Bi-directional resistance exercise apparatus designed to offer resistance to opposing muscle groups. The apparatus provides continuous and sequential resistance during the extension and flexion phases. The apparatus includes a controller including a graphic display. Resistance is provided by a variable resistance element such as a magnetic brake. A chair or other body supporting devices support the user depending on the exercise being performed. Force is applied by the user to a rotatable limb or torso retaining member and is transferred to the shaft of the magnetic brake. The brake applies variable resistance determined by the software instructions issued by the controller. The resistance levels can be pre-programmed or specifically selected by the user. The brake force varies instantaneously during the flexion and extension phases based on the angular position of the input shaft. A record of the exercise activity can be stored and displayed by the microprocessor controller.
Fig. 3
Mechanical input for exercise → Gear box for increase in rotational speed → Electro-Magnetic Brake

Gear box for increase in rotational speed → Rotation position sensor

Rotation position sensor → Controller

Controller → Power supply

Fig. 31
Block Diagram

1st Half Cycle Resistance Force

Electromagnetic Brake

Moveable Member

2nd Half Cycle Return Force

Direction/Position Sensor

Slip Clutch

Return Motor

Microprocessor

Display/Keyboard

Power Supply

Fig. 32
; list directive to define processor
#include <p16f874a.inc> ; processor specific variable definitions

_CONFIG CP_OFF & _WDT_OFF & _BODEN_OFF & _PWRT_OFF & _HS_OSC & _WRT_OFF
& _LVP_OFF & _CPD_OFF

; '_CONFIG' directive is used to embed configuration data within .asm file.
; The labels following the directive are located in the respective .inc file.
; See respective data sheet for additional information on configuration word.
; Changed low and high forces

;***** EEPROM DEFINITIONS
; None.

;***** VARIABLE DEFINITIONS
w_temp EQU 0x20 ; variable used for context saving
status_temp EQU 0x21 ; variable used for context saving
counterL EQU 0x22
counterH EQU 0x23
counter EQU 0x24
Flags EQU 0x25
counterI EQU 0x26
Sdec2 EQU 0x27
Sdec1 EQU 0x28
Sdec0 EQU 0x29
SRecN EQU 0x2A
STemp EQU 0x2B
EEcounter EQU 0x2C
FileCounter EQU 0x2D
CurveNumber EQU 0x2E
EEpagenumber EQU 0x2F
Temp EQU 0x30
PrevPosition EQU 0x31
PresPosition EQU 0x32
rpTemp EQU 0x33
rpCounter EQU 0x34
PosOffset EQU 0x35
TentativeOffset EQU 0x36
ForceFromEeprom EQU 0x37
counters EQU 0x38

;***** Bit definitions for Flags
GoingDownBit EQU 0 ; High if going down, low if going up.
JustStoppedBit EQU 1 ; High if a stop occurred.

;***** Bit definitions for port A
; EQU 0 ;
; EQU 1 ;
SW1 EQU 2 ; Curve switch.
; EQU 3 ;
SW2 EQU 4 ; Curve switch.

FIG. 2A
Bit definitions for port B

- EQU 0
- EQU 1
- EQU 2
- EQU 3
- EQU 4
- EQU 5
- EQU 6
- EQU 7

Bit definitions for port C

- EQU 0
- EQU 1
- EQU 2
- EQU 3
- EQU 4
- EQU 5
- EQU 6
- EQU 7

Bit definitions for port D

- Inputs from the encoder.

Bit definitions for port E

- EQU 0
- EQU 1
- EQU 2

******************************************************************************************

ORG 0x000 ; processor reset vector
nop ; Mandatory nop for ICD!
clr PCLATH ; ensure page bits are cleared
goto PerifSetting ; go to beginning of program

******************************************************************************************

ORG 0x004 ; interrupt vector location
movf w_temp ; save off current W register contents
movf STATUS,w ; move status register into W register
bcf STATUS,RPO ; ensure file register bank set to 0
movf status_temp ; save off contents of STATUS register

; isr code can go here or be located as a call subroutine elsewhere

bcf STATUS,RPO ; ensure file register bank set to 0
movf status_temp,w ; retrieve copy of STATUS register
movf STATUS ; restore pre-isr STATUS register contents
swapf w_temp,f
swapf w_temp,w ; restore pre-isr W register contents
retfie ; return from interrupt

FIG. 2B
PerifSetting

; Begin setting the ports.
clearf PORTA

clearf PORTB

bit PORTB, CTS ; stop serial data.
clearf PORTC

clearf PORTD

clearf PORTE

bit STATUS, RPO ; Bank 1.

; Port A - 0 input analog, 1 unused, 2 input digital, 3 unused, 4 input digital, 5 used.
; For now we do not use the A/D converter.
movlw B'00000010' ; RA0 analog input, rest digital. VCC and GND as references. Left justified. See page 126 (or 112) of data sheet.
movwf ADCON1

movlw B'00011111'
movwf TRISA

; Port B - 0 unused output 1 and 2 outputs, 4 output, 5 input, 3, 6, 7 inputs reserved only for ICD.
movlw B'11101000'
movwf TRISB

; Port C - 0, 1, 2 output for PWM, 3 output SCL, 4 Initial output SDA, 5, 6 serial TX and 7 serial RX.
ValTrisC EQU B'11100000'
movlw ValTrisC

movwf TRISC

; Port D - 0, 1, 2, 3, 4, 5, 6, 7 inputs.
movlw B'11111111'
movwf TRISD

; Port E - 0, 1, 2 outputs.
movlw B'00000000'
movwf TRISE

movlw B'00000000' ; Port B pullups enabled, interrupt on falling edge, internal clock for TMR0, low to high for TOCKI, prescaler for TMR0, prescale rate 1:2.
movwf OPTION_REG

bit STATUS, RPO ; Bank 0.

; For now let's leave the A/D converter asleep.
; movlw B'010000001' ; FOSC/8 conversion clock, channel RA0 selected, A/D stopped, A/D on. See page 125 (or 111) of data sheet.
; movwf ADCON0

; Set USART

bit STATUS, RPO ; Bank 1.
movlw D'64' ; 9600 baud

movwf SPBRG

bit TXSTA, BRGH ; high speed

bcf TXSTA, SYNC ; asynchronous

bit TXSTA, TXEN ; enable transmission

bit STATUS, RPO ; Bank 0.
bsf RCSTA, SPEN ; serial port enabled
bsf RCSTA, CREN ; serial port enabled

ResetMemory
clrfl Flags
clrfl PrevPosition

SetPWMMode
; At the beginning we set it for low friction.
bsf STATUS, RP0 ; Bank 1.
movlw D'254'
movwf PR2
bsf STATUS, RP0 ; Bank 0.
movlw D'10'
movwf CCP1CON
movlw B'00000100'; 1:1 postscale, TMR2 on, prescaler 1.
movwf T2CON
movlw B'00000100'; lsb 00, PWM mode.
movwf CCP1ICON

nop
nop

goto Working

Wait4fileTransmissionRequest
call TxSendFile

ReceiveFile
; First we must receive the curve number as 1<CR>.
; We are going to receive 2 x 255 decimal numbers
; under the format 136<CR>003<CR>000<CR>...
; Each number must be less than 256.
; Any deviation from this format will be
; considered an error.
; The numbers will be converted in binary and
; saved directly in the eeprom.

bcf PORTB, CTS ; accept serial data.

Wait4CurveNumber

WcN
btfs PIR1, RCIF
goto WcN
movf RCREG, W ; got the curve number.
andlw 0xf
movwf CurveNumber
bcf STATUS, C
rlf CurveNumber, F ; FA - change 256 to 512

cnCR
btfs PIR1, RCIF
goto cnCR
movf RCREG, W ; got the carrage return.
sUBLW H'D' ; is it carrage return?
btsf STATUS, 2

FIG. 2D
goto SrError  ; Nope!

EEBufferSize  EQU  D'64'
FileSize      EQU  D'512'/EEBufferSize

movlw FileSize
movwf FileCounter
clr e EEpageNumber

Get1Buffer
nop

; Let's send the start condition.
; Both SDA and SCL must be high at the beginning.
  bsf PORTC, SDA
  call DelayNus
  bsf PORTC, SCL
  call DelayNus
  bcf PORTC, SDA
  call DelayNus
  bcf PORTC, SCL
  call DelayNus
; Now both SDA and SCL must be low.

; Let's send the eeprom hardware address with the write bit. See page 11 data sheet.
  movlw B'10100000'
  movwf SRecN
  call SendByte2eprom

; Let's send the MSB of the page address. See page 11 data sheet.
  movf CurveNumber, W
  movwf SRecN
  btfsc EEonenumber, 2  ; PA - change 256 to 512
  baf SRecN, 0          ; PA - change 256 to 512
  call SendByte2eprom

; Let's send the LSB of the page address. See page 11 data sheet.
  movf EEpageNumber, W
  movwf SRecN
  bcf STATUS, C
  rrf SRecN, F
  rrf SRecN, F
  rrf SRecN, F
  call SendByte2eprom

  movlw EEBufferSize
  movwf EECounter
  incf EEpageNumber, F

  bcf PORTB, CTS       ; accept serial data.

Get1Byte
  clrf SRecN
SrN2
  btfss PIR1, RCIF
  goto SrN2
  movf RCREG, W         ; got the most significant decimal digit.
andlw 0xf
btfsc STATUS, Z
goto SrN1
movwf STemp
decfsz STemp, F
goto SrN2a
movlw D'100'
addwf SRecN, F
goto SrN1
SrN2a
decfsz STemp, F
goto SrError
movlw D'200'
addwf SRecN, F
goto SrN1
SrN1
btfss PIR1, RCIF
goto SrN1
movf RCREG, W ; got the middle decimal digit.
andlw 0xf
movwf STemp
bcf STATUS, C
rlf STemp, W
rlf STemp, F
rlf STemp, F
addwf STemp, W
addwf SRecN, F
btfsc STATUS, C
goto SrError
SrN0
btfss PIR1, RCIF
goto SrN0
movf RCREG, W ; got the least significant decimal digit.
andlw 0xf
addwf SRecN, F
btfsc STATUS, C
goto SrError
call SendByte2EEPROM
SrCR
btfss PIR1, RCIF
goto SrCR
movf RCREG, W ; got the carriage return.
sublw H'D' ; is it carriage return?
btfss STATUS, Z
goto SrError ; Nope!
decfsz ECounter, F
goto Get1Byte
nop
nop

**FIG. 2F**
bsf PORTB, CTS ; stop serial data.

; Let's send the stop condition.
; Both SDA and SCL must be low at the begining.
  call DelayNus
  bsf PORTC, SCL
  call DelayNus
  bsf PORTC, SDA
  call DelayNus
  bcf PORTC, SCL
  call DelayNus
; Now SCL must be low.

call wait500ms

decfsz FileCounter, F
  goto Get1Buffer

call TXokFile
  movlw D'150'
  ;reset stop counter
  movwf counterS
  ;initialize

Working
  ;call wait100ms
  ;call wait100ms

nop

nop
  call ReadPosition
  movwf PresPosition

VerifyStoped
  subwf PrevPosition, W
  btfss STATUS, Z
  goto MovementCounterReset

StopCounts ; Movement stoped, count number of cycles
  decfsz counterS, F
  ; count down
  goto CheckDirection

  movlw D'150'
  ;reset stop counter
  movwf counterS
  ;brake

BrakeIt
  movf PresPosition, W
  movwf TentativeOffset ; Save the tentative offset.

  bcf PORTE, LED1 ; Turn on the LED.
  movlw D'80'; Set high brake changed from 220
  movwf CCPRI1 ; send it to PWM.

bsf Flags, JustStoppedIt
  movlw D'1' ; let's wait for 0.1 second.
  movwf counter

B11 call wait100ms
  movf PORTE, W ; Blink
  xorlw 1<<LED1 ; the
movwf PORTE ; LED.
decfsz counter, F
goto BI1

; movlw D'80' ; Set brake medium changed from 60
; movwf CCPR1L ; send it to PWM.
movlw D'150' ; reset stop counter
movwf counterS ; after break

bcf PORTB, CTS ; accept serial data.
; let's wait for change while checking
; if the serial interface needs attention.
BI2
nop
nop
nop

CheckSerial
btfs PIR1, RCIF
goto NoSerialRequest
movf RCREG, W ; got the character.
sublw 0x61 ; is it "a"?
btfs STATUS, Z
goto CheckSerial ; no. Try again.
goto Wait4fileTransmissionRequest ; Yes. Get the file.

NoSerialRequest
call ReadPosition
movwf PresPosition
subwf PrevPosition, W
btfscc STATUS, Z
goto BI2
goto CheckDirection

MovementCounterReset
movlw D'150' ; Reset movement counter
movwf counterS

CheckDirection
bsf PORTE, LED1 ; Turn off the LED.
bsf PORTB, CTS ; deny serial data.
; First of all we need to check for decoder overflow.
; That is hex Fx->Cy or hex 0x->Fy.
closeValue EQU H'F'
nop
nop

PrevPositionCloseZero
movlw closeValue
subwf PrevPosition, W ; Is previous position close to zero?
btfscc STATUS, C
goto PresPositionCloseHigh ; Yes ; No

PrevPositionCloseHigh
movlw closeValue
addwf PrevPosition, W ; Is previous position close to hex FF?
btfscc STATUS, C
goto PresPositionCloseZero ; Yes

FIG. 2H
goto CheckDirectionStraight ; No

PresPositionCloseHigh
movlw closeValue
addwf PresPosition, W ; Is previous position close to hex FF?
btfsc STATUS, C
goto CheckDirectionStraight ; No
movf PresPosition, W
movwf PrevPosition
goto GoingDown ; Yes

PresPositionCloseZero
movlw closeValue
subwf PresPosition, W ; Is present position close to zero?
btfsc STATUS, C
goto CheckDirectionStraight ; No
movf PresPosition, W
movwf PrevPosition
goto GoingUp ; Yes

; Now the overflow is out of our way.
; Let's check straight for direction.
CheckDirectionStraight
nop
nop
movf PresPosition, W
subwf PrevPosition, W
movwf PrevPosition ; This instruction does not change carry flag.
btfss STATUS, C
goto GoingUp
goto GoingDown

GoingUp
btfss Flags, JustStoppedBit
goto ContinueGU
cf Flags, JustStoppedBit
btfss Flags, GoingDownBit
goto ContinueGU
goto StartGoingUp

ContinueGU
bcl Flags, GoingDownBit ; We are going up.
call SetForce
goto Working

GoingDown
btfss Flags, JustStoppedBit
goto ContinueGD
cf Flags, JustStoppedBit
btfsc Flags, GoingDownBit
goto ContinueGD
goto StartGoingDown

ContinueGD
bsf Flags, GoingDownBit ; We are going down.
call SetForce
goto Working

FIG. 21
StartGoingDown
    movlw D'150' ; reset stop counter
    movwf counterS ; change of direction
    bsf flags, GoingDownBit ; We are going down.
    movf TentativeOffset, W
    movwf PosOffset ; New offset.
    goto ContinueGD

StartGoingUp
    movlw D'150' ; reset stop counter
    movwf counterS ; change of direction
    bcf flags, GoingDownBit ; We are going up.
    movf TentativeOffset, W
    movwf PosOffset ; New offset.
    goto ContinueGU

SetForce ; Read the force from the EEPROM table.

; Let's send the start condition.
; Both SDA and SCL must be high at the beginning.
    bsf PORTC, SDA
    call DelayNus
    bsf PORTC, SCL
    call DelayNus
    bcf PORTC, SDA
    call DelayNus
    bcf PORTC, SCL
    call DelayNus
; Now both SDA and SCL must be low.

; Let's send the EEPROM hardware address with the write bit. See page 11 data sheet.
    .movlw B'10100000'
    movwf SRecN
    call SendByte2eeprom
; Let's send the MSB of the page address. See page 11 data sheet.
; The MSB address is of the form of B00000xyz where
; x = SW1 (PA2), y = SW2 (PA4) and z = GoingDownBit (of Flags).
    clrf SRecN
    btfsc flags, GoingDownBit
    bcf SRecN, 0
    movf PORTA, W
    movwf Temp
    btfsc Temp, SW1
    bcf SRecN, 2
    btfsc Temp, SW2
    bcf SRecN, 1
;movlw B'011' ; xxx just for tests
;movwf SRecN ; xxx just for tests
    call SendByte2eeprom
; Let's send the LSB of the page address. See page 11 data sheet.
; The LSB address is as follows
; Going up address = PresPosition-PosOffset,
; Going down address = PosOffset-PresPosition. btfsc Flags, GoingDownBit
  goto SFgoDown
  goto SFgoUp
SFgoUp
  movf PosOffset, W
  subwf PresPosition, W
  goto SF1sb
SFgoDown
  movf PresPosition, W
  subwf PosOffset, W
  goto SF1sb
SF1sb
  movlw H'F3' ; xxx just for tests
  movwf SRecN
  call SendByte2eeprom

; Let's send the start condition again for reading.
; Both SDA and SCL must be high at the beginning.
  bsf PORTC, SDA
  call DelayNus
  bsf PORTC, SCL
  call DelayNus
  bcf PORTC, SDA
  call DelayNus
  bcf PORTC, SCL
  call DelayNus
; Now both SDA and SCL must be low.
  nop
  nop
  nop
  nop
  nop
  nop
; Let's send the eeprom hardware address with the read bit. See page 11 data
  movlw B'10100001' ;
  movwf SRecN
  call SendByte2eeprom

ReadDataFromEEprom
; SCL must be zero at this point.
  bcf PORTC, SCL
; Let's make SDA an input.
  bsf STATUS, RP0 ; Bank 1.
  movlw ValTrisC | (1<<SDA) ; make SDA an input
  movwf TRISC
  bcf STATUS, RP0 ; Bank 0.
  movlw 8
  movwf counter
RDF1
  nop
  bsf PORTC, SCL
  bcf STATUS, C
  call DelayNus
  movf PORTC, W
  movwf Temp

FIG. 2K
btfs Temp, SDA
bsf STATUS, C
rlf ForceFromEEprom, F

bcf PORTC, SCL
call DelayNus

decfsz counter, F
goto RDF1

bsf PORTC, SCL ; "not acknowledge" clock pulse.
call DelayNus
bcf PORTC, SCL
call DelayNus

bsf STATUS, RP0 ; Bank 1.
movlw ValTrisC & ~(i<<SDA) ; make SDA an output
movwf TRISC
bcf STATUS, RP0 ; Bank 0.
bcf PORTC, SDA

; Let's send the stop condition.
; Both SDA and SCL must be low at the begining.
call DelayNus
bsf PORTC, SCL
call DelayNus
bsf PORTC, SDA
call DelayNus
bcf PORTC, SCL
call DelayNus

; Now SCL must be low.

; Now the force from EEprom is in ForceFromEEprom.
; Let's make sure that the force value is
; between 60 and 250.
CheckLowValue
movlw 0-D'60'
addwf ForceFromEEprom, W
movlw D'60'
btfss STATUS, C
movwf ForceFromEEprom

CheckHighValue
movlw 0-D'250'
addwf ForceFromEEprom, W
movlw D'250'
btfsc STATUS, C
movwf ForceFromEEprom

ThatsTheForce
movf ForceFromEEprom, W
movwf CCPR1L ; send it to PWM.
; call wait100ms

return
SrError
nop
nop
nop
nop
bcf PORTC, SCL

; Let's send the stop condition for the EEPROM.
bcf PORTC, SCL
call DelayNus
bcf PORTC, SDA
call DelayNus
bsf PORTC, SCL
call DelayNus
bsf PORTC, SDA
call DelayNus
bcf PORTC, SCL
call DelayNus
bcf PORTC, SDA

bcf PORTB, CTS ; accept serial data.
call wait4s
call wait4s
bsf PORTB, CTS ; deny serial data.
movf RCREG, w ; flush the usart receiver.
bcf RCSTA, CREN
call TxErrorFile

goto 0 ; Reset the device.

EeError
nop
nop
nop
nop
bcf PORTC, SCL

EeError1
nop
nop
goto EeError1

;*******************************************************************************
WhatsUp ; If we arrive here there is something wrong.
nop
goto WhatsUp
;*******************************************************************************

;*******************************************************************************

; Begin routines
;*******************************************************************************

DelayNus
;*******************************************************************************
nop
nop
nop
nop
nop

FIG. 2M
nop
return
;

ReadPosition
; Reads the position of the decoder and converts it from Gray to binary.
; The result is returned in W register.
movlw 7
movwf rpCounter
movf PORTD, W
xorlw B'11111111' ; negative logic decoder output.
movwf rpTemp
ConvertGray2Binary
bcf STATUS, C
rrf rpTemp, F
xorwf rpTemp, W
decfsz rpTemp, F
goto ConvertGray2Binary
return
;

TxSendFile
; Sends text to serial interface.
movlw high(TxSendFileData)
movwf PCLATH
movlw D'13'
movwf counter

tsf
btfss PIR1, TXIF
goto tsf

movf counter, W
call TxSendFileData
movwf TXREG

decfsz counter, F
goto tsf

return

TxSendFileData
addwf PCL, F
nop
retlw H'A'
retlw H'D'
retlw 'e'
retlw 'l'
retlw 'i'
retlw 'f'
retlw '
retlw 'd'
retlw 'n'
retlw 'e'
retlw 'S'
retlw H'A'

FIG. 2N
retlw H'D'  

;*******************************************************************************

SendByte2eeprom  
;*******************************************************************************

; SCL must be zero at this point.
; SDA must be an output at this point.
; The byte to be sent must be in SRecN.
movlw 8
movwf counter
bcf STATUS, C
SB2Ea
nop
bcf PORTC, SCL
call DelayNus
bcf PORTC, SDA
clrf SRecN, F
btfsc STATUS, C
bsf PORTC, SDA
call DelayNus
bsf PORTC, SCL
call DelayNus
decfsz counter, F
goto SB2Ea
bcf PORTC, SCL
call DelayNus
bsf STATUS, RP0 ; Bank 1.
movlw ValTrisC | (1<SDA) ; make SDA an input
movwf TRISC
bcf STATUS, RP0 ; Bank 0.
call DelayNus
bsf PORTC, SCL
call DelayNus
nop ; xxx btfsc PORTC, SDA
nop ; xxx goto EeError
call DelayNus
bcf PORTC, SCL
bsf STATUS, RP0 ; Bank 1.
movlw ValTrisC & ~(1<SDA) ; make SDA an output
movwf TRISC
bcf STATUS, RP0 ; Bank 0.
call DelayNus
bcf PORTC, SDA
call DelayNus
return

;*******************************************************************************

ADconversion  
;*******************************************************************************

bsf ADCON0, GO_DONE ; Start A/D converter.
Wait4ADconversion
btfsc ADCON0, GO_DONE
goto Wait4ADconversion
ConversionReady
return

wait100ms
; return ; xxx just for tests

;******************************************************************************
delayV EQU D'100'; in miliseconds.
delayVc EQU delayV*D'253'; in cycles,
delayLow EQU low delayVc ; clock 10 MHz, 10 instructions
delayHigh EQU high delayVc ; make a total of 4 uS per cycle.

movlw delayLow
movwf counterL
movlw delayHigh
movwf counterH
wD1 decfsz counterL, F
goto wD2
decfsz counterH, F
goto wD1
return
wD2
nop
nop
nop
nop
nop
return

wait500ms
;******************************************************************************

call wait100ms
call wait100ms
call wait100ms
call wait100ms
call wait100ms
call wait100ms
return

wait4s
;******************************************************************************

call wait500ms
call wait500ms
call wait500ms
call wait500ms
call wait500ms
call wait500ms
call wait500ms
call wait500ms
return

TxErrorFile
;******************************************************************************
; Sends text to serial interface.

movlw high(TxErrorFileData)
movwf PCLATH

FIG. 2P
movlw D'14'

movwf counter

tef

btfss PIR1, TXIF
goto tef

movf counter, W
call TxErrorFileData

movwf TXREG

decfsz counter, F
goto tef

return

TxErrorFileData

addwf PCL, F

nop

retlw $A$

retlw $D$

retlw 'e'

retlw 'l'

retlw 'i'

retlw 'f'

retlw '

retlw 'r'

retlw 'o'

retlw 'r'

retlw 'r'

retlw 'E'

retlw $A$

retlw $D'$

;*****************************************************************************

TXokFile

;*****************************************************************************

; Sends text to serial interface.
movlw high(TxokFileData)
movwf FCLATH

movlw D'14'
movwf counter
tof

btfss PIR1, TXIF
goto tof

movf counter, W
call TxokFileData

movwf TXREG

decfsz counter, F
goto tof

return

TxokFileData

addwf PCL, F
nop
retlw H'A'
retlw H'D'
retlw 'x'
retlw 'r'
retlw 'i'
retlw 'e'
retlw 'l'
retlw 'f'
retlw '
retlw 'K'
retlw 'O'
retlw H'A'
retlw H'D'

END
BI-DIRECTIONAL RESISTANCE EXERCISE APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] Provisional Applications—No. 60/585,448 filing date Jul. 06, 2004—Title “Bidirectional Exercise Apparatus”

[0002] No. 60/19,611 filing date Oct. 18, 2004 Title “Adjustment Mechanisms for Exercise Equipment.”

[0003] No. 60/619,613 filing date Oct. 18, 2004 Title “Firmware Design For Bidirectional Exercise Equipment.”

[0004] Certified Mail Number 7003 1680 0004 1550 6534, Filing Date Jun. 23, 2004 Title “Improved Bidirectional Exercise Apparatus”

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0005] Not Applicable

DESCRIPTION OF ATTACHED APPENDIX


BACKGROUND OF THE INVENTION

[0007] This invention relates generally to the field of exercise equipment and more specifically to a bi-directional resistance exercise apparatus.

[0008] Exercise devices for improving the strength of various muscle groups in the human body are well known. The most simple exercise equipment involves weighted elements such as bar bells which the user lifts, to burden arm various muscle groups so they become stronger. More recently, exercise equipment such as that made by Nautilus Corp. includes benches, chairs and other body supporting means so that a person may sit or lie on an apparatus and then exert weighted force on a particular muscle group. One such Nautilus apparatus can be seen in U.S. Pat. No. 4,500,089 by Jones. The weights tend to be in stacks so that the user can add or subtract weights according to his or her level of muscle development and fitness.

[0009] More recently, exercise devices that include alternative resistance elements have become popular. For example, the Life Cycle manufactured by Bailey Manufacturing, is a stationary exercise bike that incorporates an automotive type alternator to provide variable resistance that can be selected by the user through a control panel. The resulting experience approximates that of a person pedaling up or down a hill thereby producing an aerobic workout. Furthermore, F. Joutras et al, in U.S. Pat. No. 5,954,621, disclose a knee brace type joint having an electronic braking means as resistance element. A controller can adjust the braking force on the joint thereby providing resistance to flexion and extension in a controlled manner. Additionally, M. Anjanappa, in his U.S. Pat. No. 5,583,403, discloses an apparatus for use with exercise machines to achieve programmable variable resistance. The machine includes a motor and an attached magnetic clutch.

[0010] However, there are deficiencies in the above mentioned prior art in that none of the prior art incorporates a programmably controlled bi-directional resistance element built into specific pieces of exercise equipment where a resistance element such as a magnetic brake provides repeatable and instantly variable resistance and where a single repetition or sequence of cycles of repetitions of extension and flexion of two opposing muscle groups can be instantly adjusted in varying degrees depending on the location of the limb or torso being exercised. Additionally, the Anjanappa patent discloses the use of a variable speed motor and is designed to be attached to an existing piece of standard exercise equipment. The present invention does not rely on a motor of any kind and is designed as an integrated system of software and hardware that results in a novel exercise apparatus.

BRIEF SUMMARY OF THE INVENTION

[0011] The primary object of the invention is to provide an exercise apparatus that allows bi-directional resistance during use.

[0012] Another object of the invention is to provide an exercise apparatus that produces balanced muscle development of opposing muscle groups.

[0013] Another object of the invention is to provide an exercise apparatus that can be programmed to produce variable resistance within a single use cycle.

[0014] A further object of the invention is to provide an exercise apparatus where the resistance load can be changed quickly without getting out of the seat.

[0015] Yet another object of the invention is to provide an exercise apparatus that eliminates uncontrolled spring back found in traditional weight training machines.

[0016] Still yet another object of the invention is to provide an exercise apparatus that is safer to use than to other one way resistance exercise machines.

[0017] Another object of the invention is to provide an exercise apparatus that can be quickly adjusted to adapt to various sized users.

[0018] Another object of the invention is to provide an exercise apparatus that can record and display historical information regarding exercise performance of the user or users.

[0019] A further object of the invention is to provide an exercise apparatus that is lighter than traditional adjustable weight type machines.

[0020] Yet another object of the invention is to provide an exercise apparatus that is easy to set up and use.

[0021] An additional object of the present invention is to provide a bidirectional exercise device that allows the user to select either resistance for extension or flexion for one half of the cycle, and no significant resistance for the other half, allowing the machine to function as two separate units, either flexion or extension of a muscle group.

[0022] Another object of the invention is to provide firmware design that can control an electronic brake or other electrically controlled resistance element associated with bi-directional exercise equipment.
A further object of the invention is to provide a firmware design that can adjust resistance at different points along the resistance and flexion halves of the exercise cycle.

Another object of the invention is to provide a firmware design that can sense angular position offset and respond with reset each time the direction of travel changes.

Other objects and advantages of the present invention will become apparent from the following descriptions, taken in connection with the accompanying drawings, wherein, by way of illustration and example, an embodiment of the present invention is disclosed.

In accordance with a preferred embodiment of the invention, there is disclosed a bi-directional resistance exercise apparatus comprising: a chair portion including a seat, a backrest and supporting legs, a pair of elongate padded ankle retaining members, an elongate padded thigh retaining member, a first pivotally mounted swinging arm attached to said ankle retaining members, a second pivotally mounted swinging arm attached to said thigh retaining member, said pivot pins mounted to and through the side wall of a control box, said control box containing a variable resistance mechanism such as a magnetic brake, a pulley attached to the shaft of said brake, a larger arc reducing pulley, a belt joining said shaft pulley and said arc reducing pulley, said ankle pivot pin fixedly attached to the central aperture of said larger arc reducing pulley, and a microprocessor or personal computer and associated software that is attached to said variable resistance mechanism so that the resistance can be controlled by said computer, wherein said computer retains custom software that allows the user to select from pre-programmed resistance levels or manually adjust the resistance of the inward and outward stroke of said second swinging arm and attached ankle retaining members when a user flexes his or her thigh muscles.

Additionally, there are disclosed adjustment mechanisms for exercise equipment comprising: a seat servo motor, a seat position sensor, a micro sensor, an input keyboard, a thigh servo motor, a thigh retaining pad, a thigh pad pressure sensor, a leg length servo motor, a pair of ankle pads, and an ankle space adjusting servo motor, said servo motors mounted in conjunction with standard components of a stationary exercise equipment apparatus so that said servo motors can adjust the position of said exercise equipment's seat, thigh pads and ankle retaining pads to the measurements of a particular user.

Additionally, there is disclosed a bi-directional exercise apparatus comprising: a chair portion including a seat, a backrest support member and supporting legs, additional standard leg and arm supporting and retaining members, a control box containing a variable resistance mechanism such as an electromagnetic brake, a microprocessor that controls the said variable resistance mechanism, a positive force device such as an elec...
FIG. 20 is a side perspective view of a multi use exercise machine.

FIG. 21 is a side perspective view of a multi use exercise machine set for row push/pull.

FIG. 22 is a side perspective view of a multi use exercise machine set for row push/pull with the back support adjusted inward.

FIG. 23 is a perspective view of a multi purpose exercise machine set for quadriceps/hamstring.

FIG. 24 is a perspective view of a multi purpose exercise machine set for abdominal/back.

FIG. 25 is a perspective view of a multi purpose exercise machine set for biceps/triceps.

FIG. 26 is perspective view of a biceps/triceps exercise machine.

FIG. 27 is a perspective view of a unidirectional brake/motor assembly.

FIG. 28 is a chart showing a resistance curve for a bi-directional system.

FIG. 29 is a chart showing a unidirectional resistance curve in the first half of its cycle.

FIG. 30 is a chart showing a unidirectional resistance curve in the second half of its cycle.

FIG. 31 is a block diagram showing the bi-directional system.

FIG. 32 is a block diagram showing the unidirectional system.

FIG. 33 is a right rear perspective view of a bi-directional quadriceps/hamstring machine with thigh pad and servo motor.

FIG. 34 is a side view of the control box and thigh and ankle pads for the bi-directional quadriceps/hamstring exercise machine.

FIG. 35 is a perspective view of a bi-directional quadriceps/hamstring exercise machine showing range of motion of ankle pads.

FIG. 36 is a flow chart of the firmware process needed to control a bi-directional exercise device.

FIGS. 2A through 2R shows the entire detailed flow diagram of the software design of the present invention.

DETAILED DESCRIPTIONS OF THE PREFERRED EMBODIMENTS

Detailed descriptions of the preferred embodiments are provided herein. It is to be understood, however, that the present invention may be embodied in various other forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but rather as a basis for the claims and as a representative basis for teaching one skilled in the art to employ the present invention in virtually any appropriately detailed system, structure or manner.

Referring now to FIG. 1 we see a perspective view of the quadriceps/hamstring version of an exercise apparatus using the unique continuous sequential bi-directional system of the present invention. FIGS. 1 through 5 show a preferred embodiment of a apparatus that is designed to exercise the quadriceps and hamstring muscles, however, as will be described later in this patent, other versions of exercise apparatus have been contemplated for exercising other muscle groups such as biceps/triceps, thoraco-lumbar/abdominal, chest/back, latissimus dorsi/pectoralis and others that employ a common bi-directional resistance muscle training system for multiple groups of muscles.

In the quadriceps/hamstring version, there is a chair portion comprised of a seat 32 and a backrest 33 supported by a standard chair frame 24 which is known in the current art of exercise equipment such as Nautilus and the like. Hand grips 14 allow the user to retain greater control when doing the intended leg exercise. A pair of ankle retaining elongate members, shown as an upper pad 17 and a lower pad 16 are attached at one end to a leg pivot arm 34 by input shaft 29. The leg pivot arm 34 is adjustable in length by means of lead screw 20 and attached servo 13 which is controlled by operator console 10. Lead screw 21 attached servo 15 enables the user to adjust the distance between ankle pads 16, 17 by input to the operator console 10 as shown in FIG. 2. Continuing with FIG. 2 we see adjustment knob 18 which allows the user to move and fix the seat back 33 to an ideal location for the user. Thigh retaining pad 11 is attached at one end to thigh pad pivot arm 36. Adjustment knob 19 allows the user to adjust the angle of pivot arm 36 as it rotates about thigh pad pivot shaft 35. Counter weight 25 allows easy adjustment of thigh pivot arm 36.

FIG. 3 shows a top perspective view of the quadriceps/hamstring version of the invention. Input shaft 22 penetrates control box in the shell of housing 12 and, as shown in FIGS. 4 and 5, is attached to a large pulley 26 which is in turn engaged, by drive belt 31, with small pulley 27 which is fixedly attached to shaft 30, which in turn is an output of electromagnetic brake 28. Brake 28 can produce instantaneous varying resistance as directed by a micro-processor or computer within console 10. In FIG. 1 this varying of resistance is transferred to the ankle pads 16, 17 via the drive mechanism described above. In this way, the user can experience varying degrees of resistance on the quadriceps and hamstring muscles within each cycle of the movement arc 23 in FIG. 2 as well as over the course of a plurality of cycles of the movement arc 23. The above described variable resistance electromagnetic brake assembly allows for a smooth and gradual increase in resistance during the first third of the upward movement of a body part such as a leg then decreased resistance during the latter portion of the upward movement. On reversing movement, the force is also reversed. The magnitude of the force is adjusted appropriately, with the maximum resistance occurring at the end of the first third of the movement. This relationship is shown in the force vs. distance curve in FIG. 28. The magnetic brake is a preferred resistance element. Other resistance elements may be used including electromotive, fluid flow restriction or simple mechanical resistance pads. Electrical power is provided to the entire system by standard means such as AC voltage found in homes or gyms, or by rechargeable batteries or the like.

To prepare for use the user sits in the chair seat 32 in FIG. 2, and adjusts the thigh pad 11 to firmly rest against his leg, locking it in place with locking knob 19. The user’s ankles are placed behind and against the forward ankle pad 17. The leg length of the machine is adjusted so the forward ankle pad 17 rests at the ankle bend. To do this adjustment
the user presses a switch on the operator console 10 to activate the leg length servo-motor 13, to either raise or lower the ankle pad 17 assembly as required. The user then presses a switch on the console 10 to activate ankle pad servo motor 15 which moves the rear pad 16 until it firmly contacts the back of his ankle. Each of these actions can be accomplished with one finger. Because there are no heavy weights or strong springs in the present invention, the position of moveable members can be adjusted with minimal effort before the exercise cycle begins.

To activate the system, the user accesses his personal exercise program via the keyboard included with the microprocessor or computer within the operator console 10. If the user has already programmed his information, the cycle can begin immediately. Otherwise, the user will enter his specific physical information, and a resistance cycle will be provided by the operating program. Returning users can access their previous workouts and modify the cycle if desired.

The user now begins the exercise cycle by lifting and dropping his or her leg or legs as shown by movement arc 23, with the display of operator console 10 providing information such as number of cycles completed, relative performance, and number of cycles remaining. A typical cycle will provide greater resistance during the lift portion of the program than the return portion. The ratio is preprogrammed so that an appropriate workout of the agonist/antagonist groups, along with the stabilizers and synergists, will occur. As each initial movement is completed and motion stops, a wait period of approximately two tenths of a second is provided. During this time the moveable machine member is effectively locked in position, so that no force is required by the user to maintain the resting position. At that time, opposing muscles can get ready for the rest of the cycle. Visual and/or auditory signals can be provided to indicate the end of the rest period, and signal the user to resume movement.

To exit the system, the user unlocks the ankle pad 16 and thigh pad 11 and exits the machine. The history of the workout can be stored in the computer memory of the microprocessor within console 10. Workout results can also be printed out or transferred to a standard storage medium such as compact disk or the like. Additionally, results can be transferred to a central computer which could then integrate data and provide the user with a complete workout analysis. The above described exercise apparatus and the variations described below all produce balanced muscle development of opposing muscle groups. The user may change resistance levels without getting out of the seat of the apparatus. Additionally, the apparatus can easily be adjusted to accommodate various sizes of individuals. The apparatus is relatively light compared to traditional weight based exercise machines. The apparatus is easy to set up and use.

Referring now to FIGS. 6, 7 and 8, we see a version of the bi-directional resistance muscle training system that is designed to exercise arm and shoulder muscles. To prepare to use the apparatus the user sits down and adjusts the seat 113 for height, so that the hand grips 110 can be grasped comfortably and lined up with the user’s body plane. He or she then adjusts the thigh pad 112 using the thigh pad adjustment knob 117, so his legs are held securely against the seat 113. The user can now select the desired exercise routine using the control panel which is not shown, but is similar to that shown and described in FIG. 1.

To use the overhead push/pull apparatus shown in FIG. 6, the user pulls down on the hand grips 110, and the grips rotate about the axis of rotation 118. This angular rotation is transmitted to the input shaft 115 by a belt inside the hand grip support column 114. The input shaft 115 rotation transfers to the brake inside the control box 116 through a gear set, which increases the angle of rotation. The force applied by the brake is regulated by the electronic controller, which detects the direction and position of the hand grips 110 and generates a control signal to the brake, based on the selected force curve. At the end of the downward movement, the user pushes up on the hand grips 110, reversing the rotation of the input shaft 115. The function of the control circuit and brake are fully described in the detailed description of the quadriiceps/hamstring bi-directional resistance equipment.

Referring now to FIGS. 9, 10, 11, 12, we see a version of the invention that exercises the arms in a rowing, push/pull manner. The user sits down and adjusts the seat 213 for proper height, so that the hand grips 210 can be grasped comfortably and properly positioned in line with the center of the user’s pectoral muscles. The user then adjusts the foot rest 214 for his leg length, so as to provide support during the press cycle. The user can now select the desired exercise routine using the electronic input control panel as shown in FIG. 1.

The hand grips 210 are attached to the hand grip offset member 218, and rotate about the axis of rotation 217. This rotation drives a belt within the hand grip support column 211. This belt drives the input shaft 215. The input shaft 215 is connected to the brake through a gear set which increases rotation angle. An electronic controller regulates the brake. The controller detects the direction and position of the hand grips 210 and generates a control signal to the brake, based on the selected force curve. As the user pushes outward, the hand grips 210 rotate about the axis of rotation 217, producing a large arc. The movement is generally in the horizontal plane. The user’s body is restrained by pressure against the seat back 212, and seat 213. On pulling back, the user applies pressure against the foot rest 214. The function of the control circuit and brake is fully described in the description of the quadriiceps/hamstring exercise apparatus.

Referring now to FIGS. 13, 14, 15, 16, 17, 18, we see a version of the invention that exercises the abdominal and back muscles. The user sits down and adjusts the seat 314 for the proper height, allowing a comfortable hold on the hand grips 310, with elbows placed on the elbow pads 311. The user then adjusts the foot rest 316 to the proper length, and tightens the ankle pads 315 to securely hold his or her ankles. The user can now select the desired exercise routine using the electronic input control panel as shown in FIG. 1.

The user grasps the hand grips 310, applying pressure so that his back is firmly pressed against the upper seat back 312. As the user leans forward, the upper seat back 312 pivots about the axis of rotation 317. This rotation is transferred to the input shaft 318 by a drive belt within the seat back column 320. The user then leaans backward applying force to the seat back 312, reversing the pivot angle, rotating the input shaft 318 in the opposite direction. The
input shaft 318 is connected to the brake inside the control box 319, by way of a gear box which increases the angle of rotation to the brake. The force applied by the brake is regulated by an electronic control unit, which detects the direction and position of the seat back 312, and generates a control signal to the brake, based on the selected force curve. The function of the control circuit and brake are fully described in the description of the quadriceps/hamstring apparatus. FIG. 17 also shows clearly the padded back rest 313.

[0081] Referring now to FIGS. 19, 20, 21, 22, 23, 24, 25, we see a version of the invention that exercises several body muscle groups and is therefore called a multiple muscle group personal use system. Dotted line 410 shows the axis of rotation for the overhead/row feature. The upper seat back 420 is adjustable 411 and supported by fixed seat back column 419. Pads 412 act as elbow rests as well as thigh pads. Hand grips 413 help the user during the overhead/row exercise. The seat 418 is height adjustable 414. Foot and ankle pads 415 allow the user to do leg exercises. Control box 416 houses the magnetic brake and other mechanical elements described in FIG. 1. The axis of rotation for doing abdominals/low back exercises is indicated by dotted line 417. Front 421 and rear 422 input shafts transfer rotational movement to the internal components in the control box 416. The row push/pull arc is represented by curved line 423. The axis of rotation for quadriceps/hamstring exercise is represented by dotted line 425. The arc of movement for the abdominals/low back exercise is represented by curved line 426. In one embodiment hand grips 427 for use in arm exercises are used in place of the ankle pads 415. Arc line 428 shows the rotational movement of hand grips 427. Elbow pads 412 can be lowered to match seat height. The elbow pad/thigh pad can be adjusted up and down by adjustable height column 430. The seat is lowered 431 to provide proper rotation axis at the user’s elbow. Movable member 432 allows the user to do quadriceps/hamstring as well as biceps/triceps exercises. Ankle restraining pad 433 is added for quadriceps/hamstring exercises. The actual patterns for exercising on the multiple use version of the present invention have been previously described in the alternate versions of the invention. These are designed to exercise discrete muscle groups and therefore are not explained in detail in the present multi use version. The present multi use version is also designed for possible home use and is able to be folded for storage.

[0082] FIG. 26 shows a version of the present invention that is designed to exercise the biceps/triceps muscle groups. To prepare to use the apparatus, the user adjusts the seat height 516 so that his elbows rest comfortably on the elbow pad 513. The user then adjusts the seat back 514 to provide proper positioning of his chest against the elbow pads 513 rear face. The user can now select the desired exercise routine using the electronic input control as described in FIG. 1.

[0083] When the hand grips 510 are pulled up, the rotation is transferred by the gear boxes 515, 515A to a common shaft 519, which in turn is connected to the brake rotation 512 to be slightly above the face of the elbow pad 513 and in line with the user’s elbow joint. This matches the elbow rotation axis and insures safety and comfort for the user. The drive belt is fully encased inside support column 511 for the elbow pad 513 and hand grip 510 assembly, providing protection to the user from possible pinch point injury. When the user extends the triceps, the rotation is reversed. The input rotation shaft 517 is connected to the brake inside the control box 518. Gears increase the angle of rotation from the input rotation shaft 517 to the brake. The brake force is regulated by an electronic controller, which detects the direction and position of the hand grips 510, and generates a control signal to the brake, based on the selected force curve.

[0084] FIG. 28 shows a graph of the relationships of the basic components of the resistance force unit of the bi-directional resistance apparatus of the present invention. The bi-directional quadriceps/hamstring machine can be used in the unidirectional mode.

[0085] Referring back to FIG. 2, a person sits on chair seat 32 and retains his or her ankles between cushioned supports 16, 17 and thighs under restraining member 11. Member 11 can be adjusted to the user by rotating bar 36 about pivot point 35. The user then flexes his or her legs and causes swing rod assembly 20, 21 to rotate about shaft 22 causing swinging action 23. A resistance device such as an electromagnetic brake is located within housing 12. FIG. 27 shows the inside of housing 12 where brake 27 communicates with drive pulley 26 via drive belt 31. In the present embodiments we have added an electric motor 40 whose shaft 42 engages with an electronically controlled slip clutch 44 which in turn engages with reverse force drive belt 46. With the addition of motor 40, the current exercise apparatus is programmed to apply a return force on shaft 22 thereby simulating the effect of a stack of weights forcing a user’s arms, leg or torso to baseline during the second half of the exercise cycle. The current apparatus can be programmed to apply resistance to flexion or extension in the initial half of the exercise cycle and to then apply an automatic return force in the other half of the exercise cycle. In this way, the user can have the feeling of a standard free weight exercise machine and still retain all the advantages of the variable resistance assembly as described in detail in the earlier portion of the present description. For example, in the embodiment shown in FIG. 27 the user can apply controlled resistance in the upward swing or his or her lower legs and then, with the use of motor 40, feel an automatic positive return force similar to that of a weight stack during the downward swing. Alternately, the present exercise apparatus can be programmed to provide resistance during the downward motion of the user’s leg and provide an automatic positive force during the upward swing. As an alternate [text missing or illegible when filed] mechanism, instead of slip clutch 44 supplying the variable force, a DC motor torque is controlled by a microprocessor can be used to supply variable force. Finally, other force means can be employed such as a brake, air pressure or adjustable springs. An active device such as a motor could cock the spring during the resistance cycle. At the end of the first half cycle the spring would then engage the moveable member and apply the automatic positive return force. It would also be possible to have a weight stack incorporated, however this would negate several of the advantages of the basic design. As with the spring method, an active device such as a motor would drive the weights during the resistance cycle, engaging them at the end of the cycle and allowing gravity to produce the return force. FIG. 32 is a block diagram of this embodiment of the invention. This diagram shows how the microprocessor interacts with the slip clutch which in turn affects the moveable member. The return motor is attached to the slip clutch and affects the
return half of the exercise cycle. The electronic brake causes resistance during the first half of the exercise cycle as described in the earlier portion of the present description. FIG. 29 is a chart that shows the resistance force during the first half of the cycle. FIG. 30 is a chart showing the automatic positive return force during the second half of the cycle.

[0086] Referring now to FIGS. 33, 34, 35 we see perspective views of a stationary exercise apparatus. A servo motor 2 located on the extension shaft 3 of the seat back 33 moves seat back 33 forward or backward relative to the pivot point of the moveable member. The actual position of the seat back 33 is determined by a standard position sensor, not shown. The position of the seat back 33 is moved based upon the information stored in microprocessor 60 via input keyboard 10. A start up menu is used the first time they engage the equipment. The user’s profile is then saved in the memory section of the microprocessor 60. A servo motor 4 is attached to the rear extension of the thigh pad assembly 7 by way of connection shaft 5 to extend, retract, raise or lower the thigh pad 7 onto the user’s thigh as shown in FIG. 34. The microprocessor 60 monitors the current to the servo 4 to insure that the holding force does not become excessive. The microprocessor 60 also determines the final position based on the setup values stored for the user. The same menu used to adjust the seat back 33 is used to store the initial position and force the individual user. Upon completing the thigh pad adjustment, the microprocessor then adjusts the leg length 9 by use of a servo motor 1 as shown in FIG. 34. The servo motor 1 either raises or lowers the ankle pad assembly 8 to the proper position. For the initial setup the same menu is used to select the correct position of the ankle pad assembly 8. The value is stored for the individual user. The spacing between ankle pads 8 is adjusted by the user of a servo motor 333 as shown in FIG. 34. The microprocessor 60 activates the servo motor 1 which moves the pads towards each other until the correct position, as determined by load current of the servo motor 333 or position sensor, is achieved.

[0087] When the exercise apparatus is used for physical rehabilitation, it is often desirable to limit the overall movement of the individual members of the equipment. Using a separate setup menu, the user or their trainer can enter the desired start and stop locations. The start position and stop position can be entered as angular values, or the moveable member can be positioned to the desired point and the position measured by the microprocessor from a standard internal position sensor, not shown. During use, when the moveable member reaches either limit position, the force is increased to a maximum value, stopping any further movement. After a short delay, the force, produced by an internal resistance mechanism housed in enclosure 12, is reduced, and the moveable member allowed to reverse direction. If the movement direction is not reversed, then the force again increases to maximum, preventing further movement past the limit position. The system can be set at a fixed position in order for the user to perform isometric exercise. The system can be set to provide a fixed time at the locked position. To do this, the user sits on the apparatus and initiates a cycle. After all the predetermined adjustments are made, the user raises his or her legs, and at the predetermined position the moveable member locks. The force during the movement portion can be programmed at an appropriate value, allowing a variety of resistance from minimal to high. After the programmed time duration, the microprocessor 60 indicates to the user that he or she has completed the time and then slowly reduces the locking force allowing the user to lower his or her legs. There may be situations where dynamic levels to the holding force of the thigh pad 7, ankle pads 8 or leg length setting might need to be adjusted differently during the extension half of the cycle. This would likely occur during a very rigorous training exercise or as part of a physical rehabilitation program. The microprocessor can use the directional information, provided by the internal angular position sensor of the moveable member, to change the servo motors, repositioning the seat back 33 thigh pad 7 and ankle pads 8 or leg length. Obviously, any one of the adjustment mechanisms described above can be used independently or in any combination with one another. FIG. 35 shows ankle pads 8 in the down position 8A and the up position 8B.

[0088] Referring to FIG. 36, we see a flow chart of the unique firmware process needed to control a bi-directional exercise device. The numbering sequence used in FIG. 36 has no relation to earlier numbering sequences used in the description of the physical apparatus of the present invention. Accordingly, the user turns on the power 2 and the microprocessor is initialized 4 clearing and setting ports, variables, and other normal functions. The force range is read 6. The angular position offset 8 is set to the current position. The position transducer is read 10 and the RS 232 port is read 14. If the port input flag has been set 12, the system will wait for data download. To set the input flag 12 the ASCII character “a” is sent from an external computer through the RS 232 post. The system responds and the “SEND FILE” and waits for data. The data is transferred as simple ASCII text, with the first line indicating the relative storage address (zero to four) for the EEPROM 16, and the next five hundred and twelve lines being relative force values 18. The data is stored in non-volatile EEPROM 16. Upon completion of the data download, the program returns to normal operation.

[0089] The system uses a floating start point 20 for each change in angular direction 22. The angular position offset is the absolute physical position of the moveable member as defined by the position transducer 22 each time the direction changes. For each loop 50 of the firmware, the position transducer is read 22. The value is compared to the previous value. If the value does not change for one hundred and fifty cycles (approximately one tenth of a second) the brake force to increase to a high level. [text missing or illegible when filed] 32, 34 is compared to the start point 6, 8 in order to define the relative movement. The resolution of the system is on half of one degree, with each half degree increment being able to have a different force value. If the direction of movement changes 36, the angular position offset value is reset 40. The stop counter is reset 38 and the offset value is reset 40 to the new angular position. Each time prior to reading the value from the force table memory 44, the force range switch 42 is read. This allows the user to change the force range 46 at any point during the cycle. The signal 48 called “go to working” instructs the system to loop back to the “working” 10 portion of the microprocessor instruction set. FIGS. 2A through 2R shows the entire detailed flow diagram of the software design of the present invention. The user may stop at any point. Shut down requires only turning off the power 2.
the scope of the invention to the particular form set forth. On the contrary, it is intended to cover such alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. Bi-directional resistance exercise apparatus comprising:
   a chair portion including a seat, a backrest, a backrest support member and supporting legs;
   a pair of parallel spaced elongate padded ankle retaining members;
   an elongate padded thigh retaining member;
   a pivotally mounted swing arm attached to said ankle retaining members;
   said pivot pins mounted to and through the side wall of a control box;
   said control box containing a variable resistance mechanism such as a magnetic brake, a pulley attached to the shaft of said brake, a larger arc reducing pulley, a belt joining said shaft pulley and said arc reducing pulley;
   said ankle pivot pin fixedly attached to the central aperture of said larger arc reducing pulley;
   a microprocessor or personal computer and associated software that is attached to said variable resistance mechanism so that the resistance can be controlled by said computer.

2. Bi-directional resistance exercise apparatus as claimed in claim 1 wherein the length of said swing arms is adjustable.

3. Bi-directional resistance exercise apparatus as claimed in claim 1 wherein said chair portion includes hand grips mounted on either side of said seat portion.

4. Bi-directional resistance exercise apparatus as claimed in claim 1 wherein said back rest is adjustable in and out with respect to said backrest support member.

5. Bi-directional resistance exercise apparatus as claimed in claim 1 further comprising alternate embodiments of said apparatus that are designed to provide said bi-directional resistance exercise for other muscle groups by incorporating said variable resistance device and associated said microprocessor controlling software into other traditional exercise apparatus including chest/row, overhead press/pulldown, quadriceps/hamstring, abdominals/lower back and biceps/triceps type exercise devices.

6. Bi-directional resistance exercise as claimed in claim 1 wherein:
   said microprocessor or personal computer and associated software can direct said variable resistance mechanism so that the resistance can be controlled instantly and sequentially, and wherein said computer retains custom software that allows the user to select from pre-programmed resistance levels or to manually adjust the resistance of the inward and outward stroke of said second swing arm and attached ankle retaining members, when a user flexes his or her quadriceps and hamstring muscles.

7. Bi-directional resistance exercise apparatus as claimed in claim 6 wherein said bi-directional resistance can be programmed to change within a single in and out cycle and can be also programmed to change over a plurality of cycles.

8. Bi-directional resistance exercise apparatus as claimed in claim 6 wherein the said user’s exercise results can be recorded, stored and retrieved by said computer or microprocessor or can be sent to a second central computer where exercise results can be further analyzed.

9. Bi-directional resistance exercise apparatus independently claimed comprising:
   a chair portion including a seat, a backrest support member and supporting legs;
   additional standard leg and arm supporting and retaining members;
   a control box containing a variable resistance mechanism such as an electromagnetic brake and an electric motor that provides an automatic positive return force;
   a microprocessor that controls the said variable resistance mechanism and said automatic positive return force mechanism;
   associated software that allows said exercise device to act as both a bi-directional resistance machine, and a machine that provides resistance in one direction and an automatic positive return force in the opposite direction.

10. Bi-directional exercise apparatus as claimed in claim 9 wherein said resistance mechanism can be used during the flexion portion of the cycle and said automatic positive return force portion can be used in the extension portion of the exercise cycle or conversely, the said automatic positive return force mechanism can be used during the flexion portion of the cycle and said resistance force mechanism can be used during the extension portion of the cycle.

11. Bi-directional resistance apparatus as claimed in claim 9 wherein said automatic positive return force mechanism includes a slip clutch that can be electronically adjusted to provide more or less force during said return portion of the cycle.

12. Bi-directional exercise apparatus as claimed in claim 9 wherein alternate means can be used to provide return force such as compressed air or springs or a weight stack.

13. Bi-directional exercise apparatus as claimed in claim 9 wherein a microprocessor controlled DC motor can provide variable force instead of a motor with a slip clutch.

14. Bi-directional exercise apparatus independently claimed wherein adjustment mechanisms are delineated comprising:
   a seat servo motor;
   a microprocessor;
   an input keyboard;
   a thigh servo motor;
   a thigh retaining pad;
   a thigh pad pressure sensor;
   a leg length servo motor;
   a pair of ankle pads; and
   an ankle space adjusting servo motor;
said servo motors mounted in conjunction with standard components of a stationary exercise equipment apparatus so that said servo motors can adjust the position of said exercise equipment’s seat, thigh pads and ankle retaining pads to the measurements of a particular user.

15. Bi-directional exercise apparatus as claimed in claim 14 wherein said servo motors are controlled by inputting measurement information into said microprocessor via said keyboard.

16. Bi-directional exercise apparatus as claimed in claim 14 wherein said measurement information can be stored in said microprocessor so that before a user starts his or her exercise, he can enter a specific code and said exercise apparatus will automatically adjust to said user’s dimensions.

17. Bi-directional exercise apparatus independently claimed wherein specific firmware is implemented comprising:

- a microprocessor and associated electronics for controlling the electronic resistance mechanism of a bidirectional exercise device including an RS-232 input port, an EEPROM, an angular position transducer, a timing circuit, a reset circuit, a force range switch reader, a brake force reader, a memory storage device and a power supply.

18. Firmware design for bidirectional exercise equipment as claimed in claim 17 wherein when said power is turned on, the said microprocessor is initialized, clearing and setting ports, variables, and other normal functions.

19. Firmware design for bi-directional exercise equipment as claimed in claim 17 wherein said angular position transducer provides data to a floating start point that recalibrates force and resistance to said resistance mechanism at each step of the extension and flexion halves of the resistance cycle.

20. Firmware design for bidirectional exercise equipment as claimed in claim 17 wherein said angular position transducer is accurate to within one half of one degree.

21. Firmware design for bi-directional exercise equipment as claimed in claim 17 wherein said microprocessor includes a force table in its memory so that as the force range is read, the user can change force range at any point during the cycle.

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