OFFICIAL SPONSOR

MOTOROLA

EVENT HOST

First NH Bank

U.S.FIRST

COMPETITION

OFFICIAL SUPPLIERS

Autodesk, Inc.
D&W Carpet and Rug Co., Inc.
Delco Electronics Corporation
McMaster-Carr Supply Co.
Milwaukee Electric Tool Corp.
Molex Inc.
Panduit Corporation
Rohm Tech, Inc.
Rubbermaid
Small Parts, Inc.
Termiflex Corporation
Thomson Industries, Inc.
United Parcel Service

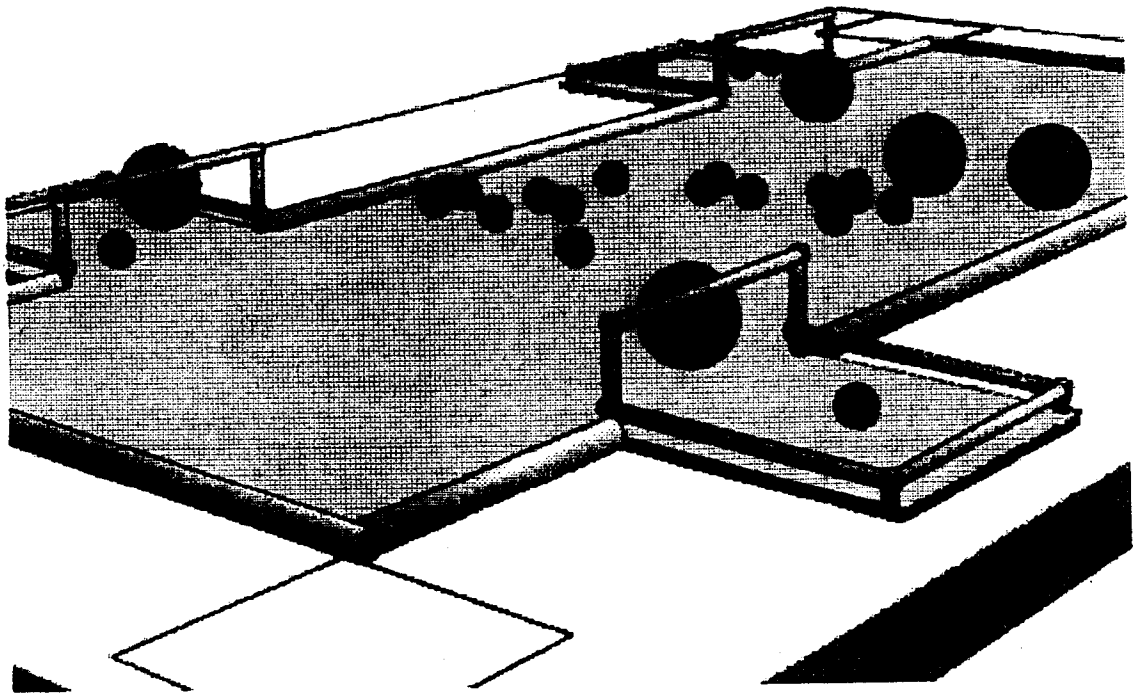
Rules

1 9 9 3

JANUARY 8 - FEBRUARY 26 & 27, 1993

The U.S. FIRST Competition is a design challenge in which high school students are paired with professional engineers to design and build a remotely operated mechanical device which competes against other machines of its type to win national honors.

The object of the U.S. FIRST Competition is to collect as many kick balls as possible into the team's own goal. In each match four teams compete for 5 high-value large diameter kick balls and for 20 low-value, but heavy, balls lying on the field between the four goals. Each match lasts 2 minutes. The winner is the team that has the highest total point value of kick balls within its goal at the ending buzzer. In case of a tie, the team with more high value balls wins.



OBJECTIVE

To design and build a remotely-controlled device to collect kick balls from the playing field, and to defend them against opponents. The playing field is illustrated in the attached diagram.

CONSTRAINTS

Materials

With the following exceptions, each machine must be constructed solely from materials provided in the "Kit":

- up to $300 worth of materials purchased from the Small Parts Catalog
- selected materials available from a hardware store (see attached list)
- fasteners, washers, and adhesives may be used for fastening and joining only
- adhesive tape may also be used as an electrical insulator
- lubricants used only to reduce friction within your own device
- nonfunctional decorations
- a common, 9-volt, "transistor radio" battery
- the Rubbermaid container and packing materials are not part of the kit
- the control system is part of the kit, but it may not be tampered with.

Energy Sources

The energy used by the devices in the competition must come solely from:

- electrical energy derived from the onboard battery pack
- storage achieved by deformation of the tension, compression and constant force springs provided in the Kit
- a change in the altitude of the center of gravity of the device
- electrical energy derived from the common 9-volt "transistor radio" battery that participants may add to the kit materials.

Size

At the start of each match the machine must fit, unconstrained, in a 3 ft. by 3 ft. by 3 ft. cube.

Weight

The weight of the machine may not exceed 50 lb.

EVALUATION

The prestigious Chairman's Award and the Judges' Awards will be determined by an independent panel of judges, evaluating the teams and their machines throughout the two days of competition. The winner of each contest will be the team with the highest point value of kick balls within the confines of its goal at the end of a 2-minute match. The overall winner will be determined in a double elimination tournament.

DETAILS

SAFETY

Due to the nature of the event, in which electrical equipment and tools are used, safety may not and will not be compromised.

1. Safety first.
2. Any machine which appears to be a safety hazard will be disqualified by the referees.
3. For safety reasons, rubber bands may not be used as energy storage devices.
4. Power supply, batteries, charger and control system may not be tampered with.
5. If a projectile is used, it must have a frontal area greater than 10 square inches.
6. All team members must wear safety glasses (provided at the event) during their matches.

MACHINE

7. Machines must be designed to operate by reacting only against the top surface of the playing field, the pipe forming the rim, the posts (including flanges), the kick balls, the opponents, and the air.
8. Machines must display their company and/or school or team names or logos.
9. During the contest the machine may be interacted with only through normal operation of the wireless control system.
10. Gaining traction by use of adhesives, or by abrading or breaking the surface of the field is not allowed.
11. The machine must remain within the maximum size limit, unconstrained, until control is enabled at the beginning of the competition. Once the match begins, the machine may unfold and change size through its own power .
12. All machines will be inspected for compliance with the regulations before the contest. The winning machine will be inspected again following the tournament.
13. If the 9-volt battery is used, it must be connected in such a way so as not to affect the position of the balls immediately following the end of a match.
14. No substitute machines will be permitted. Spare parts are allowed.
15. All machines must be shipped to the site of the competition by United Parcel Service. You may ship up to 100 lb. of machine parts, tools and components courtesy of UPS. They must arrive between February 24 and 26, 1993. The machines will be released from custody following the surrender of the transmitter. When shipping, batteries must be unplugged and packaged separately from the rest of machine. This is a Federal Law.
16. The machines may not leave the competition site until the conclusion of the tournament on February 27, 1993. If repairs are required, they must be performed on site.
17. Following the contest, the machines become the property of U.S. FIRST. Arrangements can be made for release of the machines for display and educational purposes.

FIELD

18. Damaging the field, the controls or the kick balls may result in disqualification, i.e. using spiked wheels is considered damaging to the field and is illegal.

19. A machine may not intentionally contaminate the playing field or an opponent's machine with lubricant.
20. At the start of the competition, the machine may be placed anywhere inside the marked area without touching the rim.
21. To receive credit for a kick ball, its center must be inside the goal area defined by the vertical planes passing through the center axis of each goal pipe, regardless of whether or not the ball is inside of the competing device. Referees' determinations will be final.
22. Playing field will be on the floor. No players are allowed on the field or outside the designated team box area during a match.

CONTROL SYSTEM

23. The control system is provided to allow wireless control of the devices. Micro controller, transmitting and receiving R-Nets, batteries, battery charger, power supplies, joystick, controller and the wire harness may not be tampered with or adjusted in any way.
24. The micro controller, receiver, battery holder and the battery are the only components of the control system which may be attached to the machine. Battery holder (empty charger shell) may be modified for mounting purposes.
25. All the motors and electrical devices must be connected to the micro controller through supplied connectors. The battery must be plugged directly into the empty charger shell, which in turn must be plugged directly to the micro controller unit. Connecting any other device or part directly to the battery is illegal. Only one battery per match may be used.
26. The transmitter will be impounded for the entire competition. When competing, do not bring the power supply with the control system to the field. The wire which usually connects the controller to the transmitter will plug into a cable connected to an official transmitter. The cable will also supply power to the controller.
27. No transmitter should be turned on within the confines of the competition building. For bench testing use a tether.
28. If you are making a powered tandem device, you may attach a separate umbilical, connecting the two devices, to the output jacks of the micro controller box. You may not tamper with the jack itself, i.e. remove pins, solder, etc. The umbilical may not be attached to any overhead support; it is part of the machine and thus subject to the same constraints.

KIT

29. Kit materials may not be changed chemically. Exceptions: leads of strings may be singed to prevent loose ends; resin and hardener may be mixed to result in epoxy.
30. Components may be built out of fiberglass cloth and epoxy provided in the kit. Additional epoxy may be purchased for this purpose.
31. Except for wire, no electrical components from the printer may be connected to the controllers. Do not throw away any components disassembled from the printer. **Printer parts must be returned to U.S. FIRST for proper disposal.**
32. Limited numbers of replacement parts are available from U.S. FIRST upon a justified request. Otherwise, lost or damaged kit material may be replaced only with identical components which includes same material, dimensions and treatment.

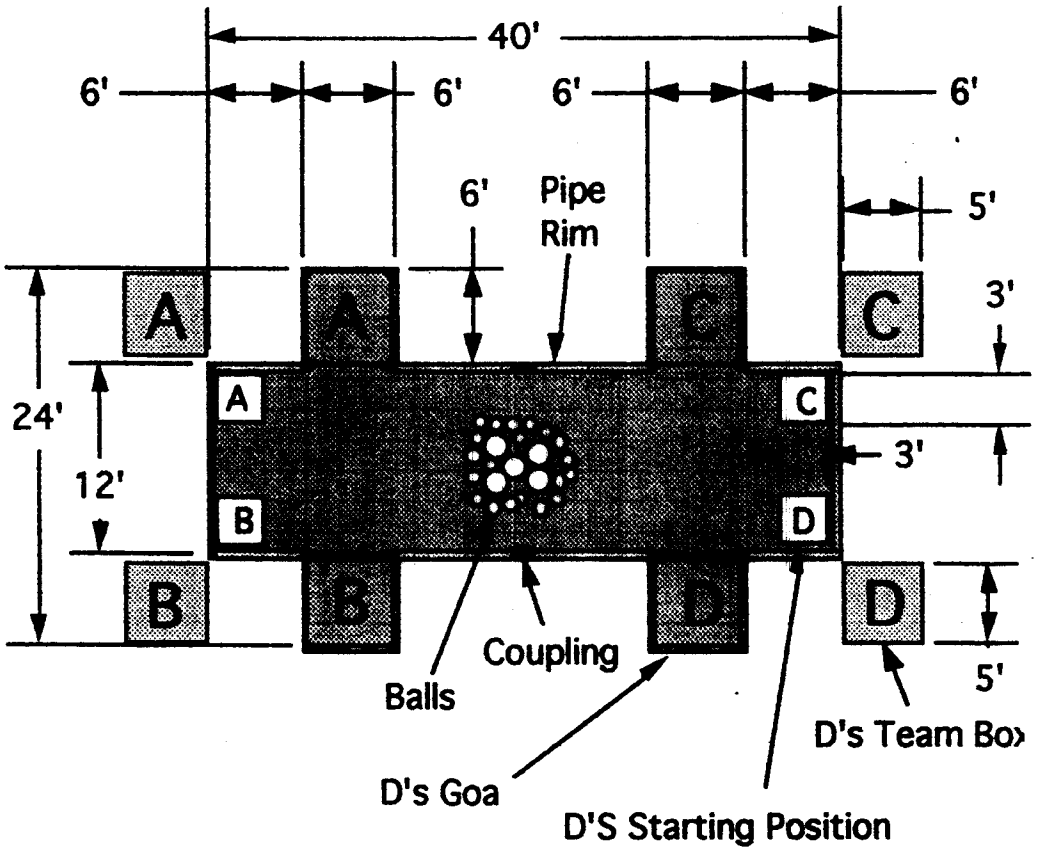
TOURNAMENT

33. Referees have ultimate power during the competition.
34. Each contest will start when the control system is enabled and will end 2 minutes later, when the control system is disabled, unless whistled dead by the referees.
35. During the tournament a maximum set-up time of one minute will be allowed once the team arrives at the field. Teams will be notified of their field and position assignment at least 2 minutes prior to the match.
36. A maximum of 1 minute will be allowed for removal of all parts of each machine from the playing field, including any detachable segments.
37. Only two students and two coaches/engineers wearing the supplied team shirts are allowed in the team box. Hats displaying company and high school team names or logos should become part of the uniform.
38. During the contest, only the two students may operate the control keypad and the joystick. The engineers may assist during set up and removal of the machine, but during the match they may only coach the students from inside the team box marked on the floor.
39. Strategies aimed only at destruction, damage or entanglement of an opponent's machine are not in the spirit of the contest and will not be allowed. Turning over an opponent's machine is not considered damaging; but stabbing, cutting, etc. is illegal. Referees will disable a contestant's control system if a major breach of the rule occurs.
40. No points will be awarded for large balls which were jammed under the goal cross bar. The goal cross bar may not be jacked up or moved on purpose.
41. During a match the control system is enabled for 2 minutes. Match ends when all balls stop moving or upon a referees' decision.
42. A machine may not win a match through advantage gained by breaking a rule even if done accidentally. Referees may decide to rerun a particular match in such a case.
43. If during a match any part of the a machine (with the controller on it) touches a 2 foot wide margin surrounding the field, it will be disabled for the remaining duration of the match. This includes machines which are pushed out of bounds.
44. Each team will be provided with a table as a pit area. Each team may bring a hand-held toolbox with basic hand/power tools. If a part requiring machining is broken during competition, consult U.S. FIRST. We will make best effort given local shop and material availability to help replace the part.
45. Practice time will be available and monitored on Thursday in 1/2 hour time slots. A sign-up list will be formed.

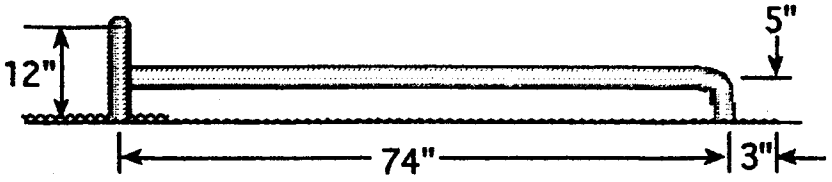
FIELD

The dimensions and the layout of the playing field are shown below. The surface consists of a close-looped, low pile carpet spread directly on a gymnasium floor. The narrow carpet cross legs which form the goals are placed directly underneath the main carpet. The perimeter of the field is defined by a 4 inch diameter, schedule 40 PVC pipe, connected using elbows, in line couplings and end caps 1/2" larger in diameter than the pipe. The pipe, or the rim is attached to the carpet with Velcro strips every few feet. The starting areas for machines are in the corners of the main field. The limits of the starting area are marked on the rim. The goals are made out of 2" diameter PVC pipe mounted in cast iron flanges attached to the shorter piece of the carpet. The flange is 3/8" thick and 5.5" in diameter. Except for the flange, all material is non-metallic and non-magnetic. All pipes forming the sides and back of the goal are 5" (center distance) above the surface. The cross pipe on the front of the goal is 12" (center distance) above the surface, allowing the small balls to roll in, restricting the large ones. To score a large balls, a machine has to lift it over the cross bar.

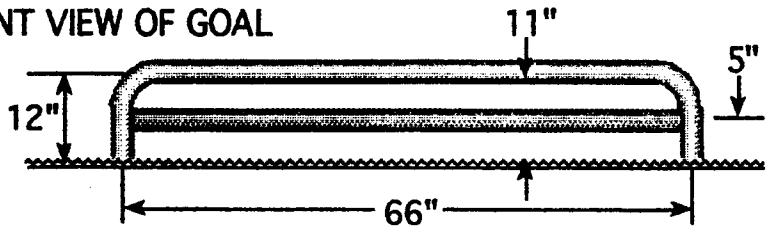
There are five 13" diameter red kick balls, each worth 5 points and twenty 6" diameter balls filled with water worth 1 point. At the beginning of each match, the large balls will be randomly surrounded by the small balls in the center court. Dimensions of the field and goal are shown below and on the next page. The pipe of the rim lies entirely within the outside dimensions of the carpet.



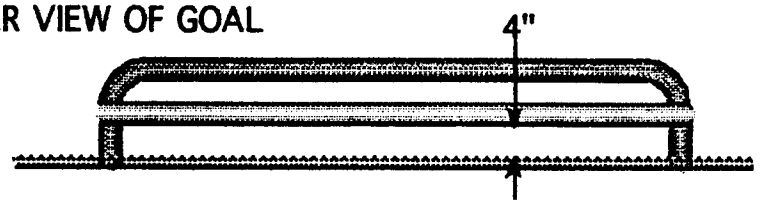
RIGHT SIDE VIEW OF GOAL



FRONT VIEW OF GOAL



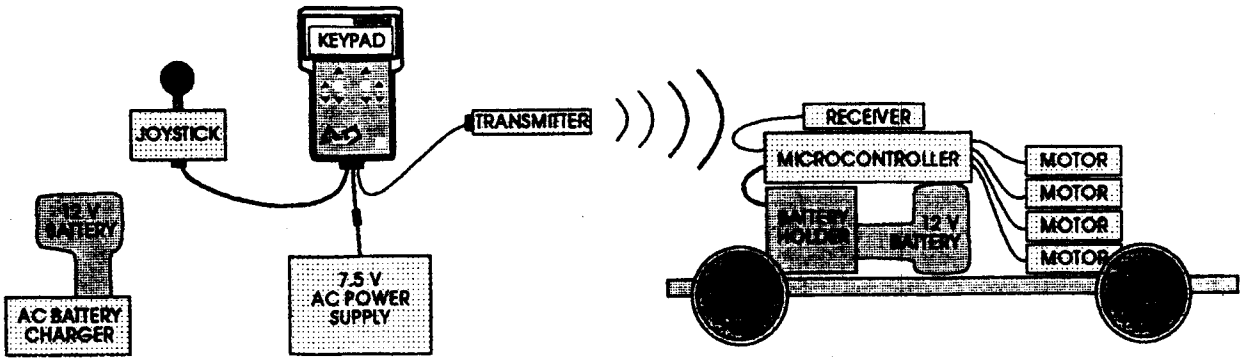
REAR VIEW OF GOAL



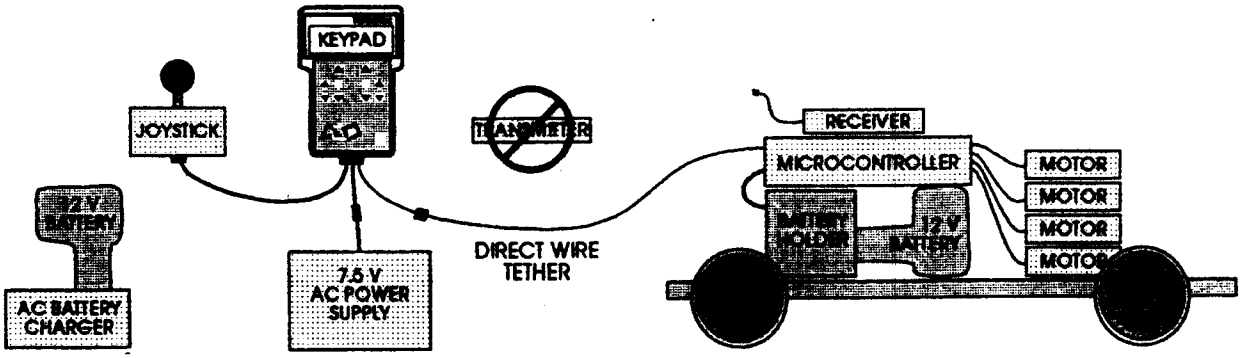
CONTROL SYSTEM

Kits contain a Termiflex keypad controller, an 8-position joystick, a transmitter-receiver pair, a micro controller with relays, power supply, two batteries and a battery charger. There are three different modes of operating the control system as shown in a diagram on following page. While designing and building your machine at your home site, use the full wireless mode to test your machine. The controller and the transmitter is powered by an external AC power supply which plugs into the wiring harness. The control is via a RF link with the onboard receiver and a micro controller unit, powered by the battery. This mode is available to you only at your home site, because you will be the only one using the particular frequency licensed by U.S. FIRST. When your machine arrives at the competition site, the transmitter will be impounded, so as not to interfere with any other machines. While at the competition site you can test your machine using a tether. Plug one end of the tether into the wire harness (where transmitter used to be plugged in) and the other into the micro controller (disconnect the receiver first), thus establishing a direct link. While practicing or competing on the official competition fields, you will have to use the official transmitter set up at the competition. To use it, plug the cable at the team box into your wire harness (where transmitter used to be plugged in) and disconnect your power supply. The transmitter set up will supply the keyboard controller with power and it will synchronize all the transmissions to eliminate interference. The receiver on your machine needs to be plugged into the micro controller again.

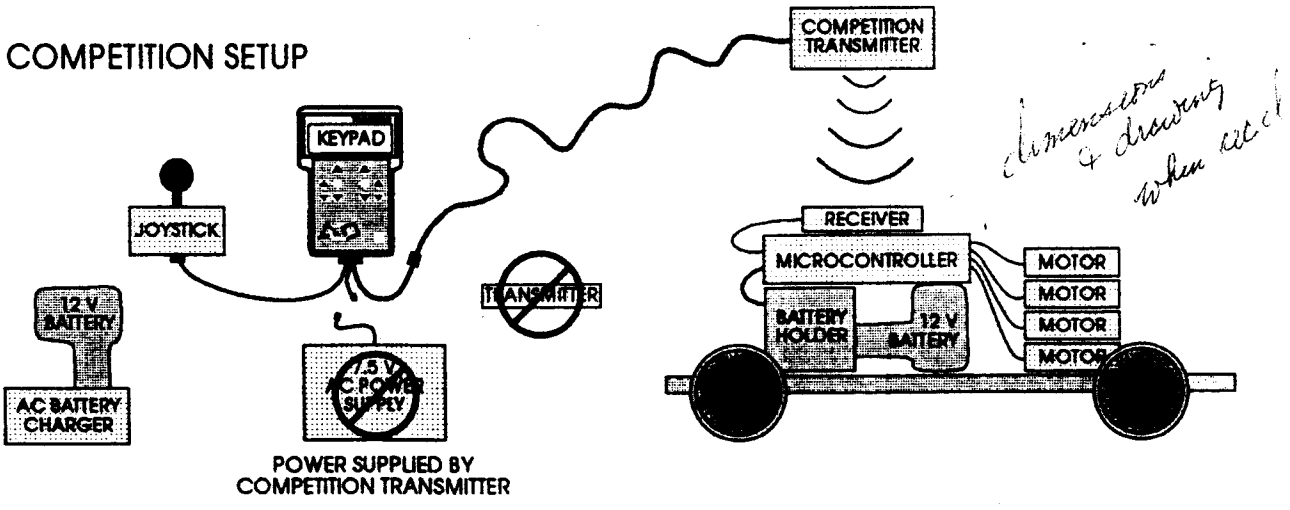
DEVELOPMENT SETUP



PIT AREA SETUP

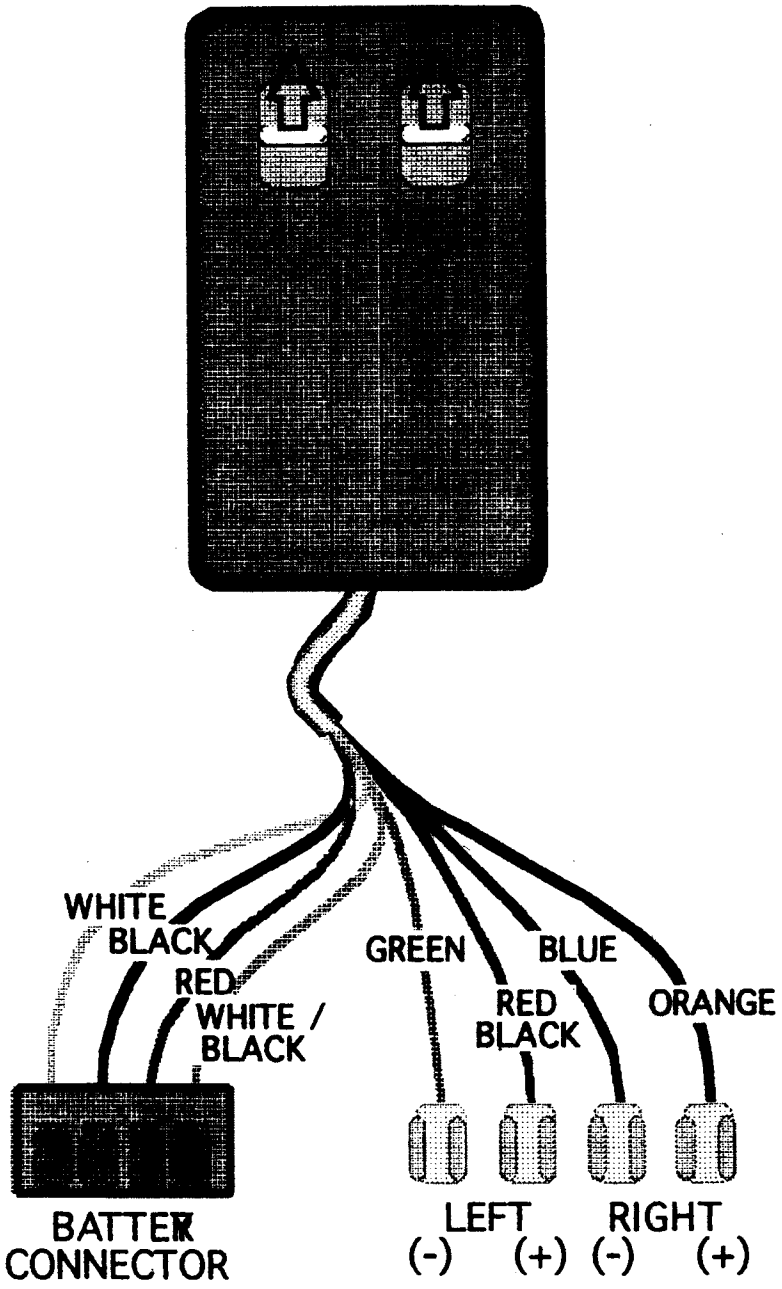


COMPETITION SETUP

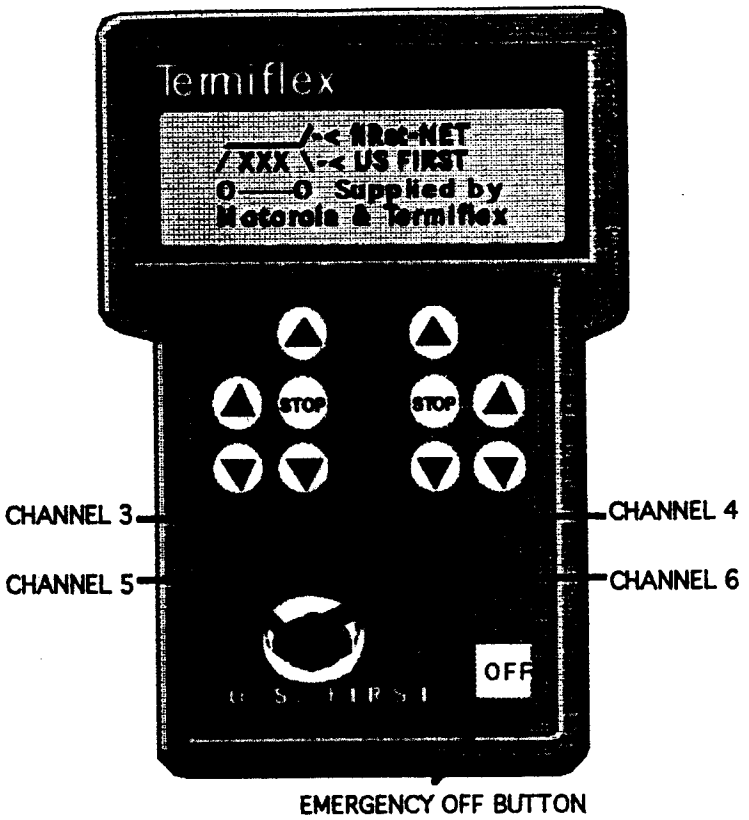


SWITCH BOX HARNESS

Every kit is supplied with a switch box harness as shown below in the drawing. The harness may be connected to the battery holder and up to two separate motors. Using the double pole, double throw switches, the motors may be fully tested in both directions, bypassing the wireless control system. We strongly encourage the use of the wire harness during the initial components and early machine development. Using the switch harness will prevent unnecessary wear and tear of the micro controller relays and traces in case of a short circuit. If in spite of using precautions a relay is burned out, the micro controller will have to be returned to U.S. FIRST for repair.



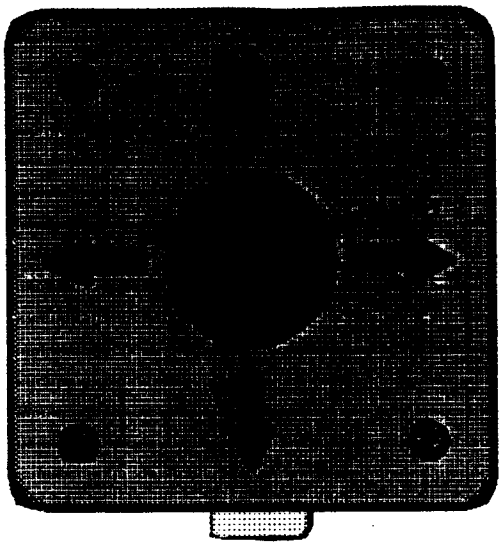
TERMIFLEX CONTROLLER



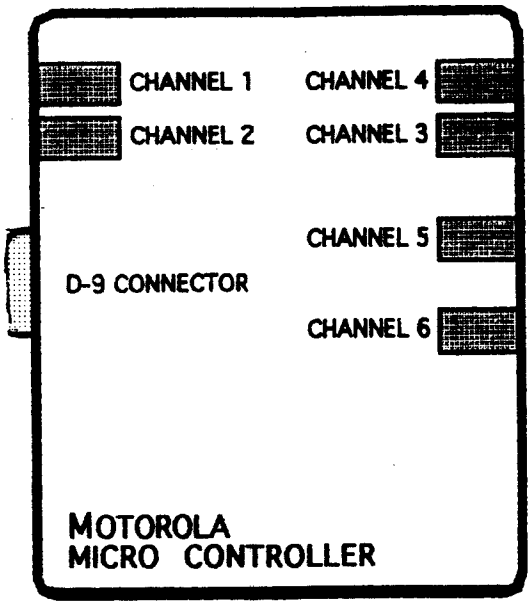
CHANNELS 1 AND 2 ARE REVERSIBLE
(THE ARROWS ARE MOMENTARY)

CHANNELS 5 AND 6 ARE PROPORTIONAL
(THE ARROWS ARE MOMENTARY,
STOP RESETS THEM TO 0)

A Termiflex keypad controller is shown above. The unit provides interface between the user and the micro controller on board of the vehicle. It is equipped with four reversible channels, each one allowing the user to turn the motor on, off or turn it in reverse. By pressing the 'up' arrow on the channel 3, the corresponding jack on the Motorola micro controller will have 12 volts across the pins, with the upper pin (red wire) being positive, and lower pin (black wire) being ground. When the 'down' arrow is pressed, the situation is reversed and now the upper pin is ground and the lower pin is power. Buttons for channels 3 and 4 are momentary switches, so when released, there is no output. Channels 5 and 6 allow the user to press the arrow keys and release, leaving the output on. The output will remain on, unless either opposite arrow key or the stop key is depressed. (You may press either arrow up to seven times, so to return back to off, you need to press the opposite arrow seven times). Pressing the 'off' button will stop transmission of any commands being sent out by the controller or the joystick, stopping all the motors on board of the machine. NO MODIFICATION OF CONTROL KEYPAD OR ANY OTHER PART OF THE CONTROL SYSTEM IS ALLOWED.



D-9 CONNECTOR



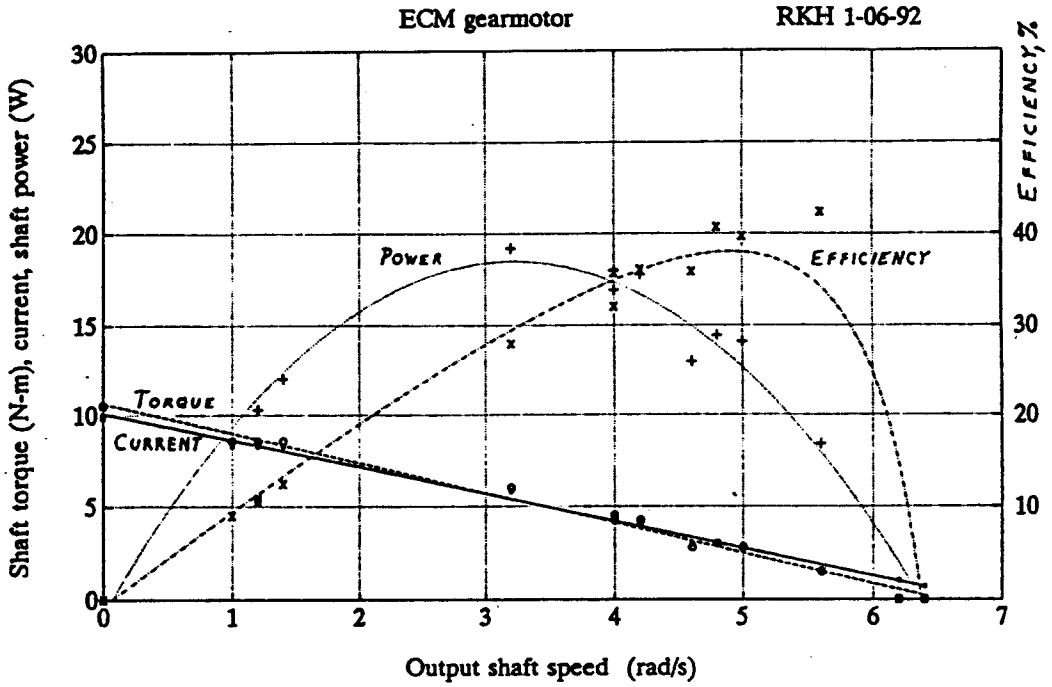
JOYSTICK CHANNEL ASSIGNMENTS

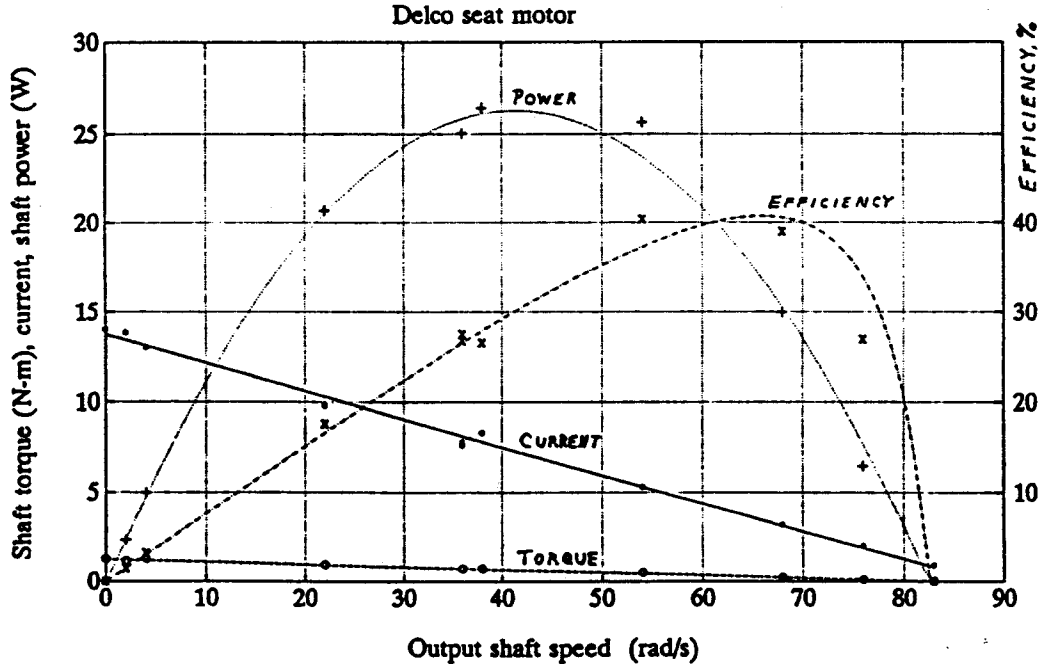
MICRO CONTROLLER CONNECTOR LAYOUT

To control channels 1 and 2, an 8 position joystick shown below is used. By pushing the handle forward (connector is in the back), the corresponding jack on the micro controller will have 12 volts across the pins, with the upper pin (red wire) being positive, and lower pin (black wire) being ground. Situation is reversed when the joystick is pulled back, with the upper pin becoming ground and lower pin becoming power. Same type of arrangement is on channel 2, which corresponds to the side-to-side motion of the joystick, with the red wire being power when joystick is to the right. If the joystick is moved diagonally, both channels are activated simultaneously. Hint: rotating the joystick 45° to the right and connecting channel 2 to left motor, channel 1 to right motor, a caterpillar-type control of a vehicle may be obtained. To activate different channels and directions, you need to return the joystick back to the center.

POWER SPECS FOR MOTORS

The Delco motors and the ECM motors have been tested on a dynamometer. Test results are shown below.





ORDERING PROCEDURE
FROM SMALL PARTS CATALOG

1. To complete your device, you may need parts and components in addition to those provided in your kit. **U.S. FIRST has made arrangements with SMALL PARTS, Inc.** to provide you with component parts and materials available from their catalog 14. Each team has a $300 limit for these component parts and material.

2. At the January 8 workshop, your Team will be given a **Team number** for use when placing an order with SMALL PARTS, Inc.

3. When placing an order, please have the following information available:
   a. Team Authorization Number and name of the TEAM MEMBER ordering
   b. SPI part number
   c. Quantity required (please use standard catalog quantities)
   d. Complete shipping address including the person receiving the shipment.
   e. **Reach** telephone number or FAX number.

4. For same day shipment place your order before 3:00 pm EST:

a. Telephone	**(305) 557-8222**
b. FAX	**1-800-423-9009**

5. Upon receipt of your order, Small Parts will immediately advise you, by fax or phone, if any part is temporarily out of stock, when it will be available and request your advice on whether you wish to change your order.

6. Small Parts, Inc. and U.S. FIRST will share the cost of 2nd day delivery (UPS Blue Label). If your team requires overnight delivery (UPS Red Label) the entire shipping charge will be billed to you.

7. It would be appreciated if you would order all your parts in one order to minimize shipping charges. For the duration of the competition only two orders per team, up to the **$300** cumulative limit, will be accepted.

8. Purchases over the $300 limit, such as spare components, can be made at team's cost, however only $300 worth of parts are allowed to be part of the machine.

SHIPPING ADDRESS OF THE COMPETITION SITE

Nashua Bishop Guertin High School
194 Lund Rd.
Nashua, NH 03060

TECHNICAL AND JUDICIAL HOTLINE

If at any point in the design process you run into technical difficulties or need clarification of any of the rules, you may reach:

Anjay Skoskiewicz @ 603-669-5139; email @ anjay@athena.mit.edu
or Kevin Grant @ 603-669-5139

to answer your questions.

In addition, U.S. FIRST has established a bulletin board at 603-666-3979 as a means of encouraging information exchange between individual teams and the organizers. Items such as travel arrangements, rule clarifications or technical questions and answers will be posted there.

If any rule updates are required, they will be faxed to every team and posted on the bulletin board.

Chairman's Award

The Chairman's Award is presented to the team which is judged to have created the best partnership effort between a school and university or between a school and business. Judging criteria include the level of student participation, teamwork, sportsmanship, team spirit, creativity of effort, and overall cooperation and effectiveness between school and partner. This prestigious award is judged on materials submitted to U.S. FIRST prior to the national championship. Documentation may consist of any combination of video footage (30 minute maximum), photos or written chronicle. This material need not be professionally produced, but should clearly convey the effort made to develop a successful school/university or school/business partnership. ALL DOCUMENTATION MUST BE IN U.S. FIRST OFFICES NOT LATER THAN 5:00 PM ON FRIDAY, FEBRUARY 19. The Chairman's Award is presented at the end of play on Saturday. The winning team will carry home a high-tech, custom crafted Dean Kamen Clock, which the *New York Times* called "Art That Ticks."

Judges' Awards

On Friday evening, February 26, U.S. FIRST will host an awards celebration. At this event, a special judging panel will present the following awards:

- Most Creative Design
- Best Offensive Round
- Outstanding Defense
- Best Play of the Day
- Best Team Spirit Display
- Best Sportsmanship
- Number One Seed

Past judges of the U.S. FIRST Competition include Dr. D. Allan Bromley, Science Advisor to President Bush; Burt Rutan, designer of the Voyager Aircraft; and Terrence Lynch, Northeast Editor of Design News Magazine. We look forward to seeing you at what promises to be a great celebration!

Hardware List

In addition to the materials provided in the kit or through the Small Parts Catalog, you may purchase and use in your machine the following additional material (a 2" sample of each is included as part of the kit):

PVC pipe, ø1/2" x 10'
PVC pipe, ø3/4" x 10'
PVC pipe, ø1" x 10'
PVC pipe, ø1 1/2" x 10'
Electrical conduit pipe, ø1/2" x 10'
Electrical conduit pipe, ø3/4" x 10'
Electrical conduit pipe, ø1" x 10'
Copper water pipe, ø1/2" x 10'
Wooden broom stick, ø1" x 5'
Nylon braided rope, ø5/32" x 10'
Clothesline, ø1/4" x 10'
2 conductor wire, 18 gage, 10'
Chain, 10'
Bead chain, ø3/16 x 10'
Hose clamps, ten (10)
steel cable, ø1/8" x 10'

You may also purchase:

Plywood, 1/4" x 4' x 8' (12"x12" piece included in kit)
Lexan (or Plexiglas), 3/8" x 4' x 4' (6"x9" piece included in kit)
Lexan (or Plexiglas), 1/4" x 4' x 4' (no sample)
One screen and storm door shock absorbing door closer (no sample)

All of the above materials can be found in a local hardware store. If you have problems obtaining any of the items, let us know which of the parts and in what quantity you need and we will try to supply you with them. You may purchase standard pipe couplings for the use on the PVC, copper and electrical conduit pipes. You may use as many couplings as you need, but you are restricted to only 45°, 90° elbows, T's and end caps. The couplings have to be a standard off-the shelf item.

KIT COMPONENTS CHECK LIST

- [ ] 1 Digital printer (do not throw away)
- [ ] 1 Aluminum sheet, 1/16" x 12" x 18"
- [ ] 1 Aluminum sheet, 1/8" x 10" x 12"
- [ ] 1 High Density PE, 1" x 8" x 12"
- [ ] 1 ABS Sheet, 1/4" x 14" x 18"
- [ ] 1 Lexan sheet, 1/16" x 12" x 12"
- [ ] 1 Particle board, 1/2" x 12" x 18"
- [ ] 1 Plywood, 1/4" x 12" x 12"
- [ ] 1 Semicurcular black fiber sheet
- [ ] 1 Hardware mesh, 1/4 12" x 18"
- [ ] 1 Structural foam, 1" x 8 3/4" x 22"
- [ ] 1 Carpet sample, 12"x12"
- [ ] 1 Teflon, 1"x1 1/2"x2"
- [ ] 2 Wood strapping, 1" x 3" x 18"
- [ ] 1 Wood strapping, 1" x 4" x 18"
- [ ] 1 2" Floor flange
- [ ] 1 PVC pipe, ø3/4" x 18"
- [ ] 1 PVC pipe, ø1" x 18"
- [ ] 1 PVC pipe, ø2" x 22 "
- [ ] 1 Aluminum rod, ø1/2" x 12"
- [ ] 1 Aluminum rod, ø1/2" x 24"
- [ ] 2 Thomson 60 Case hardened, ø1/4"x24"
- [ ] 2 Drill rod, ø1/4" x 18"
- [ ] 3 Drill rod, ø3/16" x 18"
- [ ] 6 Brazing rod, ø1/16" x 18"
- [ ] 4 Brazing rod, ø1/8" x 18"
- [ ] 1 Threaded rod 1/4-20 x 24"
- [ ] 2 Wood dowel, ø1/4" x 24"
- [ ] 1 Fiberglass cloth, 1/16" x 36" x 36"
- [ ] 1 5 minute epoxy
- [ ] 1 Panduit terminals, box
- [ ] 10 Panduit ties
- [ ] 1 Panduit marker book
- [ ] 2 Tubing, ø3/16" x 48"
- [ ] 1 Plastic wire wrap, ø1/4" x 30"
- [ ] 1 Cord, 2 conductor, 5'
- [ ] 1 Velcro Strip, male/female, 1" x 24"
- [ ] 2 Steel keystock 4mm x 4mm
- [ ] 2 Flexible shaft for Delco motor
- [ ] 2 Molded flexible shaft end
- [ ] 1 Corner Mate
- [ ] 1 String, thin, 20'
- [ ] 1 String, medium, 20'
- [ ] 1 Twine, 20'
- [ ] 2 Rubber straps
- [ ] 1 Clear plastic strip, 1/16" x 6" x 24"
- [ ] 1 PVC sheet, 1/16" x 14" x 22"
- [ ] 1 Lexan sheet, 3/8"x6"x9"
- [ ] 1 Rubber strip, 6" x 36"
- [ ] 1 13" rubber ball (deflated)
- [ ] 1 6" rubber ball (deflated)
- [ ] 1 Small Parts Inc. Catalog
- [ ] 1 Tennis ball
- [ ] 1 Pole clamp

Parts in plastic bag

- [ ] 4 Nuts, 1/4-20
- [ ] 8 Nuts, 6-32
- [ ] 8 Socket head cap screws, 6-32 x 1/2"
- [ ] 4 Cotter pins
- [ ] 1 Inflation needle
- [ ] 10 Washers, 1/4"
- [ ] 1 Hex wrench, #6
- [ ] 1 Torx Wrench, T-10
- [ ] 5 Rubber bands, small
- [ ] 5 Rubber bands, large
- [ ] 2 Hinges with clasps
- [ ] 2 Compression spring
- [ ] 2 Tension spring
- [ ] 2 Constant force spring
- [ ] 4 Button snap assembly
- [ ] 2 Toggle clamp
- [ ] 2 Thomson linear bearing, ø1/4"

- [ ] 2 Delco motor
- [ ] 2 Delco motor connector
- [ ] 2 ECM motor
- [ ] 1 Portescap motor, 28P11
- [ ] 1 Hardware sample bag

Non consumable items

- [ ] 1 Joystick
- [ ] 1 Switch box harness
- [ ] 1 Rubbermaid container

To Be Sent Seperately

- [ ] 1 battery holder (consumable)
- [ ] 1 Milwaukee battery charger
- [ ] 2 Milwaukee rechargeable battery
- [ ] 1 Power supply
- [ ] 1 Motorola micro controller
- [ ] 1 Wiring harness
- [ ] 1 Termiflex keypad controller
- [ ] 2 R-Net unit
- [ ] 2 R-Net antenea
- [ ] 1 R-Net ribbon cable

..... has received all components checked off above.
Team name and number

....
Signature Date

Check each item off and return to U.S. FIRST upon kit receival