Dec. 29, 1942. J. R. MacKAY 2,306,819

SOUND SIGNAL APPARATUS

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Fig. 1

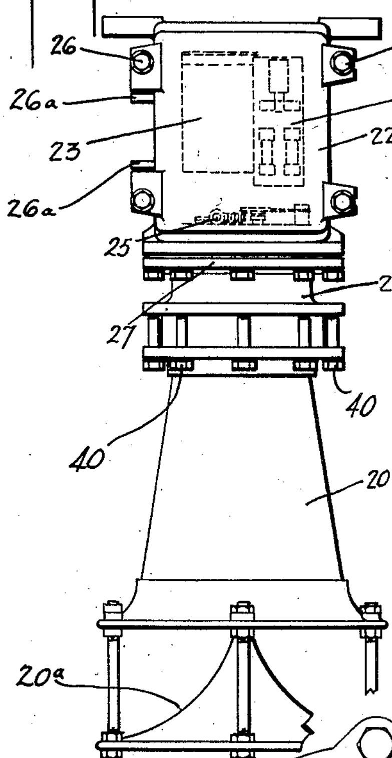


Fig. 2

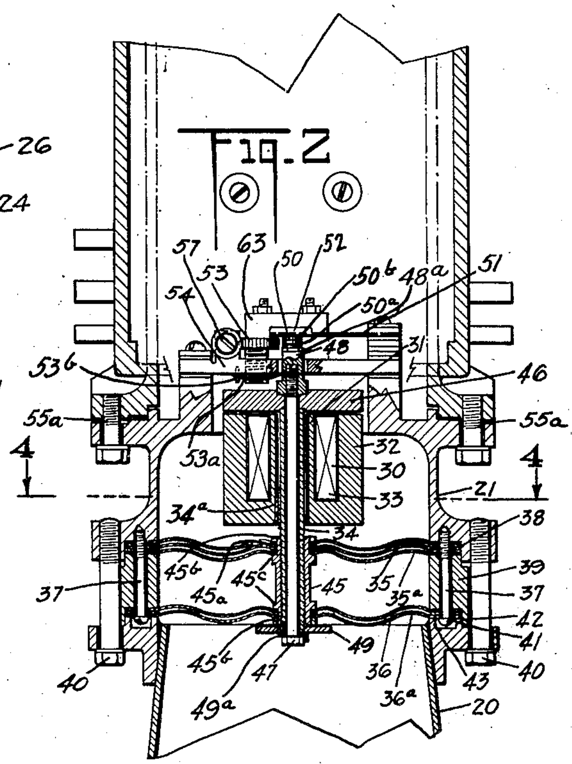
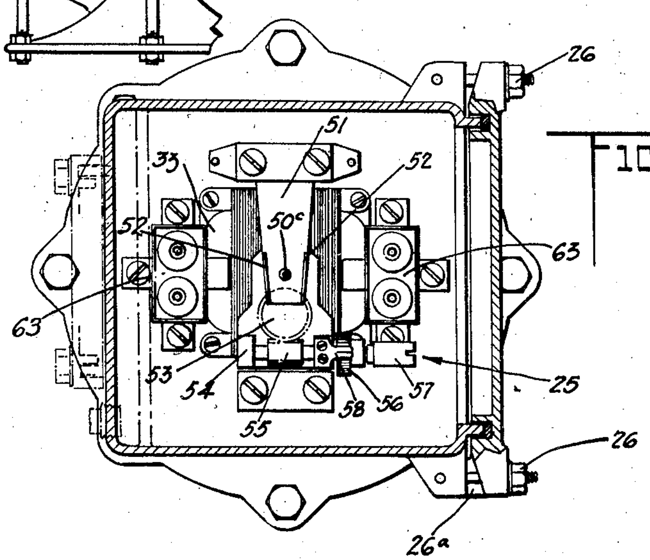


Fig. 3



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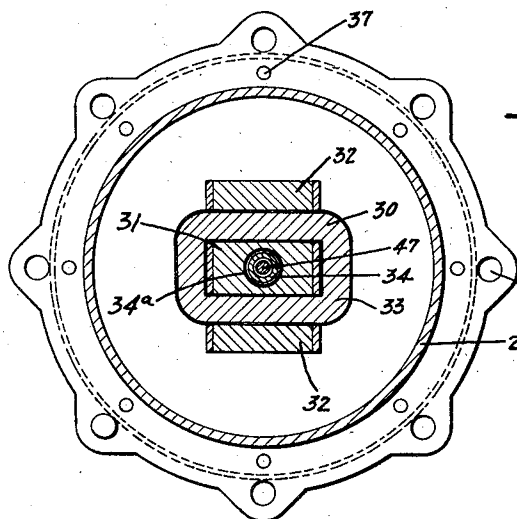

FIG. 4

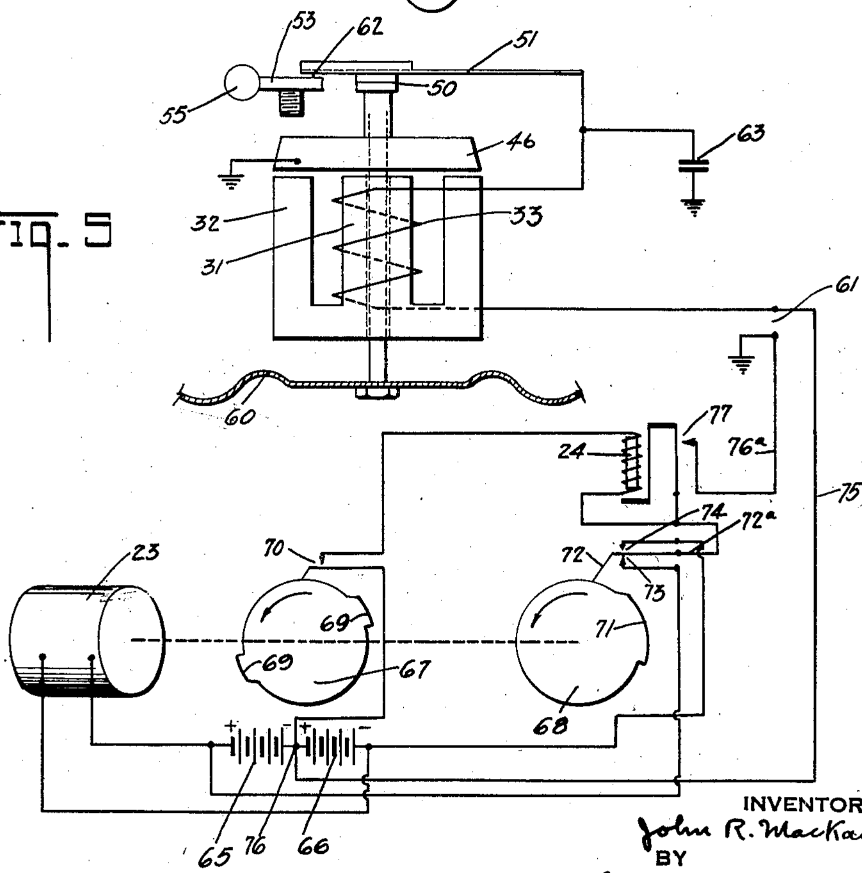

FIG. 5

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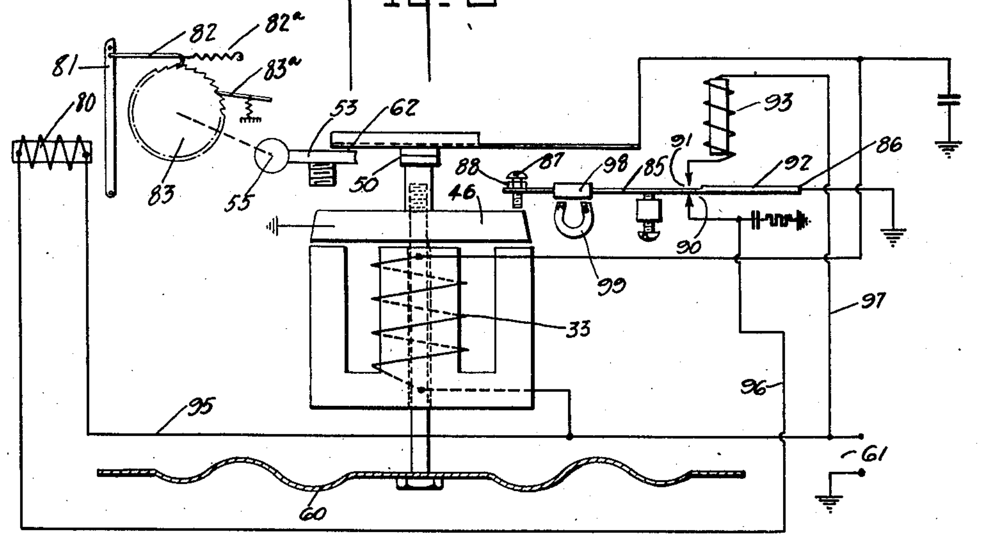
Fig. 6



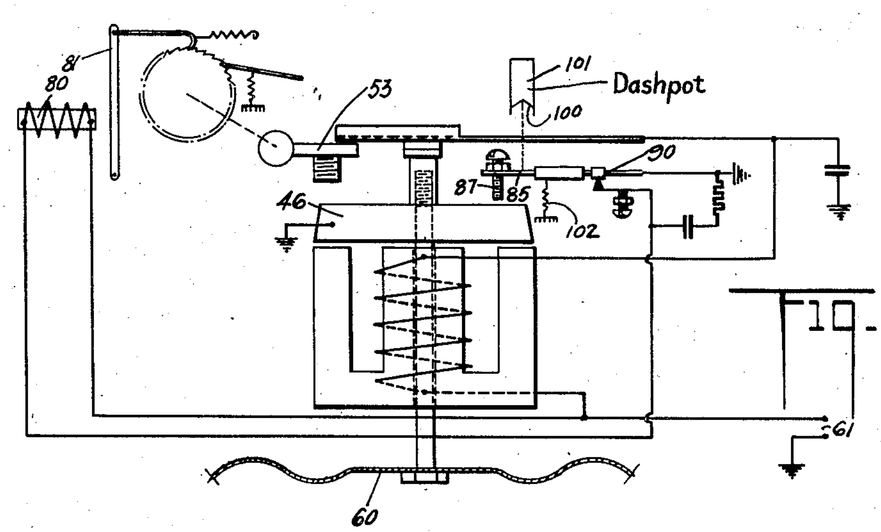


Fig. 7

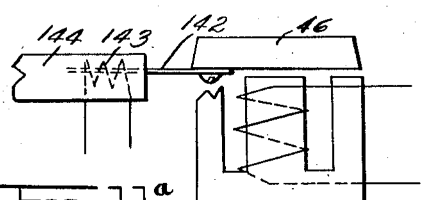


Fig. 11a

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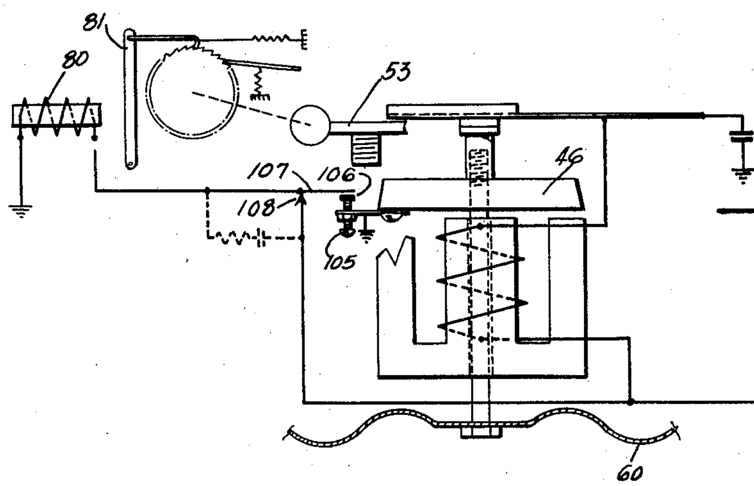

Fig. 8

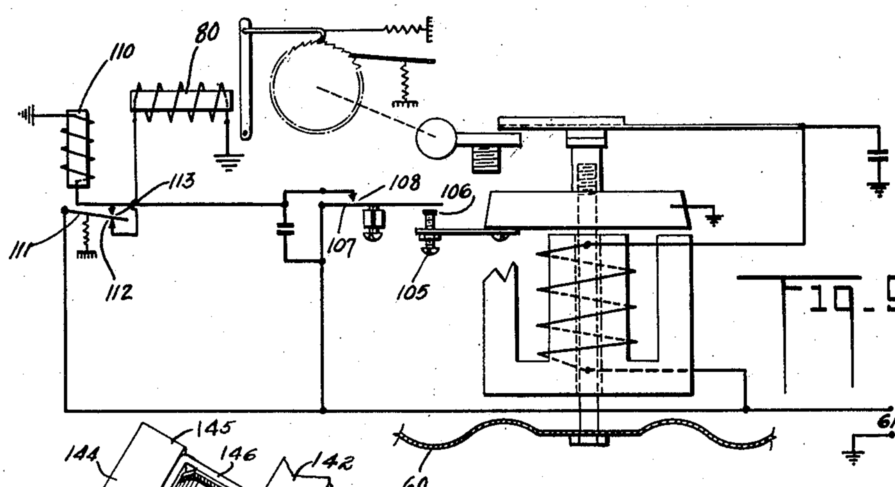

Fig. 9

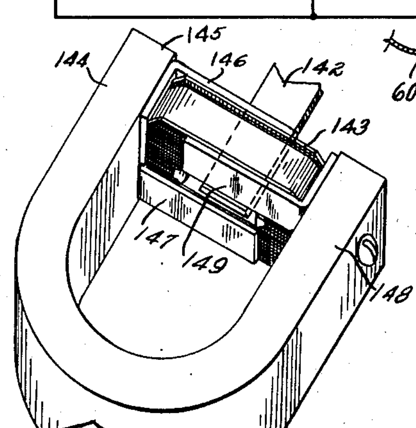

Fig. 11a

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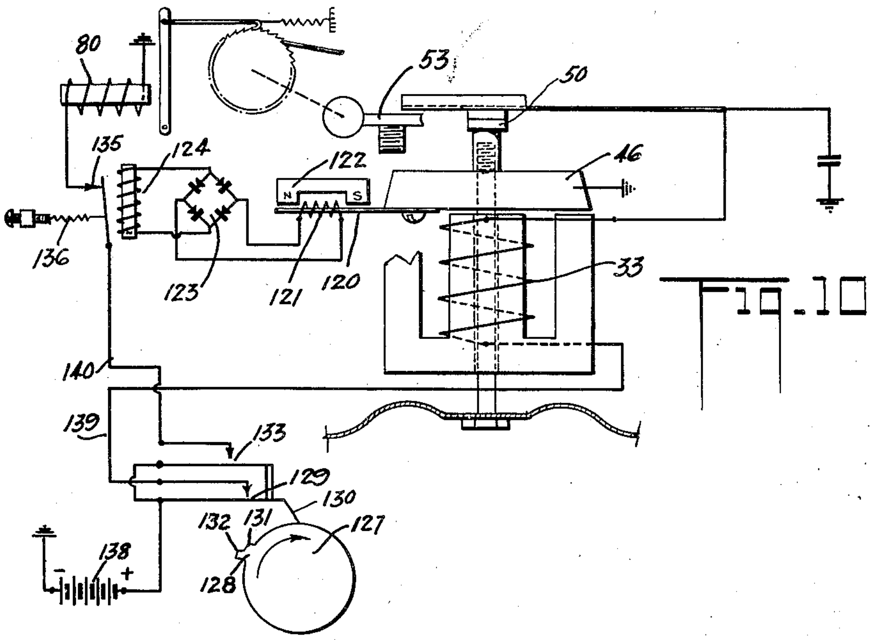

Fig. 10

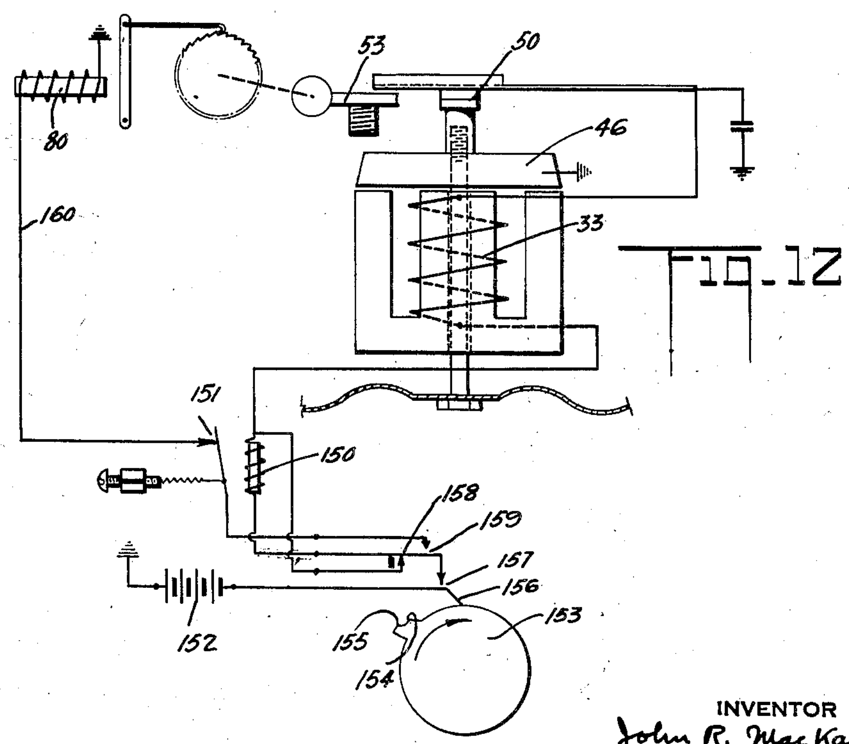

Fig. 12

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UNITED STATES PATENT OFFICE

2,306,819

SOUND SIGNAL APPARATUS

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Application March 14, 1938, Serial No. 195,893

20 Claims. (Cl. 177—7)

This invention relates to sound signal apparatus, and more particularly to signalling or alarm devices of electrically operated type, such as horns, and to control means for signalling apparatus of the character stated. An especially advantageous use or embodiment of the invention is in fog horns, wherein ruggedness, power of sound, and dependability over long periods of time are important criteria. Such horns are often used on floating buoys, and the requirements of a satisfactory horn for such use are particularly severe. All parts must be of a type suitable for use on buoys, where they will be subject to continuous operation, exposure to the elements and to frequent submergence, and to operation at all angles due to the swinging and listing of the buoy. As buoys are frequently collided with all parts of the horn and program mechanism must be of such construction that they will not be damaged or operation affected by any jar or bump which the buoy may receive, other than one where the horn or mechanism is actually hit and damaged in consequence. It is a common requirement of horns so used, that they must sound from two to four blasts of about one second per minute, and that this operation is continuous for 24 hours per day for each day of the year.

In general, sound signals such as fog horns have comprised an electromagnet, an armature, a diaphragm associated with the armature, and make-and-break contacts operated, buzzer fashion, by the armature. Certain difficulties, however, have been found with devices heretofore known or available. For example, the pitch of the horn depends on the stiffness of the diaphragm, and inversely on the weight of the armature; and attempts to obtain a pitch high enough for good carrying quality have either required a sacrifice of power or involved a tendency to break on the part of the relatively stiff diaphragm used, when flexed with sufficient amplitude to create a powerful signal. Furthermore, although it is usually desirable to space the diaphragm relatively far away from the armature, with a connecting member, it has been found that the spring then employed to support the end of the armature distant from the diaphragm, is very apt to break upon continued vibration of otherwise desirable power.

The present invention is particularly designed to remedy one or more of these and other difficulties inherent in prior art devices, and a further object of the invention is to provide apparatus of the character described having satisfactory power and pitch characteristics, which is at the same time highly reliable and adapted for operation over extremely long periods of time without even partial failure or appreciable reduction in its output due to wear.

Another object is to provide a sound signal device having novel and improved means for automatically controlling the device and for operating it, for example, at regular intervals and with uniformity of power and efficiency; other objects being to provide more satisfactory contact structures in sound signals, and likewise efficient arrangements for preventing or greatly reducing wear of the contacts.

A still further and notably important object is to provide an improved structure in sound signal devices whereby the amplitude of vibration may be accurately adjusted or set, and a like important object is the provision of novel means for maintaining a constant amplitude of vibration over long periods of operation, or for making automatic adjustment in response to decreased amplitude or effects concomitant therewith.

Another object is to provide novel interlocking means for synchronously controlling both the signal characteristic and a reversal of current flow through the horn contacts and associated current controlling contacts, periodically and without conflict between the signal current controlling and current reversing means.

Other objects are to provide, relative to fog horns and like signal apparatus: an improved and long-wearing diaphragm structure; a simpler and more efficient assembly of vibrating parts; and generally sturdier and more reliable arrangement of operating and control elements.

Other objects and advantages include those which are hereinafter stated or apparent, or which are incidental to the invention. The nature of the latter will be conveniently explained by reference to the following description and accompanying drawings, which set forth, by way of example, certain presently preferred embodiments of the invention.

In the drawings:

Fig. 1 is an elevation of a complete fog horn and control unit embodying the invention;

Fig. 2 is an enlarged longitudinal section of the horn and its operating parts;

Fig. 3 is a plan of the upper end of Fig. 2;

Fig. 4 is a section on line 4—4 of Fig. 2;

Fig. 5 is a general wiring diagram;

Figs. 6 to 10 inclusive are diagrammatic views of various modifications of the invention;

Fig. 11*a* is a diagrammatic view of an alternative structure of certain elements in Fig. 10;

Fig. 11*b* is a perspective view of a generator device shown diagrammatically in Fig. 11*a*; and

Fig. 12 is a diagrammatic view of a further modification of the invention.

As generally shown in Fig. 1, the sound signal device and its associated control instrumentalities may be conveniently combined in a single unit, comprising an open-mouthed trumpet or bell **20**, bolted to a housing **21** for the horn-driving elements, the housing being in turn secured to a case **22**. The latter encloses an electric motor unit **23**, having associated program cams and contacts as hereinafter described, and also encloses fuses and a relay **24** for operating the horn. Certain adjustable elements of the horn proper, generally designated **25**, may be disposed within the casing **22**, and the face of the latter shown in Fig. 1 may conveniently comprise a door or cover plate hinged (at **26***a*) to open upon release of the toggle bolts **26**, for access to the enclosed parts, including the elements **25**. For convenience of access and adjustment the parts generally designated **23** and **24** are mounted on the inside of the door and are swung out of the casing with it. It will be understood that particularly where the apparatus is to be used at sea or off shore, as on a floating buoy, or where it is otherwise to be exposed to weather or moisture, the entire assembly of casing **22**, housing **21** and the inner end **27** of bell **20**, must be thoroughly water-tight. To that end, the peripheries of diaphragms, interposed gaskets, and other joined elements, may be embedded in waterproof plastic material, such as glyptol lacquer. A cone-shaped or other deflector **20***a* may be disposed below the mouth of bell **20**, and may be vertically adjusted on its supporting bolts to permit some change of the resonant length of the air column in the bell or trumpet.

Referring now to Figs. 2 to 4 inclusive, there is supported within the housing **21** an electro-magnet generally designated **30**, and comprising a laminated iron or preferably laminated steel core, having a central pole **31** and flux-returning portions **32** terminating in the same plane as the pole **31**, to provide adjacent pole elements of opposite polarity, for powerful signal action; the magnet winding **33** is conveniently disposed about the central pole member **31**, as shown. The central portion of the field core, viz., the pole member **31**, is conveniently provided with a longitudinal hole or tunnel, to admit a tubular shaft or connecting member **34** which is part of the vibrating assembly hereinafter described. The hole or tunnel is conveniently lined with a copper tube **34***a*, pressed in place, to prevent displacement of the laminations of the member **31** and to guard against an accumulation of rust in the hole, which might otherwise interfere with free movement of member **34**.

The diaphragm structure of the horn advantageously comprises a plurality of relatively thin diaphragms disposed in parallel and preferably arranged so that the distance between the diaphragms at the respective ends of the entire set is of substantial extent. For example, in the construction shown, there are provided two groups of diaphragms **35** and **36**, separated by a substantial space; the inner diaphragm group **35** conveniently comprises three diaphragms **35***a* spaced slightly apart, while the group **36** comprises two diaphragms **36***a*, likewise spaced slightly apart. The diaphragms are peripherally retained to the housing **21** by a plurality of bolts **37**, circumferentially spaced around the assembly. Thin supporting rings **38** serve to space the diaphragms within the respective groups, and the groups are separated by a cylindrical spacing member **39**, and all parts are preliminarily retained in place by the bolts **37** and securely clamped to the housing **21** by a plurality of bolts **40** spaced around and passing through a flange on the bell or trumpet **20**, whereby the latter is also clamped against the diaphragm assembly and housing **21**. It will be noted that the annular face of the bell which abuts against the diaphragm assembly, specifically the outer diaphragm group **36**, is provided with a relatively wide annular groove **41**, so that the area of contact between the bell or horn proper, and the diaphragm assembly, is confined to a pair of spaced, concentric and relatively narrow annular paths **42** and **43**, affording an extremely close fit of the bell **20** against the diaphragm assembly and the housing.

The several diaphragms **35***a* and **36***a* are centrally pierced by and secured to a sleeve **45**, having its interior in threaded engagement with the outside of tube **34**. Intermediate the several diaphragms of each group on the sleeve **45**, central spacing washers **45***a* are provided for accurately spacing the diaphragms at the center, and when the assembly is made up, the ends of the tube **45** are advantageously upset or riveted against the heavy terminal washers **45***b*, whereby each diaphragm group is firmly secured against its corresponding shoulder **45***c* on the tube **45**. The opposite end of the tube **34** on the other side of the electro-magnet **30**, is seated in an armature **46**, which comprises laminations of iron or preferably steel in the same plane as laminations of the field core **31**, **32**, and which is disposed in proximity to the poles of the latter. A long bolt **47** extends through the tubular shaft **34** into threaded engagement with a member **48**, which provides an extension for the shaft **34** beyond the armature **46**, and into which the bolt **47** may be tightened so that the head of the latter engages a lock washer **49***a* against a large knurled washer **49** which is keyed to and abuts the end of sleeve **45**, and the sleeve is locked in adjusted position on the shaft **34**. Before the bolt **47** is tightened, the knurled washer **49** may be turned to screw the sleeve **34** longitudinally in the sleeve **45** so as to adjust the air gap between armature **46** and the core **31**, **32**.

It will be understood that in the preferred construction shown, the passage of shaft **34** through the hole in pole **31** (strictly speaking, through the tube **34***a*) is completely free—i. e., there is no contact anywhere—and indeed the shaft is entirely clear of supporting engagement or abutment at any point above the diaphragm assembly as seen in Fig. 2. That is, the spaced groups of diaphragms **35** and **36**, serve alone, and very satisfactorily, to support the remainder of the vibrating assembly, including shaft **34** and the driving armature **46**. Frictional, spring or other supplementary supports for the vibrating instrumentalities are thus entirely eliminated, and at the same time the arrangement is such that the respective positions of the various parts carried by or connected to the shaft **34** may be readily adjusted and the parts accurately locked in adjusted position. Furthermore, by virtue of the inclusion of a plurality, and preferably a multiplicity, of spaced parallel diaphragms which are each relatively thin, an eminently desirable stiffness is obtained for the diaphragm structure without tendency of breakage on the part of its individual constituents. In other words, the diaphragm arrangement may safely be stiff enough to provide a desirably high pitch, although a relatively heavy armature **46** is used to obtain powerful driving action. For example, a horn of the type shown has been satisfactorily constructed to produce a note of 205 to 210 cycles per second, yet strong enough to be heard clearly for several miles, under average listening conditions.

The outer end of the member **48** carries one contact **50***a* of a pair of contacts generally designated **50**, and arranged to open or close in accordance with longitudinal displacement of the shaft **34**. The other contact **50***b* of the set is mounted on a spring **51**, conveniently secured to but insulated from the casing **22**. To avoid flexing of its end portion, the spring **51** may have a reinforcing plate, or it may preferably have integral upwardly turned ears **52** along its sides, which not only reinforce the end of the spring, but enlarge its end area so as to prevent breakage adjacent the hole where contact **50***b* is mounted. The contact **50***b*, moreover, preferably has a tubular shank **50***c* whereby it is riveted in the hole of the spring, so that when the contact heats up in use, the shank may expand inwardly and avoid straining the spring **51**. The outer end of the spring **51** extends beyond the contacts and is adapted to strike an anvil member **53** which is thus arranged to limit the motion of the spring downward as seen in Fig. 2. The anvil member **53** advantageously comprises a worm gear mounted on a shaft which is threaded into a cross member **54** that is suitably insulated from the housing **21** and case **22** (it being understood that the housing and case are conveniently bolted together at **55***a*, as shown). The lower end of the worm gear shaft has threaded on it a leaf spring **53***a*, which has its ends abutting the under side of the member **54** and which strongly biases the worm gear in a downward direction to prevent play and chatter. A pin **53***b*, carried by member **54**, engages a slot in the leaf spring **53***a* to prevent rotation of the latter.

A worm **55** is journaled in suitable supports on the member **54**, for rotative engagement with the gear **53**, and is provided with a milled or toothed wheel **56**, and an operating shaft **57** having a slotted head. A check spring **58** releasably engages the teeth of the wheel **56**; and the arrangement is such that by inserting a screw driver in the slot of member **57**, and turning the same, the worm **55** will rotate the gear **53** and raise or lower the upper or anvil face of the latter with respect to the outer end of spring **51**. During such adjustment the check **58** clicks over the teeth of wheel **56**, but serves to lock the assembly in any adjusted position. The slotted shaft or head **57** is preferably insulated from the assembly of wheel **56** and worm **55**, so as to prevent electric shock to the operator making adjustments, or inadvertent grounding should his screw driver also touch the metal casing. Preferably both the anvil **53** and contact spring **51** are of hardened steel construction, for maximum wear resistance. It may now be explained that the parts generallly designated **25** in Fig. 1 may comprise the elements **57**, **55**, **53**, **51** and **50**, which are thus readily accessible, through the door of casing **22**, for inspection and adjustment.

It will be understood that the lower contact **50***a* may be mounted for vertical adjustment in member **48**, as by a shank threaded into the latter and carrying a lock nut **48***a*, so that the contact may be locked in position of best alignment with contact **50***b*.

The instrumentalities hereinabove described are also diagrammatically shown at the upper part of Fig. 5, except that for purposes of simplicity the diaphragm structure is shown as a single diaphragm member **60**. It will here be seen that the internal wiring arrangement of the horn is simply such that the winding **33** is connected in series with the contacts **50** across the input terminals **61**, the path from the contacts **50** to the lower one of the terminals **61** being conveniently through ground as diagrammatically indicated. Actually, in the apparatus of Figs. 1 to 4, this grounded path extends from contact **50***a* through the shaft **34** and the diaphragm assembly, to housing **21**.

Assume for the time being that a suitable source of current, such as a storage battery, is connected across the terminals **61**. Contacts **50** are normally in closed position, and the winding **33** being thus energized, the armature **46** is attracted by the field poles **31**, **32**. The contacts remain closed, i. e., the spring **51** follows the downward displacement of the armature **46** (Fig. 5), until the outer end of the spring strikes the anvil **53**. The downward stroke of the armature and diaphragm assembly **46**, **60** then continues, as will be well understood, and upon the return stroke (initiated by the energy stored in the diaphragm), contacts **50** again close, and under a presently preferred adjustment with respect to the natural period of the vibrating system, the spring **51** is flexed back to and past its original position as shown in Fig. 5, and the cycle is repeated. Other things being equal (except the current consumption) the amplitude of diaphragm vibration is dependent upon the space **62** intermediate the upper surface of anvil **53** and the outer end of spring **51** in its neutral or rest position; that is, the wider the space the longer the contacts **50** are closed during each stroke, and the greater the force exerted on the armature **46**. It will now be seen that the described horn structure, including the worm **55** for varying the position of anvil member **53** with respect to the spring **51**, is provided with effective means for adjusting the amplitude of diaphragm vibration, so as to obtain and maintain the desired amplitude at all times and without excess current consumption.

When the horn is used for marine signalling purposes, for which it is notably adapted, it must draw a relatively substantial current in order to produce a signal sufficiently powerful to be heard, say, for several miles. Under such circumstances—for example, where the horn is located and hooked up, as on a floating buoy, to operate automatically at frequent intervals—long continued use is apt to wear down the surfaces of the rapidly operated contacts **50** (even though a condenser **63** or a condenser-resistor unit, is connected across them, as shown in Fig. 5), or more particularly to carry metal from one contact to the other, thus causing the pitting of one contact and the building up of the other contact so as to disturb their parallelism and their relative positions in operation. Fig. 5 accordingly shows a particularly advantageous arrangement for automatic intermittent operation of the horn, and at the same time, for avoiding or greatly reducing the wear on the contacts.

It has been explained hereinabove that the casing **22** may contain a motor **23**, together with an associated cycling mechanism and a horn controlling relay **24**. As shown diagrammatically in Fig. 5, the electric motor **23**, which may be energized from a pair of storage batteries **65** and **66**, connected in series, is adapted to drive a pair of cams **67** and **68**. Although other motors may be satisfactorily employed in many cases, I prefer to use a motor of the type described and claimed in United States Patent No. 1,985,357, to Charles F. Wallace, for Electric motor apparatus; it will be understood that where the device is expected to operate continuously for long periods of time and without attention, it is desirable to employ a motor having the low current consumption, constant speed and general dependability characteristic of the patented motor.

Cam **67** is provided, for example, with two oppositely disposed rises or high spots **69**, and a pair of normally open cam contacts **70** are arranged to be closed by each passage of a rise **69**—thus in the instance shown, twice during each revolution of cam **67**. Cam **68**, which may be assumed to rotate at the same speed as cam **67**, is provided with a single rise **71**, which is longer in extent than either rise **69** of cam **67**, and which is so disposed that it shifts a contact-operating follower **72** shortly before contacts **70** are closed by one rise **69** of cam **67**, and keeps the follower in shifted position until after the same rise **69** (on cam **67**) has passed the contacts **70** and permitted them to reopen. When shifted, the follower **72** is adapted to open the normally closed contacts **73** and to close the normally open contacts **74**.

One of the input terminals **61** of the horn is connected through conductor **75** to the connection **76** between the batteries **65** and **66**: the other input terminal of the horn is connected through conductor **76**a, heavy duty contacts **77** (normally open) of the relay **24**, to the common contact member **72**a of the contacts **73** and **74**. The other sides of the contacts **73** and **74** are respectively connected to the opposite ends of the batteries **65** and **66**, and it will now be appreciated that, assuming contacts **77** to be closed, the horn is connected to battery **65** or battery **66** respectively according to whether contacts **73** or **74** are closed. Furthermore, since the sides of the batteries **65** and **66** which are connected together through the common connection **76** are opposite in sign, the current flow through the horn when contacts **73** are closed is in the reverse direction from the flow when contacts **74** are closed. The low-current relay **24** is conveniently used to avoid the association of heavy duty contacts with the timing cam **67** (although in some cases, heavy duty contacts may be used at **70** and the relay **24** omitted), and the winding of the relay may be connected, as shown, through contacts **70** to the midpoint **76** of the batteries, and also through the contact arm **72**a and selectively through contacts **73** or **74**, to the other side of one or the other of the batteries in the same manner as the horn itself.

Assume now that the motor **23** is rotating the cams **67** and **68**, in a counterclockwise direction, from the position shown in Fig. 5. The rise **71** of cam **68** first shifts the follower **72** so as to close contacts **74** and open contacts **73**. Thereafter one rise **69** of cam **67** causes contacts **70** to close and the relay **24** is accordingly energized from battery **66**. Energization of relay **24** closes its contacts **77**, so that current is supplied to the horn, through its input terminals **61**, from battery **67**—contacts **74** being now closed. The horn continues to blow until the rise **69** passes contacts **70**, opening them, thereby de-energizing relay **24** and opening its contacts **77** in the supply circuit to the horn. Thereafter, the follower **72** drops down from the rise **71**, and contacts **73** are closed. They remain closed during the time that the other or opposite rise **69** of cam **67** closes the contacts **70**; and it will now be understood that when the contacts **70** are thus again closed to energize the relay **24** and operate the horn, both the relay and the horn are supplied from battery **65**, and current flows through the horn in the reverse direction from that during the immediately previous period of energization. In other words, as the motor **23** continues to drive cams **67** and **68**, the horn is periodically sounded and the direction of current flow through it is reversed each time, so that wear or other disturbance of the horn contacts **50**, particularly as occasioned by transposition of metal between these contacts, is very greatly reduced; the action at the contacts **50** is thus, so to speak, a series of brief tendencies to carry the metal first one way and then back again respectively, so that over a long period of time the contacts are relatively unaffected by metal transposition.

It will be noted that the arrangement of cams **67** and **68** is such that contacts **73** and **74** are operated at times when no current is flowing, so as to avoid wear of these contacts by arcing. At the same time, it will be noted that the program contacts **70** and the heavy duty relay contacts **77** both benefit by the same reversal of current flow which is provided for the horn; in consequence, wear or other deformation of contacts **70** and **77** is greatly obviated.

It will be appreciated, of course, that the number of rises **69** on cam **67** and correspondingly the use of one or more rises **71** on cam **68** may be varied to suit requirements of design or operation. In one embodiment of the invention, the arrangement has been that shown in Fig. 5, with the rises **69** of such length, and with the motor **23** driving the cam **67** at such rate (2 R. P. M.), that the horn makes four one-second blasts each minute; and with continuous operation of that character for a period exceeding six months—four blasts per minute, day and night—there was no appreciable deformation of the contacts **50** and very little appreciable wear.

It will be understood that the capacity of condenser **63** (for ease in mounting, two condensers **63** are shown in Fig. 3 and will be understood as connected in parallel) may be readily selected to coordinate the period of the electrical circuit with the natural period of the mechanical elements.

It will be appreciated, of course, that over longer periods of time, or under conditions requiring a very heavy current through contacts **50**, the latter eventually wear down. As a result the space **62** is shortened, and the amplitude of diaphragm vibration correspondingly decreased. Furthermore, over a given period of time the voltage of the supply batteries **65** and **66**, may gradually decrease, resulting in a decreased current through the horn and likewise a decreased amplitude of vibration, even though space **62** remains the same. It is accordingly an important feature of my invention to provide instrumentalities to adjust automatically for these and other variations in amplitude, current consumption, or the like; whereby over even very long periods of time, the amplitude of the horn may be kept substantially constant, or so controlled as to keep the power of sound well above a predetermined minimum.

Referring now to Figure 6, the general arrangement of the horn itself is here shown as in Figure 5 and as previously described. There is also provided a ratchet motor comprising an electromagnet having a winding 80 and adapted when energized to attract an armature 81 which thereby shifts a pawl 82 to the left and rotates a ratchet wheel 83 to a predetermined extent corresponding, say, to one or more notches of the wheel. The ratchet wheel 83 is connected—for example, by gearing or by direct mounting on the same shaft—to rotate the worm 55 which in turn, as previously explained, effects adjustment of the anvil member 53 in a vertical direction. For the purposes presently to be described, it will be understood that the operation of the ratchet motor, upon energization of its winding 80, is such as to shift the anvil 53 downward for a predetermined distance upon each energization of the motor.

The apparatus shown in Fig. 6 also includes a spring 85 having one end fixed at a point 86 and having a screw 87 adjustably disposed at its other end in the path of the armature 46 when the latter moves upwardly on a return stroke. To prevent wear, the screw 87 may have a hardened tip and a hardened insert (not shown) may be placed in the upper face of the armature where the latter will strike the screw tip. The spring 85 may be weighted to make its action more positive and to minimize "stray" vibration (transmitted, for instance, from the diaphragm when operating), and the screw 87 may be set with the lock nut 88 in any desired adjusted position relative to the upper surface of armature 46. A pair of contact elements are respectively mounted on opposite sides of the spring, so as to provide, in cooperation with stationary contact elements, a set of contacts 90 closed when the spring is in its normal or unshifted position, and a set of contacts 91 which are normally open; contacts 90 being opened, and contacts 91 closed, when the spring is shifted upwardly. Intermediate the contacts 90 and 91, and the anchorage 86, the spring 85 carries an armature 92, adapted to be attracted upwardly by an adjacent electromagnet having a winding 93 and thus providing a lock-up relay for the spring.

The pawl 82 of the ratchet motor has a retracting spring 82*a* to restore the pawl to its original position upon de-energization of the winding 80, and a releasable check 83*a* holds the ratchet wheel 83 (and other driven parts) against any displacement, accidental or otherwise, which is not occasioned by energization of the winding 80.

It will now be understood that the input terminals 61 of the apparatus shown in Fig. 6 may be conveniently connected to a control apparatus for intermittently supplying current to the horn. For example, these terminals may be connected to a cycling and current-reversing arrangement such as shown in Fig. 5; indeed, in Fig. 6 the horn winding 33 and horn contacts 50 are connected in series across the terminals 61 just as in Fig. 5. The circuit of the ratchet motor winding 80 extends from the upper of the terminals 61, through conductor 95, winding 80, conductor 96, contacts 90 (normally closed when the horn is quiet), spring 85, and through ground back to the lower of the terminals 61. The winding 93 of the lock-up relay is connected at one side through conductor 97 to the upper of the terminals 61, and at the other side through contacts 91 (normally open, however, when the horn is not in operation), spring 85 and through ground back to the lower of the terminals 61.

When the apparatus is to be used, the worm 55 and anvil 53 may first be adjusted manually to provide the proper amplitude and operative characteristics of the horn as previously described. The screw 87 is also pre-adjusted so that if the desired or any greater amplitude of vibration of the diaphragm 60 is obtained, the armature 46 will strike the screw 87 for the purposes now to be explained. Let it be assumed that by virtue of a cycling mechanism (such as in Fig. 5) current is applied to the input terminals 61 and the armature 46 is set in vibration. On its first return stroke, or at least, practically immediately after it starts to vibrate, the armature 46 strikes the screw 87 and throws the spring 85 upward so as to close contacts 91 and open contacts 90. Closure of contacts 91 establishes current flow through the relay winding 93, whereby its armature 92 is attracted and held; and the spring 85 is thus locked in its upper position, by the relay, throughout the interval that the horn is actually in operation. Upon cessation of current supply to the terminals 61, the relay 93 is de-energized, releasing its armature 92 and restoring the spring 85 and associated parts, including contacts 90, 91, to their original or normal positions. The set of operations just described is repeated each time the horn is energized, as by the cycling mechanism, and it will now be seen that so long as the horn is working at its full and proper amplitude, the contacts 90 are opened throughout each period of energization, so that the ratchet motor winding 80 is never energized, or never sufficiently energized to operate the ratchet, and in consequence no adjustment is made of the anvil 53.

If, however, because of wear of the contacts 50, or because of decrease in battery voltage, or for any other reason, the amplitude of diaphragm vibration is reduced below the desired value, the armature 46 will fail to strike the screw 87 when the horn is turned on, or at least will fail to move the screw sufficiently for operation of contacts 90 and 91 as previously described; that is, the contacts 90 will remain closed at least long enough to energize the winding 80 and operate the rachet motor. In consequence the ratchet wheel 83 is rotated to the predetermined extent, and the anvil 53 is correspondingly adjusted downward to widen the gap 62 and increase the amplitude of horn vibration as previously explained. It will be understood that unless the one adjustment is sufficient, the anvil 53 is shifted again, and thus progressively, each time the horn is set in operation by the cycling mechanism, until the desired amplitude is re-obtained—i. e., until armature 46 again so strikes the screw 87 as to open the contacts 90 promptly and bring the lock-up relay into play.

Although a supplemental or restoring spring may be provided for the control spring 85, my present preference is to employ a magnetic restoring or holding arrangement. Thus the weight 98, which may serve to weight the spring (enhancing its momentum, for positive closure of contacts 91 when the armature 46 strikes the screw 87), may be made of ferrous material, and a permanent magnet 99 may be disposed below and in proximity to the weight 98. The magnet thus positively holds the weight 98, and the spring 85, in normal position, but permits ready release of the same at desired times. That is, this magnetic arrangement is substantially unaffected by vibrations which are necessarily present in the horn because of the vibrating diaphragm assembly, and which would tend to cause such natural vibration of any spring, for example a holding spring or the spring 85 itself, as to interfere with proper positive functioning of the contacts 90 and 91. Furthermore, the pull of the magnet 99 on the weight 98, is greatly reduced when the armature 92 is locked up, thus permitting a more effective locked-up condition than would be possible against a restoring spring, which would necessarily have in increased tension in its extended position. The magnet 99 is preferably made of a magnetic alloy that is practically immune to demagnetizing effects of vibration, such as the alloy commercially known as Alnico.

It will now be seen that the described arrangement affords a prompt, efficient and automatic adjustment of horn amplitude, particularly to restore the latter to a desired value whenever it drops below that value.

The arrangement shown in Fig. 7 is in general similar to that of Fig. 6, except that the contacts 91 and the lockup relay are dispensed with, and mechanical means are provided for preventing operation of the ratchet motor when the horn is operating at the desired amplitude. To that end, the spring 85 is mechanically connected to the plunger 100 of a dash pot 101 of the delayed return type, i. e., so constructed as to afford little resistance to upward movement of the spring 85, but to provide a substantial delay or retardation in the return of the spring 85 after it has been moved up.

It will now be seen that if the horn is operated at its full proper amplitude, the spring 85 will, as in the case of Fig. 6, be thrown promptly upward each time current is applied to the horn motor, opening contacts 90 and preventing energization of the ratchet motor. Furthermore, during the remainder of each operating interval of the horn, the dash pot 101 prevents the return of the spring 85 to normal position before screw 87 is struck by the rapidly vibrating armature; that is, the mechanical lag afforded by the dash pot, cooperating with succeeding impingements of the armature 46 on the screw 87, maintains the spring 85 in its upper position. On the other hand, if the amplitude of horn vibration is low, the screw 87 will not be struck by the armature 46, or will not be struck sufficiently to open contacts 90; in consequence the ratchet motor will, as in the case of Fig. 6, be operated one step for each interval of horn energization, until the anvil 53 has been so adjusted as to restore the amplitude of vibration of diaphragm 60 to its desired value.

For variety of illustration, a holding or restoring spring 102 is shown connected to the member 85 in Fig. 7, in lieu of the magnetic arrangement shown in Fig. 6. Although magnetic means are now deemed to be preferable, as explained above, the spring device shown in Fig. 7 is satisfactory in a number of cases.

A somewhat simplified arrangement for automatic amplitude control is illustrated in Fig. 8, wherein the horn armature 46 carries an adjustable striker screw or pin 105 having an insulated tip 106 and disposed so that the latter abuts upwardly against the end of an auxiliary contact spring 107. The latter has an associated set of contacts 108 which are arranged to be opened when the tip of screw 105 strikes the spring 107 and moves it up. In this arrangement, as in the case of Figs. 6 and 7, the connections of the horn motor and its attendant cycling mechanism through terminals 61 may conveniently be assumed to be the same as shown in Fig. 5. The winding 80 of the ratchet motor is connected at one side through contacts 108 to the upper of the input terminals 61, and at the other side through ground to the other of the input terminals.

Assuming that the horn has been otherwise adjusted to obtain the proper amplitude of diaphragm vibration, the screw 105 is adjusted so that when the horn is thus properly operating, contacts 108 are opened during at least a substantial part of the upper half of each cycle of vibration of the horn diaphragm and armature assembly. Under those circumstances, the circuit of the ratchet motor winding 80 is rapidly interrupted, preventing sufficient flow of current to operate the ratchet motor, and thereby preventing displacement of the anvil 53. However, if the amplitude of horn vibration decreases below a value predetermined by the adjustment of screw 105, the latter will no longer provide the normal intermittent opening of contacts 108 during intervals of horn energization, and the ratchet motor will thus receive sufficient current to operate it during each such interval. That is, as before, the ratchet motor then operates one step for each such interval of horn energization, until the anvil 53 has been so adjusted as to restore the desired amplitude of horn vibration.

The arrangement of Fig. 9 is found similar to that of Fig. 8, except that further instrumentalities, including a sensitive relay, are provided for more accurate and dependable operation, and particularly for avoiding any disadvantage due to wear or pitting of the contacts 108 in Fig. 8. The winding 110 of the sensitive relay thus provided in Fig. 9 is connected at one side through the contacts 108 to the upper of the input terminals 61 and at the other side through ground to the other of the input terminals. The armature 111 of the sensitive relay is adapted in its retracted position (as shown) to close a pair of contacts 112, and in its attracted or upper position, to close a pair of contacts 113. The contacts 113 are connected in parallel with the contacts 108 so as to provide a stick circuit for the relay when the latter is energized by a relatively momentary closure of contacts 108. The circuit of the ratchet motor winding 80 extends at one side through contacts 112 to the upper of the input terminals 61, and at the other side, through ground to the other of the input terminals.

The striking screw or pin 105 is adjusted in generally the same manner as for the arrangement of Fig. 8 and it will now be appreciated that when the horn is vibrating at true or proper amplitude, the spring 107 is promptly shifted up at the starting of each interval of horn energization. As soon as contacts 108 are thus closed, the sensitive relay 110 is promptly energized: attracting its armature 111; opening contacts 112 so as to prevent flow of current to the ratchet motor and to prevent operation of the latter; and closing contacts 113 of the stick circuit so that the relay 110 remains energized until current supply is discontinued from terminals 61 by the cycling mechanism. If the amplitude of horn vibration, however, drops below a predetermined value, the contacts 108 will not be closed or will not be sufficiently closed to operate the relay 110; in consequence, contacts 112 remain closed and the ratchet motor operates to adjust the anvil 53 one step. As before, successive steps of adjustment are made, if necessary, for each interval of horn energization until the desired amplitude is re-obtained.

It will be appreciated that in this arrangement the ratchet motor is positively locked out of circuit at times when there is sufficient amplitude of horn diaphragm vibration. At the same time, contact wear is practically eliminated—not only because the current drawn by the sensitive relay may be much less than that required to operate the ratchet motor (with respect to contacts 108, in comparison with Fig. 8), but also because current flow through contacts 108 need be merely established at the start of each interval of horn energization (under normal conditions), by virtue of the immediately following closure of the stick circuit contacts 113. Furthermore, by virtue of the locked-up arrangement of the relay 110, such frying of the ratchet motor contacts (here contacts 112 in lieu of contacts 108 of Fig. 8), as might be occasioned by vibrations existing in the horn, is eliminated—except, of course, during periods of low amplitude when such vibrations are at a minimum. Moreover, the inclusion of a sensitive relay, such as relay 110, generally permits finer and more accurate adjustment, since the only frictional load of this relay is the small constant load of operating its contacts; whereas when the ratchet relay 80 is operated directly, the quality of adjustment may be somewhat inferior since its frictional load (of ratchet and attendant instrumentalities) may vary.

Fig. 10 illustrates a somewhat different form of amplitude control arrangement, but including a ratchet motor or like device corresponding to that shown in Figs. 6 to 9. The armature 46 of the horn motor carries a strip 120 of ferrous material, having a winding 121 and disposed in proximity to the poles of a permanent magnet 122 (preferably made of the same material as magnet 99 in Fig. 6, for the same reasons) so that when the armature 46 vibrates, alternating electro-motive force is induced in the winding 121. The latter is connected through a suitable rectifier 123—for example, a plurality of small copper oxide rectifier-elements connected in the usual bridge connection for full wave rectification—to the winding 124 of a sensitive D. C. relay. It will here be understood that in some cases, a suitable alternating current relay of sensitive type may be employed, eliminating the necessity for a rectifier.

For convenience of illustration, the cycling mechanism is shown in more simplified arrangement than that of Fig. 5, and without the current-reversing means; but it will be understood that the latter may, if desired, be readily and advantageously included in the apparatus of Fig. 10. As shown in Fig. 10, the program cam 127, to be driven by a suitable electric motor (for example such as the motor 23 in Fig. 5) is provided with a two-step rise 128 for each desired interval of horn energization per revolution of the cam. Associated with the cam 127 are a pair of contacts 129 normally open but having a relatively small gap and adapted to be closed upon displacement of the follower 130 by either the lower level 131 or the upper level 132 of the rise 128. A further pair of contacts 133 are also associated with the cam 127, to be operated by the same follower 130; these contacts 133 may conveniently have a relatively large gap or be otherwise so arranged as to close only when the follower 130 is lifted to the upper surface 132 of the rise. The sensitive relay 124 has a pair of normally closed contacts 135 which are adapted to be opened by the relay armature upon sufficient energization of the relay winding; the relay armature being provided with an adjustable holding or restoring spring 136 so that the relay may be adjusted to open its contacts 135 only upon energization by current of not less than a selected strength.

The circuit of the horn motor is as follows: From battery 138, through contacts 129, conductor 139, horn winding 33, horn contacts 50, and back through ground to the other side of battery 138. The circuit of the ratchet motor winding 80 is as follows: from battery 138, through contacts 133, conductor 140, contacts 135 of the sensitive relay, winding 80, and back through ground to the other side of the battery.

It will now be appreciated that the sensitive relay is preferably so adjusted, as by its spring 136, that when the horn is operating at the full desired amplitude, just enough current is induced in winding 121 and supplied to the relay winding 124 to open the contacts 135, and keep the same open while the horn is actually operating. Thus let it be assumed that the program cam 127 is rotating clockwise and that the follower 130 rides up on the lower part 131 of the rise 128. Contacts 129 now close, establishing current flow to the horn motor and setting the horn in operation. At this time, however, no current can flow to the winding 80 of the ratchet motor, since contacts 133 are still open. After a time, usually short, but sufficient to allow the horn to build up to its full amplitude of vibration, the follower 130 is lifted to the upper part 132 of the rise 128. The horn continues in operation, since contacts 129 are still closed; but at the same time contacts 133 are closed in the circuit of the ratchet motor winding 80. If, however, the horn is operating at its full desired amplitude, the electromotive force induced in winding 121 has already operated the senstive relay, i. e., its contacts 135 have been opened before contacts 133 were closed by the cam; and current from winding 121 continues to keep the contacts 135 open as long as the horn remains in operation at full amplitude.

On the other hand, if the amplitude of horn vibration is below the desired value, or if the horn is undesirably slow in building up to the intended amplitude, the sensitive relay is insufficiently energized to open its contacts 135 and in consequence current flows through the winding 80 of the ratchet motor, causing a single step operation of the latter as before.

When the follower 130 reaches the end of the rise 128, both contacts 129 and 133 are opened, respectively turning off the horn and preventing or interrupting current supply to the ratchet motor. Thus, if the horn amplitude is correct, no adjustment is made; but if the amplitude has unduly decreased, the ratchet motor will be brought into operation during each interval of horn energization so as to shift the anvil 53 downwardly one step, so to speak, until the amplitude of diaphragm vibration is restored to its desired value.

It will be noted that the arrangement shown in Fig 10 permits the horn motor to reach its full amplitude of vibration before current can be applied to the ratchet winding 80; thus insuring a positive operation of relay 124 before the end of that preliminary interval, if the horn amplitude is proper; and at the same time preventing pitting or other injury of the contacts 135 and 133, since the normal opening of the former will be during that preliminary interval, and the only times that the latter are called upon to make and break a current flow are the periods of actual amplitude correction. In some cases, however, the delayed operation obtained with contacts 133 may be dispensed with—since the heavy ratchet relay 80 is usually slower-acting than relay 124—although there will then usually be some current flow through contacts 135 each time they open.

Where a sensitive control relay is used—such as relay 110 in Fig. 9 or relay 124 in Fig. 10—it may be desirable to mount the same (suitably enclosed) out of the horn housing and apart from it, to avoid the disturbing effects of vibration on the relay and thus to permit greater sensitivity of adjustment.

Figs. 11*a* and 11*b* show a somewhat modified arrangement of certain instrumentalities in Fig. 10. In Fig. 11*a* the horn armature 46 carries and vibrates a supplementary soft iron armature 142, which thus moves within a winding 143, the vibration being in a direction perpendicular both to the plane of member 142 and to the axis of the winding. A U-shaped permanent magnet 144 is provided (see also Fig. 11*b*) having inwardly extending projections disposed alongside of the winding, the arrangement being such that one pole 145 (say, the north pole) of the magnet has a projection 146 extending along one side of the winding 143 at the top, and another projection 147 extending along the other side of the winding at the bottom, while the south pole 148 of the magnet has corresponding projections along the winding, oppositely arranged—only one of such projections 149 being visible in Fig. 11*b*, beside the winding at its top and opposite the projection 146. Thus the armature 142, as it vibrates within the winding, moves first toward a pair of magnet poles arranged, for example, with the north pole near the end of the armature and the south pole toward the center, and thereafter moves back toward a set of magnet poles oppositely arranged with respect to the armature. Hence as the armature approaches first one set of poles and then the other, electromotive forces will be induced in successively opposite directions in the winding 143; that is, there is a complete reversal of flux as the armature moves, say, from its lower to its upper position, as seen in Figs. 11*a* and 11*b*.

It will be understood that the arrangement just described may be substituted for the parts 120—122 in Fig. 10, the winding 143 being connected in lieu of the winding 121 in Fig. 10. Indeed, the structure of Figs. 11*a* and 11*b* is at present preferred, since it may afford a greatly increased flow of current to the sensitive relay, and the latter may thus be more accurately adjusted for selective response; it being particularly noted that the structure of Figs. 11*a* and 11*b* provides a more efficient generator in that it produces a much greater change of flux, including a complete reversal of flux for each cycle of vibration.

The apparatus shown in Fig. 12 represents a still further modified system of automatic adjustment of horn amplitude, and here, as in Fig. 10, the circuit and arrangement of the cycling mechanism is shown in simplified form; it being understood that if desired, control apparatus of the type shown in Fig. 5, may be readily and advantageously included. The apparatus of Fig. 12 comprises the horn and ratchet motor for adjustment of anvil 53, as previously described. The winding 150 of a series relay is arranged to be connected in series in the horn energizing circuit, and this relay is provided with a pair of contacts 151 in the circuit of the ratchet motor 80, so that when the current supplied to the horn drops below a predetermined value—for example, because wear of the contacts 50 has reduced the time of energization of winding 33 in each vibratory cycle (thus reducing the horn amplitude), or because the voltage of the supply battery 152 has dropped (likewise reducing the horn amplitude)—the contacts 151 will remain closed during each interval of horn operation and effect a step of ratchet motor operation, as in Figs. 6 to 10.

A presently preferred arrangement for controlling the instrumentalities just described includes a program cam 153, corresponding to the cams 127 and 67 of Figs. 10 and 5, respectively, and provided with a rise having at least two levels, viz., a preliminary low level 154 and a subsequently advanced, higher level 155. A set of contacts is arranged to be operated by a follower 156 as follows: normally open contacts 157 are adapted to be closed when the follower 156 rides up on either level of the cam rise; contacts 158, normally closed, are adapted to be opened some time after closure of contacts 156—say, when the follower reaches the highest spot or level 155 of the cam; and contacts 159, normally open, are adapted to be closed only when the follower 156 is on the high spot 155. As will be seen, the circuit of the horn motor is from one side of the battery 152, through contacts 157 (when closed), through relay winding 150 (except when shorted by closure of contacts 158), and through horn winding 33, contacts 50, and back through ground to the other side of the battery. The circuit of the ratchet motor is from one side of the battery through contacts 157 and 159 (when both are closed), contacts 151, conductor 160, winding 80, and back through ground to the other side of the battery. The normally closed contacts 158 are connected across relay winding 150 to short circuit the latter except at desired times as will presently be explained.

Assume now that the cam 153 is rotated until the follower 156 rides up on the low spot 154. Contacts 157 now close, initiating an interval of horn energization. At this time relay 150 is short circuited, and current is prevented from flowing through the ratchet motor winding 80 because contacts 159 are still open. After the preliminary high surge of current through the horn has subsided to normal flow, the follower 156 rides up on the high spot 155. Contacts 157, of course, remain closed and the horn remains in operation. Contacts 158 open (as hereinafter stated, preferably prior to the closure of contacts 159), thereby inserting the relay winding 150 in series with the horn. If the current through the horn is now at its proper desired value, the relay is sufficiently energized to open its contacts 151 so that no current can flow through the ratchet motor winding 80. On the other hand, if the horn driving current is low, as for either of the reasons mentioned hereinabove, or for any other reason, the relay 150 will not be sufficiently energized to open its contacts 151; and since contacts 159 are now closed by the high spot 155, current will be supplied to the ratchet motor winding 80. The ratchet motor thus effects one step of adjustment of the anvil 53; and as before, the horn may thus be progressively adjusted, step by step, during succeeding intervals of energization, until its current is brought up to the desired value corresponding to full amplitude.

As mentioned, horns of the type here described are apt to draw an abnormally heavy current when power is first applied and for an extremely small fraction of a second thereafter, but this current is promptly reduced to normal value by the counter electro-motive force of the horn motor, during normal operation. It will thus be seen that the control afforded with contacts 156 to 159 and the associated instrumentalities prevents a false operation of relay 150 which might be occasioned by the heavy preliminary current at times when the normal horn-driving current is too low and adjustment of the horn is actually desired. As will now be readily understood, the contacts 156, 157 and 158 may easily be so adjusted in relation to each other that the series relay 150 will attract its armature (and open contacts 151), or will be given the opportunity to attract its armature, before current is applied to the circuit of its contacts 151; for example, the arrangement is preferably such that before contacts 159 close, contacts 158 open for a sufficient time to provide for operation of the relay 150 and thereby avoid such wear of the relay contacts 151 as would be occasioned if they were opened when current was actually starting to flow through them to the winding 80.

Although in Figs 6 to 10 and 12 a simple step-by-step ratchet motor is illustrated for operation of the adjusting worm 55, other devices may be used in some cases, such as a rotary motor conveniently geared down to drive very slowly, or a vibratory motor having self-interrupting secondary contacts. Apparatus of the type illustrated is at present generally preferred, however, since the horn is usually intermittently operated and the program mechanism, therefore, conveniently furnishes the necessary impulses for operation of a ratchet motor or the like. Furthermore, in ordinary circumstances, only very minute increments of adjustment are desired and the same may be effectively and economically obtained with the type of motor illustrated.

It will now be appreciated that the present invention not only affords a horn which is relatively simple in construction, dependable in operation, and easily built, to have any predetermined pitch within a wide range, but also affords distinctively improved control arrangements for such horns so as to avoid contact wear and impairment of normal operation and also to provide for effective automatic adjustment of the horn to keep it at a normal standard of operation throughout a long period of time. The advantages realized by the invention are, furthermore, of special importance where the signal device is to be automatically intermittently operated at frequent intervals and in a location (as on a marine buoy) where it must give reliable service without frequent attention. On the one hand, the working vibration of the diaphragm and associated driving assembly is necessarily powerful, and tends to set up disturbing vibrations in every part that is mechanically connected with the apparatus; on the other hand, the electrical parts, notably contacts, are subjected to driving or control operation on each of the many hundred or often several thousand separate occasions on which the signal is operated every day. The invention is particularly effective in obviating or minimizing the wear or other derangement which would otherwise inevitably result from the strenuous operating conditions just described.

In accordance with the provisions of the patent statutes, I have herein described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiments thereof, but I desire to have it understood that the apparatus disclosed is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combinations and relations described, some of these may be altered and others omitted and some of the features of each modification may be embodied in the others without interfering with the more general results outlined, and the invention extends to such use within the scope of the appended claims.

I claim:

1. The combination with sound signal apparatus comprising an armature and electromagnetic means for effecting vibration thereof, of means for maintaining production of a sound signal of high amplitude, comprising means for adjusting the amplitude of vibration of said armature, and means responsive to variation in said amplitude of vibration and including control means operated by the armature, for operating said adjusting means to restore said amplitude of vibration to a predetermined value.

2. In sound signal apparatus, in combination, an armature and driving means therefor comprising an electromagnet and make-and-break contacts in series with the same and associated with the armature for causing vibration of the latter toward and away from the electromagnet, one of said contacts being carried by the armature and the other contact having a supporting spring for maintaining the contacts closed during a substantial part of each cycle of vibration, and anvil means adjustably disposed for abutment by said supporting spring, whereby the interval of contact closure during each cycle may be adjusted, as desired, said anvil means comprising a worm gear having a transverse face disposed for direct abutment by said spring, a fixed support, a shaft for said gear threaded in said support, and a worm engaging the gear for rotating the gear and thereby rotating said threaded shaft to adjust the position of said spring-abutting face axially of the shaft.

3. In electric sound signal apparatus, in combination, a vibrating member, means for adjusting the amplitude of vibration thereof, and means responsive to variations in amplitude of vibration of said member for operating said adjusting means to restore said amplitude to a predetermined value.

4. In electric sound signal apparatus, in combination, a vibrating member, means for adjusting the amplitude of vibration thereof, a member disposed in the path of said vibrating member for displacement thereby, contacts associated with said last mentioned member and adapted to be opened upon displacement of said member when the vibrating member is operating at a predetermined normal amplitude, and means energized by closure of said contacts to operate the adjusting means when the amplitude of vibration of the first mentioned member is less than a predetermined value.

5. In sound signal apparatus, in combination, an electrically driven vibrating member, means for adjusting the amplitude of vibration thereof, means normally biased to operate said adjusting means in a direction to increase said amplitude of vibration, and means controlled by said vibrating member and responsive to the amplitude of vibration thereof, for preventing

operation of said last-mentioned means when the amplitude of vibration is above a predetermined value.

6. In sound signal apparatus, in combination, electrically actuated vibrating means, means for intermittently supplying energy to said vibrating means to operate the same during the intervals of energy supply, means for adjusting the amplitude of vibration of said vibrating means, means having an energy supply circuit and normally biased to operate said adjusting means during each interval of energy supply to the vibrating means, and means responsive to the amplitude of vibration of said vibrating member for opening said supply circuit during each interval of energy supply to the vibrating means, at times when the latter is vibrating at more than a predetermined amplitude.

7. The combination of claim 6, in which the last-mentioned means includes a pair of contacts in the aforesaid supply circuit, control means displaced by said vibrating means upon each initiation of vibration thereof, to open said contacts when the vibration has more than a predetermined amplitude, and lock-up relay means including an armature associated with said control means, for keeping the contacts open until the end of the interval of energy supply to the vibrating means.

8. The combination of claim 6, in which the last-mentioned means includes normally closed contacts in the aforesaid supply circuit, means shifted by initial vibration of said vibrating member to open said contacts only when the amplitude of vibration is more than a predetermined value, and retaining means responsive to shift of said last-mentioned means for preventing closure of said contacts until the end of the interval of energy supply to the vibrating means.

9. The combination of claim 6, in which the last-mentioned means includes relay means, circuit controlling means operated upon initiation of vibration of said vibrating means to energize said relay means when the amplitude of vibration is above a predetermined value, circuit-controlling means responsive to energization of the relay means for opening the aforesaid supply circuit and for keeping said relay means energized until the end of the interval of energy supply to the vibrating means.

10. In sound signal apparatus, in combination, a vibrating member, means for adjusting the amplitude of vibration thereof, means controlled by said member for setting up an electromotive force variable in accordance with the amplitude of vibration of the member, and means controlled by said electromotive force, for operating the adjusting means when the electromotive force is below a predetermined value.

11. The combination of claim 10 wherein the last-mentioned means is adapted for control by an alternating electromotive force, and wherein the means for setting up an electromotive force comprises an armature vibrated by the vibrating means and a field winding disposed for induction of alternating electromotive force therein upon vibration of said armature.

12. In electric sound signal apparatus, in combination, electrically driven vibrating means, means for intermittently supplying energy to said means to operate the same during the intervals of energy supply, means for adjusting the amplitude of vibration of said vibrating means, means energizable by said energy supplying means and normally biased to operate said adjusting means during each interval of energy supply, means operated by said vibrating means for setting up an electromotive force in accordance with the amplitude of vibration thereof, relay means energizable by said last-mentioned means when the electromotive force has more than a predetermined value, for preventing operation of the means for operating the adjusting means, and circuit controlling means associated with the intermittent energy supplying means for maintaining the adjusting means inoperative during a preliminary portion of each interval of energy supply, to delay controlling action of the relay means until the vibrating means has built up its full amplitude of vibration.

13. In sound signal apparatus, in combination electrically driven vibrating means, means for adjusting the amplitude of vibration thereof, a current supply circuit for said vibrating means, and means associated with said circuit and responsive to variations in current consumption by said vibrating means, for operating the adjusting means in a direction to increase the amplitude of vibration when the current consumption is less than a predetermined amount.

14. In electric sound signal apparatus, in combination, a vibrating member, electrically actuated driving means therefor, including means for successively making and breaking current supply to said driving means for effecting vibration thereof, means associated with said driving means for controlling said last-mentioned means to adjust its intervals of current supply and interruption, and means responsive to variations in current consumption by said driving means for operating said adjusting means to restore the current consumption to a predetermined value.

15. In sound signal apparatus, in combination, electrically driven vibrating means, means for adjusting the amplitude of vibration thereof, means for intermittently supplying energy to said vibrating means to operate the same during the intervals of energy supply, actuating means biased to operate said adjusting means in a direction to increase the amplitude of vibration during each interval of energy supply, and control means responsive to variations in the current consumption of said vibrating means, for preventing operation of said actuating means when said current consumption is above a predetermined value.

16. The combination of claim 15, which also includes supplementary means associated with the intermittent energy supplying means, for keeping both the actuating means and the current-responsive control means inoperative during a preliminary portion of each interval of energy supply, to prevent any false operations occasioned by preliminary energy surge to the vibrating means.

17. In sound signal apparatus, in combination, means to be vibrated for production of sound, electrically actuated driving means therefor, including control means for successively making and breaking current supply to said driving means at the desired frequency of vibration, adjusting means associated with said driving means for varying the respective intervals of current supply and interruption by said last-mentioned means, intermittently actuated switch means for connecting the driving means with a source of current to operate the same during the times of connection, and means brought into play when the intervals of current supply by the control means have less than a predetermined duration,

for causing said adjusting means to operate to a predetermined extent in each successive time of current supply by the switch means, until the aforesaid intervals of current supply are restored to the aforesaid predetermined duration.

18. An automatic electric fog horn, comprising in combination, means to be vibrated for production of sound, electrically actuated driving means therefor, means for adjusting the amplitude of vibration of said first mentioned means, means for intermittently supplying energy to said driving means to operate the first mentioned means during the intervals of energy supply, and means responsive to variations in amplitude of vibration of said first mentioned means for progressively operating said adjusting means during successive intervals of energy supply, until said amplitude is restored to a predetermined value.

19. In sound signal apparatus, in combination, a vibrating member, electromagnetic means controlled by said member for generating an alternating current in accordance with the amplitude of vibration of the member and including a winding and means for creating a reversal of flux through said winding in each cycle of vibration of the member, and means controlled by said electromagnetic means and in response to said alternating current, for adjusting the amplitude of vibration of the member.

20. The combination of claim 19 in which the electromagnetic means includes an armature carried by the vibrating member and disposed for vibration thereby within the winding, and magnetized means for establishing a pair of opposite magnetic poles spaced along the armature at one end of its vibratory path in the winding, and a reversed pair of similarly spaced opposite magnetic poles at the other end of said path.

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