Disclosed is an unusually light-weight, compact, self-contained, self-powered ball thrower (10) adapted to be carried and transported in the trunk of a passenger vehicle. All rotary components are driven by miniature DC motors (18, 30, 35) having permanent magnet stators to maximize lightness without sacrificing performance. The low power requirements of these motors is readily provided by an onboard AC to DC power converter (70) or by a rechargeable storage battery (65). The housing is power-oscillated to vary lateral ball trajectory and the throwing wheels (48, 49) are tiltable to vary the vertical delivery trajectory. An ample capacity ball hopper (23) collapses compactly when not in use and a special control circuit (70) assures uniform ball velocity during closely spaced successive ball throwing cycles.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>Austria</td>
<td>FR</td>
<td>France</td>
<td>ML</td>
<td>Mali</td>
</tr>
<tr>
<td>AU</td>
<td>Australia</td>
<td>GA</td>
<td>Gabon</td>
<td>MB</td>
<td>Mauritania</td>
</tr>
<tr>
<td>BB</td>
<td>Barbados</td>
<td>GB</td>
<td>United Kingdom</td>
<td>MW</td>
<td>Malawi</td>
</tr>
<tr>
<td>BE</td>
<td>Belgium</td>
<td>HU</td>
<td>Hungary</td>
<td>NL</td>
<td>Netherlands</td>
</tr>
<tr>
<td>BG</td>
<td>Bulgaria</td>
<td>IT</td>
<td>Italy</td>
<td>NO</td>
<td>Norway</td>
</tr>
<tr>
<td>BJ</td>
<td>Benin</td>
<td>JP</td>
<td>Japan</td>
<td>RO</td>
<td>Romania</td>
</tr>
<tr>
<td>BR</td>
<td>Brazil</td>
<td>KP</td>
<td>Democratic People's Republic</td>
<td>SD</td>
<td>Sudan</td>
</tr>
<tr>
<td>CF</td>
<td>Central African Republic</td>
<td>KO</td>
<td>Democratic People's Republic</td>
<td>SE</td>
<td>Sweden</td>
</tr>
<tr>
<td>CG</td>
<td>Congo</td>
<td>KR</td>
<td>Republic of Korea</td>
<td>SN</td>
<td>Senegal</td>
</tr>
<tr>
<td>CH</td>
<td>Switzerland</td>
<td>LI</td>
<td>Liechtenstein</td>
<td>SU</td>
<td>Soviet Union</td>
</tr>
<tr>
<td>CM</td>
<td>Cameroon</td>
<td>LK</td>
<td>Sri Lanka</td>
<td>TD</td>
<td>Chad</td>
</tr>
<tr>
<td>DE</td>
<td>Germany, Federal Republic of</td>
<td>LU</td>
<td>Luxembourg</td>
<td>TG</td>
<td>Togo</td>
</tr>
<tr>
<td>DK</td>
<td>Denmark</td>
<td>MC</td>
<td>Monaco</td>
<td>US</td>
<td>United States of America</td>
</tr>
<tr>
<td>FI</td>
<td>Finland</td>
<td>MG</td>
<td>Madagascar</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HAND CARRIED POWER CONVERTER BALL THROWING APPARATUS

1 TECHNICAL FIELD

This invention relates to a ball throwing apparatus and more particularly to a unique compact hand portable ball thrower powered by an onboard AC to DC power converter or by a storage battery.

BACKGROUND ART

The widespread interest in ball sports, particularly baseball and tennis, has stimulated numerous proposals for power-driven ball throwing equipment enabling athletes to develop playing skill without need for opponents. Prior proposals to meet this need are subject to many disadvantages and shortcomings including complexity, excessive weight, high cost, unsuitability for transport except by truck, requiring handling by two or more persons and an available source of power. A major source of the size and weight of prior machines is the motor components having the requisite speed and torque characteristics to throw balls as often as once each second while maintaining a constant ball throwing velocity. Prior machines have achieved constant ball throwing velocity by using such large and powerful motors that their speed drops negligibly and recovers almost instantaneously while throwing a ball. The power requirements for motors meeting these needs have been grossly in excess of that available by storage batteries of a reasonable size for on-board portable use. No such equipment or machine to date has been perfected or is available which overcomes these disadvantages and shortcomings.

DISCLOSURE OF THE INVENTION

This invention provides a highly versatile ball thrower avoiding the foregoing and other shortcomings and disadvantages of prior constructions. The new and improved ball thrower is not only self-contained with an on-board
1 power source, but it is unusually compact, light in weight, 2 readily hand portable and regularly accommodated in the 3 trunk or cabin of a motor vehicle. Both the ball feeding 4 mechanism and the ball throwing wheels are powered by mini- 5 ature DC motors with permanent magnet stators. The two ball 6 throwing motors are equipped with a solid state power control 7 circuit operable to switch power on and off many times per 8 second in pulses of variable duration to provide wide-range 9 speed control and more particularly to expedite speed re- 10 covery immediately following a ball throwing cycle. To this 11 end utilization is made of an oscillator activated by a 12 voltage clamped substantially below a nominal battery volt- 13 age to provide a stable output signal until the battery 14 charge is substantially consumed. The output oscillator 15 signal is utilized to turn the power to the ball thro- 16 wing motors on and off many times per second for variable 17 time intervals in relation to the sensed back EMF of 18 these motors as their speed decays when a ball is thrown and 19 recovers in an interval of approximately three seconds or 20 less. A three second interval was selected as the minimum 21 time between successive ball throwing operations, based upon 22 the reaction and recovery time of an individual player to a 23 ball throwing operation. The ball throwing motors were sele- 24 cted to be the minimum size and power rating possible to 25 throw successive balls at three second intervals at the de- 26 sired speed with the motors controlled by a solid state motor 27 controller. The lower power and torque characteristics of 28 these smaller motors causes them to slow down just enough 29 during a ball throwing operation, so that the solid state po- 30 wer control circuitry can recover the lost speed within the 31 three second interval before the next ball throwing operation, 32 so that successive ball throwing operations are at a consistent 33 speed. Motor speed is regulated by varying the time interval 34 during which power is switched on to the motors. The control 35 circuitry includes a jack for connecting the on-board battery 36 to a source of charging power and includes visual means indica-
ting the charge or condition of the battery while charging.

Mechanical features include a housing having a collapsible ball hopper opening into a ball indexing mechanism delivering individual balls to the counter rotating throwing wheels irrespective of their tilted position. These wheels and driving motors are pivotally supported to eject balls in a wide range of vertical trajectories. The apparatus housing is pivotally supported for power-driven oscillatory movement to provide wide range horizontal ball trajectories.

Although the self-contained ball thrower, including a battery or a power converter, typically weighs only 35 pounds, it is preferably equipped along one bottom edge with a set of rollers and with a collapsible towing handle to facilitate towing of the device over level surfaces.

Accordingly, it is a primary object of this invention to provide a unique self-contained hand portable ball thrower with an on-board power supply.

Another object of the invention is to provide an inexpensive light-weight portable ball thrower having improved means for automatically ejecting balls in wide range horizontal and vertical trajectories.

Another object of the invention is the provision of a compact light-weight ball thrower readily carried in the hand and accommodated in the trunk of a motor vehicle.

Another object of the invention is the provision of a self-contained ball thrower having an attached collapsible ball hopper opening into a motor powered ball feeder.

Another object of the invention is the provision of a self-contained ball thrower operable by either an on-board
storage battery or by an AC to DC power converter connected
to the miniature ball throwing motors by a control circuit
having unique means for expediting motor speed recovery imm-
ediately following a ball throwing operation.

Another object of the invention is the provision of a
ball thrower in which the counter-rotating ball throwing de-
vices are pivotally supported and manually adjustable about
an axis positioned forwardly of a generally upright plane co-
taining the axes of the ball throwing wheels and motors.

Another object of the invention is the provision of a
ball thrower which, in addition to being hand portable, is
equipped with carriage wheels and a collapsible towing handle.

Another object of the invention is the provision of a
ball thrower with a time delay that allows the ball throwing
wheels to reach normal operating speed before the ball feeder
is activated, and which allows a player to reach his playing
position before ejection of the first ball thereby eliminating
wasted ball throws and replacing the functionality of a rem-
ote control to begin the ball feeding cycle.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of an illustrative em-
bedment of my improved hand-portable self-powered ball thr-
ower with its collapsible ball hopper in open position;
Figure 2 is a top plan view of Figure 1 with portions
of the housing broken away to show internal components;
Figure 3 is a view taken along line 3-3 on Figure 2;
Figure 4 is a view taken along line 4-4 on Figure 3;
Figure 5 is a view taken along line 5-5 on Figure 3;
Figure 6 is a cross-sectional view taken along line 6-6 on Figure 2;
Figure 7 is a view of the ball thrower as positioned
for towing while supported on a pair of rollers mounted along one vertical corner of the housing and showing the towing handle extended in full lines and collapsed in dot and dash lines;

Figure 8 is a condensed schematic of the electrical circuitry;

Figure 9 is a schematic of the control circuitry for the two ball throwing motors; and

Figure 10 is a graphical representation comparing drive motor RPM vs. time characteristics of certain prior art ball throwers and contrasting these with the superior characteristics of this invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to Figures 1 to 7, there is shown an illustrative embodiment of the invention light-weight ball thrower designated generally 10. The apparatus has a main housing 11 formed of light-weight material such as aluminum. As is best shown in Figure 6, this housing is pivotally supported on the supporting base 12 for oscillation about the vertical connecting bolt 13 on a plurality of rollers 14 supported on the upper side of base 12 inwardly of the housing skirt 15. Bolt 13 is secured to base 12 and extends through the bottom of housing 11 and thrust bearing 16.

Housing 11 and its contents are oscillated through a horizontal arc by a small DC gear motor 18 driving a crank arm 19 operatively connected to the outer end of a lever 20 pivotally connected to base 12 by a bolt 21. Crank 19 and lever 20 are so proportioned that the rotation of crank 19 operates to pivot housing 11 through a desired horizontal arc to vary the horizontal trajectory of the ball thrown by apparatus.

The balls to be thrown by the apparatus are contained in a hopper 23 overlying the top of housing 11 and formed of
four panels 24 equipped with hinges 25 along their lower edges permitting these panels to be folded compactly against one another when not in use. A low height flange 26 embracing the lower edges of the panels limits outward expansion of the hopper walls.

The hopper bottom 27 slopes into the entrance of a ball indexing ball feeder 28 having an armed ball feeding rotor 29 mounted on the upper end of the shaft of a DC gearmotor 30. Each arm of the rotor will accommodate a single ball 31 which exits through the sole outlet opening 32 of the indexing feeder onto the upper end of a nonadjustable stationary ball chute 33 for delivery by gravity into the ball throwing mechanism now to be described. A close wound guard spring 34 (Figures 1 and 6) overlies outlet 32 and safeguards against more than one ball entering the outlet at one time.

The ball throwing mechanism is best shown in Figures 2 and 6. This mechanism comprises a pair of counter-rotating motors 35 supported in an upright position on a shelf 36 pivotally and adjustably supported at its ends by trunnions 37 socketed in sound-absorbing elastomeric rings 38. Compression springs 39 surrounding trunnions 37 serve to compress the sound deadening material and prevent vibration and frictionally resist pivotal movement of the shelf. Adjustment of the shelf is accomplished by a manual clamping knob 40 rotatively supported on the outer end of a bolt 41 carried by an arm 42 projecting laterally from shelf 36. Bolt 41 extends through an arcuate slot 43 (Figure 1) in the sidewall of housing 11 and is provided with washers 45 resting against the inner sidewall of the housing. These serve to clutch the shelf in a desired tilted position when knob 40 is tightened against the housing.

The shafts of motors 35 project through shelf 36. Rigidly anchored to the shafts of the counter rotating motors
35 are the ball throwing wheels 48 each equipped with cylin-
drical elastometric tires 49. Figure 2 best shows the wheels' peripheries being spaced apart in an area overlying the lower end of the ball delivery chute 33, the spacing being the best suited for gripping and thrusting a ball outwardly through the delivery port 50 in the front wall of housing 11.

An important feature of the ball throwing wheels is the fact that their axes lie in a generally upright plane offset rearwardly of the axis of the shelf supporting trunnions 37 as is indicated at 54. This offset (Figure 6), typically about 1/2 inch, enables the supporting shelf 36 to be pivoted throughout a wide range without impairing the ability of the wheels to grasp and throw a ball delivered from the rigidly and immovably supported delivery chute 33. Thus the vertical trajectory of the balls can be changed throughout its full range without need for making any adjustment in the position of chute 33 and without sacrificing the effectiveness of the throwing wheels.

The complete apparatus, including either an on-board 12-volt storage battery or an AC to DC power converter weighs approximately 35 pounds and has a sidewall length of not in excess of 18 inches. Accordingly, it is readily carried by hand using collapsible carrying handles 58 and is readily insertable into the trunk of an ordinary motor vehicle, or even the passenger compartment.

To further facilitate handling, one lateral edge of the housing is preferably equipped with a set of rollers 59 (Figure 7) and a cooperating set of equal-height rubber feet 60. A collapsible towing handle 61 is pivotally connected by a bracket 63 to the housing diagonally opposite rollers 59. A portion of the towing handle extends beyond the pivot connection to bracket 63 and bears against the adjacent outer surface of the housing when the towing handle is pivoted to its
towing position illustrated in Figure 7. This permits the apparatus to be readily towed over a smooth surface after which handle 61 is pivoted back to its collapsed storage position.

THE ELECTRICAL SCHEMATIC AND MOTOR CONTROL ELECTRONICS

Before proceeding to describe the improved control circuitry for the present invention it is advantageous to comment briefly about the state of the prior art ball throwers and typical operating characteristics thereof contrasted with those of this invention. Typical prior art ball throwing machines have power requirements very substantially in excess of that feasible with storage batteries. These machines are of two general types, one being the counter-rotating wheel type utilizing approximately 300 watts and the other being a compressed air type to throw balls and typically consuming approximately 1000 watts of power. In striking contrast, the invention apparatus utilizes 15 to 60 watts readily and economically provided by a sealed on-board rechargeable 12-volt storage battery weighing approximately 6 pounds which provides for approximately 2 to 3 hours of normal use.

The machine of this invention is oscillated by a gear motor 18 and the balls are fed by gear motor 30 each consuming about 3 watts. The ball throwing motors 35 have permanent magnet stators, are rated at 1/8 horsepower each, and together consume power between 10 and 55 watts depending upon the ball throwing velocity.

Figure 10 contrasts the RPM vs. Time characteristics of this invention with two typical types of prior art machines, one of which utilizes voltage control and the other large high torque motors, each using these design expedients to avoid decrease in operating speed in successive ball throwing cycles. Each graph is based on a 3-second ball
delivery cycle.

The top graph shows the operating characteristics of this invention which functions in a highly stable and satisfactory manner to fully restore the operating speed of motors 35 between 3-second ball throwing cycles.

The prior art design utilizing voltage control is incapable of fully restoring operating speed between 3-second cycles and in consequence, the operating speed gradually fades.

The prior art large motor type depicted in the lower graph avoids speed drop between cycles and is capable of operating in shorter intervals of time at the expense of heavy bulky non-portable equipment consuming very substantial quantities of power.

The simplified schematic shown in Figure 8 shows the sealed 12-volt storage battery 65 supplying power via control switch 66 to the drive motor 18 for oscillating the ball thrower in a horizontal arc. The ball feeding motor 30 is supplied with power through the double throw switch 67 via the time delay circuit 68 and a speed control rheostat 69. The power supply to the ball throwing motors 35 is controlled by the second blade of switch 67 and the solid state circuitry represented at 70 and the associated speed control potentiometer 71, the details of this important circuitry being shown in detail in Figure 9.

The solid state control circuitry 70 illustrated in Figure 9 operates at approximately 98% efficiency, so important to a ball thrower having portability and powered by an on-board battery. Moreover, the entire circuitry is very small; weighs only a few ounces; permits ball speed over a range greater than 2 to 1; provides for full motor speed as
loads vary; and provides full motor speed up from a standing
start in less than 6 seconds as contrasted with the up to
15-second spin-up time if using voltage control. Another
important feature is a constant motor drive speed for a given
setting of the ball speed control knob as the battery voltage
decays during use. This is accomplished as will be explained
by a voltage clamping circuit set at a level substantially
below normal battery charge level and functioning in concert
with motor voltage feedback.

The electronic control circuit for ball throwing mo-
tors 35 operates to switch the power on and off in pulses of
variable width at a frequency generated by an oscillator to
restore quickly the speed lost as a ball is thrown. The
width of the power pulse is determined by comparing the back-
electromotive force generated by the motors with a reference
voltage signal to provide for constant speed control as the
battery voltage decays during discharge. The reference volt-
age signal is provided by a circuit clamping the voltage at a
stable reference value, such as 6.8 volts. This clamping ci-
circuit comprises resistor R9, diode D3, zener diode Z1 and
capacitor C4. Diode D3 serves as a disconnect diode to prevent
negative transients from discharging filtering capacitor C4.
Zener diode Z1 clamps the voltage on the line at a suitable
reference voltage such as that mentioned above.

This reference voltage activates an oscillator circuit
comprising an integrated circuit comparator IIA and its ass-
ociated components R1 to R6 and C1, this comparator having a
square wave output of a suitable frequency, such as 50 cycles,
and an amplitude which varies between 6.8 volts and 0 volts.
This output signal alternately charges and discharges capaci-
tor C1 via resistor R4, creating a triangular reference
voltage signal which is applied to the positive input of the
integrated circuit comparator I1b.
At the instant a ball is thrown, the speed of motors 35 drops as does the back EMF, the latter being represented by the signal VEMF below motors 35 in Figure 9. This signal appearing at the junction of T1, R17 and motors 35, is applied to the base of transistor T2 which is a common emitter amplifier stage having a gain output determined by the values of resistors R14, R15, R16 and R17. The motor back EMF signal inverted by transistor T2 appears at the junction of R13 and R14 and is represented graphically to the right of that junction. The signal passes through resistor R13 and is offset by a DC voltage determined by resistors R11, R12 and the motor speed control potentiometer 71, the latter serving to vary the DC offset voltage added to the feedback signal. Diode D1 clips the positive portion of this feedback signal and passes only the pure feedback portion Vfb to the negative input of the integrated circuit comparator IIb which offsets the positive bias supplied through R8, Capacitor C3 filters out the higher frequency components of the feedback signal. Capacitor C2 filters the feedback signal so that the comparator sees an average value of Vfb. As the signal decreases or increases on the comparator IIb negative input, the comparison of that signal with the triangular wave form present at the comparator positive input provides an output signal which is proportionally wider or narrower respectively and this output is delivered to the gate of transistor T1 through current limiting resistor Rl9. Transistor T1 comprises four metal oxide semi-conductor field effect transistors in parallel. When T1 is driven by comparator IIb it conducts thereby placing the negative terminals of motors 35 at ground potential. Since the positive terminals of the motors are at positive 12 volts, the full supply voltage of the battery is placed across the motors for the time interval controlled by the output signal of comparator IIb. If the oscillator provides a 50 hertz signal, then this full power pulse is applied to the motors 50 times per second. As now will be apparent, this feedback action provides
the speed regulation for these motors. It also provides
constant throwing motor speed for a specific setting of the
speed control potentiometer 71 even though the battery voltage
is falling during battery discharge. This constant motor
speed is achieved because the reference voltage signal appli-
cated to the positive input of comparator I1b is clamped at 6.8
volts. The comparator compensates for decreasing back EMF by
widening its output pulse width in an amount to supply const-
stant power to the motors until the battery voltage has fallen
so far the comparator remains fully on. The output of
comparator I1b, which is stabilized by current flowing through
resistor R10 when it is not in an output state, not only
drives the gate of transistor T1 but also completes a hystere-
sis loop to ground through resistors R6 and R7. The hystere-
sis loop prevents oscillation when the comparator is in an
output state.

The solid state control circuitry also includes import-
ant circuit protection features. For example, when transi-
stor T1 is shut off an inductive spike is produced. This
spike is clamped by diode D2 which is in parallel with motors
35. This prevents a large potentially dangerous positive
voltage from reaching transistor T1. This voltage spike is
shown clamped at the plus 12-volt level in the graph below
the motors in Figure 9.

There is also a rate suppression network consisting
of capacitor C5 and resistor R18 connected across the termi-
nals of motors 35. This network reduces radio frequency
noise and controls the rise and decay times of the voltage to
motors 35 when power is applied and removed. In addition,
varistor V1 acts as a transient suppression device to clamp
any extraneous inductive pulses which might appear on the
positive voltage supply line to less than 22 volts.

Another adjunct comprises a battery charge monitor
which includes a jack J having its plug receiving end mounted
in the sidewall of the apparatus housing shown in Figure 1
into which a plug connected to a source of charging power can be inserted. This jack is connected in circuit with dual light emitting diodes 72 mounted on the control panel of the apparatus housing (Figure 1), a zener diode Z2, and resistors R20, R21.

The battery monitoring circuit is only in operation when a plug is present in Jack J. The light emitting diode D4 in circuit with resistor R20 is green whereas the other diode D5 is red, both being enclosed in the same physical package so that their light output is combined. When the battery voltage is below 12 volts, the red diode glows whereas the other diode does not begin to glow green until the battery voltage approaches 13 volts. The green diode does not glow until the battery voltage exceeds the zener voltage of zener diode Z2. Resistors R20 and R21 provide current limiting for diodes D4 and D5 respectively.

When the battery is discharged and the charging power plug is inserted into jack J only the red diode will glow. As the battery charges, the green diode will begin to glow and as the charge increases it will glow more brightly than the red diode, the green color dominating as the full battery charge is reached. The increasing green light as the battery charges will cause the light output of the two diodes to change from red, to orange, to yellow, and finally to green as the battery becomes fully charged, thereby providing a changing visual indication of the state of battery charge.

OPERATION

Ball throwing apparatus 10 is placed in operation by transporting and/or hand carrying it to a playing area and placing the stationary base 12 on a supporting surface. The hopper sidewall panels 24 are then placed in use by releasing them from a catch (not shown) holding them collapsed and
opening them to their extended position and filling the hopper with a supply of balls. Shelf 36 supporting the motors and the ball throwing wheels 49 is adjusted to eject the balls in a desired vertical trajectory by loosening the clamping knob 40, adjusting the tilt position of the shelf and then clamping it firmly in this position by tightening knob 40. The oscillator motor, if desired, is then turned on by closing switch 66 to drive motor 18 to oscillate the apparatus housing 11 to-and-fro horizontally about pivot bolt 13. The ball feed control potentiometer 69 is adjusted to index balls for gravity flow down chute 33 and into the ball throwing wheels position at desired intervals after the ball feed motor 30 has been activated. Switch 67 controlling current flow to this motor and to the motor control electronics complex 70 is typically made after all other adjustments have been made. However, the time delay component 68 delays energization of the ball feed motor 30 for an appropriate length of time, such as 8 seconds, after energization of the solid state circuitry 70 to permit motors 35 to reach full operating speed. This gives time for the player to reach his playing position and prevents the premature ejection of balls before the motors are up to their proper operating speed.

The solid state circuitry then functions as outlined above by generating a steady state oscillating signal converted to a triangular configuration and supplied to the positive terminal of comparator Ilb. As each ball is thrown there is a precipitous and almost instantaneous decrease in motor speed accompanied by a decrease in their back EMF. This signal is converted into pulses and supplied to the base of the amplifier transistor T2 where it is inverted in amplified form at the junction of R13, R14. This back EMF signal proportional to motor speed is delivered to the negative input of comparator Ilb to provide output signal pulses in step with the frequency of the oscillator circuit and of variable width. This variable signal is utilized to turn on
1 the field effect transistor T1 to supply full power to motors
2 35 for variable pulse periods and at the rate of the oscill-
3 tor output signal. In this manner the resumption of full
4 speed of motors 35 is restored in a most efficient and
5 expedited manner. If the operator wishes to vary the speed
6 of motors 35 he adjusts the potentiometer 71 to vary the DC
7 offset voltage added to the feedback signal enroute to com-
8 parator IIb.
9
10 Suitable values and identification of the solid state
11 components found to provide excellent results in the high
12 efficiency control circuit shown in Figure 9 are as follows:
13
<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>24K ohm</td>
</tr>
<tr>
<td>R2</td>
<td>33K ohm</td>
</tr>
<tr>
<td>R3</td>
<td>470K ohm</td>
</tr>
<tr>
<td>R4</td>
<td>510K ohm</td>
</tr>
<tr>
<td>R5</td>
<td>10K ohm</td>
</tr>
<tr>
<td>R6</td>
<td>270 ohm</td>
</tr>
<tr>
<td>R7</td>
<td>100K ohm</td>
</tr>
<tr>
<td>R8</td>
<td>1M ohm</td>
</tr>
<tr>
<td>R9</td>
<td>330 ohm</td>
</tr>
<tr>
<td>R10</td>
<td>1.8K ohm</td>
</tr>
<tr>
<td>R11</td>
<td>390 ohm</td>
</tr>
<tr>
<td>R12</td>
<td>39K ohm</td>
</tr>
<tr>
<td>R13</td>
<td>100K ohm</td>
</tr>
<tr>
<td>R14</td>
<td>8.2K ohm</td>
</tr>
<tr>
<td>R15</td>
<td>1K ohm</td>
</tr>
<tr>
<td>R16</td>
<td>1.2K ohm</td>
</tr>
<tr>
<td>R17</td>
<td>6.8K ohm</td>
</tr>
<tr>
<td>R18</td>
<td>160K ohm</td>
</tr>
<tr>
<td>R19</td>
<td>82 ohm</td>
</tr>
<tr>
<td>R20</td>
<td>1K ohm</td>
</tr>
<tr>
<td>R21</td>
<td>22K ohm</td>
</tr>
<tr>
<td>P1</td>
<td>5K linear taper</td>
</tr>
</tbody>
</table>
C1, C2 .33 microfarads
C3 .022 microfarads
C4 470 microfarads
C5 .47 microfarads
D1, D3 IN4148
D2 IN 5400
D4, D5 Dual diode, red/green, RS276-025
Z1 6.8V, IN754
Z2 12V, IN4742
V1 Varistor, SL4KL4
T1 MOSFET, BUZ 71
T2 2N3906
IC1A, IC1B Integrated Circuit, LM393N

The resistors are rated at one-half watt and the capacitors are rated at 50 volts.

While the particular hand-carried selectively operable by on-board battery or an AC to DC power converter ball throwing apparatus herein shown and disclosed in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiment of the invention or design herein shown and the scope and spirit of the invention is not limited or restricted other than as defined in the appended claims.

CLAIM:
1. Self-contained, light-weight DC powered apparatus for throwing balls therefrom in rapid succession comprising:
   a housing adjustably supporting a pair of motor-driven counter-rotating horizontally spaced apart wheel means operable to throw balls in succession therefrom;
   motor-driven means for delivering individual balls from a supply thereof into the space between said counter-rotating wheels; and
   DC power supply means on said housing operatively connected to each of said motor-driven means and including circuitry means operable to switch the power on and off to said motor-driven counter-rotating wheels many milli-second periods per second to expedite the recovery of the speed thereof after each ball throwing cycle.

2. DC powered ball throwing apparatus as defined in claim 1 characterized in that said circuitry means for said motor-driven counter-rotating wheels includes means for varying the length of said millisecond time periods when power is turned on thereto.

3. DC powered ball throwing apparatus as defined in claim 2 characterized in the provision of manually adjustable means for varying the operating speed of said motor-driven counter-rotating wheels.
4. DC powered ball throwing apparatus as defined in claim 1 characterized in that said motors driving said counter-rotating wheels have permanent magnet stators.

5. DC powered ball throwing apparatus as defined in claim 1 characterized in that said apparatus is adapted to be hand carried and is sized for convenient transport in the trunk of a conventional passenger motor vehicle.

6. DC powered ball throwing apparatus as defined in claim 1 characterized in that said housing includes a ball hopper having sidewalls movable between collapsed storage position and an extended operating position for containing a large number of balls.

7. DC powered ball throwing apparatus as defined in claim 6 characterized in that sidewalls of said hopper are hinged to the upper portion of said housing for pivotal movement between a collapsed position against the top of said housing and an extended generally upright hopper-forming position.
8. DC powered ball throwing apparatus as defined in claim 6 characterized in that said ball hopper overlies the main body of said housing and includes in the bottom thereof said means for delivering individual balls in succession from said hopper into the space between said counter-rotating wheels.

9. DC powered ball throwing apparatus as defined in claim 1 characterized in that said motor-driven counter-rotating wheels are mounted in said housing for bodily pivotal movement about a horizontal axis to vary the trajectory of thrown balls in a vertical plane.

10. DC powered ball throwing apparatus as defined in claim 9 characterized in the provision of means for manually adjusting the pivotal position of said counter-rotating wheels and for retaining the same selectively in different pivoted positions.

11. DC powered ball throwing apparatus as defined in claim 9 characterized in the provision of sound and vibration absorbing means operatively associated with said pivot axis between said housing and said counter-rotating wheel means.
12. DC powered ball throwing apparatus as defined in claim 11 characterized in that said sound and vibration absorbing means includes elastomeric spring-biased friction means between said housing and the adjacent ends of pivotable shelf means supporting said counter-rotating ball throwing wheels.

13. DC powered ball throwing apparatus as defined in claim 9 characterized in that the pivot axis of said counter-rotating wheels is offset forwardly of a plane containing the axes of said wheels.

14. DC powered ball throwing apparatus as defined in claim 13 characterized in that said means for delivering balls to the space between said counter-rotating wheels includes stationary duct means operable to deliver successive balls between said ball throwing wheels throughout wide range pivotal adjustment of said wheels about a horizontal axis.

15. DC powered ball throwing apparatus as defined in claim 1 characterized in that said housing includes an underlying base pivotally connected thereto about an upright axis; and DC motor-driven means operable to pivot said housing to-and-fro in a predetermined horizontal arc about said upright axis to vary the lateral trajectory of successive balls.
Self-contained hand-carryable, battery-powered ball throwing apparatus transportable in the trunk of a passenger vehicle operable to throw balls selectively and repetitively in a range of trajectories for more than one hour comprising:

- a housing power-pivotal about an upright axis through a horizontal arc;
- a collapsible ball hopper supported by said housing and opening into a motor-driven ball feeder;
- a pair of motor-driven counter-rotating spaced apart wheels operable to throw successive balls from said housing including means for feeding successive balls from said ball feeder into the space between said wheels;
- means for pivoting said ball throwing wheels in unison to positions for ejecting said balls along different vertical trajectories; and
- storage battery means carried by said housing including means supplying power therefrom to operate each of said power-driven components.

Ball throwing apparatus as defined in claim 16 characterized in that said counter-rotating wheels are driven by separate DC motors each having a permanent magnet stator.

Ball throwing apparatus as defined in claim 16 characterized in that said last mentioned means includes solid state circuit control means operable to expedite the recovery of speed of said counter-rotating wheels to full speed following each ball throwing cycle.
19. Ball throwing apparatus as defined in claim 16 characterized in that said counter-rotating wheels are pivotable bodily and in unison about a horizontal axis spaced forwardly of a common plane containing the axes of said wheels.

20. Ball throwing apparatus as defined in claim 16 characterized in that the pivotable supports for said counter-rotating wheels includes sound and vibration absorbing means.

21. Ball throwing apparatus as defined in claim 16 characterized in the provision of manually adjustable means for holding said counter-rotating wheels in different tilted positions to vary the vertical trajectory of the balls thrown therefrom.

22. Ball throwing apparatus as defined in claim 16 characterized in that said means for feeding balls into the space between said wheels is stationary and equally effective to deliver balls thereto irrespective of the tilted position of said wheels.
Ball throwing apparatus as defined in claim 16 characterized
in the provision of control circuit means inter-connecting
said storage battery means and said ball feeding means to provide sufficient time between the
delivery of successive balls to said counter-rotating
wheels for said wheels to recover to substantially the
same normal operating speed before the start of the
next ball throwing cycle whereby successive balls are
launched at substantially the same velocity.

A portable power-driven ball thrower comprising:
a housing enclosing a pair of DC powered motor-driven counter-rotating ball throwing wheels mounted for pivoting
in unison about a horizontal axis positioned forwardly
of a plane common to the axes of said wheels; and
DC powered motor-driven ball feeder means having a stationary
delivery chute positioned to deliver a ball between
said wheels irrespective of the tilted position of
said wheels.

A portable ball thrower as defined in claim 24 characterized
in that said housing is equipped with a ball hopper
collapsible compactly against a wall of said housing
when not in use and including means for supporting the
same expanded into a ball storage hopper when said
apparatus is in use.
26. A portable ball thrower as defined in claim 24 characterized
in that said motor-driven wheels are powered by DC
motors having permanent magnet stators.

27. A portable ball thrower as defined in claim 24 characterized
in that said thrower is completely self-contained and
powered by an on-board storage battery.

28. A portable ball thrower as defined in claim 27 characterized
in that said housing includes power-driven means
powered by said storage battery to oscillate said hou-
sing through a horizontal arc to vary the lateral
trajectory of balls thrown from between said counter-
rotating wheels.

29. A portable ball thrower as defined in claim 24 characterized
by provision of control circuit means for the motors
of said motor-driven wheels including means for gene-
rating an oscillating signal and for utilizing said
signal to control the flow of power to said last
mentioned motors in pulses in synchronism with said
oscillating signal.
30. A portable ball thrower as defined in claim 29 characterized in that said control circuit includes means for varying the duration of said power pulses in response to the magnitude of the contemporaneous back EMF of the motors driving said ball throwing wheels.

31. A portable ball thrower as defined in claim 29 characterized in that said control circuit includes means for varying the normal operating speed of said motors for said motor-driven wheels.

32. A portable ball thrower as defined in claim 29 characterized in that said control circuit includes means for supplying power to said oscillating signal generating means at a predetermined voltage lower than the voltage supply for said motors driving said motor-driven wheels.

33. A portable ball thrower as defined in claim 29 characterized in that said control circuit includes means responsive to changes in the back EMF of said ball throwing motors incident to a ball throwing cycle to supply power thereto in pulses of varying width and thereby effective to expedite the return of said motors to normal operating speed for the next ball throwing cycle.
3. A portable ball thrower as defined in claim 33 characterized in that said control circuit includes means for clamping the voltage activating said signal oscillating means to a predetermined value less than the activating voltage supplied to said motors of said motor-driven wheels.

35. A portable ball thrower as defined in claim 29 characterized in that said control circuit means is connected to a storage battery supported in said housing for said ball thrower.

36. A portable ball thrower as defined in claim 29 characterized in that said control circuit means includes charge monitoring means mounted on said housing operable to provide a visual indication of the state of charge of said storage battery as said battery is being charged from an external power source, said charge monitoring means including dual visual indicators and means in circuit therewith one of which provides a visual indication when the battery voltage is at a relatively low charge value and the other of which provides a visual signal when the battery is at a relatively high charge value.
37. A portable ball thrower as defined in claim 36 characterized in that one of said visual indicators is operable to provide a visual indication that said battery is in need of recharging from power supplied solely from said storage battery.

38. A portable ball thrower as defined in claim 36 characterized in that said means for providing a visual indication of the charge condition of said storage battery comprises a dual light emitting diode, each diode of different color when energized.

39. A portable ball thrower as defined in claim 38 characterized in that said light emitting diodes are in closely spaced partially shrouded condition and operable to display a characteristic distinctive color as well as a distinctive combined color as said battery undergoes a generally complete charging cycle thereby to indicate the state of charge at different times.
A self contained lightweight DC powered apparatus for throwing balls therefrom in rapid succession comprising:

a housing adjustably supporting a pair of counter-rotating spaced apart ball throwing wheels driven by a pair of DC motors having permanent magnet stators in circuit with an onboard storage battery and circuit control means, means therefor operable to expedite the speed recovery of said motors during each ball throwing cycle and including means for switching the power to said pair of motors off and on many times per second and including manually adjustable means for varying the interval of time power is switched on to said motors.

Ball throwing apparatus as defined in claim 40 characterized in the provision of means for connecting a source of battery charging power to said on-board storage battery and including indicator means operable to provide a visual indication of the charge condition of said storage battery.
42. Ball throwing apparatus as defined in claim 40 characterized in that said housing is provided with spaced-apart wheel means along one exterior edge thereof; and a propelling handle pivotably connected to the diagonally opposed exterior edge of said housing; said handle being foldable against the said housing when not in use and being constructed and arranged to pivot to a stable extended position for use in tilting said housing to an inclined towable travel position supported on said wheel means.

43. Ball throwing apparatus as defined in claim 18 characterized in that said solid state circuit control means includes time delay means for activating said ball feeding means after a time interval adequate for said motors driving said counter-rotating wheels to reach substantially full operating speed and for the user to reach a playing position before ejection of a ball from said apparatus.
COMPARISON OF DRIVE MOTOR RPM VS. TIME CURVES

**Comments**

- **This approach uses 3 second “dead time” between ball deliveries to allow motors to spin back up to speed. This allows using smaller motors.**

- **R.P.M. gradually falls off using this approach if the balls are fired this frequently (every 3 seconds).**

- **This approach uses large motors to decrease R.P.M. drop under load. Balls can be delivered as often as once per second.**

**Fig. 10.**
**INTERNATIONAL SEARCH REPORT**

**International Application No.** PCT/US 88/00743

### I. CLASSIFICATION OF SUBJECT MATTER
- According to International Patent Classification (IPC) or to both National Classification and IPC
  - IPC (4): A63B 69/40
  - U.S. Cl. 124/78; 273/26D

### II. FIELDS SEARCHED
- Minimum Documentation Searched
  - **U.S.**
    - 124/1, 6, 41, 45, 47, 49, 78; 273/26D; 314/139, 558, 810
    - 811; 363/124; 320/2; 220/4A, 6; 248/62A, 638; 298/24

Documentation Searched other than Minimum Documentation to the extent that such Documents are Included in the Fields Searched

### III. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of Document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to Claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US, E, 24,493 (PHILLIPS) 24 June 1958, see column 1, lines 17-25.</td>
<td>6-8,25</td>
</tr>
<tr>
<td>A</td>
<td>US, E, 28,462 (HALSTEAD) 01 July 1975, see column 1, line 45 to column 2, line 30.</td>
<td>1,9-10,14-16</td>
</tr>
<tr>
<td>A</td>
<td>US, A, 252,389 (LIVINGSTONE) 17 February 1882, see page 1, lines 15-40.</td>
<td>6-8,25</td>
</tr>
<tr>
<td>A</td>
<td>US, A, 1,204,468 (MARTY) 14 November 1916, see page 1, lines 17-28.</td>
<td>1,9-10,14-16</td>
</tr>
<tr>
<td>A</td>
<td>US, A, 2,678,796 (ROY) 18 May 1954, see column 1, line 1 to column 2, line 5.</td>
<td>40,42,24</td>
</tr>
<tr>
<td>A</td>
<td>US, A, 3,052,435 (ROLLER) 04 September 1962, see column 1, line 1 to column 2, line 68.</td>
<td>10-12,20</td>
</tr>
<tr>
<td>A</td>
<td>US, A, 3,198,324 (KALLENBACH ET AL) 03 August 1965, see column 2, lines 30-50.</td>
<td>10-11,20-21</td>
</tr>
<tr>
<td>A</td>
<td>US, A, 3,223,909 (SENSING ET AL) 14 December 1965, see column 5, line 29 to column 6, 75.</td>
<td>1-3,16,18,24</td>
</tr>
<tr>
<td>A</td>
<td>US, A, 3,243,681 (DANNETTELL) 29 March 1966, see column 1, line 10 to column 2, line 72.</td>
<td>27-35,40,43</td>
</tr>
<tr>
<td>A</td>
<td>US, A, 3,349,309 (DANNETTELL) 24 October 1967, see column 1, line 25 to column 2, 6.</td>
<td>1-4,16-18,24</td>
</tr>
</tbody>
</table>

* Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier document but published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed

*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

*Z* document member of the same patent family

### IV. CERTIFICATION

- **Date of the Actual Completion of the International Search:** 24 May 1988
- **Date of Mailing of this International Search Report:** 12 Jul 1988

International Searching Authority: ISA/US

Authorized Officer: John A. Ricci

John A. Ricci
### III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of Document</th>
<th>Relevance to Claim No</th>
</tr>
</thead>
<tbody>
<tr>
<td>A US, A</td>
<td>3,568,553 (EARLE ET AL) 09 March 1971</td>
<td>15,16,28</td>
</tr>
<tr>
<td>A US, A</td>
<td>3,570,466 (WHITE ET AL) 16 March 1971</td>
<td>1,16,24,40</td>
</tr>
<tr>
<td>A US, A</td>
<td>3,604,409 (DOEG) 14 September 1971</td>
<td>1,9-10,14-16</td>
</tr>
<tr>
<td>A US, A</td>
<td>3,716,767 (KURIYAMA ET AL) 13 February 1973, see the Abstract, and column 2, lines 25-37</td>
<td>1-3,16,18,24</td>
</tr>
<tr>
<td>A US, A</td>
<td>3,753,059 (BERMAN) 14 August 1973, see the entire document</td>
<td>1-3,16,18,24</td>
</tr>
<tr>
<td>A US, A</td>
<td>3,774,584 (PAULSON) 27 November 1973, see column 1, lines 30-62</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>Y US, A</td>
<td>3,777,732 (HOLLOWAY ET AL) 11 December 1973, see the entire document</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A US, A</td>
<td>3,785,358 (D'ANGELO ET AL) 15 January 1974, see column 1, lines 20-59</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>Y US, A</td>
<td>3,901,552 (STONE) 26 August 1975, see the Abstract</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A US, A</td>
<td>3,913,552 (YARUR ET AL) 21 October 1975, see column 2, lines 6-42</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A US, A</td>
<td>4,086,903 (SCOTT) 02 May 1978, see column 1, line 59 to column 2, line 10</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A US, A</td>
<td>4,092,580 (PRINSZE) 30 May 1978, see column 2, line 53 to column 3, line 32</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>Y US, A</td>
<td>4,140,097 (LEWIS) 20 February 1979, see column 1, lines 1-43</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A US, A</td>
<td>4,206,502 (HARRIES ET AL) 03 June 1980, see column 1, line 1 to column 2, line 32</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A US, A</td>
<td>4,398,139 (PRINSZE) 09 August 1983, see column 1, lines 54-64</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A US, A</td>
<td>4,583,514 (NOZATO) 22 April 1986, see column 1, lines 1-51</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A,P US, A</td>
<td>4,678,095 (BARNETT ET AL) 07 July 1987, see the Abstract</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>Y,P US, A</td>
<td>4,692,680 (SHERER) 08 September 1987, see the Abstract</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>A,P US, A</td>
<td>4,705,257 (LEO ET AL) 10 November 1987, see the Abstract</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td>Y FR, A</td>
<td>2,459,668 (POP LOB) 01 January 1981, see the entire document</td>
<td>1-3,16,18,24,40,43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>