

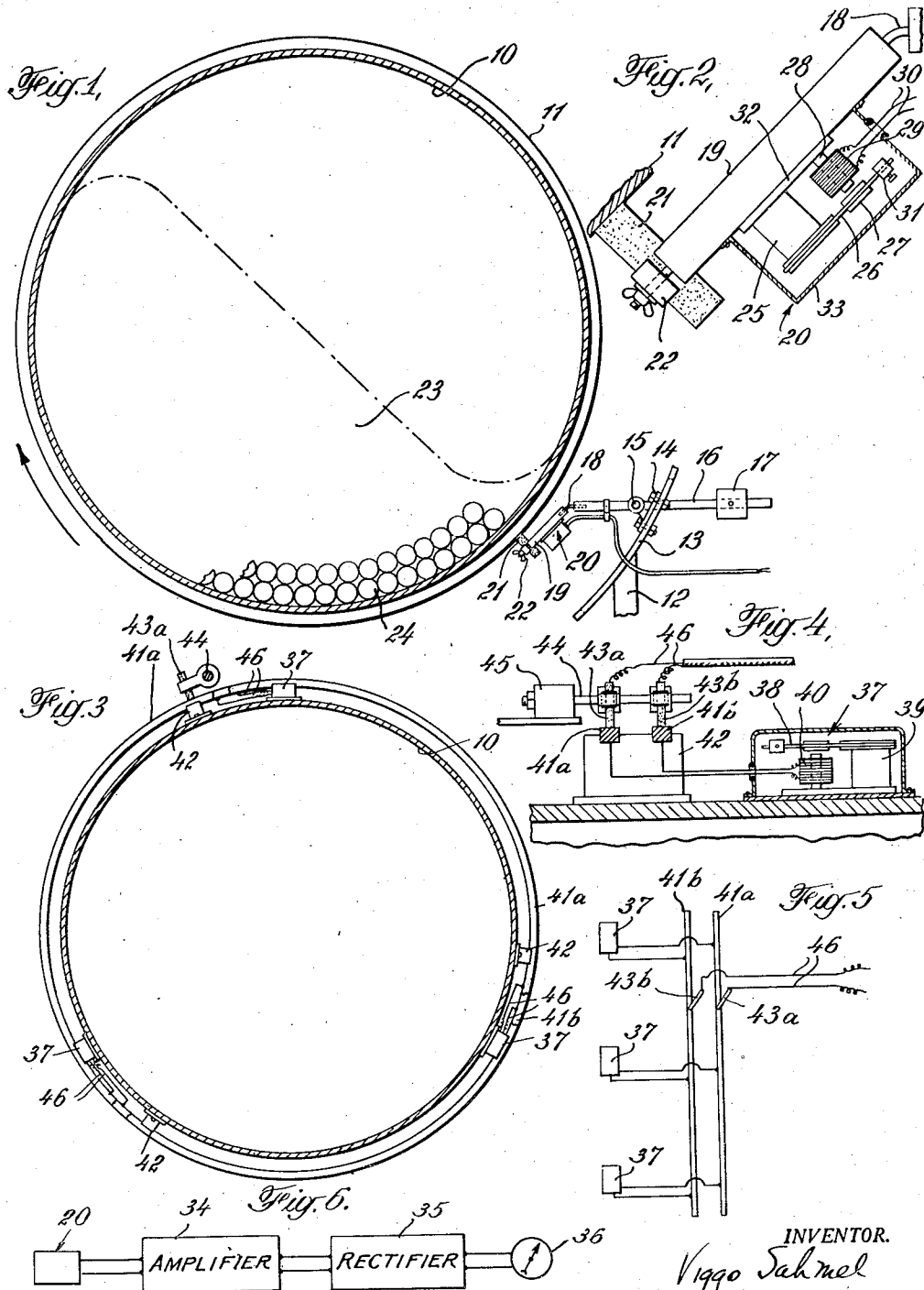
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INDICATING DEVICE FOR MATERIAL TREATING APPARATUS

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INDICATING DEVICE FOR MATERIAL
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This invention relates to apparatus in which material is tumbled with metallic balls or other bodies in a rotating shell or chamber for the purpose of crushing, grinding, drying, mixing, or feeding the material, typical examples of such apparatus being ball, tube, and rod mills. More specifically, the invention is concerned with apparatus of the kind mentioned which is equipped with novel means by which the conditions within the shell may be indicated, recorded, or controlled to the end that optimum working conditions can be maintained at all times. While the invention may be embodied in apparatus of various kinds, it may be utilized to especial advantage in mills which comprise a shell containing grinding media and the application of the invention to such a mill will be illustrated and described in detail for purposes of explanation.

In the operation of a mill, such as a ball mill, it is well known that best results are obtained only when certain conditions are maintained, and, while for complete knowledge of working conditions, the operator should be informed as to the levels of the material and the grinding media, the condition of the mill lining and of grinding media with respect to wear, and the working conditions of the screens between compartments in multi-compartment mills, ordinarily he relies mainly on indications of the material level in controlling mill operations. To provide such indications of material level to the operator, various devices are employed but all such expedients now in use are either limited in application or not wholly satisfactory in the performance of their functions.

In air swept mills, the pressure drop across the mill in the air stream flowing through the mill varies with the level of the material and such pressure drop has been utilized in devices for indicating the material level. Such devices are not of general application but may be employed only in that specific type of mill.

In mills of the horizontal type employed for wet or dry grinding, a number of different indicating devices which include parts extending into the mill chamber through the trunnion have been employed. One of these devices includes exploring tubes, which contact with the material and through which air is drawn, variations in the choking effect of the material at the ends of the tubes being used to actuate the indicating and control mechanism. Another such device includes mechanical floats or paddles riding on the material and a third device includes electrically insulated exploring rods which act as antennae for

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a high frequency oscillating system, the changing capacity effect resulting from variations in the level of the material in relation to the antennae being used to unbalance the system and to actuate relays. All these devices are limited in application to horizontal mills and they are objectionable, because the parts which extend through the trunnion constitute an undesirable obstruction to the material flow and the elements lying within the mill chamber are subject to damage and wear by the hammering action of stray grinding bodies. The device which includes the electric exploring rods has the further objection of presenting insulation problems, which arise, for example, from condensation on insulators.

Another method of indicating and controlling mill operations, which is applicable to mills of all kinds, depends on the actuation of a microphone, which is disposed outside the mill, by airborne sounds and vibrations emanating from the mill during operation. The microphone picks up a spectrum of the sounds which are translated therein into complicated wave bands of various frequencies, and tone or band filters are, accordingly, required to eliminate frequencies which have no direct bearing on mill performance. While such a control system is not affected by mill design and does not interfere with normal mill operation, it is not possible to shield the microphone completely against extraneous noises, such as those produced by adjoining mills or by repair work involving riveting or hammering. Also, since the sounds and vibrations are airborne, their effect on the microphone is weak and amplification is required in order to provide sufficient power to operate relays. While such a system offers advantages over the other types, it is subject to inaccuracies in indication and control and is, therefore, not wholly satisfactory.

The present invention is directed to the provision of a novel apparatus in which material is treated by being tumbled with metallic or other bodies in a rotating shell and which includes means by which the working conditions within the shell may be indicated, with or without a record being made, and, if desired, controlled, as, for example, with respect to the rate of feed of material to the shell, the rate of rotation of the shell, and the like. The provision of such indicating and control means, accordingly, makes it possible to maintain conditions within the shell which are found to be optimum for a certain kind and size of raw material, taking into account the nature of the output, as, for example, with re-

spect to fineness in the case of a mill, and other factors, such as the cost of power and fixed charges. In the use of the new apparatus, close control over working conditions can be exercised either by the operator or by automatic means and such working conditions can be varied, without interference with continuous operation, as may be required by changes in the material being treated or changes desired in the product issuing from the apparatus.

The control mechanism of the invention makes use of the powerful basic low frequency or sonic vibrations generated in the rotary shell of the apparatus by the hammering action of the material and of the bodies on the shell. In the new mechanism, such vibrations are picked up directly from the shell through pick-up means to which the vibrations are transmitted through a solid medium and this may be accomplished in various ways, as, for example, by mounting the pick-up device directly on the shell or on a member disposed adjacent to the shell and in direct contact with a part thereof. Since the pick-up is direct, disturbing influences in the form of extraneous noises and vibrations are substantially eliminated and the device, accordingly, gives the operator accurate information as to operating conditions and permits the exercise of close control over such conditions.

For a better understanding of the invention, reference may be made to the accompanying drawing, in which

Fig. 1 is a transverse section through an embodiment of the invention in the form of a mill equipped with one type of the new device, a few of the grinding media being shown in the mill in exaggerated size for the sake of clearness;

Fig. 2 is a longitudinal section through a portion of the apparatus shown in Fig. 1;

Fig. 3 is a view similar to Fig. 1 showing a modified form of the indicating and control device;

Fig. 4 is an enlarged sectional view at right angles to Fig. 3 showing details of the control apparatus;

Fig. 5 is a diagrammatic view showing the connections employed in the device illustrated in Fig. 3; and

Fig. 6 is a diagrammatic view showing the use of amplifying and rectifying means in the new device.

The mill illustrated in Fig. 1 includes a shell 10 of conventional construction provided on its outer surface with a circumferential track 11, which has a smooth outer surface. In modern mills of welded construction, the track forms part of the shell itself, while in riveted mills with longitudinal straps, the track may be a narrow ring straddling the straps and tack welded to the body. The track is preferably mounted not far from the feed end of the mill and, in the case of compartment mills, each of the mill chambers may be provided with such a track. Adjacent the mill on a suitable standard 12 is mounted a curved arm 13, on which is adjustably secured a bracket 14 carrying a pivot pin 15 on which a lever 16 is mounted for swinging movement. The pivot pin lies generally parallel to the axis of the mill shell and the lever is provided with a weight 17 which may be adjusted lengthwise of one arm of the lever. A leaf spring 18 is mounted at the end of the other arm of the lever and on the free end of the spring is a plate 19 carrying a pick-up device generally designated 20. At the free end of the plate, a contact shoe 21, which may be of hard carbon, is held in posi-

tion by means of a clamp 22. The shoe 21 bears against the outer surface of track 11 with a pressure determined by the position of weight 17 on lever 16 and the surface of the track is made smooth so as to eliminate vibration of the pick-up device which would be caused by surface irregularities in the track. The contact shoe preferably bears against the track near the lower end of the slope of the material 23 being treated, since in this region, vibrations generated by the grinding media 24, which are carried upward with the material and fall down to the lower end of the level of the material as the mill rotates, are at a maximum.

The pick-up device used may be of various types, but because of the severe mechanical and temperature conditions encountered in mill practice, the pick-up in the form of the permanent magnet device shown in Fig. 2, is preferred. This device includes a permanent magnet 25, on one end of which is mounted a leaf armature 26 carrying a damping block 27 disposed above a core 28, all these parts being of magnetic material. The core 28 is encircled by a generating coil 29 which has leads 30 and the armature carries a movable weight 31 at its free end, which may be adjusted along the armature to vary the response of the armature to vibration. The core 28 is attached to a plate 32 of magnetic material extending to the permanent magnet and attached thereto and to the plate 19. The device is enclosed within the housing 33, which is also secured to plate 19 in any appropriate manner.

In the operation of the mill equipped with the pick-up device described, the audible or sonic vibrations generated in the mill shell by the impact of the grinding bodies and material being treated against the mill lining at the lower end of the slope of the material are transmitted to the pick-up device through a solid pathway made up of track 11, contact shoe 21, and plate 19. The vibrations cause movements of the armature 26 of the permanent magnet device toward and away from the end of core 28 with resultant variations in the magnetic flux threading the generating coil 29. Such variations in flux generate currents in a circuit which may ordinarily be used to actuate a suitable indicating instrument for indicating and control purposes. If desirable, the output of coil 29 may be fed to a suitable amplifier 34 and the output of the amplifier may be rectified in a conventional rectifier 35. The output of the rectifier may then be employed to actuate instrument 36, which may indicate or record, or both, and by reference to the instrument, the mill operator controls the feed to the mill in the manner required to maintain proper working conditions within the mill. If desired, the currents generated by the vibration of the mill shell during operation may be employed for automatically controlling the feed and, for this purpose, the output of rectifier 35 is fed to relays controlling the means by which the material is fed to the mill. Such relays and their associated mechanism may be of conventional construction well known in the art.

In the system described, the magnetic induction type of pick-up described is preferred because of its ruggedness, but other conventional electrical pick-ups, such as carbon pile, electrodynamic moving coil, condenser, or crystal units, may be used. Also, where indications only are desired, ordinary mechanical vibration indicators or devices of the mechanical-optical type may be used. Such a mechanical-optical device may in-

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clude a pivoted mirror reflecting a light beam on a scale, the angular deflection of the beam giving the indication, or the device may be used for control purposes in the usual way by means of photoelectric cells responsive to the beam from the mirror.

The system shown in Figs. 3, 4, and 5 includes a plurality of pick-up devices 37 mounted directly on the mill shell and spaced angularly about the shell. Each device includes a vibratory element in the form of an armature 38 mounted on a permanent magnet 39 and varying the flux threading a generating coil 40 in response to vibrations transmitted from the shell through a solid pathway formed by the pick-up device. The generating coils 40 of the several devices are connected in parallel to slip rings 41a, 41b mounted on insulators 42 secured to the shell. Current is taken from the rings by brushes 43a, 43b mounted on insulators on an arm 44 secured to a suitable standard 45 adjacent to the mill, appropriate means being provided to maintain contact of the brushes with the rings as the mill rotates. The currents generated in coils 40 are conducted from the brushes by leads 46 and utilized for indicating and control purposes as previously described.

The embodiment of the invention shown in Figs. 3, 4, and 5 is well adapted for application to mills of the vertical type or to high speed horizontal mills in which grinding takes place around the full circumference of the mill. It may also be used on horizontal low speed mills in which there are mechanical difficulties in providing the track 11 required in the first form of the apparatus. When used in low speed horizontal mills, the second form of the apparatus gives average values of grinding performance but the accuracy of the indications may be increased by increasing the number of pick-up devices employed.

In both forms of the apparatus, working conditions within the shell are made known to the operator by the powerful vibrations set up in the shell by the action of the material and the bodies with which the material is tumbled. As these vibrations are transmitted directly to the sensitive element of the pick-up device through a solid pathway instead of through air, errors, such as arise in the use of devices employing air-borne vibrations, are eliminated. The pick-up unit of the new device is responsive to vibrations within a band of frequencies and thus provides the operator with information that would be obtainable through means responsive to air-borne vibrations only under ideal conditions never encountered in actual practice. The new device gives prompt indications of changing conditions within the rotating shell or chamber and it has been found that those indications are responsive to small changes in both the material level within the chamber and the rotative speed of the chamber. The new device is of rugged construction, so that it functions satisfactorily under severe conditions, such as are encountered in connection with the operation of mills and by its use, the operator can readily carry out the desired operations under optimum conditions. The device affords the several advantages mentioned, while, at the same time, overcoming the objections to the systems of control heretofore employed.

I claim:

1. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter ro-

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tates and causing radial sonic vibration of the wall of the chamber, and pick-up means including an element sensitive to said vibrations and a solid pathway through which said vibrations are transmitted from the chamber wall to the element, said pathway including a part mounted on the outside of the chamber wall and rotating therewith.

2. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, and pick-up means including an element sensitive to said vibrations mounted on the outside of the chamber wall to rotate with the chamber and a solid pathway through which said vibrations are transmitted from the chamber wall to the element.

3. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, pick-up means including an element sensitive to said vibrations, a solid pathway through which said vibrations are transmitted from the chamber wall to the element, said pathway including a part mounted on the outside of the chamber wall and rotating therewith, and means generating currents varying with the response of the element to said vibrations, and means for conducting said currents from said generating means.

4. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, pick-up means mounted on the outside of the chamber and including an element sensitive to said vibrations, a solid pathway through which said vibrations are transmitted from the chamber wall to the element, means generating currents varying with the response of the element to said vibrations, a pair of rings encircling and mounted upon said chamber and connected conductively to the generating means, and means engaging the rings for conducting current therefrom.

5. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, pick-up means including an element sensitive to said vibrations, a solid pathway through which said vibrations are transmitted from the chamber to said element, said pathway including a part mounted on the outside of the chamber and rotating therewith and means generating currents varying with the response of the element to said vibrations, and a device connected to said generating means and responding to variations in the currents generated thereby.

6. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall

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of the chamber, pick-up means mounted on the outside of the chamber and including an element sensitive to said vibrations, a solid pathway through which said vibrations are transmitted from the chamber wall to the element, and means generating currents varying with the response of the element to said vibrations, a pair of rings encircling and mounted upon said chamber and connected conductively to the generating means, and a device connected electrically to said rings and responding to variations in the currents generated by said generating means.

7. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, pick-up means mounted on the outside of the chamber wall and including an element sensitive to said vibrations, a solid pathway through which said vibrations are transmitted from the chamber wall to the element, and means generating currents varying with the response of the element to said vibrations, and a device connected to said generating means and responding to variations in the currents generated thereby.

8. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, a track encircling and mounted upon the chamber and having a smooth surface, said track being independent of the mounting for the chamber, pick-up means mounted adjacent the chamber and including an element sensitive to vibration, and a mounting for the element which has a part engaging the surface of the track and provides a solid pathway through which vibrations of the chamber wall are transmitted to the element.

9. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, a track encircling and mounted upon the chamber and having a smooth surface, said track being independent of the mounting for the chamber, pick-up means mounted adjacent the chamber and including an element sensitive to vibration and means for generating currents varying with the response of the element to vibration, a mounting for the pick-up means which has a part engaging the track and provides a solid pathway for transmitting vibrations from the

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chamber wall to the element, and a device connected electrically to said generating means and responding to variations in the currents generated thereby.

10. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, a track encircling and mounted upon the chamber and having a smooth surface, said track being independent of the mounting of the chamber, a member mounted outside the chamber for vibratory movement, a contact carried by the member and engaging the track, pick-up means mounted on the member and including an element sensitive to vibrations of the chamber wall and means for generating currents varying with the response of the element to said vibrations, and a device responding to currents generated by said generating means.

11. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, a track encircling and mounted upon the chamber and having a smooth surface, said track being independent of the mounting for the chamber, a lever mounted adjacent the chamber, a member mounted on the lever for vibratory movement, a contact carried by the member and engaging the track, pick-up means mounted on the member and including an element sensitive to vibrations of the chamber wall and means for generating currents varying with the response of the element to said vibrations, and a device responding to currents generated by said generating means.

12. Apparatus for the treatment of material, which comprises a chamber mounted for rotation and containing bodies for acting on material supplied to the chamber, the material and bodies tumbling within the chamber as the latter rotates and causing radial sonic vibration of the wall of the chamber, a track encircling and mounted upon the chamber and having a smooth surface, said track being independent of the mounting for the chamber, a contact biased against the surface of the track, a pick-up means connected mechanically to the contact and including an element sensitive to vibrations of the chamber wall and means for generating currents varying with the response of the element to said vibrations, and a device actuated by currents from the generating means and responding to variations therein.

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