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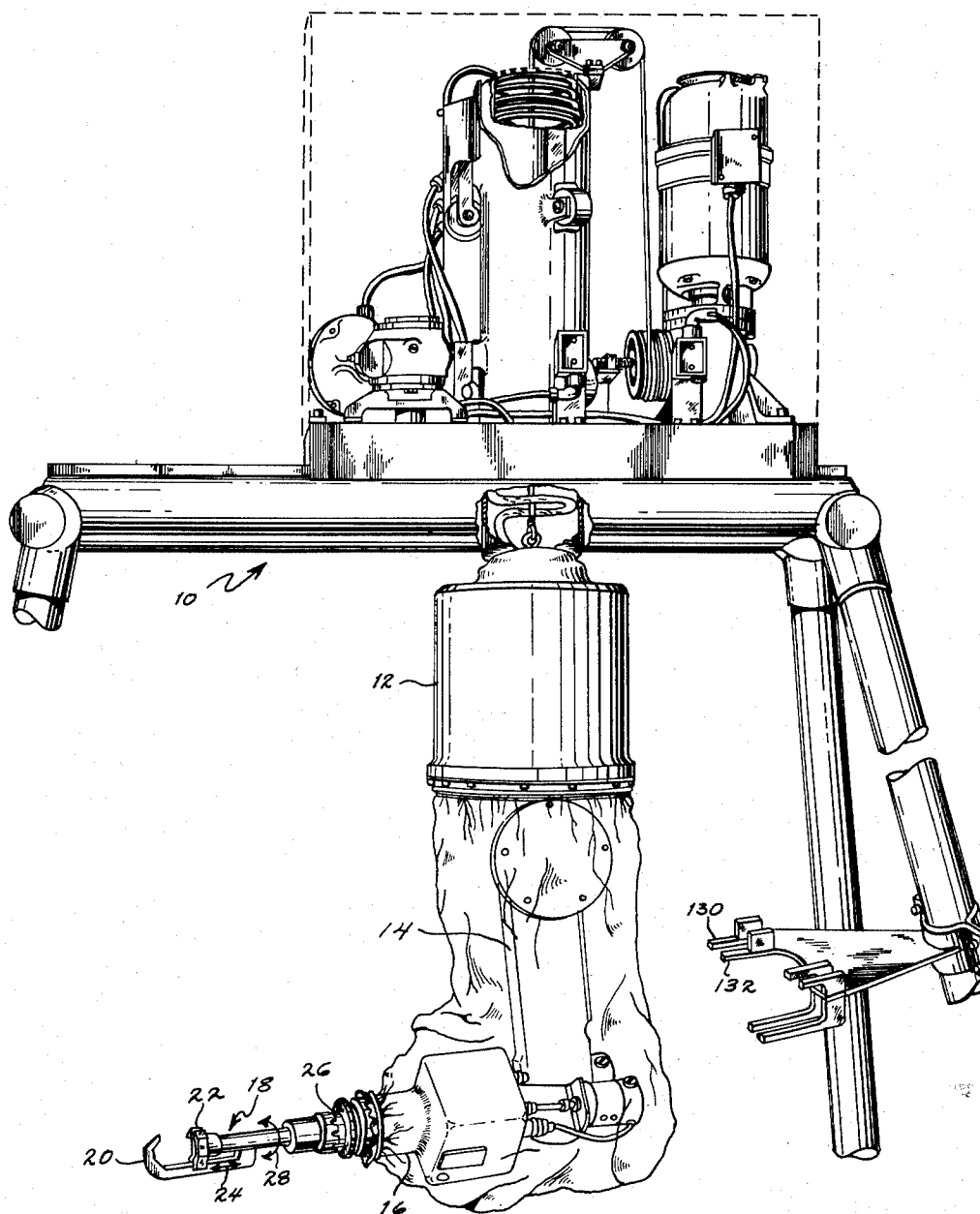
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AUDIO GRIP FORCE AND DISCONNECT INDICATOR AND METHOD

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2 Sheets-Sheet 1

FIG. 1



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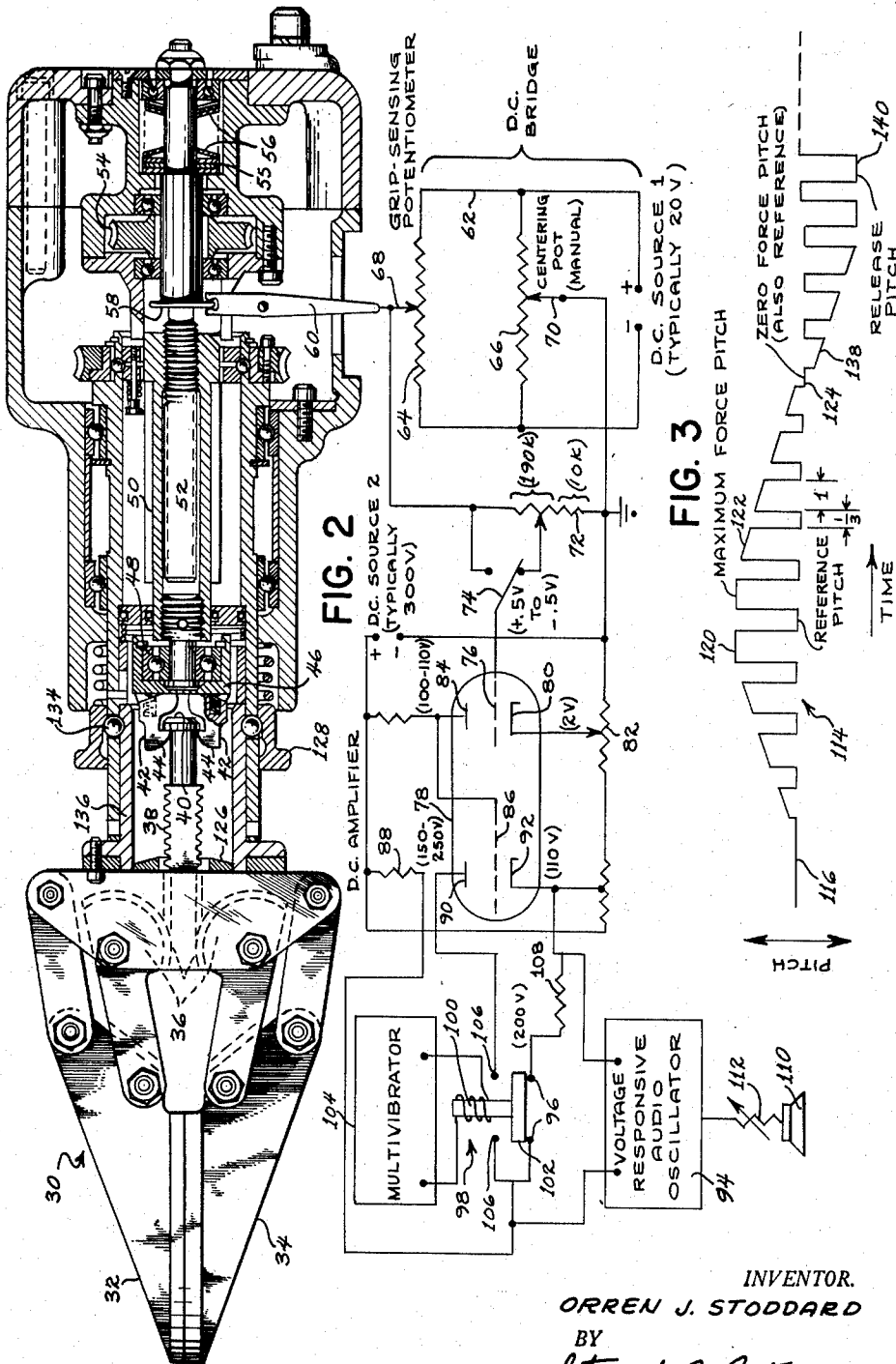
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AUDIO GRIP FORCE AND DISCONNECT
INDICATOR AND METHOD

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14 Claims. (Cl. 340-282)

This invention relates in general to signaling systems and pertains more particularly to an audio grip force indicator and method for signifying to an operator the degree or magnitude of pressure being applied to an object held between two relatively movable clamping members.

The instant invention will find especial utility in remote control handling units such as that disclosed in the application of Charles H. Bergsland et al., U. S. Serial 456,226, filed September 15, 1954. In handling radioactive materials, a procedure contemplated in the above alluded to Bergsland application, it is frequently necessary to manipulate frangible or fragile articles from a remote, safe vantage point, and such action demands the utmost care, lest the articles inadvertently become broken with a consequent heavy loss, in many instances, of time and money. Sensitivity of control is not enough, for the operator must also be constantly warned of the force being mechanically applied to breakable articles so that he may always exercise the proper degree of control over the equipment.

Since the operator has no "feel" over the work being handled, there being a total absence of personal contact, resort has been made to visual indicators. However, these visual indicators have been grossly inadequate, mainly due to the fact that the operator's attention must be devoted to the watching of what the equipment is doing without having to shift his gaze to some instrument not always precisely in his line of sight. In order to obviate the foregoing difficulty encountered with visual indicators, an object of the present invention is to provide an audible force indicator that will be practical, reliable and satisfactory in its operation.

Rather broadly, the invention has for an aim the audible indication of the degree of force being applied to a pair of clamping jaws by producing a tonal pitch variable in accordance with such force and providing a ready comparison of such pitch with a given or reference pitch. More specifically, the invention has for a feature the alternating of the reference pitch with the variable one. By accomplishing such alternations in a rapidly successive fashion or cycle, the operator has no time in which to "lose" the reference pitch. Thus, the operator is constantly presented with a basis upon which he can predicate gripping force changes, increasing or moderating them as circumstances dictate. In this way even relatively "tone deaf" individuals are enabled to operate properly handling apparatus equipped with indicating means constructed in accordance with the teachings of the instant invention. Those endowed with better tone discernment, however, will be able to detect such tones as thirds, minor thirds, fifths, augmented fifths, ninths and, of course, octaves. Once having audibly recognized the correlation between such tones and gripping force, it can be recognized that the operator can thereafter determine with fairly good accuracy various degrees of force actually being applied to a remotely handled object. In any event, practical use is made of the sound produc-

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ing apparatus to indicate when zero force is being applied, as by having the variable pitch tone then equal the reference tone, and to indicate when, say, a maximum force is being applied, as by having the variable tone rise in pitch to an octave above the reference tone.

In remote handling systems of the character referred to, it has become necessary to at times change from one type of clamping device to another. These clamping devices or "hands" as they are frequently termed are, therefore, detachably connected to a forearm. Since certain manipulations must be undertaken to switch from one mechanical hand to another, it is essential to know when the release point has been reached, and it is a desideratum of the invention to indicate in an audible manner the moment this release is effected. More specifically, it is an object to indicate when the release has been accomplished in such a way that there can never be any confusion between "force" tones and "release" tones, the invention envisaging the employment of reference tone pulses that are of shorter duration than either said force and release tones. Stated somewhat differently, the tones produced as the hand is moved toward release are of course lower than the reference tone, and the tones generated as the clamping force is increased are always higher than the reference tone. With the reference tones being shorter, a fixed plateau or tone level can never prevail by which tone pulses below the true reference might be confused with the true reference pulses in such a way as the operator would interpret the lower tone pulses to be the reference pulses and the higher or true reference pulses to be pulse tones indicating (erroneously) force tone pulses and vice-versa.

Yet another very important object of the invention is to provide an audio system of the foregoing nature that will not require that the voltage source be absolutely constant for proper functioning. In this regard, it is to be noted that it is the difference in pitch between the reference and that which is a measure of applied force which is instrumental in allowing the operator to determine to what extent any clamping action should be changed.

Still another object of the invention is to provide an exceedingly simple system and method for determining on a relative basis force differences, thereby permitting the apparatus to be of comparatively low cost as far as its manufacture is concerned.

Other objects will be in part obvious, and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application which will be indicated in the appended claims.

In the drawings:

Figure 1 is a perspective view of a material handling unit with which my invention will find especial utility;

Fig. 2 is a detailed section through the forearm of the handling unit, this view illustrating a different mechanical form which the hand or grip may assume over that pictured generally in Fig. 1 together with certain associated electronic circuitry for generating the audio tones; and

Fig. 3 shows a hypothetical curve of pitch plotted against time, the attributes of this curve having been selected so as to explain certain features derivable from a practicing of the invention.

While it is felt that a general understanding of a material handling unit, such as that more fully treated in the hereinbefore mentioned Bergsland et al. application, and the attendant need for substituting one mechanical hand for another may be had from the ensuing description, nonetheless resort should be made to said Bergsland et al. application for such details that might not be wholly

clear to the reader. Actually, all of Fig. 1 and the mechanical portion of Fig. 2 have been taken directly from the Bergsland et al. application, being presented here largely for convenience in showing and claiming the instant invention.

With the above remarks in mind, attention is now directed to Fig. 1. In this figure a framework 10 is depicted. Surmounting the framework is certain power supplying superstructure not considered essential to the present invention. Relatively movable with respect to the framework is a shoulder unit 12 to which is pivotally connected an upper arm 14. The upper arm 14 in turn has pivotally attached to it a forearm 16, and it is this forearm that carries what will be termed a hand or claw grip 18.

The construction of the hand 18 is susceptible to a variety of forms. Here the hand 18 includes a hook jaw member 20 movable longitudinally relative to an anvil jaw member 22 in the direction of the arrow 24. By reason of meshing teeth 26, the hand unit is also capable of rotation in the direction of the arrow 28.

The material handling apparatus, as already indicated, is intended for use where objects are to be moved in an atmosphere detrimental to human health. Accordingly, in order to render the apparatus versatile enough to handle items of various sizes and shapes, it becomes necessary to at times change from one type of hand to another. One such hand has already been given the reference numeral 18.

Another type of hand that may be substituted for the hand 18 is depicted in Fig. 2, this hand bearing the reference numeral 30. In this situation the hand 30 resembles more a tong type of clamping device, comprising a pair of flat jaw members 32 and 34 mounted for articulative movement in a transverse direction through the agency of sector gear elements 36 and a gear rack 38 meshed therewith. Integral with one end of the rack 38 is a flanged head 40 normally engaged by a pair of spring biased dog elements 42 provided with cam surfaces 44 by which the dog elements may be urged apart for the insertion of the head 40.

The dog elements 42 are pivotally carried by a rotatable and reciprocable bearing housing 46, said housing being recessed for the captive reception of the outer race of a ball bearing assembly 48. Via a threaded arrangement, an internally threaded sleeve 50 is connected to the inner race of the bearing 48 for transmission of applied operating force to the rack 38. The end of the sleeve 50 opposite the bearing 48 is also internally threaded for the accommodation of one end of a screw member 52 having a power driven gear 54 circumscribed about and keyed to another portion thereof. The end of the screw member 52 remote from its threaded end is shouldered at 55 for abutment against a stack of spring washers 56. These concavo-convex washers of course yield to an extent dependent upon the force transmitted to the clamping jaws 32 and 34, becoming progressively more planar with an increase in applied force.

By reason of a flange 58 integral with the screw member 52 any motion of said screw member is transferred proportionally to a pivotal arm 60. The pivotal arm is utilized in actuating a potentiometer 64 set forth schematically in Fig. 2. Actually, reference to the arm 60 provides an apt introduction to the circuitry with which the invention is primarily concerned.

Proceeding now with a description of exemplified circuitry by which the objects of the invention may be carried into practical being, it is to be noted that the potentiometer 64 is wiped by a brush 68 mounted on the lower end of the pivotal arm 60, and that a potentiometer 66 is wiped by a manually adjustable wiper 70. The two potentiometers 64 and 66 have their extremities connected together to a D. C. source (typically 20 volts), thus constituting a D. C. bridge whose output, which is the D. C. signal fed to the electronic indicator, is pro-

portional to the grip force (or release force) being exerted by the hand or claw. The "centering" potentiometer 66 may be used to "balance" the bridge at a time when no grip force or release force is being exerted.

Henceforth, increasing the grip force will effect an increase in the bridge output voltage up to ten volts having one polarity; conversely, increasing the release force will effect an increasing in the bridge output voltage up to ten volts of the opposite polarity.

The brushes 68, 70 are connected to opposite ends of a voltage divider 72. For low sensitivity the voltage divider is adjusted substantially as shown so that whatever voltage signal is produced by the potentiometer 64 will be divided so that only $\frac{1}{20}$ of such voltage is utilized. (As will presently become manifest, full swing, when divided down, is adjusted to give a tonal difference of two octaves.) When the full, undivided voltage of the potentiometer is used, then the sensitivity of the system is increased substantially twenty fold, permitting the handling of extremely frangible articles of "egg shell thinness."

In accomplishing the above objective, a double throw single pole switch 74 is connected so that manipulation thereof will give the proper sensitivity range of operation. It is to be noted that the switch 74 is connected electrically to one grid 76 of a dual D. C. amplifier tube 78 such as a 12AT7 tube. The corresponding cathode 80 of this triode is connected to an audio centering adjustment potentiometer 82, which adjusts the fixed grid-to-cathode voltage or "bias"; this pre-sets the D. C. amplifier at the center of its range of operation.

The plate 84 of the tube 78 is connected through its plate resistor to a plate supply source and to the grid 86 of the second triode (control triode) of the tube 78. The cathode 92 of the control triode is connected to a suitable positive D. C. voltage point, and to one terminal of a voltage-responsive audio oscillator. The plate 90 of this same triode is connected to one of a pair of contacts 106 on relay 98. When this relay is operated, contacts 106 close to connect the plate 90 through a suitable plate resistor 88 to the plate supply source.

The relay 98 has a coil 100 and an armature 102. The coil 100 is alternately energized and de-energized by the operation of a multivibrator 104 in a cyclic fashion. During the period when the coil is de-energized (typically one-third second), contacts 96 are closed, connecting a fixed resistor 108 in series with the plate resistor 88. Resistor 108 has a value identical to the plate-to-cathode resistance of the control triode when at the center of its range of operation. When the relay coil 100 is energized, the armature 102 is retracted, opening contacts 96 and closing contacts 106. This removes the resistor 108 from the circuit in series with resistor 88 and replaces it with the plate-to-cathode resistance of the control triode. The lower end of the resistor 88 is connected to one of the contacts 106, one of the contacts 96 and to the second terminal of the audio oscillator; in this manner, the alternations of the multivibrator 104 cause the relay 98 to present to the input terminal of the audio oscillator D. C. voltages which alternate between a fixed value obtained when the relay is de-energized and a variable value obtained when the relay is energized.

From the typical voltage values shown in parenthesis in various points in the diagram of Fig. 2, it may be seen that cathode 80 operates at a typical potential of +2 v., cathode 92 at +110 v., grid 76 in the range of +.5 v. to -.5 v., amplified in the input triode so that plate 84 operates in the range +100 v. to +110 v. (also the range of grid 86), amplified in the control triode so that plate 90 operates over the range +150 v. to +250 v. (typical). This results in the plate 90 being always positive with respect to its cathode 92 in a typical range of 40 v. to 140 v. This is the variable voltage impressed on the input of the audio oscillator when the relay 98 is energized.

As explained above the function of the multivibrator 104 is to energize the relay 98. This is done in a repetitive manner, the circuit constants of the multivibrator being selected so that the period of energization of the coil 100 is different from its period of de-energization. Suggestively, the period of energization might be one second and the period of de-energization might be $\frac{1}{3}$ second. Thus the resistor 108 is placed in the oscillator circuit less time than is the control triode, and in this way the desired time ratio is obtained between the reference and variable pitch tones.

By initially setting the audio centering potentiometer 82, the mid-point of the tonal range, through which the variable pitch extends, may be obtained. The over-all range of the audio oscillator 94 should preferably be two octaves. The mid-point of this range should correspond in frequency level with the reference tone and should indicate when no clamping force exists as far as the jaws 32 and 34 are concerned. One octave above this frequency is selected so as to represent audibly the maximum amount of gripping force to which the jaws 32 and 34 should be subjected. For instance, such a maximum might be governed by the frangibility of the article to be handled or it might be dependent upon the degree of clamping force at which the driving slip clutch (not described) starts to slip. As for making it possible for the operator to recognize when the jaws 32 and 34 have been opened to the hand-release point, a low pitch tone, i. e., a pitch well below the reference pitch is selected, a tone an octave below being easily discernible and therefore recommended.

The above may be succinctly presented in a visual manner by reference to Fig. 3 where there appears a curve generally indicated by the reference numeral 114. As can be seen from this figure the curve is plotted with pitch or frequency as the ordinate and time as the abscissa. The curve is rather hypothetical inasmuch as in actual practice the various promontories will not deviate so abruptly from those next adjacent.

Assuming that there is no gripping force applied to the jaws 32 and 34, then the variable pitch will equal the reference pitch and that portion of the curve will appear as a straight horizontal line 116. However, when the jaws 32 and 34 are moved under the supervisory control of the operator in a direction to apply pressure against an object being held, the variable pitch starts to increase in accordance with the force exerted as indicated by the numeral 118. These "pulses," "periods," or "promontories" as they might be loosely termed here increase until an octave level above the reference pitch is reached, such a level being indicated by the numeral 120. Proceeding with the description of curve 114, we will now assume that the clamping force is moderated, starting with the pulse 122 and returning to zero at 124.

Having returned to the zero force or reference point, for the sake of illustration it will now be presumed that the operator is desirous of releasing the hand 30 for substitution with the hand 18 (Fig. 1). To do this the jaw members 32 and 34 are actuated to a wide open position causing the cam surfaces 44 of the dog elements 42 to strike the cam face of a collar 126 so as to urge the dog elements apart. There is also a locking ring 128 that must be pushed in by forcing the forearm 14 down against cantilever arms 130 and 132 affixed to the framework 10. Such action is instrumental in freeing locking balls 134 from a drive sleeve 136 on which the jaws 32 and 34 are indirectly supported.

All of the preceding detail is set forth fully in the aforementioned Bergsland et al. application. The information needed at this point, however, is that the flange 58 is being moved during this period in a direction opposite to that in which it is moved when a clamping force is being applied via the screw member 52. Such a procedure results in the potentiometer 64 applying a different volt-

age to the grid 76 of the amplifier tube 78. Through the medium of the control triode of tube 78 a different control signal is impressed on the oscillator 94 with the result that the oscillator emits a signal having a progressively lower pitch, proceeding from a frequency locus 138 on the curve 114 down to the release point 140, preferably an octave below the reference level and two octaves below the maximum force pitch earlier designated by the numeral 130.

In other words, the pitch represented by the numeral 140 is indicative of the condition in which the hand 30 has been readied for depression of the locking ring 128, thereby to release the tong type hand 18 so as to permit replacement thereof with the hook type hand 18.

While a number of audio frequencies might be utilized in the effectuation of the reference tone and the maximum and minimum pitch levels represented by the numerals 120 and 140, respectively, nonetheless a frequency of approximately 180 cycles per second may be employed as the reference pitch, thus in such an instance causing the highest pitch to be 360 cycles per second and the lowest pitch to be 90 cycles per second (i. e., an octave above and an octave below).

From the foregoing description it is believed apparent that the instant invention has dealt with a method and apparatus by which an untrained individual will quickly grasp the rudiments of operation. With practice, especially where persons are involved who possess a tone trained ear, exceptional results can be expected as far as precise graduations of applied force are concerned. However, for most operations, because the operator's ears are continually subjected to the reference tone, it is easy to discern when the applied force is being modified and to what relative extent. It is with the musically trained ear that specific magnitudes of force can be differentiated, as by noting thirds, minor thirds, fifths, augmented fifths, and ninths. In some cases those frequencies in between can be recognized, depending largely upon the sensitivity of the operator's ear. It is to be further appreciated that the invention is quite replete, taking into consideration the fact that the mechanical hands themselves must at times be changed and affording a facile way for determining when the material handling apparatus has been properly conditioned for such change.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed:

1. In combination with a pair of relatively movable work clamping members, an audio grip force indicator comprising sound producing means, means for producing a reference tone from said sound means having a given pitch, and means operatively associated with one of said clamping members for producing a tone from said sound means having a pitch variable in accordance with the force exerted by said clamping members against an object held therebetween, and means for repeatedly alternating said reference tone, with said variable tone in a cyclic manner.

2. In combination with a pair of relatively movable work clamping members, an audio grip force indicator comprising sound producing means, means for producing a reference tone from said sound means having a given pitch, means operatively associated with one of said clamping members for producing a pitch variable in ac-

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cordance with the force exerted by said clamping members against an object held therebetween, and means for adjusting the pitch of said variable tone to that of said reference tone when no force is exerted by said clamping members.

3. In combination, an arm member, a hand mechanism including a pair of relatively movable work clamping members, means releasably attaching said hand mechanism to said arm, and audible means for indicating when said attaching means is in a releasing position including means for producing a reference tone and a signal tone differing from said reference tone by a predetermined pitch differential when said attaching means has reached its release position.

4. In combination, an arm member, a hand mechanism including a pair of relatively movable work clamping members, means releasably attaching said hand mechanism to said arm, said means releasing said hand mechanism at a preferred degree of separation of said clamping members, and audible means for indicating when said clamping members have reached said preferred degree of separation thereby signifying when said hand mechanism has been conditioned for release, said audible means producing a predetermined pitch differential when said hand mechanism has been conditioned for release.

5. In combination, an arm member, a hand mechanism including a pair of relatively movable work clamping members, means releasably attaching said hand mechanism to said arm, said means releasing said hand mechanism at a preferred degree of separation of said clamping members, an audio grip force indicator comprising sound producing means, means for producing a reference tone from said sound means having a given pitch, and means actuated by one of said clamping members for producing a pitch variable in one direction in accordance with the force exerted by said clamping members against an object held therebetween and variable in an opposite direction to a selected pitch for audibly indicating when said clamping members have reached a preferred degree of separation thereby signifying when said mechanism has been conditioned for release.

6. In combination, a clamping device including a pair of relatively movable work clamping members, means for actuating said clamping members, a potentiometer, means connected to said actuating means for positioning said potentiometer, amplifying means connected to said potentiometer, a control tube, a resistance, an audio oscillator, switch means for alternatively coupling either said control tube or resistance to said amplifying means to produce a tone having a pitch variable in accordance with the force exerted by said actuating means against said clamping members and a reference tone having a given pitch, respectively, and speaker means connected to said oscillator.

7. The combination set forth in claim 6 including a voltage divider between said potentiometer and said amplifying means, and switch means in circuit with said divider and amplifier means for changing the magnitude of the signal from said potentiometer.

8. The combination set forth in claim 6 including means

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for holding said clamping device, means for releasing said clamping device from said holding means, said amplifying means being capable of producing said variable tone so that it has a range of pitch extending approximately an octave above said reference tone and an octave below said reference tone, said lower octave indicating when said releasing means is in a release position.

9. Apparatus for indicating audibly the gripping force applied to a pair of relatively movable clamping members comprising means for producing a reference tone having a relatively constant pitch for a given period, means for producing another tone for a different period having a pitch variable in accordance with the force exerted by said clamping members against an object held therebetween, and means for alternating said constant pitch tone and said variable pitch tone with each other in a repetitive fashion.

10. Apparatus for indicating audibly the gripping force applied to a pair of relatively movable clamping members comprising means for producing a reference tone having a relatively constant pitch for a given period, and means for producing another tone having a pitch variable in accordance with the force exerted by said clamping members against an object held therebetween for a period differing in time from said given period.

11. Apparatus for indicating audibly the gripping force applied to a pair of relatively movable clamping members comprising means for alternately producing a reference tone having a relatively constant pitch for one period of time and means for producing another tone having a pitch variable in accordance with the force exerted by said clamping members against an object held therebetween for a different period of time.

12. Apparatus for indicating audibly the gripping force applied to the jaws of a clamping mechanism and the point at which said clamping mechanism is released from its holder comprising means for producing a reference tone having a relatively constant pitch for one period of time, and means for producing another tone for a different period of time variable in one direction in accordance with the force exerted by the jaws of said clamping mechanism and in an opposite direction to indicate when the clamping mechanism has been released.

13. The apparatus set forth in claim 12 in which the variable tone is variable to an octave above the reference tone to indicate a force occurring at a particular condition and to an octave below said reference tone to indicate said release point.

14. The apparatus set forth in claim 13 including means for alternating said reference and variable tones in a cyclic fashion.

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