatus and the collecting plates.

Still another and important object of this invention is the provision of efficient vibrating apparatus which produces high frequency vibration of collection plates of gas cleaning equipment without physically contacting the plates thereby eliminating uneven stresses and strains in the collecting plates.

Still another object of this invention is the provision of vibrating apparatus which is equally adaptable to utilization with either rotary or reciprocating actuator bars.

Yet another object is the provision of vibrating apparatus utilizing either permanent or electro-magnetic constructions for producing vibratory movement of the collecting plates within the cleaning system.

A still further object of this invention is the provision of new and improved vibrating apparatus for the collecting plates of gas cleaning systems which is of simple and relatively inexpensive design and construction and which is effective in operation with a minimum requirement of upkeep and replacement.

Still further objects and advantages of this invention will become more readily apparent to those skilled in the art when the following general statement and description of the invention are read in the light of the accompanying drawings.

The nature of the present invention may be stated in general terms as relating to improved apparatus for inducing vibratory motion of the collecting plates of electrical precipitation apparatus wherein the collecting plates of the gas cleaning system are provided with a series of magnets affixed thereto at predetermined locations, an actuator bar extending at right angles to the collecting plates in spaced relation to the magnets on said plates, magnets carried by said bar in complementary relationship to the magnets on said collecting plates, and means for inducing movement of said bar to vary the positions of said complementary magnets into and out of magnetic relationship.

Referring to the accompanying drawings wherein like numerals designate similar parts throughout the several views:

Fig. 1 is a top plan view of gas cleaning apparatus incorporating the present invention.

Fig. 2 is a fragmentary vertical section taken on line 2—2, Fig. 1.

Fig. 3 is a top plan view similar to Fig. 1 of a modified form of the invention.
In this form of construction, when the vibration apparatus is in an at-rest position (as shown in Fig.1) a pair of diametrically opposed magnets are supported by the actuator bar in axial alignment with the magnets on the spaced adjacent vertical edges of each pair of aligned plates between the two banks of collecting plates within the precipitator. Thus, upon activation of the vibration apparatus, the actuator bar will, under the influence of the oscillating drive motor, be reciprocated perpendicularly to the collecting plates thereby causing oscillation of the magnets on the bar relative to the magnets on the collecting plates. Rapid oscillation of the magnets on the bar relative to the magnets on the collecting plates, where the adjacent poles of such magnets are of like pole characteristics, will cause the magnets on the collecting plates, through the opposed forces of like poles, to oscillate in opposition or out of phase with the magnets on the bar creating high frequency vibrations in the collecting plates for the purpose of dislodging precipitated material from the surfaces of the plates.

It is possible to provide unlike pole characteristics between the magnets and through non-magnetic shields in the shell, across the shell in magnetic contact with the vertical edges of the plates in each bank remote to the vertical edges of such plates which are spaced on either side of the actuator bar. Magnetic coulons on the yoke establish electro-magnetic circuits through the pole arms to the collecting plates to magnetic pole tips on the adjacent vertical edges of the plates in the same location as the magnets in the structure disclosed in Fig.1. Likewise, the bar which oscillates in contact with yoke disk in a plurality of pole tips and non-magnetic shields. The pole tips are located in corresponding positions to the location of the magnets in the disclosures of Fig.1.

By this construction oscillation of the bar under the influence of the push-pull-type oscillating drive motor in magnetic contact with yoke disk will cause rapid oscillation of the pole tips on the bar relative to the pole tips on the adjacent edges of the collecting plates. Thus, when the pole tips and are energized through the magnetic coil on yoke oscillation of the pole tips will induce movement of the pole tips in coincidence therewith thereby setting up rapid vibrations in the collecting plates of the precipitator.

In Fig.4 of the drawings there is illustrated a modification of the electro-magnetic arrangement disclosed in Fig.3 wherein the single pole tips on the actuator bar of the apparatus disclosed in Fig.3 are each replaced by an arrangement of plural armatures so arranged as to produce vibration of the collecting plates through the electromagnetic attraction of cooperating pole tips.

In the vibrating apparatus disclosed in Fig.4 of the drawings in combination with the collecting plate system of an electrical precipitator the complementary pole tips on the actuator bar and on the collecting plates are so arranged as to maintain a closed, electro-magnetic circuit throughout the operation of the vibrating apparatus.

The construction of the apparatus disclosed in Fig.4 includes a precipitator shell having typical end to end aligned banks of collecting electrode plates. An actuator bar extends across and through non-magnetic shields at right angles to the plates and spaced inter-
mediate the adjacent edges of the plates in the two spaced banks.

An electro-magnetic yoke 56 provided with two coils 57 is located externally of the shell and has a pair of parallel arms 55 and 56 extending into the shell through non-particular offset pole tips 62 with each arm making electro-magnetic contact with the extended ends of the plates in one or the other of the two banks of plates in the precipitator. The bar 54 which is provided with a push-pull motor externally of the shell extends through said yoke in electro-magnetic contact therewith.

The pole tips 62 on each plate in each bank adjacent the actuator bar 54 are provided with pole tips 62 disposed toward the axis of the bar. The bar in turn is provided with an arrangement of pole tips 64 which operate in complement with the pole tips 62 on the plates. The pole tips 64 on the bar are arranged in varied formations relative to the several plates in the collecting system. Basically there are three arrangements of pole tips 64 on the actuator bar which three arrangements occur serially longitudinally of the bar so that every fourth arrangement of pole tips is identical along the length of the bar.

Taking, for purpose of illustration, the three adjacent plate pole tip and bar pole tip arrangements designated in Fig. 4 as A, B and C the cooperative functions of the varied arrangements above mentioned will become readily evident.

In arrangement A it is seen that actuator bar 54 is provided on one side thereof adjacent the pole tip 62a on the plate in one bank with two pole tips 64a and 64b which are spaced apart on the bar an equal distance on either side of the centerline of the pole tip 62a. At the same time a single pole tip 64c on the opposite side of the bar is aligned with the adjacent pole tip 62b on the adjacent plate in the second bank of the precipitator.

In the next pole tip arrangement B along the bar the pole tips 64c are provided on the one side with a pair of pole tips 64d and 64e which are spaced apart longitudinally of the bar an equal distance to the spacing of pole tips 64a and 64b, corresponding to the lateral width of the pole tips 62a and 64. However, in this arrangement, pole tip 64d is aligned with the pole tip 62c on the adjacent plate 52 while pole tip 64e is offset longitudinally of the bar in the direction of arrangement C. At the same time a single pole tip 64f extends outwardly from the opposite side of the bar and is offset toward arrangement C from the centerline of the pole tip 62d on the adjacent plate 52 in the second bank a distance equal to one-half of the offset spacing of pole tip 64e from the pole tip 62c.

In the third pole tip arrangement C longitudinally of the bar 54 on one side of the bar is provided again with two pole tips 64g and 64h where tip 64g is aligned with the pole tip 62e on the adjacent plate on one bank and pole 64h is offset longitudinally of the shaft a distance equal to the spacing of pole tips 64g and 64h. On the second side of the actuator bar a single pole 64i projects outwardly offset from the centerline of the pole tip 62f on the adjacent plate in the second bank of the precipitator toward arrangements A and B a distance equal to one-half the longitudinal spacing of pole tips 64g and 64h.

It is to be kept in mind that two electro-magnetic circuits are provided from the yoke, one through each of the arms, the plates of the bank contacted by said arms, the pole tips 62 on the plates, through the adjacent pole tips 64 on the actuator bar, through the bar and back to the yoke with which said bar maintains contact. Thus, by the particular offset pole tip formations in each of the group arrangements A, B and C it can be seen that oscillation of the bar between its mean limits in each direction will alternately place one or the other of the pole tips 64 on each side of the bar in cooperative circuit closing alignment with its adjacent plate supported pole tip 62 preventing breaking of both electro-magnetic circuits and avoiding arcing and loss through the full cycle of bar movement and at the same time alternately attracting the pole tips 62 on the collecting plates 52 in one direction and then the other to produce high frequency vibration of the plates for cleaning purposes.

In Figs. 5 through 8 of the drawings the basic concept of the present invention are illustrated as adapted to a rotating actuator bar utilizing permanent magnets for the purpose of inducing vibration of the collecting plates of the precipitator for dislodging accumulated materials.

In Fig. 5 of the drawings there is illustrated a precipitator construction including a shell 65, a plurality of collecting plates 66 arranged in two banks of end to end aligned plates with an actuator bar 68 extending at right angles to and intermediate the spaced adjacent edges of the plates in each bank. One end of the bar extends through a seal in the shell where it is operably connected to a rotary drive motor 70 with the second end of the bar being journaled in a bearing 72 in the opposite wall of the precipitator shell.

Each of the collecting plates 66 in each bank is provided on its edges adjacent the bar with a section of magnetic material 74. At the same time the bar is provided in association with each pair of aligned plates with two permanent magnets 76 which project radially from the bar to overlap the adjacent plate on one side thereof and rotate into and out of alignment with the magnetic materials on the opposed adjacent plates of the collecting system.

In this construction the magnets associated with each end to end pair of collecting plates between the two banks extend in longitudinally offset radial opposition from said actuator bar and each pair of radially opposed magnets longitudinally of the bar is angularly staggered serially throughout the length of the bar 30° apart so that in each series of six adjacent magnets along the bar thereof will always be, during rotation of the bar, one pair of magnets in overlapping relationship with the magnetic material on their adjacent plates.

In operation of this form of construction rotation of the actuator bar will alternately bring one opposed pair of magnets into operative relationship with their respective opposite plates whereupon the plates will be laterally attracted to the magnets and released from attraction as it moves out of operative relationship thus establishing vibration of the plate for the purpose of dislodging accumulated material from the surfaces thereof.

In the operation of this device there is at all times a balancing of end thrust on the actuator bar since one or another of the pairs of magnets will always be in operative magnetic relationship with their respective plates throughout the cycle of rotation of the bar.

In Fig. 7 there is illustrated a vibrating apparatus similar to that disclosed in Fig. 3 of the drawings wherein the precipitator apparatus is provided with an electro-magnetic yoke 78 having yoke arms 80 extending through non-magnetic plates 42 into the precipitator shell. Each arm has electro-magnetic connection with the collecting plates 52 in each of two banks of plates in the precipitator. The vertical edges of the plates adjacent the actuator bar 84 are provided with magnetic pole tips 86 and the bar is connected to a rotary drive motor 88 externally of the precipitator shell.

The bar is provided adjacent each pair of aligned plates with a pair of pole tips 90 extending radially from opposite sides of the bar, one pole tip being disposed on one side of the centerline of one plate in one bank longitudinally of the bar with the second pole tip being disposed on the other side of the other plate in the opposite direction longitudinally of the bar. Additionally, each pair of pole tips 90 longitudinally of the bar is radially offset 90° from those pairs of pole tips immediately on either side thereof.

In the operation of this last described construction
rotation of the actuator bar will alternately vibrate each collecting plate in each bank as the pole tips associated therewith alternately rotate adjacent one side and then the other of the pole tip on the plate. At the same time there is a substantially balanced thrust on the bar shaft occasioned by the alternately offset pair of armsatures longitudinally of the shaft.

In Fig. 9 of the drawings there is illustrated a modification of the construction shown in Fig. 5 of the drawings and described in respect thereto wherein the permanent magnets on the actuator bar in the construction shown in Fig. 5 are replaced by electro-magnetic pole tips 92 and the sections of magnetic material on the plate edges are replaced by like pole tips 94. The precipitator is also provided with an electro-magnetic yoke 96 having arms 98 in electro-magnetic contact with those edges of the collecting plates 100 in both banks remote to the rotating bar 102, and the bar rotates in electro-magnetic contact with the yoke.

It is readily evident that the operation of this modified construction embodies all of the advantages inherent in the construction described relative to Fig. 5 with the additional provision that not only is there a balance of thrust forces on the bar shaft by reason of the angularly staggered arrangement of pole tips longitudinally of the shaft but at the same time such staggered arrangement which provides for one or another of the bar pole tips being in electro-magnetic relationship with its adjacent plate pole tip at all times, prevents the breaking of the magnetic circuit during rotation of the bar.

From the foregoing descriptions of the various modifications of the present invention, it can be seen that a basic concept has been disclosed herein which embodies the use of complementary magnetic members carried by a reciprocating or rotating actuator bar and by the adjacent edges of collecting plates within the precipitator construction in which plates extend at right angles to the axis of the bar. The modifications also illustrate the use of both permanent and electro-magnets for the purpose of producing vibrations in the collection plates by moving the magnetic elements on the bar relative to the magnetic elements on the plates to produce vibratory movement of the plates.

Various modifications have been illustrated and described for the purpose of making evident the several practical and operable arrangements to which the basic concept is adaptable in carrying out the principles of this invention. Throughout all the modified forms the primary object and advantage of this invention, namely, that of providing means for vibrating collecting plates from an actuator bar while structurally eliminating any fixed contact between the bar and the plates.

1. In gas cleaning apparatus including a plurality of collecting electrode plates, vibrating apparatus including a movably mounted bar extending at right angles to the said plates, magnetic members carried by said plates in complementary relationship to the magnetic members on said bar, and means for rapidly moving said bar whereby movement of the bar carried magnetic members induces responsive movement of the complementary plate carried magnetic members.

2. A plurality of members supported for independent oscillation, an elongated movable member extending at right angles to the said plural members, complementary magnetic elements carried by said plural members and said elongated movable member, and means for moving said elongated member relative to said plural members whereby movement of the magnetic elements on the elongated member will induce responsive movement of the complementary magnetic elements on the plural members.

3. A plurality of plate members supported for independent horizontal oscillation, an elongated member horizontally supported for longitudinal oscillation at right angles to said plate members, complementary magnetic elements carried by said plate members and said elongated horizontal member, and power means for rapidly oscillating said elongated horizontal member longitudinally whereby oscillation of the permanent magnets on the elongated members will magnetically induce responsive movement of the complementary permanent magnets on the plate members.

4. A plurality of plate members supported for independent horizontal oscillation, an elongated member horizontally supported for longitudinal oscillation at right angles to said plate members, permanent magnets supported on the edges of said plate members, permanent magnets carried by said horizontal member one in complementary relationship with each of the magnets on said plate members, and power means for rapidly oscillating said elongated horizontal member longitudinally whereby oscillation of the permanent magnets on the elongated members will magnetically induce responsive movement of the complementary permanent magnets on the plate members.

5. A construction as defined in claim 4 wherein the adjacent opposed pole tips of the complementary permanent magnets on the elongated member and the plate members are of opposite magnetic polarity whereby oscillation of the permanent magnets on said horizontal member will induce corresponding magnetically responsive movement of the magnets on the plate members.

6. A construction as defined in claim 4 wherein the adjacent opposed pole tips of the complementary permanent magnets on the elongated member and the plate members are of like magnetic polarity whereby oscillation of the permanent magnets on said horizontal member will induce opposed magnetically responsive movement of the magnets on the plate members.

7. A plurality of plate members supported for independent horizontal oscillation, an elongated member horizontally supported for longitudinal oscillation at right angles to said plate members, an electro-magnetic yoke having contact with the plate members and the elongated horizontal member, complementary electro-magnetic poles carried by said plate members and said elongated horizontal member, and power means for rapidly oscillating said elongated member longitudinally whereby oscillation of the poles on the elongated member will electro-magnetically induce responsive movement of the poles on the plate members through opposed magnetic forces.

8. A plurality of plate members supported for independent horizontal oscillation, an elongated member rotatably mounted at right angles to the plate members, complementary magnetic elements carried by said plate members and said elongated horizontal member, and power means for rapidly rotating said elongated member relative to said plate members whereby rotation of the magnetic elements on the elongated member will induce responsive movement of the magnetic elements on the plate members.

9. A construction as defined in claim 8 wherein the magnetic elements on the elongated horizontal member are located in offset relationship relative to their complementary magnetic elements on the plate members whereby rotation of the horizontal member will cause rotation of the magnetic elements thereon in laterally offset relationship to the complementary magnetic elements on the plate members inducing magnetically responsive lateral movement of the magnetic elements on the plate members.

10. A construction as defined in claim 8 wherein the complementary magnetic elements on the elongated member and the plate members have adjacent opposed poles of opposite magnetic polarity whereby relative movement of the complementary members will induce responsive movement of the magnetic elements on the plate members through magnetic attraction.

11. A construction as defined in claim 8 wherein the complementary magnetic elements on the elongated member and the plate members have adjacent opposed poles.
of like magnetic polarity whereby relative movement of
the complementary members will induce responsive move-
ment of the magnetic elements on the plate members
through opposed magnetic forces.

12. A plurality of plate members supported for inde-
pendent horizontal oscillation, an elongated member rot-
tatably mounted at right angles to and spaced from the
adjacent vertical edges of said plate members, magnetic
elements carried by the adjacent vertical edges of said
plate members, magnetic elements supported abaxially
from said horizontal member, said last named magnetic
elements each being disposed in complementary laterally
spaced relationship to the magnetic element on one of
said plate members, and power means for rotating said
horizontal member to alternately dispose the magnetic
elements thereon in adjacent magnetic relationship to the
magnetic elements on said plate members whereby the
magnetic elements on said plate members will alternately
move in magnetic responsiveness to the moving magnetic
elements on the horizontal member.

13. A construction as defined in claim 12 wherein the
magnetic elements on said rotary member are disposed
longitudinally of the member alternately on opposed sides
of the magnetic elements on said plate members whereby
the end thrust forces on said horizontal member will be
equalized.

14. A construction as defined in claim 12 wherein the
magnetic elements on said plate members and said ro-
tatable member take the form of electro-magnetic poles,
an electro-magnetic yoke is provided having contact with
the plate members and the rotating member establishing
an electro-magnetic field through said plate members and
said rotatable member, and the abaxially extending poles
on said rotating members are angularly offset alternately
throughout the length of the horizontal member through
360 degrees whereby one of said pairs of complementary
poles on said rotatable member and said plate members
will always be in circuit closing relationship.

References Cited in the file of this patent

UNITED STATES PATENTS
689,483       Gilman ------------ Dec. 24, 1901
2,468,696       Westberg ------------ Apr. 26, 1949

FOREIGN PATENTS
29,073       France ------------ Feb. 3, 1925
(Second addition to 534,955)
683,488       France ------------ Mar. 3, 1930