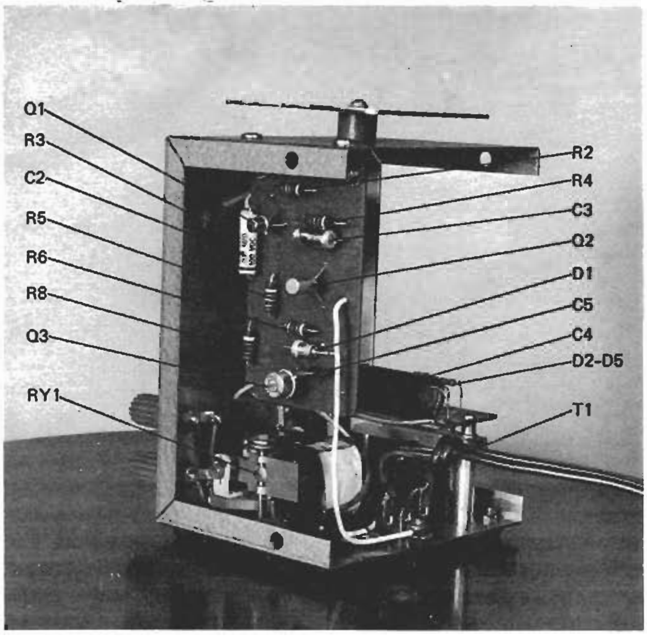


REAR VIEW shows as many parts as possible.

Sensitive Touch Switch

Made for a school demonstration project, this instrument can have a variety of uses.

by FRANK H. TOOKER

THIS SIMPLE, ELECTRONIC TOUCH-plate switch uses no mechanical latching and no ratchet relay. Yet touching its sensitive plate once with the fingertip turns it on, and touching the same plate again, a half-minute or so later, turns it off. If both hands are busy, touch it with your arm, your elbow, or even the tip of your nose! Even Rover can operate it that way!

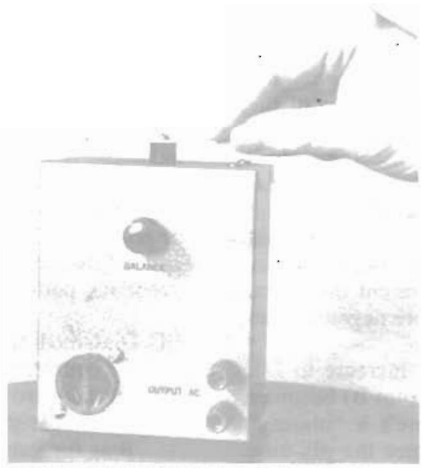
The device—shown in the photo and the schematic diagram, Fig. 1—em-ploys a silicon controlled switch (SCS) i unique circuit which, when the SCS is off, makes it ready to turn on; and when it is on, makes it ready to turn off. The sensitivity in one direction may be made equal to that in the other with control R3, labeled BALANCE in the instrument shown in the photo. It can be used to apply line voltage to a receptacle and binding posts, as in this circuit, or—as in Fig. 2—as a simple switch to operate any external device.

How it works

The silicon controlled switch has a reputation of being easy to turn on, but a so-and-so to turn off. That reputation is undeserved. In this circuit, the SCS turns off as sensitively as it turns on. And the mere touch of a fingertip flips it either way.

In the schematic, Q1 is the SCS. When it is off (nonconducting), current flowing through cathode resistor R4 is low. So low that for all practical purposes, it may be considered zero. The voltage drop across cathode capacitor C3 is, therefore, also practically zero. Under this condition, a small positive voltage at the cathode gate (GC) of the SCS turns it on. A negative potential h no effect.

When the SCS is on, it conducts heavily. Current flows through cathode resistor R4 and a voltage drop develops across capacitor C3. This voltage makes the cathode (C) positive with respect to the cathode gate (GC). As far as the SCS itself is concerned, this is equivalent to making the cathode gate negative with respect to the cathode. It is therefore a move in the direction of turning the SCS off. The cathode gate is otherwise held at an approximately fixed potential by the voltage drop across anode resistor R5 and the voltage divider made up of resistances R1, R2, and R3. For best stability, capacitor C3 should be a tantulum electrolytic.



TOUCH-PLATE SWITCH as demonstrator.

Note especially that resistor R1 connects to the anode (A) of Q1 rather than to a point of full power-supply voltage. As a result of this connection, voltage divider current drops abruptly when the SCS turns on, and rises abruptly when it turns off. This current swing moves the cathode-gate potential in a direction that assists in turning the SCS on and off.

With the component values given in Fig. 1 and the parts list, the voltage developed across capacitor C3, when the SCS is on, reduces the regenerative current flow within the SCS to a very low value; enough to keep it just turned on and no more. A small *negative* voltage at the cathode gate will turn it off. A positive one has no effect.

When the SCS turns off, capacitor C3 discharges through resistor R4, and the circuit thereby makes itself ready to turn on again. Because the circuit is sensitive, yet must be stable to be practical, approximately one-half minute is needed for it to ready itself to turn on when it has just been turned off, or to turn off when it has just been turned on.

Stability is assisted by a characteristic called hysteresis, which takes place within the semiconductor itself: When the SCS is turned on, current flowing through it raises its internal temperature slightly. This increase in temperature increases its sensitivity in the direction that helps to keep it turned on. Similarly, when it is turned off, the decrease in internal temperature helps to keep it turned off. Although this change in internal temperature is small, it is in the right direction to be useful.

The turn-on and turn-off signal is coupled from the touch-plate to the cathode-gate electrode of the SCS via capacitor C1. The signal itself is actually the minute ac potential developed on the human body (and everything else that is an electrical conductor) due to capacitance coupling with the house wiring. Small though it is, a positive-going excursion of this ac signal is quite enough to turn the SCS on when it is off, and a negative-going excursion enough to turn it off when it is on.

In either case, capacitor C3 maintains the cathode potential long enough to keep the SCS from fluctuating rapidly between its on-state and its off-state. (If the fingertip is held on the touch-plate continuously, the circuit can

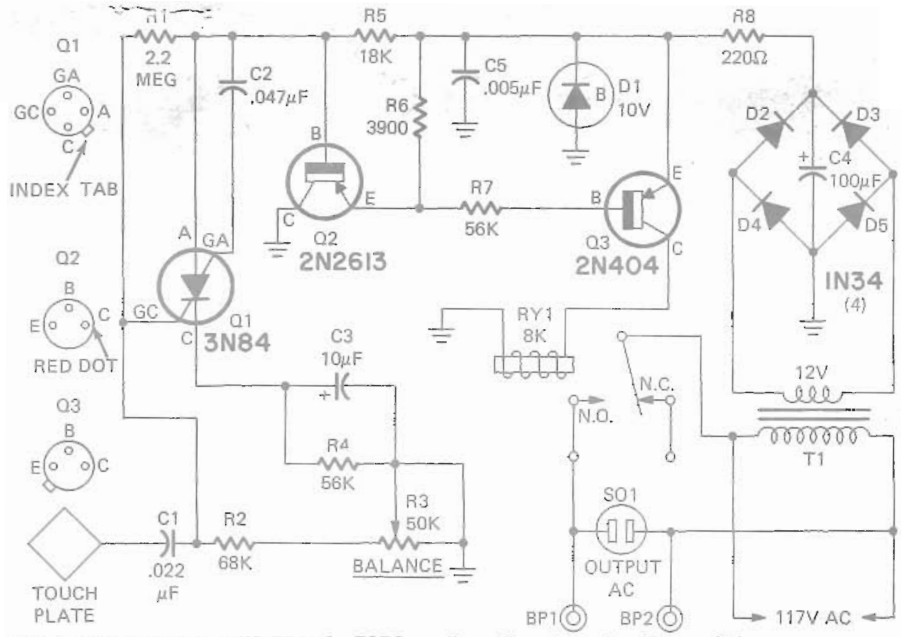
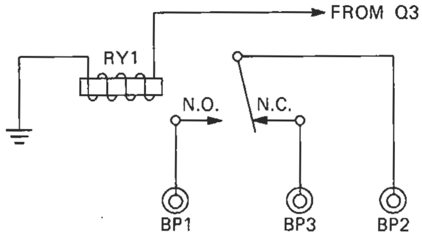


FIG. 1—ONE SCS AND TWO TRANSISTORS are the active elements of this switch.

PARTS LIST

NOTE: All resistors are ½-watt, 2% tolerance, IRC type RG20, unless otherwise specified.

R1—2.2-megohm, ½-watt, 5%
R2—68,000 ohms
R3—50,000 ohms pot, linear taper (Ohmite CU5031 or equal)
R4, R7—56,000 ohms
R5—18,000 ohms
R6—3900 ohms
R8—220 ohms in prototype (see text)
BP1, BP2—5-way binding posts
C1—.022 µF, 100 Vdc, Mylar
C2—.047 µF, 100 Vdc, Mylar
C3—10 µF, 6 Vdc, electrolytic
C4—100 µF, 25 Vdc, electrolytic
C5—.005 µF, 50 Vdc, ceramic
D1—Zener diode, 10 volts, ½ watt
D2, D3, D4, D5—Type 1N34 or any general-purpose diode
RY1—Sensitive relay, 8,000-ohm coil (Sigma 4F-8000-S/SIL or equal)
Q1—Type 3N84 silicon-controlled-switch (G-E)
Q2—Type 2N2613 transistor (RCA)
Q3—Type 2N404 transistor (G-E, RCA, T1)
SO1—117Vac receptacle
T1—Miniature filament transformer, 12 volts at 10 mA (or more) secondary



TOUCH-PLATE

FIG. 2—WITH AC DISCONNECTED, the switch can be modified to make a simple spst, or—with another binding post—a dpst switch.

turn on and turn off at a very slow repetition rate.)

When the SCS is on, its output causes a voltage drop across resistor R5. This voltage is applied direct to the base of transistor Q2, which operates as an emitter-follower or current amplifier. It functions as a buffer between the SCS and relay-driver transistor Q3. Output from Q2, taken at the emitter, is fed to the base of Q3 via resistor R7, Q3's base-current limiter. The resulting voltage change at the base of Q3 is sufficient to drive that transistor from cutoff to saturation. Thus relay RY1 is pulled in sharply when the SCS turns on, and drops out abruptly when it turns off.

Adjustments

Balance control R3 permits adjusting the circuit so that it turns on and turns off with equal ease. It compensates for variations due to component tolerances, including those of the SCS. When the instrument is first turned on, set control R3 to where its entire resistance is in the circuit. The SCS will then turn on of its own accord when power is applied to the circuit, and should remain on. Decrease the setting of R3 slowly until the relay armature just drops out, then advance the setting about 5 degrees. Touching the touch-plate now should cause the relay to pull in. Touching it again, a half-minute or so later, should cause it to drop out.

If it is found that the circuit turns on easily, but turns off by itself a few minutes later, adjusts control R3 to put a little more resistance into the circuit. If the setup has a tendency to turn on by itself, adjust R3 in the opposite direction—to *decrease* the resistance in the circuit.

With control R3 properly set, the circuit should be able to maintain its on or off state indefinitely. Large transients—voltage spikes—on the power line have a tendency to trigger it, however. Capacitor C2—connected between the anode and anode-gate (GA) of the SCS—and capacitor C5—across the power supply—reduce this tendency significantly. Thus such moderate transients as those occasioned by switching a lamp on and off, or by an electric refrigerator, or even the cycling of an oil-burner furnace with electric ignition, do not affect the touch-plate switch at all. If a particular setup seems to be bothered by such transients, reversing the plug in the wall outlet that powers the unit will usually eliminate the difficulty. In an unusually well shielded location, the unit may operate sluggishly, due to weak control signals in the area near the touch plate.

Before assembling it into the circuit, adjust the relay for a pull-in current of 1.0 milliampere dc, and a drop-out current of about 0.5 milliampere. This assures positive operation, as the actual pull-in current is somewhat higher, and the drop-out current lower, than the values just specified.

The touch-plate circuit is operated from the power line by miniature power transformer T1, a full-wave bridge rectifier, and filter capacitor C4. The voltage is regulated by Zener diode D1. Resistor R8 should be chosen to limit the current through the diode to 10 mA. In the prototype, the value of this resistor is 220 ohms.

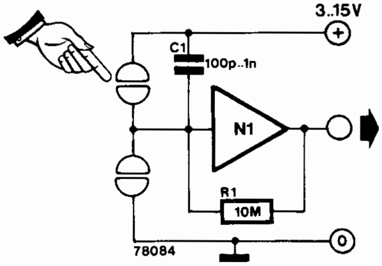
The unit shown in the photos was assembled for purely practical purposes—actually a demonstration device in a school science class. It occupies a 5 x 4 x 3-inch gray-Hammertone aluminum box. The touch-plate, located about ⅜-inch above the top of the box, is a 2½-inch square stainless steel plate. Stainless steel was chosen because it stays bright, does not corrode easily. Corrosion would act as insulation, and interfere with proper operation. For the same reason, the touch-plate must be well insulated from the metal cabinet top, and must not be coated with paint, lacquer, or other insulating substance.

For living-room applications, this touch-plate circuit can occupy a plastic box or a polished wood enclosure, with a small, bright-metal ornament serving as the touch-plate. The BALANCE control can then be a screwdriver adjustment located underneath, out of sight. This control does not require frequent resetting, except at first, while the electrolytic capacitors are forming. Connections to the lamp, radio, phonograph, or other device being controlled, can be a receptacle on the back of the enclosure or a terminal plate using binder-head screws and located underneath.

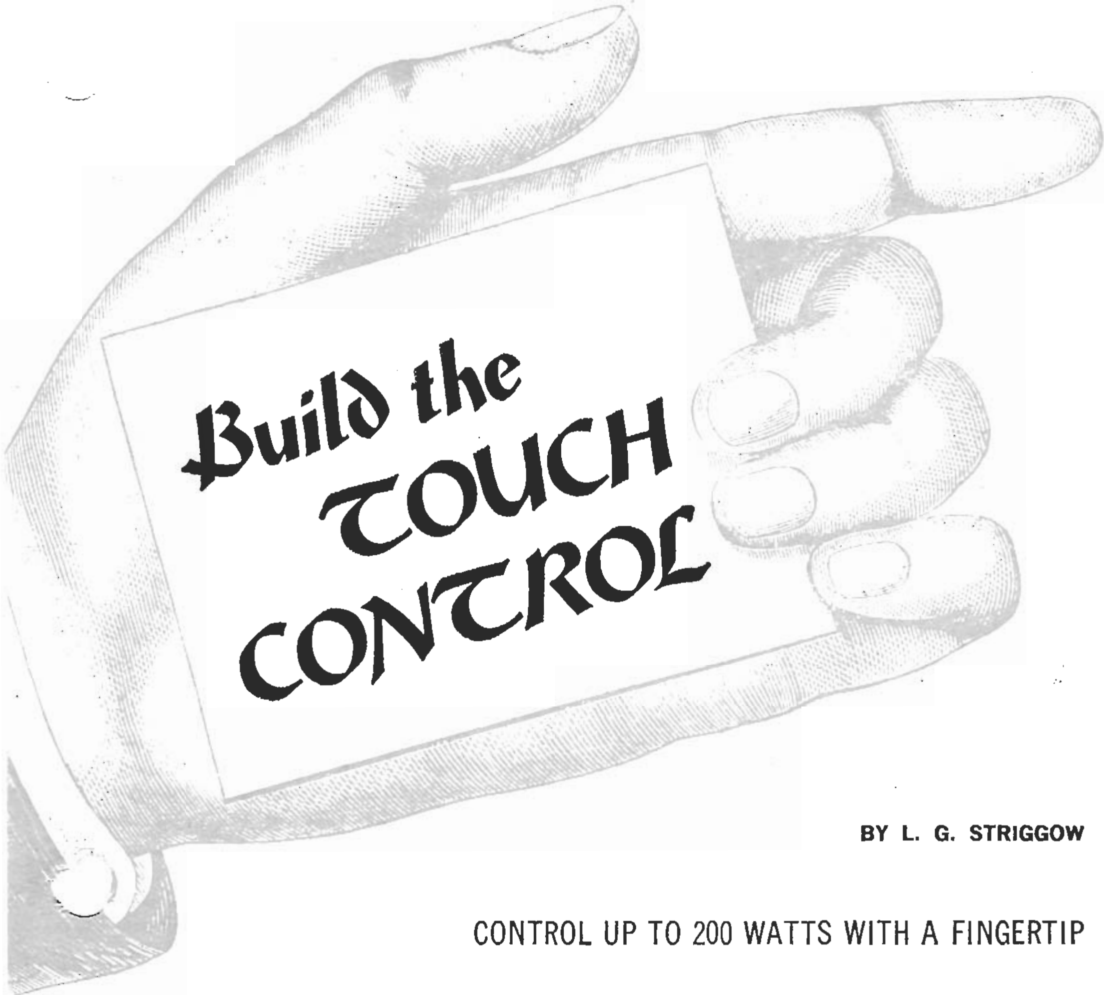
In any assembly of the circuit, make the touch-plate no larger than necessary, and the lead to it short. The larger the plate, or the longer the lead, the more it has a tendency to pick up a control signal of its own. If this signal becomes large, the circuit will operate erratically. The relay specified in the parts list has the frame "hot" to the moving contact. So insulate the relay frame from the metal cabinet. **R-E**

super-simple touch switch 14

Although there is a plethora of designs for touch switches, it is always a challenge to come up with a design that is simpler than previous versions. While most latching touch switches use a pair of NAND gates connected as a flip-flop, this circuit uses only one non-inverting CMOS buffer, one capacitor and a resistor. When the input of N1 is taken low by bridging the lower pair of touch contacts with a finger, the output of N1 goes low. When the contacts are released the input of N1 is held low by the output via R1, so the output remains low indefinitely. When the upper pair of contacts is bridged the input of N1 is taken high, so the output goes high. When the contacts are released the input is still held high via R1, so the output remains high.



N1 = 1/6 4050



Build the TOUCH CONTROL

BY L. G. STRIGGOW

CONTROL UP TO 200 WATTS WITH A FINGERTIP

ELECTRONICS experimenters are always looking for new ways to control the light fixtures in their homes. Here's the latest wrinkle—a light switch that turns on and off with just a touch. You may have seen this type of switch in the call buttons on some new elevator controls. It doesn't provide any dimming control, but the convenience of being able to turn the lights on or off with the touch of a finger, or elbow if your hands are full, is a real plus.

Construction. The circuit for the touch control is shown in Fig. 1. Although any type of construction can be used, the author built his on a small PC board whose foil pattern is shown actual-size in Fig. 2. Note that, instead of etching away copper to produce a network of interconnecting leads, in this case you only etch away relatively thin isolation lines between the copper segments. Once the board is made, assemble the components as shown in Fig. 3.

In this assembly, the SCR's and capacitors are inserted conventionally while the resistors and diodes are mounted vertically. To install the two transistors and the silicon unilateral switch, bend the leads over and mount the units upside down on the board. Use fine solder and a low-wattage soldering iron. Make sure that there are no solder bridges across the isolation lines on the board.

Caution. Because full line voltage is present at various points in the circuit, once the PC board has been built and checked and connections have been made to it, it is suggested that the entire assembly be encapsulated using any com-

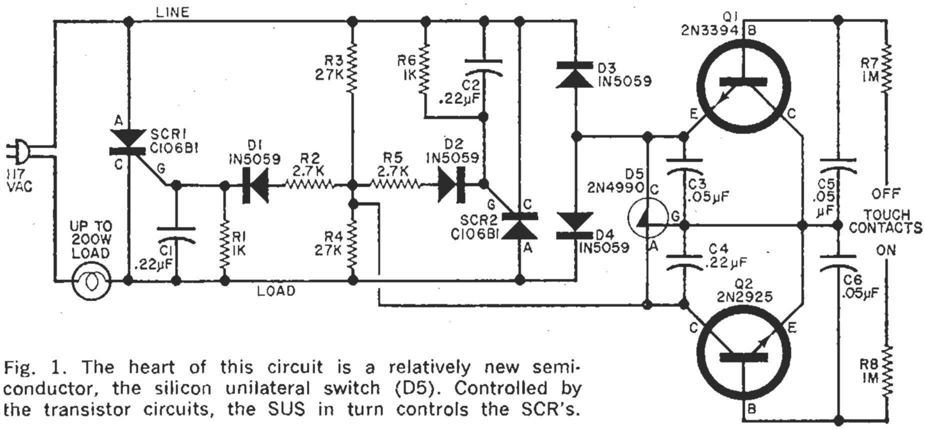


Fig. 1. The heart of this circuit is a relatively new semiconductor, the silicon unilateral switch (D5). Controlled by the transistor circuits, the SUS in turn controls the SCR's.

PARTS LIST

C1, C2, C4—0.22-µF, low-voltage capacitor
C3, C5, C6—0.05-µF, low-voltage capacitor
D1-D4—1N5059 diode
D5—Silicon unilateral switch (GE 2N4990)
R1, R6—1000-ohm, ¼-watt resistor
R2, R5—2700-ohm, ¼-watt resistor
R3, R4—27,000-ohm, ¼-watt resistor
R7, R8—1-megohm resistor
SCR1, SCR2—Silicon controlled rectifier (GE C106-B1)
Q1—2N3394 transistor
Q2—2N2925 transistor
Misc.—One-megohm resistor (optional, see text), line cord, metal for touch contacts, insulated wire.

mercial potting compound. An alternate is to give the complete board several coats of nail polish, preferably transparent, allowing each coat to dry thoroughly before applying the next. To avoid shock, take care not to damage this insulation when handling the board.

Operation. Connect a lamp of 200 watts or less to the load terminal of the board, then connect the other side of the lamp and the line terminal of the board to a source of commercial 117-volt a.c. power. Placing a finger tip on the "touch on" area should make the lamp go on; contacting the "touch off" area should make it go out. A pair of small metal plates can be connected to these terminals, using insulated wire as the connectors, to act as the actual touch plates. If the lamp should only flicker when the "touch on" terminal is contacted, reverse the power-line plug.

If you want to extend the touch plates for some distance, connect a one-megohm resistor to the line terminal and locate the other end of the resistor (by way of an insulated connecting lead) between the two touch plates. Simultaneously touching both the end of the one-megohm resistor and either of the touch plates

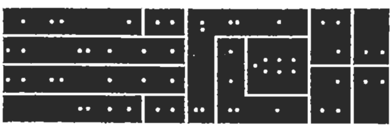
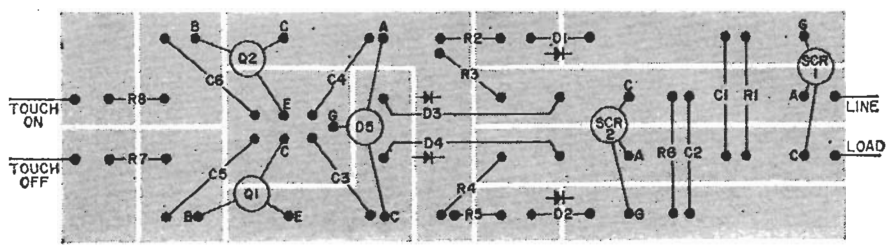
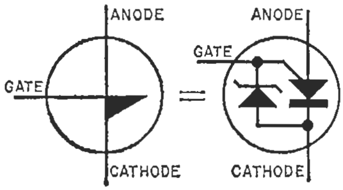


Fig. 2. Actual-size PC board is very small so use care when making it. Unlike conventional boards, this board uses area contact rather than a pattern.

Fig. 3. The components will be tightly packed (see photo at right), so mounting is rather unorthodox. Note that transistors and D5 are "upside down."





HOW IT WORKS

Operation of the touch control circuit depends on *D5*, a silicon unilateral switch (SUS). This semiconductor is essentially a miniature SCR with an anode gate (instead of the usual cathode gate) and a built-in low-voltage avalanche diode between the gate and the cathode. The SUS switches on when its gate is raised to a voltage level in excess of that required to cause the avalanche diode to saturate. When the avalanche diode is forced out of conduction, the SUS cuts off.

When power is applied, transistor *Q1*, across the gate and cathode of *D5*, automatically brings *D5* into conduction. This applies a negative voltage to the gates of the SCR's cutting them off and removing power from the load. When contact is made to the "turn on" terminal, *Q2* conducts to turn *D5* off. This automatically allows both SCR's to turn on, on the next positive-going a.c. alternation, thus providing power to the load. Contacting the "turn off" terminal causes the circuit to revert to its original condition, thus removing power from the load the next time that the a.c. line alternation goes to zero. The gating voltage for both transistors comes from the a.c. field present in the human body when the person is in the presence of commercial a.c. power lines.

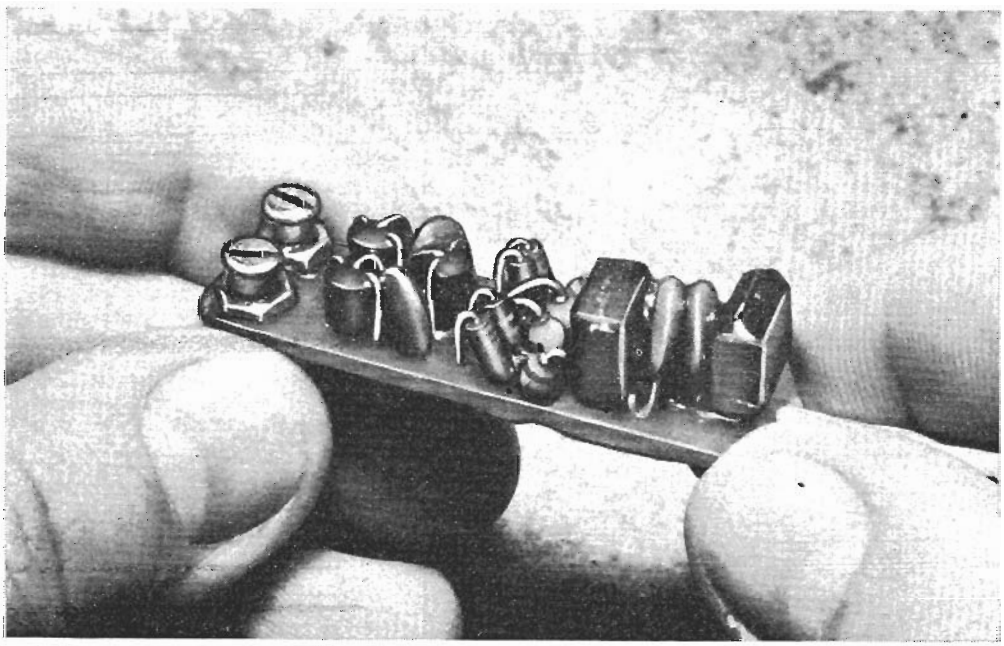
The gates of the SCR's are connected to the power supply (at the junction of *D3* and *D4*) through *D5*. Since the SUS can only turn off at the zero point of the a.c. waveform, the SCR's are turned on only at that point. This characteristic provides minimum distortion to the line current (such as that caused by the opening and closing of mechanical contacts) and therefore prevents electrical interference.

Resistors *R7* and *R8* prevent shock when either of the touch terminals is contacted.

will operate the circuits. One way of doing this is to make two isolated metal contact areas for the on-off operation, with a narrow metal strip for the resistor contact between them. In this way, contact can be made to turn the light either on or off.

Remember at all times that many portions of the circuit board are "hot" to ground and avoid getting a shock.

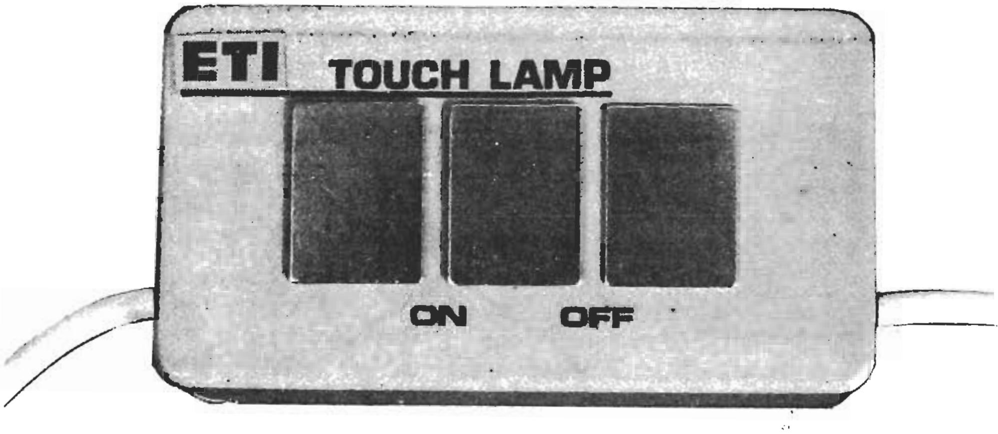
Besides a lamp, the touch control can be used to turn on any 117-volt a.c. resistive or inductive load whose power requirements are less than 200 watts. –30–



Once the board has been completed and tested, it should be encapsulated with an insulating material to prevent possibility of electrical shock. Only the two screws at left are exposed for external contacts.

Touch Lamp

Left in the dark? This project gives simple on/off touch control of your battery or AC powered bedside light.



IF YOU'RE TIRED of fumbling around in the dark in search of the lamp switch, and then fumbling around trying to actually operate the switch, our touch-operated bedside lamp is just what you need. It is a very simple and economic battery operated design which has a neglible stand-by current. The use of a touch switch makes the lamp extremely easy to operate even in the dark, since once you have found the touch contacts the unit virtually operates itself!

You can use this project to either turn a small 6V bulb on and off or alternatively to operate a relay (which can be used to switch a line-powered bulb on and off). The amount of light available from a 6V bulb, such as a flashlight bulb, is not very much, of course, but is adequate for its purpose and has the advantage of making a completely self-contained project with no trailing wires. If you choose to build in a relay to the project (as in our prototype) then AC input and output leads will be necessary.

A point worthy of note is that, wired for line control purposes, the project will not only turn a lamp on and off, but in fact most line powered equipment. The project may find other uses, therfore, particularly as an aid for handicapped persons.

Construction

Build up the project using one of our standard sized (24 hole by 10 strip) pieces of Veroboard, carefully following the overlay details in Fig. 2. Make sure the transistors are inserted correctly.

Drill the case lid to fit the three touch contacts, which can be specially bought contacts, or simply three pan head bolts. Mount the contacts using soldertags (to provide connection points) and nuts.

You must now decide whether you want the project to operate a small bulb or a relay. If you choose the small bulb, then mount it in a holder fitted to the top of the case. Drill a hold near the holder to enable the two leads from the lamp to pass through to the interior of the case.

Some sort of shade can be placed over the lamp to give a neater finish and a more diffuse light. Some food containers and aerosol caps are made of a suitable thin white plastic material, and a little ingenuity must be used here.

Fit the battery and circuit board inside the case and wire up the project as in Fig. 3.

If you choose to operate a relay and thus control a separate AC powered lamp (such as a bedside or overhead lamp) then drill the sides of the case to fit rubber grommets. Push the two grommets into position — they will protect the cable from being damaged.

Fasten the relay to the bottom of the case (double-sided, self-adhesive pads are ideal for this purpose) and connect the project as shown in Fig. 4.

Use cable ties on the AC input and output leads to prevent them from being accidentally pulled out.

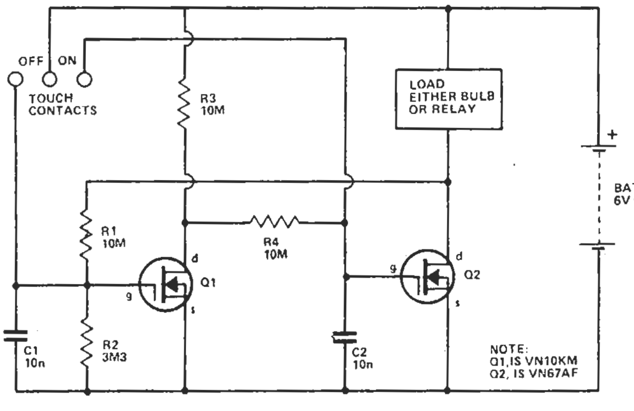


Fig. 1 Circuit of the ETI Touch Lamp.

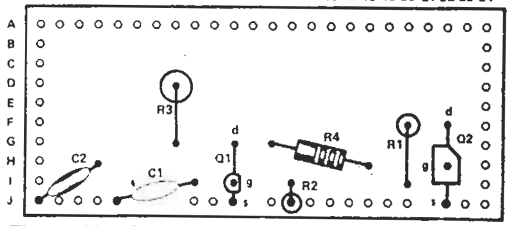
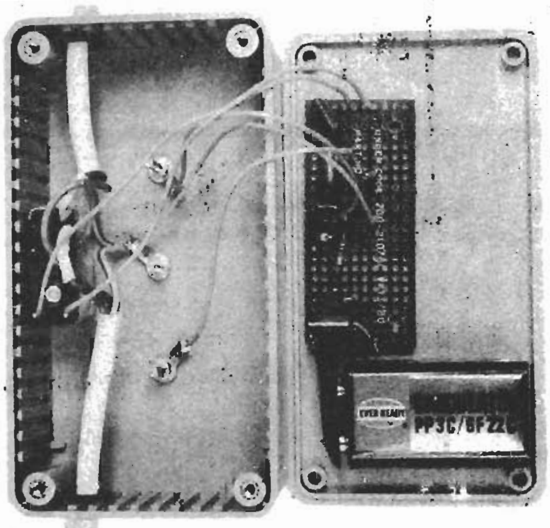


Fig. 2 Veroboard layout of the project. Note that there are no track breaks to make underneath the circuit board.



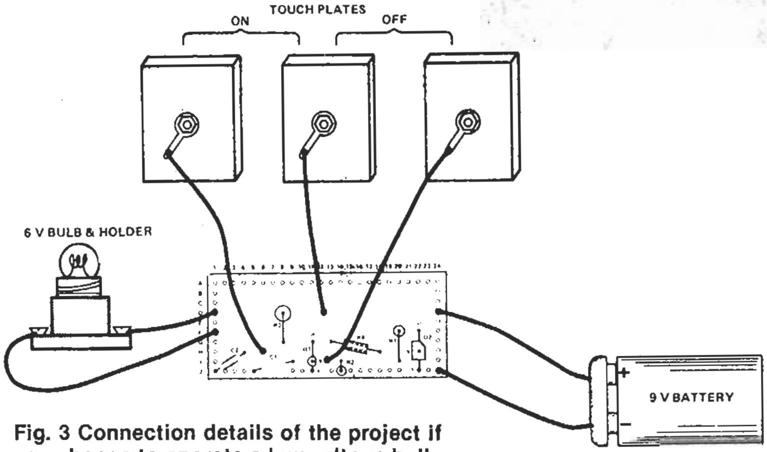


Fig. 3 Connection details of the project if you choose to operate a low voltage bulb.

PARTS LIST

Resistors (All ¼ W, 5 or 10%)

R1	10M
R2	3M3

Capacitors

C1,2	10n polyester

Semiconductors

Q1	VN10KM VMOS transistor
Q2	VN67AF or VN66AF VMOS power transistor

Miscellaneous

Suitable plastic case
Veroboard, 24 hole x 10 strip
Touch contacts.
9V type battery clip

Either: Bulb holder and a 6V 100 mA bulb for AA-sized cells and a plastic holder

Or: 6-12V operated relay (100R coil, or greater)
9V battery

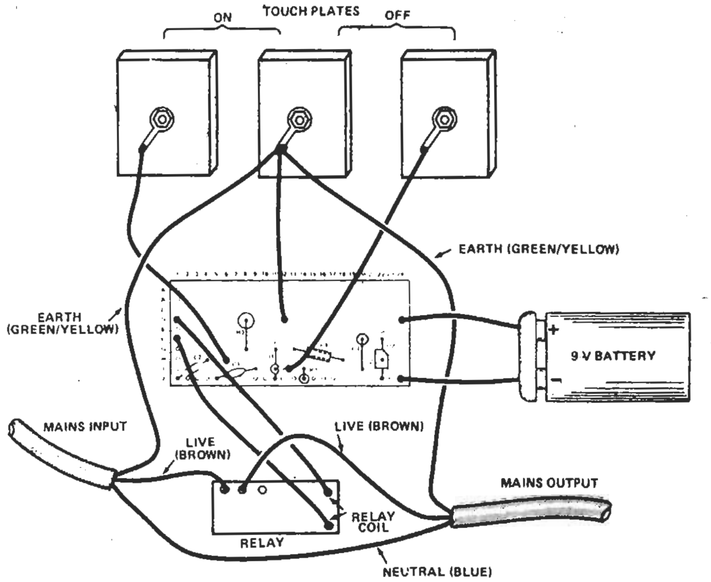
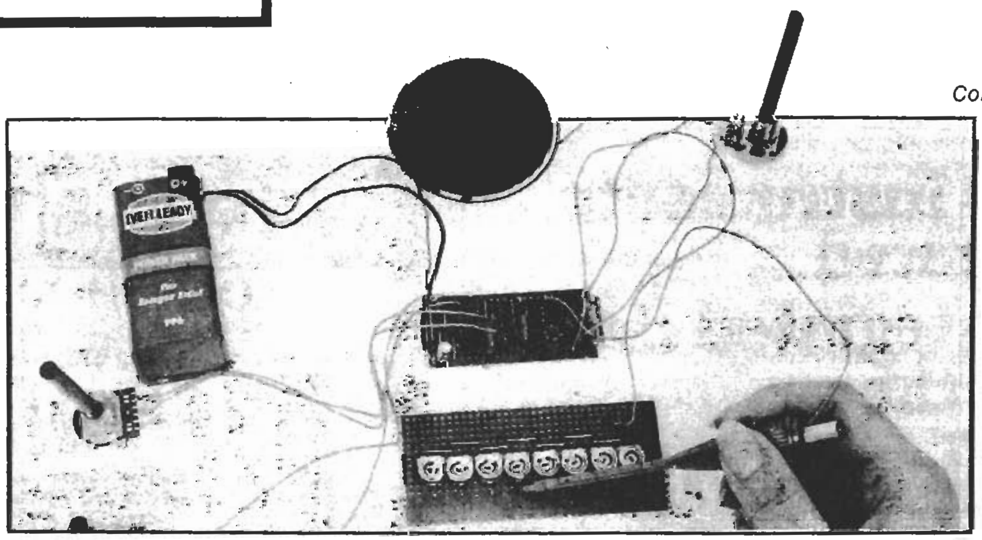
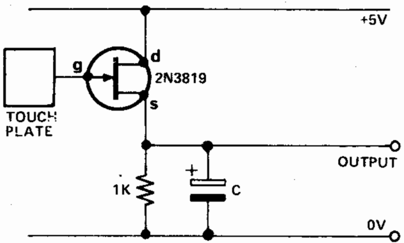


Fig. 4 Project connection details to control line powered equipment.

Continued on page 78





TOUCH-SWITCH FOR LOGIC

An n-channel field-effect transistor is the basis of this simple trigger. In its quiescent state the voltage at the output is about 3V. When the plate is briefly touched with a finger, the minute currents between the body and the plate alter the electric field at the gate of the transistor. The effect is to cause a drop in output voltage. It falls almost to zero and can be used to trigger a TTL flip-flop. This can be constructed in the usual way, using two NAND gates from a 7400 IC. If several triggering circuits are required, it is more convenient to use the 74118 sextuple bistable latch.

The value of the capacitor is not critical, but 10uF is convenient. The touch-plate can be an area of copper etched an a circuit-board, a square of aluminium foil, or simply a drawing-pin pressed into an insulating support.

SOLID STATE

(*Continued from page* 78)

Q2's base and causing a corresponding change in its collector current. This, in turn, controls *Q3*'s base bias. Transistors *Q2* and *Q3* together form a complementary d.c. amplifier. A conventional electromagnetic relay (*K1*) acts as *Q3*'s collector load, and as the control switch for an external device.

The active devices used in the project were selected from Motorola's popular HEP line. A 15-volt electrolytic capacitor is used for *C1*, while all resistors are half-watt units The relay should be a moderately sensitive type having a 12-volt coil, such as the Calectro type D1-967. The power source (*B1*) may be either a line-operated d.c. supply, a 12-volt lantern battery, or eight series-connected penlight or flashlight cells.

Well suited to either perf board or etched wiring construction, the touch switch can be assembled in just a few hours time. Although neither layout nor lead dress are overly critical, *Q1*'s gate connection leads should be kept as short and direct as possible. The touch plate can be any small piece of metal, with neither exact size nor shape important as far as circuit operation is concerned . . . use your imagination!

In practice, the relay serves to actuate an external electrical device whenever the touch plate is touched lightly by the user. The external device, operated by a separate power source, may be a safelight in a darkroom, a solenoid, a small motor, an electric light, or an alarm signal, depending on individual user needs. The relay's contacts are used as a simple switch to turn the external device "on" or "off," as needed.

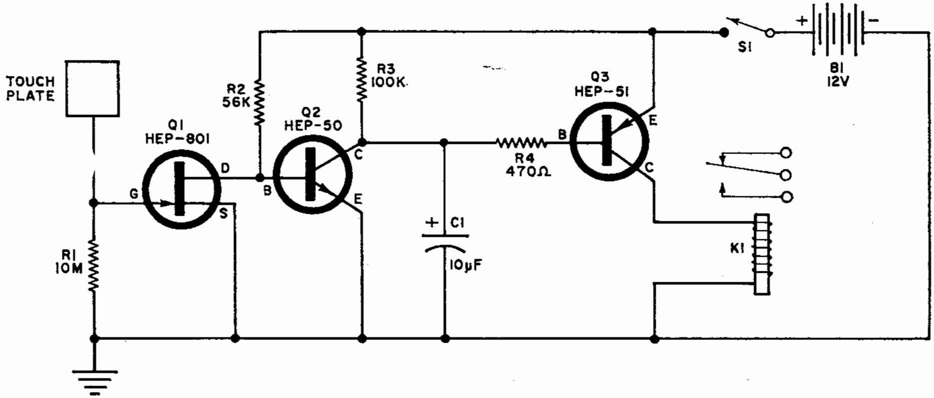
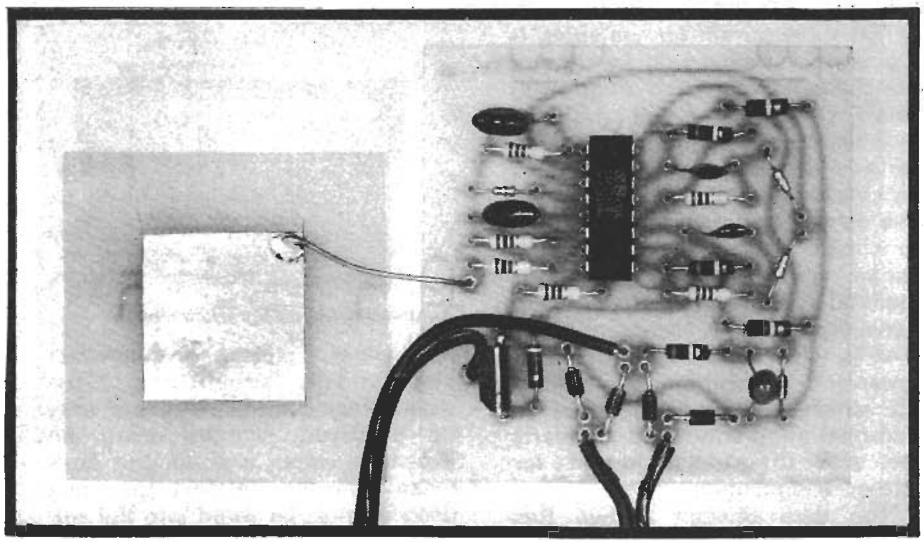


Fig. 3. A FET is used in the first stage of touch switch amplifier to achieve high input impedance.

etiproject 539



New 240V design offers toggle action and complete safety.

TOUCH SWITCH

TOUCH switches are fascinating devices and have been in use for many years in lift controls. The circuit used in lifts usually consists of a high-frequency oscillator which has a touch plate connected to the tuned circuit. When the plate is touched the additional capacitance introduced either detunes the oscillator thus changing the frequency, or couples the oscillation into the detector and switching circuitry. This approach, whilst effective, is very expensive and thus touch switches of this type are not widely used.

Most of the touch switches published in electronics magazines to date have required the sensing element actually to be touched — usually via a series resistor of about one megohm or higher. Such circuits rely on body resistance to activate the switch, and are therefore not safe for use in controlling devices operated on 240 Vac.

In the touch switch described in this project, it was specified that the action of the switch should be touch-on touch-off, and that no actual contact with the circuit be made (for safety reasons). These constraints led us to use a capacitive circuit. The touch plate is in effect a capacitor. When this plate is touched, the input of the first stage is capacitively referenced to earth, however as the supply rails to the control circuit are floating at rectified 240 Vac the 50 Hz waveform effectively appears at the input of the control circuit and initiates the switch action. The actual contact plate is a piece of single-sided printed-circuit board arranged so that the *non-copper side* is touched — the copper on the other side is connected to the control circuit. Thus a full 1.6 mm of insulation is always between the user and the circuitry at mains potential.

CONSTRUCTION

A touch switch may be constructed (and used) in many different ways. It may be mounted within the base of a lamp; fitted onto a conventional switch-plate to control overhead lights; or mounted in a piece of electronic equipment. It is however unlikely that the switch would be used as a separate unit and for that reason housing details have not been provided.

As stated above the touch plate is constructed from a piece of printed-circuit board as detailed in the drawing. The touch-plate need not be exactly as shown but can be any convenient shape or size. However make sure that the copper surface of the plate cannot touch any of the external metal surfaces and that it cannot be touched by the fingers. If the unit is to built into a lamp that has a plastic base a piece of aluminium foil may be glued to the *inner* surface of the base to act as the pickup plate.

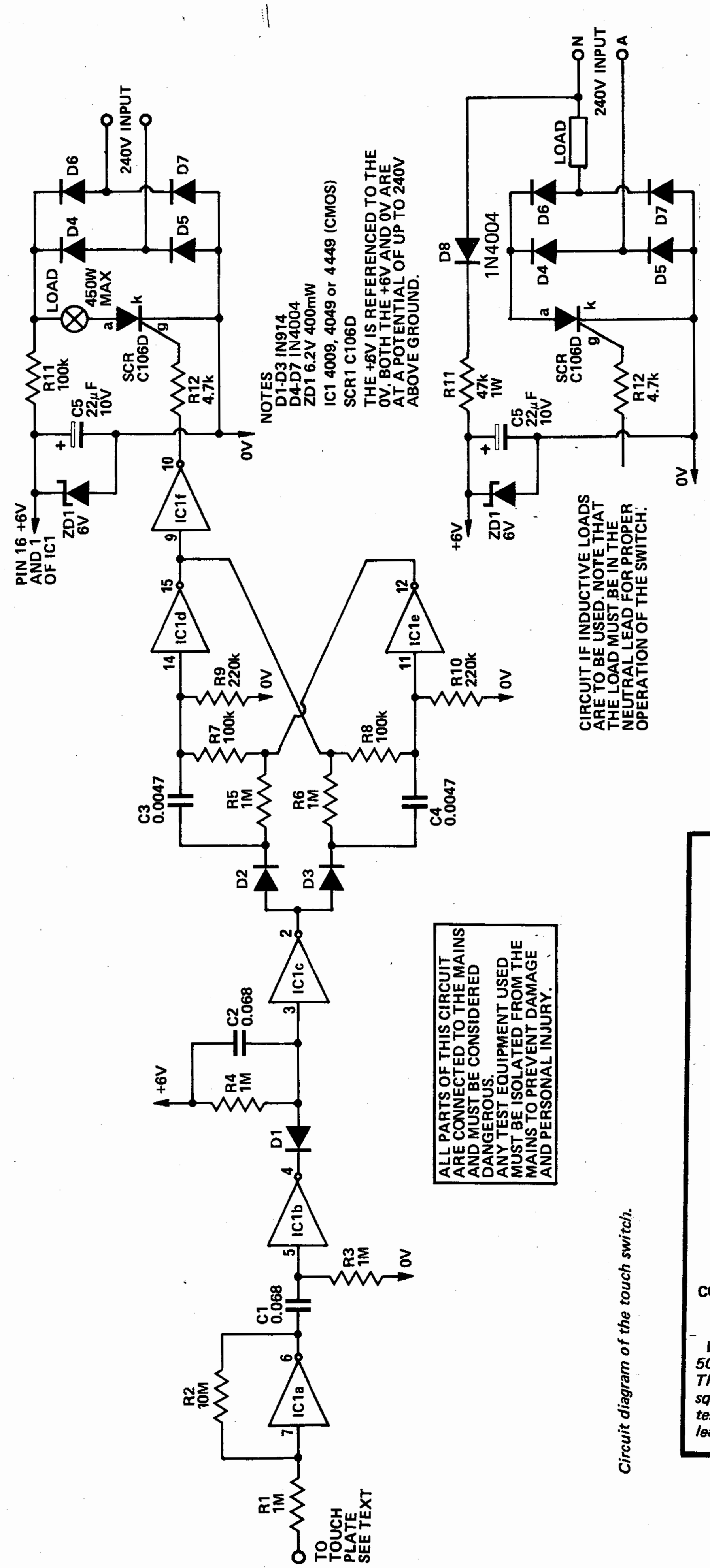
If the plate is too large or the lead connecting it to the circuit too long, stray capacitance to ground may be sufficient to prevent the switcn operating. If the lead is more than about 50 mm long shielded cable should be used (shield connected to '0' volts not to ground). If a large plate is used the gain of the first stage should be reduced by changing the value of R2. (Try 3.3 M first and if this is not effective try 1 M).

The circuit given in the main circuit diagram supplies the load with pulsating dc and is therefore suitable to drive resistive loads (such as light bulbs) only. If an inducive load must be supplied the slightly more complex alternative circuit (shown in the insert) must be used. In this circuit the load must be inserted in the neutral lead if the switch is to operate correctly. Thus it is essential to ensure that the active and neutral are connected correctly. To make the changes required for inductive loads it is necessary to instal a link between D4/D6 and the anode of the SCR. The resistor R11 is removed from the board and D8 and the new R11 are glued to the board with epoxy cement.

SPECIFICATION

Mode of Operation	touch-on, touch-off
Triggering Mode	capacitance
Power	450 VA resistive
	450 VA inductive*

*alternative circuit for load.



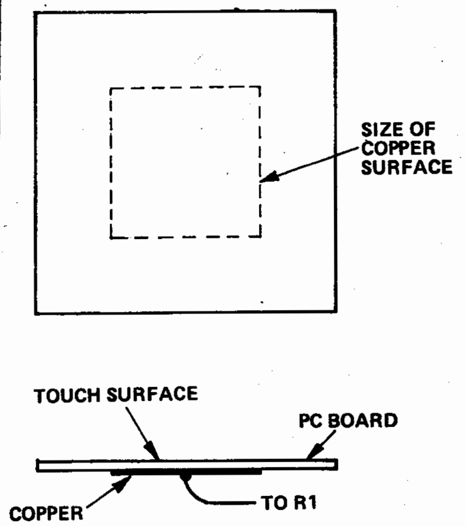
Circuit diagram of the touch switch.

PARTS LIST – ETI 539

R1,3,4,5,6	Resistor	1M	5% ½W
R2	"	10M	" "
R7,8,11	"	100k	" "
R9,10	"	220k	" "
R12	"	4.7k	" "
C1,2	Capacitor	0.068µF Polyester	
C3,4	"	0.0047µF Polyester	
C5	"	22µF 10V electro	
D1-D3	Diode	1N914 or similar	
D4-D7	"	EM404 or similar	
ZD1	Zener Diode	6.2V 400mW	
SCR	C106D		
PCB	ETI 539		

Case to suit

For inductive loads change R11 to 47k 1W add D8 — 1N4004



We constructed our touch plate from a 50 mm square piece of printed-circuit board. The board was etched to leave a 25 mm square section of copper in the centre. See text if different sized plate or long connecting lead is to be used.

HOW IT WORKS

POWER SUPPLY

The 240 Vac is rectified by diodes D4 to D7. The output of the diode bridge is then reduced, smoothed and regulated to 6 volts dc by R11, ZD1 and C5. The load is connected after the rectifier and has power switched to it via the silicon-controlled rectifier, SCR. Note particularly that the load is supplied with pulsating dc and therefore the type of load used with this circuit must be resistive, for example, an incandescent lamp. For inductive loads such as transformers etc, the load circuit must be modified as shown in the small diagram.

DETECTOR

The detector is formed by one section of a CMOS hex inverter, IC1a, in which the gain is set by the ratio of R2/R1. The touch plate is connected to the input of the detector and touching it effectively adds a capacitor to ground. However the '0' volt line (due to the diodes D4 to D7) when referenced to ground is effectively 50 Hz 240 volt rectified. The touch plate capacitance introduced therefore couples this waveform into the input of the detector and over-drives the amplifier so that the output is a 50 Hz squarewave. If the plate is not touched the capacitance is very much lower and hence the output of the amplifier is very much lower in level. The sensitivity may be altered by changing the value of R2 (lower value gives less sensitivity).

LEVEL SHIFTER

The output of IC1a is centred about 3 volts, and C1, R3 and IC1b are used to provide level shift such that the output of IC1b is normally high at +6 volts until the plate is touched. When the plate is touched the output of IC1b oscillates between +6V and 0 V at a 50 Hz rate. The hex-inverter IC has diodes internally which connect each input to ground. Thus these diodes prevent the inputs from being driven below –0.6 volts.

PULSE STRETCHER

The 50 Hz output from IC1b is not in a convenient form and must be converted into a signal which is only high and stays high whilst the plate is touched. This is performed by a pulse stretcher and inverter consisting of IC1c together with R4 and C2. The output of IC1c is normally low and goes high and stays high whilst ever the plate is touched.

FLIP FLOP

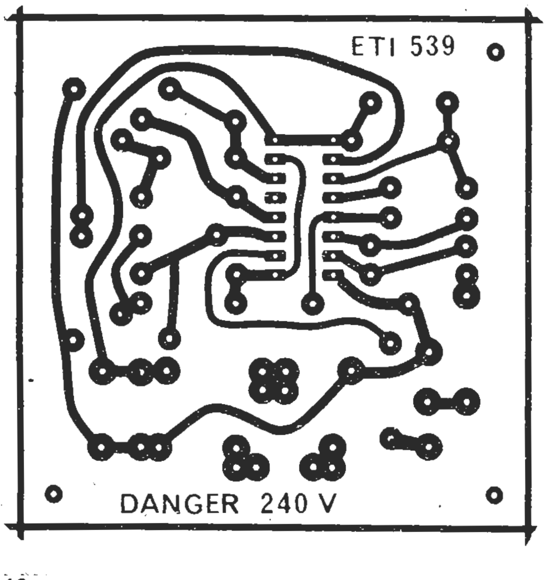
To meet our mode of operation requirement the circuit needs to be held on after the finger is removed from the plate and only switched off when the plate is touched a second time. Thus a toggle action is required and this is obtained by incorporating a flip flop formed by IC1d and IC1e. Cross coupling of gates normally provides an RS flip flop which may take up any state if both inputs are taken high together. For this reason the capacitors, resistors and diodes at the inputs to the flip flop are used to provide steering logic to ensure that correct toggle action is obtained.

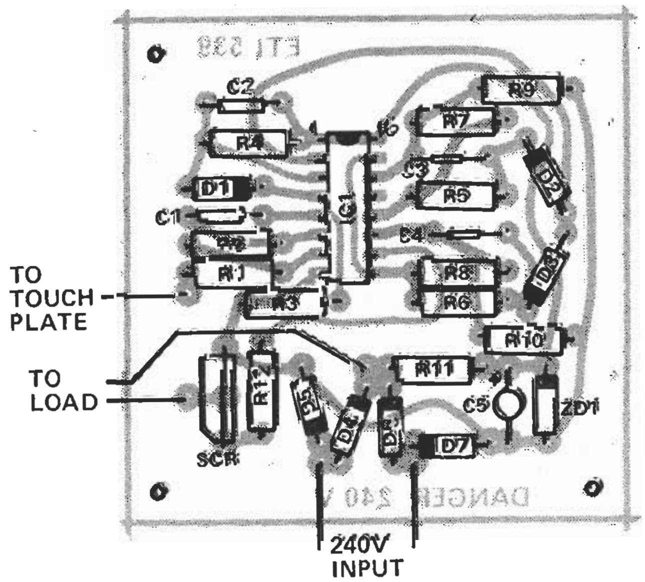
BUFFER

To prevent loading the flip flop, and because a spare section of the hex inverter is available, a buffer amplifier is inserted between the flip flop and the SCR. The SCR used is a C106D which is a sensitive gate type. This particular SCR will operate reliably with the 1 mA gate current provided. The SCR specified will be used – don't try substitutes.

TOUCH SWITCH

Printed-circuit board layout for the touch switch. Full size 68 mm by 68 mm.





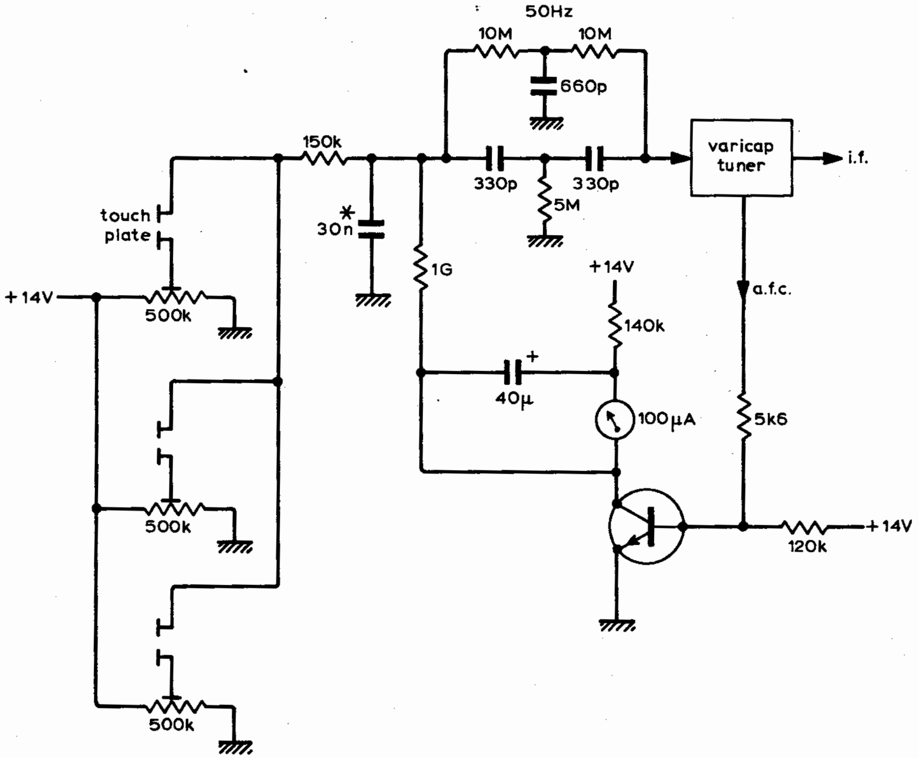
How the components are positioned on the board.

Touch controlled tuner

The control voltage in a varicap tuner must be stored in a memory – in this design an analogue memory is chosen. A feedback a.f.c. signal prevents the control voltage dropping due to leakage current of the tuner. Changing the control voltage by a current through the fingertips over-rules the a.f.c. loop because the skin resistance (max. 10MΩ) is much lower than the feedback resistance (1GΩ).

Delay time in the tuning process depends on the skin resistance and measured values are 7s (10MΩ), 3s (3.3MΩ) and 1s (1MΩ) for a frequency changing from 88 to 100MHz. Decreasing the memory capacitance (starred) to reduce delay time is difficult as static charges may be fed into the system while removing the fingertip from the "hot" contact. Due to the high impedances in this system care must be taken in choosing the isolating materials for the touch controls. In this design PVC has been used with success. A twin-T filter is used to prevent 50-Hz modulation. Control voltage ranges from 2V at 88MHz to 9V at 100MHz.

J. W. Richter
Eindhoven,
Netherlands.



C-MOS touch-switch array controls analog signals

by Max W. Hauser
Berkeley, Calif.

A few inexpensive complementary-MOS ICs can be used to create a bounceless buttonless touch-switch array. The resulting switching circuit takes advantage of the extremely high input impedance of C-MOS devices to detect the ambient signals (electrostatic charge and power-line hum) present on a person's finger. The circuit's outputs are solid-state switches that are capable of controlling audio or analog signals with negligible distortion and that, in many cases, are compatible with existing circuitry. Light-emitting diodes provide a visual display of the current state of these switches.

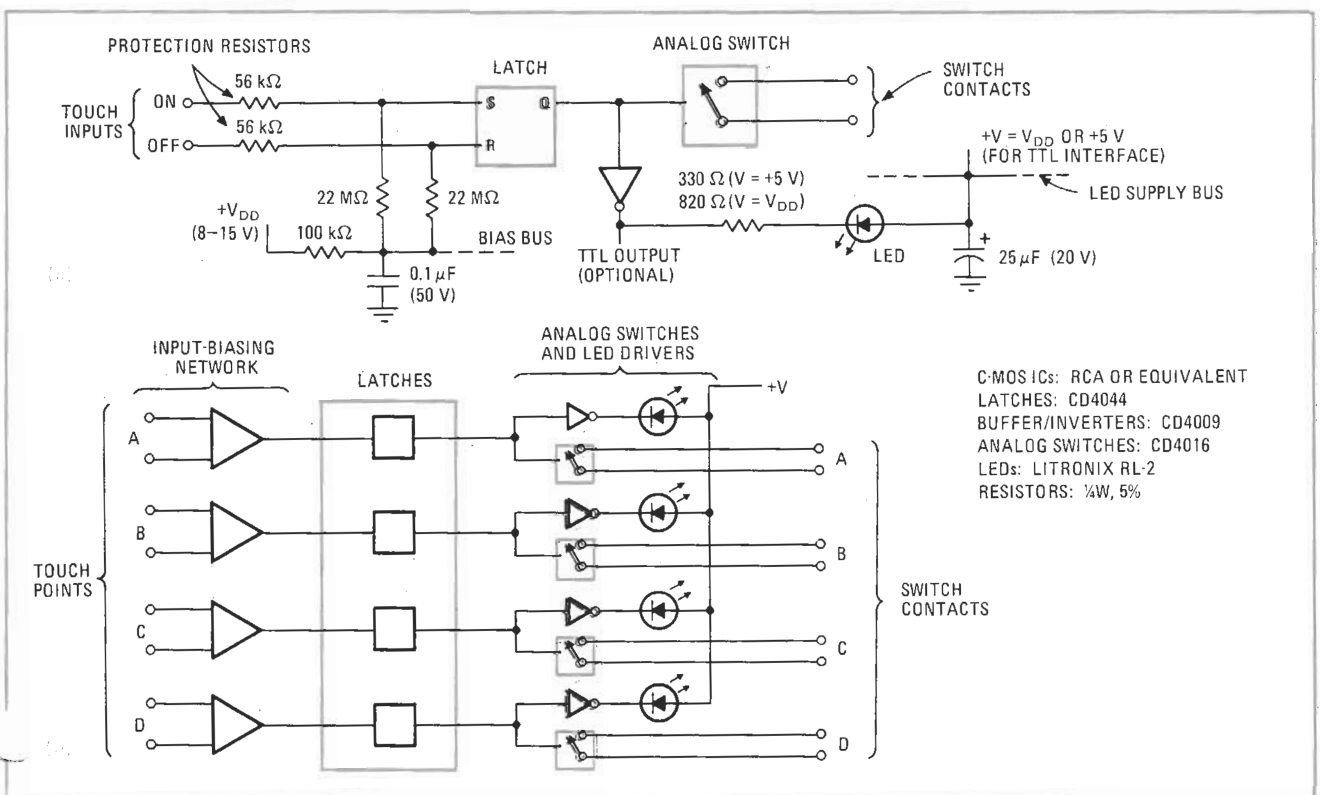
The heart of each touch-switch (a) is a set-reset flip-flop (one-quarter of a quad latch) whose inputs are biased to the V_{DD} supply through 22-megohm resistors. Under normal (resting) conditions, this renders the inputs inactive, and the flip-flop retains its last state. When a finger or large conductive object touches either the on or off input, a noise voltage appears across the bias resistor at that input and is amplified through the regenerative action of the flip-flop. This sets the flip-flop to the desired output state, where it remains until reset by touching the other input.

The flip-flop's output simultaneously controls an analog switch and a buffer/inverter that drives a panel-mounted LED. The output from the buffer can also be used to activate a TTL input, provided that the internal pull-up supply (V_{CC}) is made equal to the TTL power-supply voltage. The 100-kilohm resistor and the 0.1-microfarad capacitor serve to decouple the V_{DD} bias supply so that there is no interaction between the input and display portions of the circuit.

The block diagram (b) shows how a quadruple touch-switch array looks. The touch-sensors should be small metal plates—squares or disks having a side or diameter of 1 to 2 centimeters are best. A substantial increase in plate area results in a proportionate increase in the quiescent hum pickup, and can reduce circuit reliability unless the sensor is mounted very carefully. At the expense of added construction complexity, the LEDs or their mountings can be given a conductive coating, permitting them to serve as the solid-state equivalent of illuminated push-button switches.

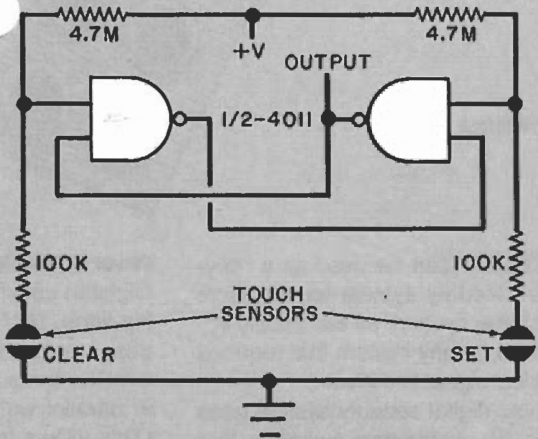
Type-CD4016 analog switches work well for noncritical applications, for example, if the circuit is to be used as a source selector for an audio-mixing console. In more critical systems, however, it may be desirable to substitute lower-impedance devices, such as type-CD4066 units. Of course, each flip-flop output can drive many analog switches, and a complex switching arrangement can be created that might be difficult or uneconomical to implement with mechanical devices. Normally closed switching is possible by driving the analog switches with the buffer/inverter outputs, but the cir-

Touch-actuated switching. A simple touch-switch (a) can be built with complementary-MOS ICs. The high input impedance of the C-MOS latch permits the ambient signals of a fingertip to be sensed. The latch's output then controls a C-MOS analog switch, which implements the desired switching function. The LED indicates whether this analog switch is on or off. A quadruple touch-switch array is shown in (b).



cuit's TTL interface must be sacrificed.

In remote locations, where power lines or other major electromagnetic-field sources are not available, it is advisable to install a second contact (at ground potential) on each sensor, so that a slight conduction between the two contacts will assure triggering. Also, to eliminate any chance of damage to the flip-flop inputs from an external power source, the inputs should be protected against excessive current flow with 56-kilohm resistors, as shown. □



Touch-Controlled Latch

6

Short the SET contacts with your fingertip and the output goes high. Later on, if you touch the CLEAR contacts, the output goes low. In this simple set-reset flip-flop, the 4.7-megohm resistors hold the NAND gates inputs high, and are disabled when the 200,000 ohms or so of finger resistance provides the "low impedance" path to ground, to force the circuit to change states.

The touch sensors may be any type of conductive material with a slight gap between the two elements.

Self-cancelling touch button control

This method of touch button control has the advantage that the buttons automatically cancel each other and that a ed button comes on when the power supplies are applied. The circuit is extendable to larger numbers of buttons by cascading further sections as shown in the dotted lines.

The system operates by detecting skin resistance across a pair of contacts. The 0-volt contact would normally be the equipment front panel. Light-emitting diodes indicate which button is currently actuated; any type of l.e.d. capable o handling 20mA may be used. The supply voltage may be from 20 to 30 volts. Outputs may be used to drive f.e.t. analogue switches directly, varactor tuning diodes via a suitable diode resistor network, or relays via suitable buffer circuits. The capacitor briefly holds the transistor on when power is first applied, so ensuring that this stage always comes on first.

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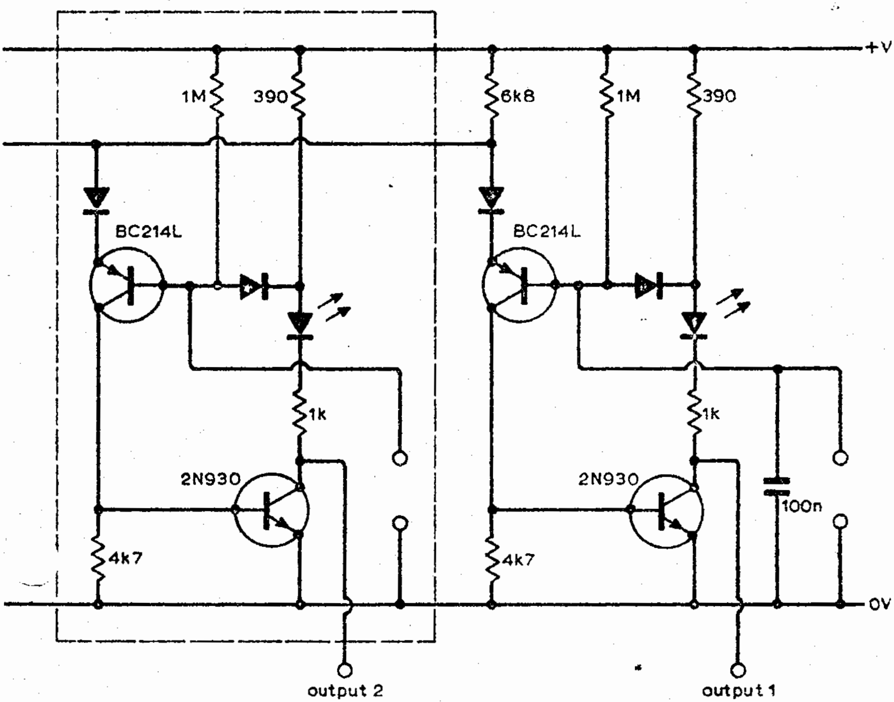
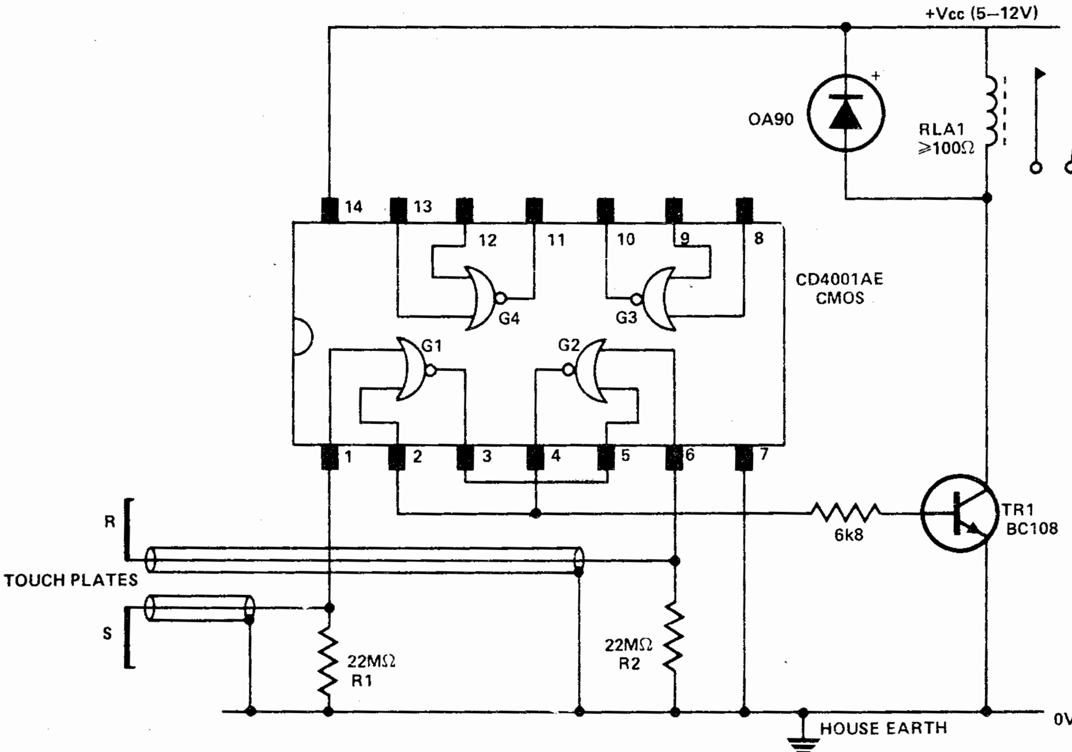
London SW15.



TOUCH FLIPFLOP

CMOS IC's have many advantages over TTL, one being the high input impedances. In Fig. 1, two NOR gates are cross coupled to form a flipflop. If plate S is touched ambient noise casuses an alternating voltage to appear at G1 input. During the first positive cycle G1 output goes negative setting the flipflop and turning RLA1 on. It remains on until the R plate is touched. R1 and R2 must not be omitted since they discharge any potentials remaining on the plates after they have been touched, thus allowing the flipflop to have its state changed rapidly. R1 and R2 also prevent any static charges building up, thud damaging the IC, while the supply is disconnected. 22Mohm resistors are difficult to get so two 10Mohm resistors in series may be used.

The unit may be left on continually as a milliameter indicates no current flow at all in the off position. If RLA1 is omitted TR1 collector becomes a TTL output with a high fan out. Connect the inputs of G3 and G4 to ground if they are not to be used. The touch plates can be placed several feet from the IC provided screened cable is used for them.



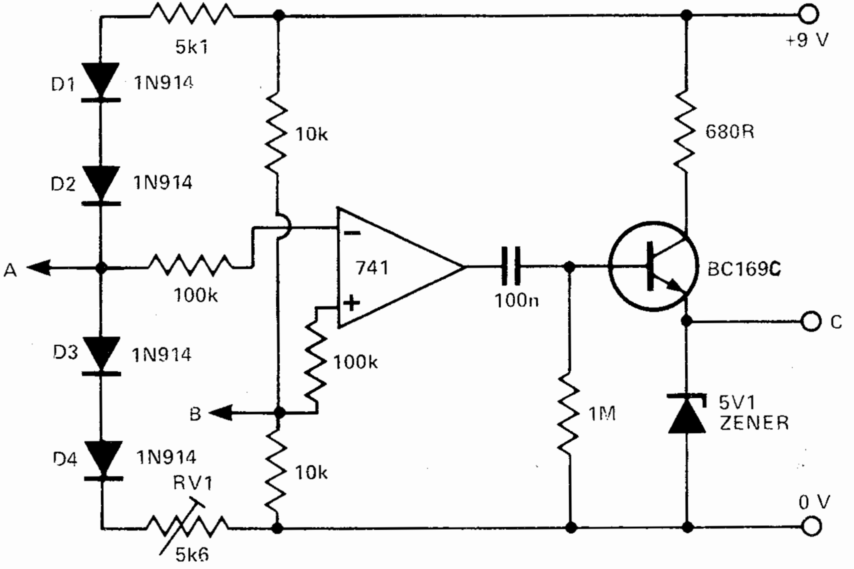
Thermo Touch Switch

S. B. Dick

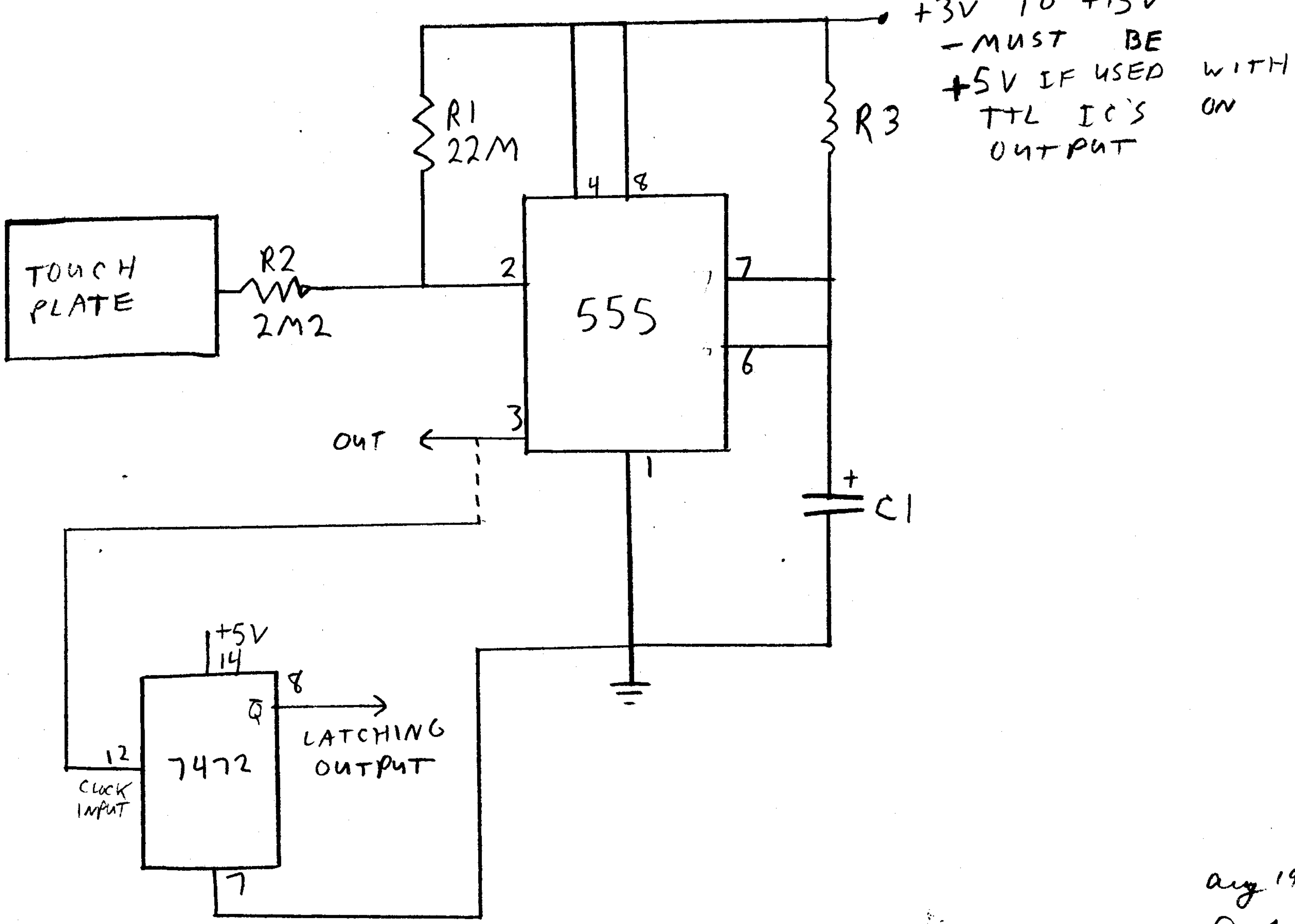
The following touch switch works on the temperature dependence of the forward voltage of silicon diodes. At 0 °C this is about 650mV, but drops by 2mV per °C increase in temperature.

When a finger is placed on D3 and D4 the voltage at A will drop below that at B and the O/P of the Op-Amp will go high, causing a TTL compatible pulse to appear at C. D1 and D2 provide compensation against ambient temperature changes. VR1 is initially set so that VA is greater than VB by about 10mV.

The system has the intrinsic advantage that it may be used in moisture-prone conditions in which ordinary touch switches would be most unsatisfactory due to their principle of operation.



TOUCH ACTIVATED SWITCH



aug 19/77
D. Froese

Touch Activated Switch

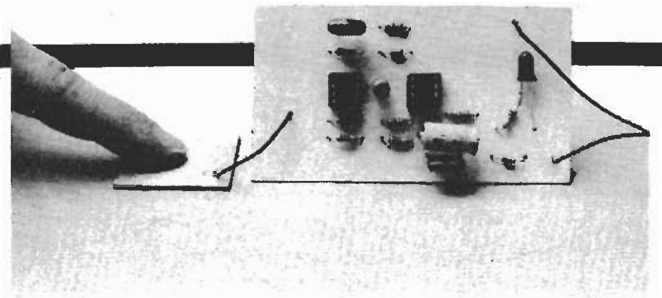
Daniel Fraser

Aug.19/77

This touch activated switch, while being very reliable, is also very low in cost. The circuit is essentially a monostable multivibrator, with its trigger input connected to a touch plate. When the touch plate is touched, the 555's output goes high and then returns low after an interval of time set by R3 and C1. This time is approximiately 1.1 X R3C1. R1 returns the trigger input high after you release the touch plate, allowing the 555 to complete its timing cycle. If the touch plate is large (over a kilogram in mass), this value may have to be reduced, possibly to as low as 1 Meg. R2 is an isolation resistor, to protect the user in the event that the power line becomes unleashed in the circuitry. If a latching operation is required, the output may then be fed to a flip-flop as shown in the schematic.

The circuit works fine on any supply voltage that the 555 will withstand(up to +18VDC), though if you feed the output to a TTL flip-flop, the Vcc must then be 5VDC. In my operation, I use a touch plate consisting of a piece of steel sheet 20 X 35 cm mounted to a floor, detecting the entry of people through a doorway. In this application, R1 had to be reduced to 1Meg for proper operation, but 22Meg is fine if your plate is much smaller, with a shorter lead than I used(2 Meters) The higher the value of R1, the more sensitive the switch will be.

TOUCH SWITCH



Above: the completed PCB. In this version we did not use a relay, connecting a resistor and the LED in series across the output.

For turning on equipment sensitive to vibration — photographic enlargers for example — or even just for a doorbell, this circuit is ideal.

IF YOU'VE EVER got involved in repairing a transistor radio, you will probably know the trick of dabbing your finger at the input to the audio stage to see if you can hear the hum and/or increase in noise level to prove that the audio stage is working.

It is also possible to make use of this effect to switch a circuit positively. Switching by touch has become quite common in the last two or three years since the IC manufacturers have introduced devices specifically to perform this funtion. TV sets and elevators are amongst the common users (though some TV sets make use of your finger bridging two terminals and operate differently).

Touch switches may seem highly extravagant but industrially they are far more reliable than mechanical types. In TV sets, touch switches have the great advantage of enabling the preset pots which control the varicap diodes in the tuner to be put at the back of the set.

PARTS LIST

RESISTORS, All ¼W, 5%

R1	56k
R2	100k
R3	10M
R4	15k
R5	15k
R6	3k3
R7	100k

CAPACITORS

C1	100n polyester
C2	100uF 25 V electrolytic
C3	2u2 25 V electrolytic
C4	100n polyester

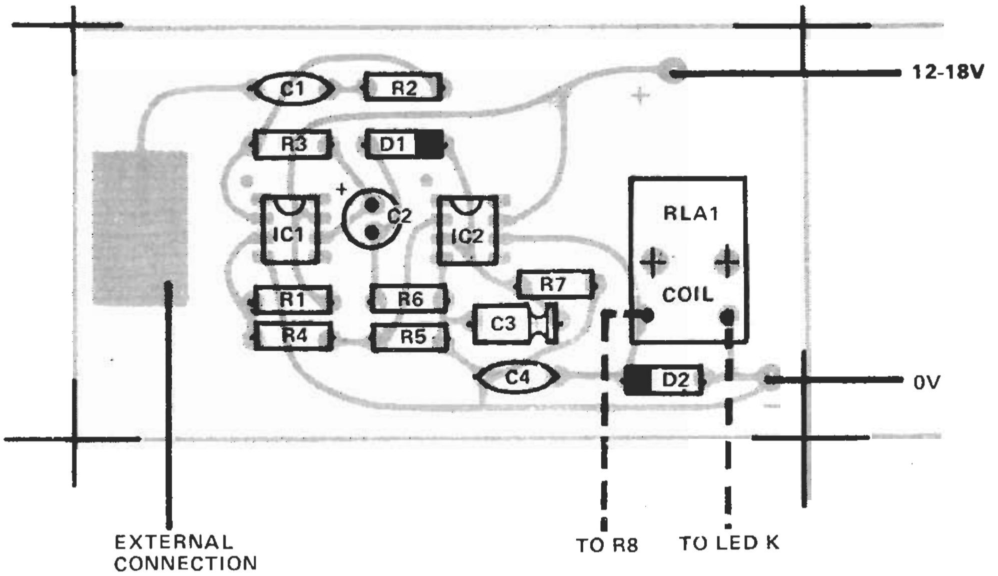
SEMICONDUCTORS

IC1, IC2	741 Op Amp
D1, D2	1N4148 silicon diode

MISCELLANEOUS

PCB as pattern, Miniature relay (500 ohm or more coil and change-over contacts).

On the right is the component overlay for the PCB. Be sure to position the polarised components C2, C3, IC1, IC2, D1 and D2 the right way round. If you're buying a relay get one to fit the holes as shown, otherwise extra drilling and soldering may be needed.



HOW IT WORKS

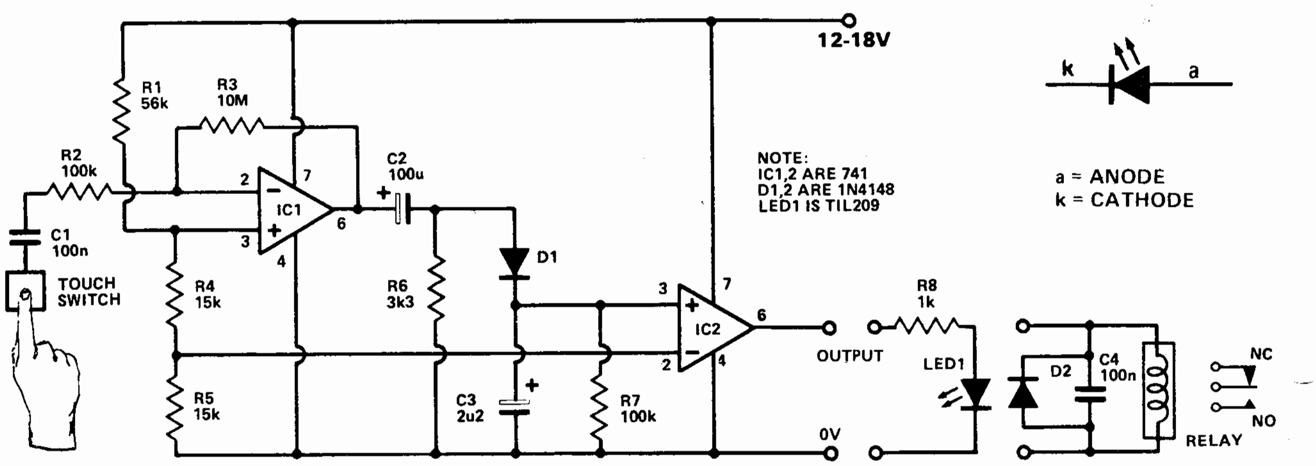
When a finger is placed on the touch contact, a low level of line hum is introduced to IC1 via the DC blocking capacitor C1 and R2. The gain of IC1 is arranged at a very high level and the hum is thus enormously amplified and switches the output of IC1 to about 7V peak-to-peak. The signal passes through C2 which blocks the DC to diode D1.

When the signal is swung positive, D1 conducts and charges up C3. When the voltage at the non-inverting terminal of IC2 (pin 3) exceeds the voltage at the inverting terminal(pin 2) the output of IC2 goes high and switches the relay.

IC2 acts as a voltage comparator. When the finger is removed, R7 discharges C3 and the output of IC2 goes low and the relay switches off.

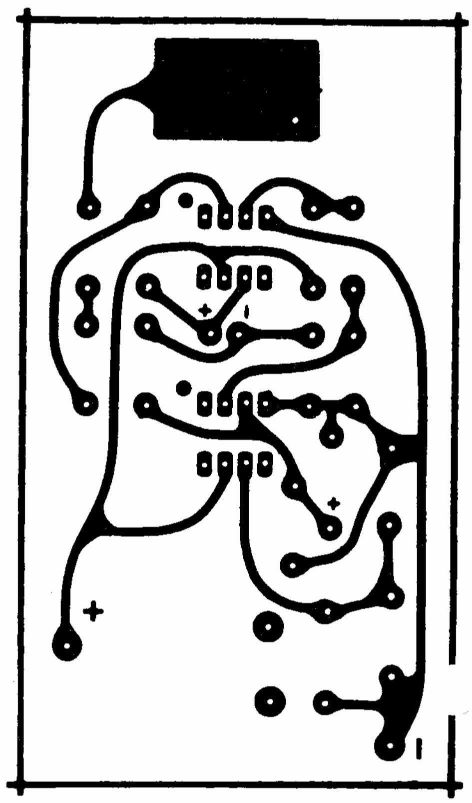
D2 and C4 are included to protect IC2 from the very high voltages caused by abruptly turning RLA1 off.

If used to switch power equipment, great care should be taken to isolate the switched power from the rest of the circuit. R2 and C1 give only a margin of safety and are no substitute for taking care. The power for the circuit itself should only be derived from batteries.



Above is the circuit diagram, showing, on the right, tne connections for either an LED or a relay.

On the right is the copper foil pattern for the PCB we used, printed actual size.



Construction

We have designed our PCB so that the touch contact is on the board itself but have also allowed a terminal for taking the touch contact to somewhere more remote.

Small relays don't normally come in standard types and for that reason we have only left a general area showing the coil contacts, though these may have to be changed. We have not even attempted to show the switch contacts but there is plenty of room to run the contacts to terminals sited between the supply connections.

Apart from the obvious precautions to ensure that the ICs, diodes and the two electrolytic capacitors (C2, C3) are connected the right way around, construction is easy.

For safety reasons, we strongly recommend that the circuit is battery operated. If it is used to switch a relay, the contact of the relay can be used to switch a line supply on.

A SIMPLE TOUCH CONTROL SWITCH

BY GEORGE PETERKA

Single FET amplifier circuit can be used to control relay or other low-current device

A TOUCH control is an electronic switch that can be activated simply by touching a small conductive plate with a fingertip.

Such controls are easy to build and can be used to enhance many projects. They can also be added to an existing circuit, such as forming an alarm "off" switch for a digital clock.

Circuit Operation. A basic touch control circuit is shown in Fig. 1A. Essentially, it consists of a FET amplifier with a high input impedance (10 megohms) and a conductive touch plate connected to its gate. Operation occurs when the ambient 60-Hz ac field flooding the area is impressed on the touchplate during the finger contact. This signal is amplified and appears at the drain as a 60-Hz square wave, alternating between ground and supply voltage.

Capacitor *C1* shunts any r-f picked up by the "antenna effect" of the touchplate, while capacitor *C2* acts as a transient suppressor.

The drain of *Q1* can be connected to the alarm-off pin of a clock chip, since most of these ICs require that the alarm-off pin be momentarily connected to the supply voltage to silence the alarm.

The circuit of Fig. 1B uses the same FET input stage, but, via *D1*, rectifies the ac waveform at the *Q1* drain and uses the generated positive voltage to turn on transistor *Q2*. The positive voltage developed across *C3* will keep *Q2* turned on until the capacitor is discharged by base current and resistor *Rx*. The value of this latter resistor determines how rapidly the switch will shut off and should be between 10,000 and 100,000 ohms.

The load on *Q2* can be a low-current relay or a resistor (1000 to 5000 ohms) with the signal generated across the resistor used to turn on a high-power transistor. Using the transistor shown for Q2, any device that requires 50 mA or less can be powered.

Construction. Any form of construction may be used since the circuit is relatively simple. It should be powered from an ac-line supply for reliable operation.

The touch plate should be relatively small—several square inches are enough. It must be insulated from ground. But it need not be a discrete metal plate; a metal door-knob on a wooden door will suffice. This latter type of touchplate makes an excellent sensor in an alarm project. ◇

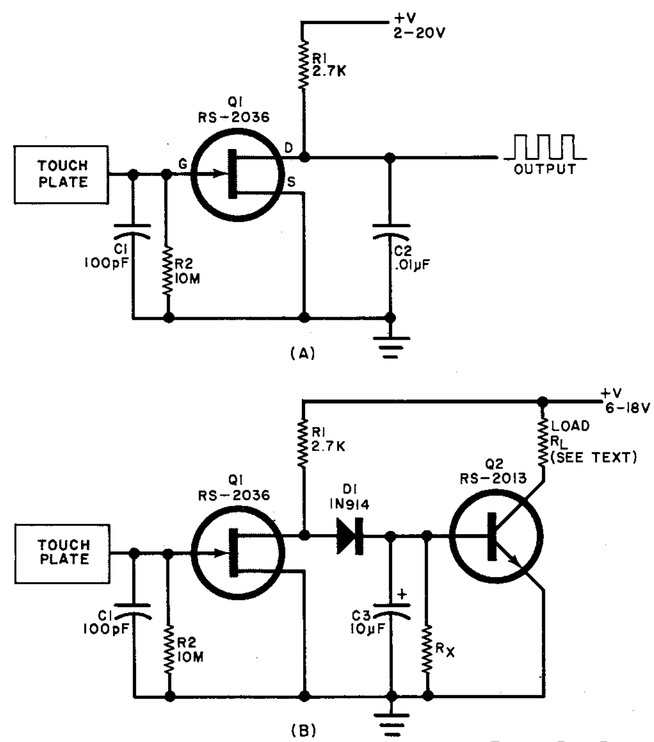


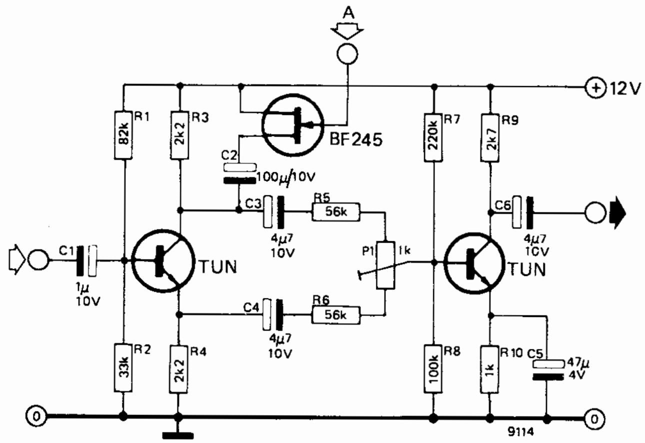
Fig. 1. At (A), high input impedance FET developes a square-wave output when gate is touched by fingertip. Transistor Q2 (B) is added to drive external devices.

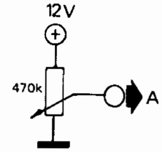
PARTS LIST

C1 — 100-pF, disc
C2 — 0.01-μF, disc
C3 — 10-μF, electrolytic
D1 — 1N914 or similar
Q1 — N-channel FET, RS2036 or similar
Q2 — Npn transistor, RS2013 or similar
R1 — 2700 – ohm resistor
R2 — 10 – megohm resistor
Rx — 10,000 to 100,000 ohms (see text)
Touchplate — see text.
Misc. — Perf board, mounting hardware, power supply, etc.

96 voltage-controlled volume

Ch. Voss





This volume-control circuit offers an unusual approach to the well-known problem of distortion in active-device attenuators. The zero-output in this case is obtained by allowing equal signals of opposite phase to cancel each other. The input transistor operates as a 'concertina' phase-splitter, producing equal-amplitude opposite-phase voltages at its collector and emitter. The two signals can be brought into complete cancellation, at the summing point, by means of preset P1. The harmonic content of the two signals is very small - but not quite identical. There will therefore actually be an - even smaller - distortion output at the nominally 'zero' point.

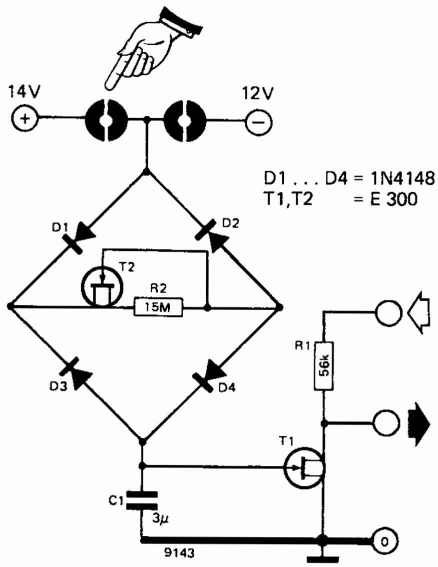
If something now happens to the amplitude ratio of the signals at the summing point, there will be output passed to the buffer-stage. The necessary unbalance is achieved by means of the JFET and capacitor C2. The gate bias on the FET is set by the DC control voltage applied to point A. With this voltage close to zero the FET will be cut off, so that the above-mentioned cancellation takes place. As this voltage is increased there will come a point at which the channel starts to 'bleed off' AC collector current from the splitter; this will upset the balance and so cause an output signal to appear. The more conductive the FET, the more output. Unfortunately, the more channel current there flows the lower will be the negative gate bias - and so the greater will be the distortion of the 'regulated' summing component.

The trick is now te employ only a moderate degree of unbalance - so that the FET operates at low distortion percentages. The process is helped also by the always-present 'clean' summing component. The buffer stage provides gain, so that a sufficient output level is obtained.

The circuit's frequency response extends from 50 Hz to 35 kHz (−3 dB points). The input voltage should be limited to 100 mV p-p; the output can be varied from '0' to 1 V p-p (by using the appropriate range for the control voltage at A).

97 fingertip volume control

R. Meschenmoser



The circuit consists of an 'electronic' attenuator, arranged to respond to a fingertip touching one of its contact plates.

Transistor T1 (a type E300 or similar JFET) operates as the variable resistor in a voltage divider (T1, R1). The channel resistance of T1 depends on the negative voltage across C1.

If one touches the contact-pair associated with the negative supply a current through D2, R2 and D3 will charge the capacitor. The charging time is determined by the values of R2 and C1. When the FET gate is biassed sufficiently negative the device will no longer conduct, so that the audio signal passes unattenuated.

To reduce the audio volume one simply touches the 'positive' contact-pair. The discharge of C1 causes the FET-bias to be reduced, so that the channel becomes conductive again and diverts signal current to 'earth'. The level will continue to slowly change as long as one of the contact-pairs is being touched.

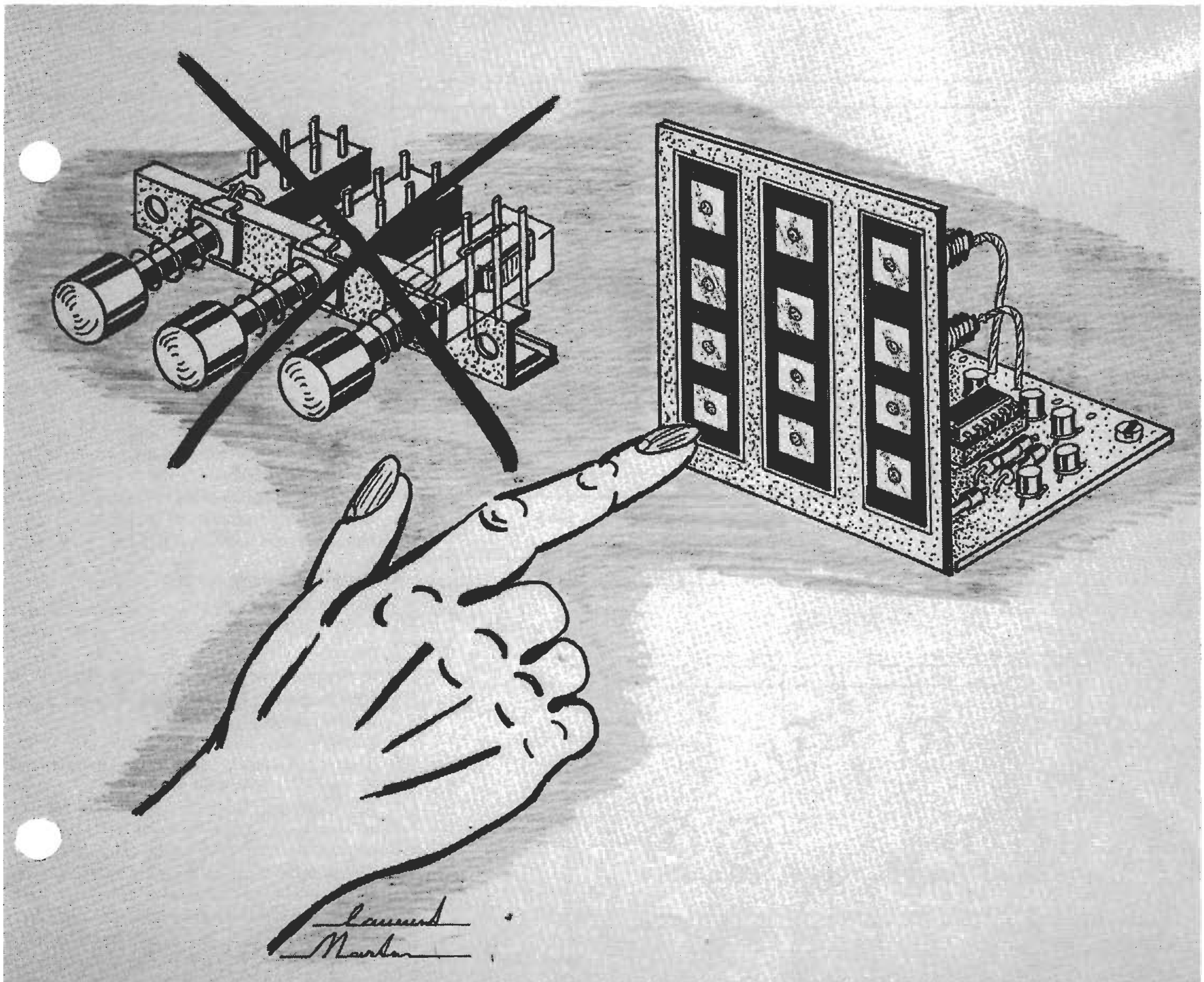
The FET channel is only approximately a linear resistor, due to the audio signal modulating the gate bias. At an input level not exceeding 30 mV there will nonetheless be no audible distortion.

tap sensor

An important alternative to the mechanical switch — rotating or push-button — is the touch switch. This has the advantages of greater reliability and a higher switching speed, as well as being noiseless and not subject to wear. Furthermore, front panels with touch contacts can be made available as printed circuits, so that it becomes much easier to build equipment with a neat appearance.
Elektor laboratories have been asked to design a touch control switch with a single touching point and costing no more than its mechanical equivalent. Consequently, our laboratories have produced the Touch Activated Programmer or TAP.

Basic possibilities

Operating a switch — touching, turning or pushing — is in effect feeding in a signal that must be stored somehow. The mechanical switches do this by remaining locked in their new positions; a touch switch, however, cannot store a signal unless it is provided with a memory.
If a switch is to be operated by touch, its input resistance must exceed the resistance of the finger if action is to be ensured. If it is a single-point touch switch, the signal fed in — the signal that activates the switch — must be the noise or hum picked up by the operator. Hence, the single-point touch switch consists essentially of an a.f. amplifier that has a high input impedance, a rectifier and a memory. This is shown in figure 3. In this system the input signal (hum voltage on the skin) is amplified in the input stage, rectified and fed



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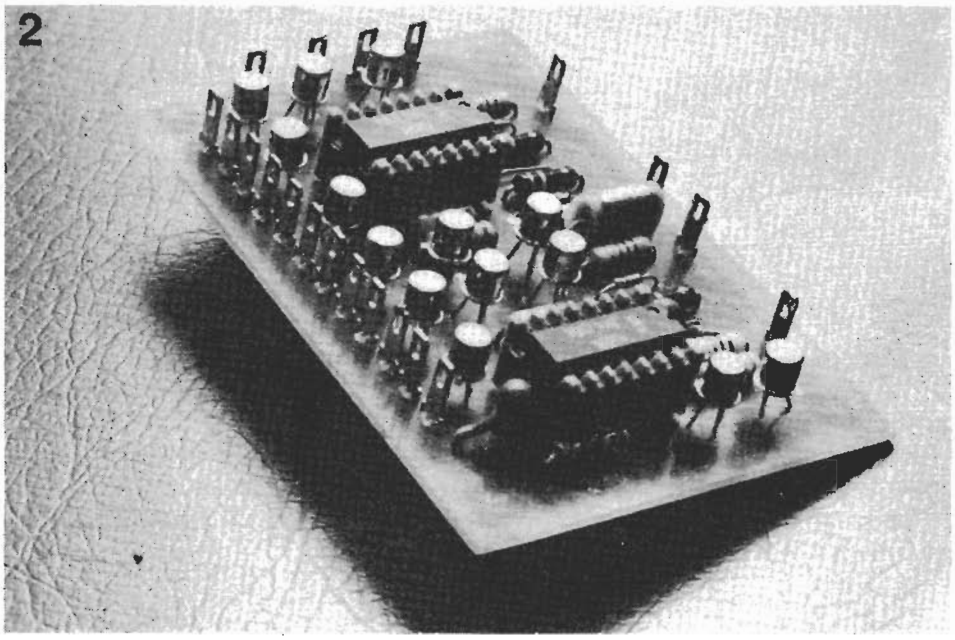

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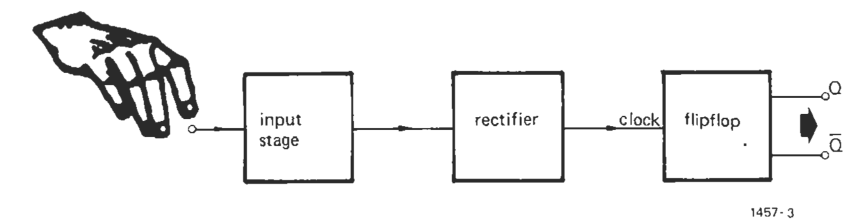

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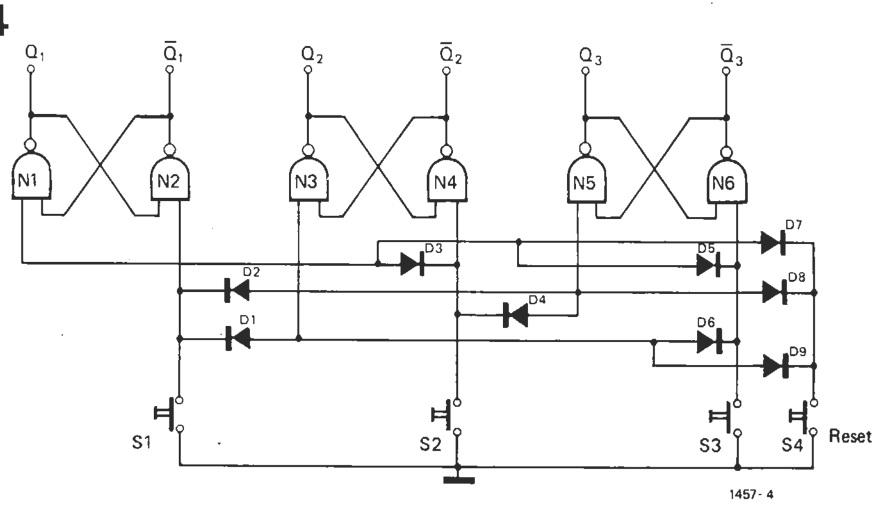

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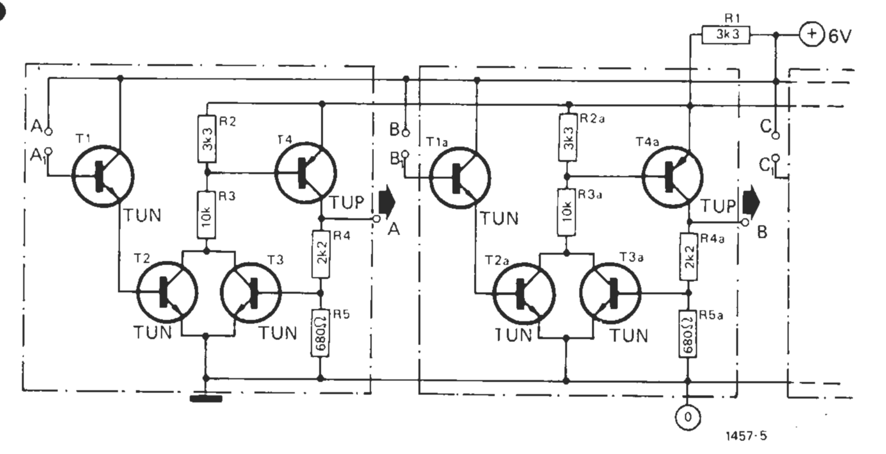


to the clock input of a flipflop. Each time the input point is touched, the flipflop will change to another stable position. A practical circuit in accordance with the block diagram of figure 3 is fairly simple to design.

A TAP (Touch Activated Programmer) that will replace a complete pushbutton unit needs a reset unit between the flip-flops of the respective switches. This will ensure that when there are several switches, all except the one operated are reset. This reset can be achieved with diodes as shown in figure 4 with a four-position switch. For simplicity the contacts are shown as push-buttons. S_4 is the total reset button. The three-position switch shown in figure 4 needs nine diodes. In general, the reset circuit requires a number of diodes equal to the square of the number of positions. Hence, an eight-position switch (plus, of course, a total reset) requires 64 diodes. So the system of figure 4 is rather expensive, and the circuit becomes complicated when there are more than four positions.

A touch control switch operating without reset diodes is shown in figure 5, points A/A_1 and B/B_1 being the touch contacts. Here reset is achieved by using a common supply resistor R_1. If one of the switches is 'on', it draws a current of about 1 mA. The voltage drop across R_1 is then 3.3 V. As soon as the second switch is operated, this one, too, will want to draw 1 mA. As a result, the voltage across R_1 drops almost to zero, the non-operated switch is cut off and the last switch to be operated remains 'on'. An advantage of such a switching system is that it can be easily expanded with more and more of the same units. There is the drawback, however, that extra components are needed to create 'hard' binary outputs. Consequently, the cost of the switch becomes so high that the financial requirements can no longer be met.

A better reset system uses a one-shot (monostable multivibrator). Each time a switch is touched, this one-shot circuit feeds a short reset pulse to each flipflop. This pulse must be so short that no audible interval occurs in low frequency applications of the switches. Laboratory experiments have shown that touch-control switches with this reset system provide the most reliable circuit. It is for that reason that they are used in the TAP.

Block diagram of the TAP

Figure 6 shows the block diagram of the TAP, points A, B and C being the touch points.

A separate overall reset is provided. Each touch point is followed by an input buffer circuit (IB-1, IB-2 . . .). These amplify the hum voltage on the skin. The input circuits of the touch points A, B and C drive the set-(S)-input of the RS flipflops. Since driving the set input of such a flipflop several times in succession will only lead to one change in its binary state, the rectifier circuit shown in figure 3 is not necessary here.

The input circuits also drive the one-shot. If, for instance, point A is touched, a 50 Hz square wave will appear on the S-input of the first flipflop (FF-1). At the

Figure 2. Photograph of the TAP.

Figure 3. Block diagram of a simple touch control switch with one input and two inverse digitale outputs.

Figure 4. A switching system with four digital (pulse) inputs and three binary outputs. The system is designed so that in all cases only one binary output assumes a set state whilst the other outputs are in the reset state or are being reset.

Figure 5. A touch control switching system where only one output at a time can be in the set state. This system can be expanded with an unlimited number of touch control switches.

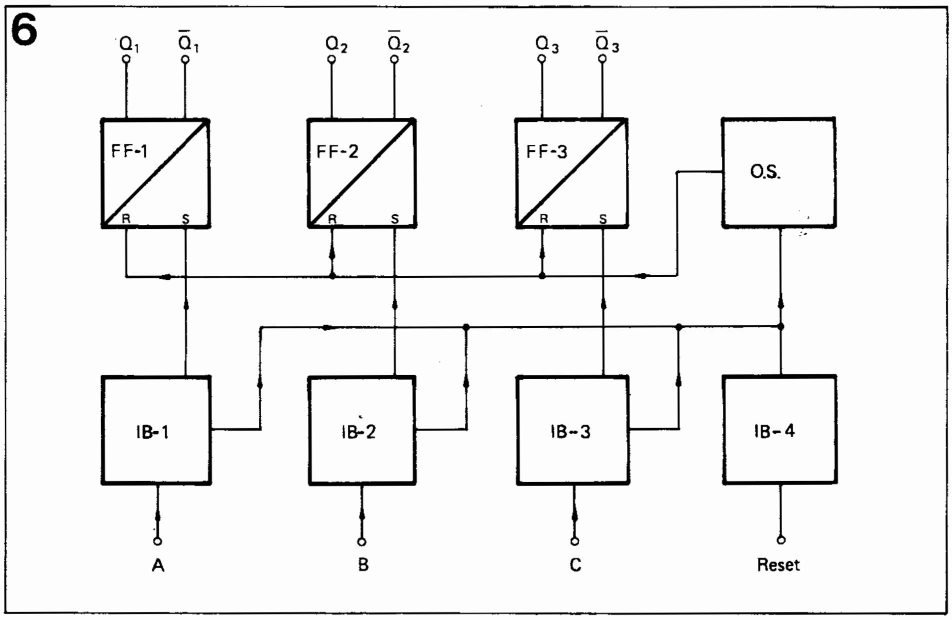
Figure 6. Block diagram of the TAP. The letters FF, OS and IB stand for FlipFlop, One-Shot (= monostable multivibrator) and Input-Buffer.

same time the one-shot produces very short reset pulses. Because these reset pulses to the R-input are short as compared with the square wave at the S-input, the flipflop is not reset immediately after being set. A switch is reset only by operating one of the other two switches or the independent reset. As the block diagram of figure 6 shows, each TAP comprises three switching positions and one total reset. The circuit is designed so that several TAPs can be combined to a maximum of about 14 switching positions plus one total reset.

The RS-flipflop

In the TAP two NAND gates are coupled to form an RS-flipflop (see figure 7).

The S-input of the flipflop is driven from a transistor, that, in the active state, draws the input of the gate to supply zero. In figure 7 this is transistor T_6, connected to input B, and driven by T_5. If point D in figure 7 is touched, the hum voltage on the skin will drive T_5 into conduction; T_6 then goes into saturation and draws input B of the NAND gate to '0' 50 times per second. If D is not touched, T_6 remains off and the NAND gate sees this as a '1' level.



The circuit diagram of the TAP

Figure 8 gives the circuit diagram of the TAP. It is designed around two ICs. The four NAND gates of IC_1 are used to form two RS-flipflops. The first one consists of the gates N_1/N_2, and the second one of N_3/N_4. A third is formed by the gates N_5/N_6 in IC_2. The two remaining gates (N_7/N_8) of IC_2 form the one-shot, which provides the reset pulse. Its pulse width is determined by resistor R_8 and capacitor C_2. Figure 9 shows an oscillogram of a reset pulse at the output of the one-shot (pin 8 of gate N_7). The pulse width is approximately 400 ns!

As appears from figure 9, the reset pulse is a '0'. The reset pulses are fed directly to the R-input of the three flipflops without diode coupling. This is possible because the emitters of the NAND gates are 'open'.

The set control for each flipflop takes place via the darlington circuit consisting of two transistors described earlier. For flipflop N_1/N_2 these are the transistors T_1 and T_2. The collector of T_1 is connected direct to the set input of the flipflop. The negative-going pulse on this collector, when point A is touched, is used for driving the one-shot. To achieve a good switching edge, the collector of T_1 is connected to '1' level via resistor R_1 (in the quiescent state). As soon as A is

The 7400

The TAP is designed around the integrated circuit type 7400, a quadruple two-input NAND. Actually, the full type number will be SN 7400, S 7400, N 7400, SN 74H00, to name a few; the letters are not so important, however. To gain a good insight into the functioning of the TAP circuit, it is necessary first to take a closer look at this integrated circuit. The part surrounded by the dashdot line in figure A represents the internal circuit of a NAND gate, and each 7400 comprises four such gates.

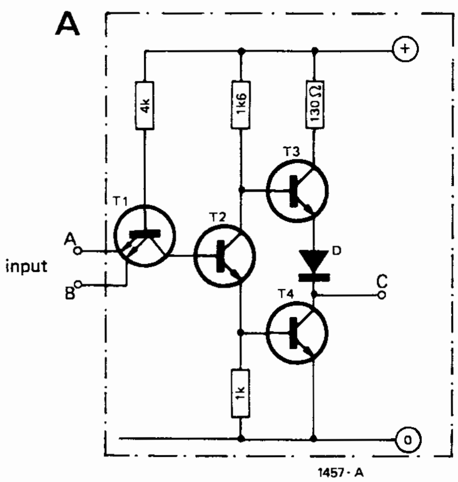
The two emitters of T_1 are the inputs of the NAND gate. When both emitters of T_1 receive a voltage $+V_b$, no current flows through its P-N base-emitter junction. The potential on the base of T_1 rises and the P-N base-collector junction conducts. Hence, here transistor T_1 can be regarded as an assembly of three diodes. The potential on the base of T_2 now rises and this transistor is turned on, so that its collector potential drops sharply. Consequently, T_3 no longer conducts and, at the same time, T_4 is driven into saturation. Point C, the NAND gate output, drops to zero potential (LOW). So when both inputs of T_1 are at $+V_b$ (HIGH), the output is LOW. It is also obvious that leaving the emitters of T_1 'open circuit' is in fact the same as applying $+V_b$.

As soon as one of the emitters of T_1 becomes LOW (logic '0'), the base voltage of T_1 will also c[illegible] As a result, the base-collector junction of T_1 does not conduct, T_2 is no longer driven, and the output (C) will assume a HIGH level.

When the output of the NAND gate is HIGH (logic '1'), the output level is equal to the supply voltage $+V_b$ minus the drop in the diode D, the collector-emitter saturation voltage of T_3 and the drop in the 130 Ω collector resistance. This output level therefore depends on the load current.

If the output of the NAND gate is LOW (logic '0'), the load current is fed to the supply zero via T_4. The maximum load current ('sink current') is then determined by the maximum permissable current through T_4, which is 30 mA for a 7400 IC.

Figure A. Circuit diagram of a NAND gate in a 7400 IC.



touched, the collector of T_1 switches from '1' to '0' and back again 50 times per second. Via diode D_1 this signal arrives on resistor R_9. Consequently, transistor T_8 becomes conductive, and the drive input of the one-shot (pin 13 of gate N_8) is drawn to supply zero, so that the one-shot produces reset pulses 50 times per second.
Resistor R_4 in the base of T_2 prevents this transistor being damaged by static charges on the skin.
To avoid instability of the TAP, a capacitor C_3 is connected across the supply. Capacitor C_1 is provided for automatic reset when the supply is turned on. This is achieved by feeding the positive voltage surge, occurring during switch on, to the base of T_7 via R_7. Consequently transistor T_7 and T_8 become momentarily conductive, and the one-shot produces a reset pulse.
As well as having a Q and $\overline{Q}$ output, each flipflop also has extra S and $\overline{S}$ outputs. These are intended as active attenuators. In the reset condition an S-output can be regarded as a relatively high-ohmic resistance relative to supply zero. Inversely, the $\overline{S}$-output is relatively low-ohmic. If, via a series resistor, a digital signal is fed to an S or an $\overline{S}$ output, this S or $\overline{S}$ output will function as a logic-controlled attenuator.
The switching speed of the various outputs is so high that nothing of the TTL character is lost. Figure 10 shows an oscillogram of a switching edge of one of the binary outputs of the TAP. As is seen from this figure, the rise time is less than 10 ns.
The circuit shown in figure 8 can be considered a universal TAP. The points RB (Reset-Bar) and CB (Contact-Bar) provide an extra output for using several TAPs in conjunction with each other.
Table 1 gives the truth table of the TAP, and table 2 gives various specifications.

The printed circuit board

Figure 12 shows the circuit board of the TAP. All the inputs are along the upper edge of the board, and the outputs along the lower edge. The supply terminals and the RB-CB rails are on one side.
Screened cable should be used for the input connections.

TAP applications

A simple TAP application, an on/off switch for a 220 V lamp, is shown in figure 13.
In figure 14 a similar circuit for operating three lamps is shown.
If the diodes D_1, D_2 and D_3 are omitted from the TAP in figure 14, the result is a triple lamp switch with one common reset. In cases where a triple touch control switch with a common reset is insufficient, more TAPs can be used in conjunction. The RB- and CB-rails of all TAPs used must then be interconnected. Figure 15 gives a simple example. Of course, only one TAP need be provided with a one-shot reset circuit.

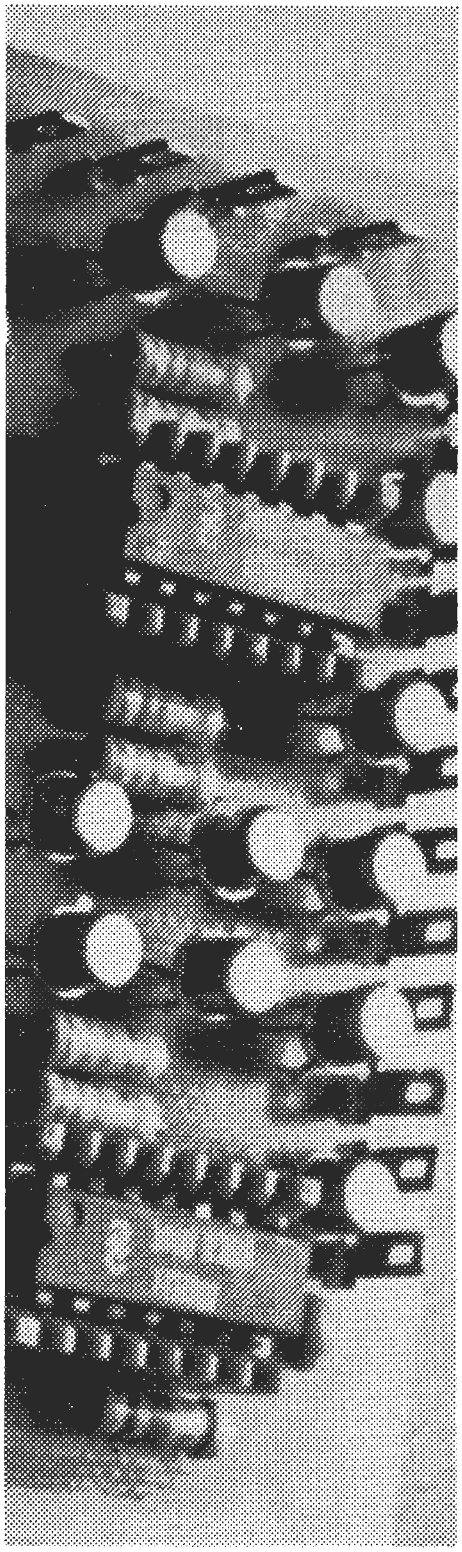


Table 1. Truth table of the TAP

		Q_1	$\overline{Q_1}$	Q_2	$\overline{Q_2}$	Q_3	$\overline{Q_3}$
after switch-on		1	0	1	0	1	0
touch point	A	0	1	1	0	1	0
	B	1	0	0	1	[illegible]	[illegible]
	C	1	0	1	0	0	1
	reset	1	0	1	0	1	0

positive logic '1' = +5 V

Figure 7. An RS-flipflop built from two NAND gates. The transistors T_5 and T_6 plus resistor R_1 form the 'set' circuit.

Figure 8. The complete circuit diagram of a TAP.

Figure 9. Photographed oscillogram of a one-shot reset pulse. The one-shot produces this pulse each time input A, B, C or the reset is touched. At a prolonged touch of any of the touch points, the one-shot produces 50 such pulses per second.

Figure 10. Photographed oscillogram of one of the binary outputs during switching.

Figure 11. Equivalent block diagram of the TAP circuit.

Parts list with figures 8 and 12.

Resistors:
R_1, R_2, R_3 = 100 k
R_4, R_5, R_6, R_7 = 10 M
R_8 = 1 k
$R_9, R_{10}, R_{11}, R_{12}$ = 27 k
R_{13}, R_{14}, R_{15} = 27 k

Capacitors:
C_1 = 270 p
C_2 = 270 p
C_3 = 47 n

Semiconductors:
D_1, D_2, D_3 = DUG
$T_1, T_2, T_3, T_4, T_5, T_6, T_7$ = BC 107 or BC 108, BC 109
T_8 = AC 126 or equiv.
$T_9, T_{10}, T_{11}, T_{12}$ = TUN
T_{13}, T_{14} = TUN
IC-1, IC-2 = 7400 (DIL)

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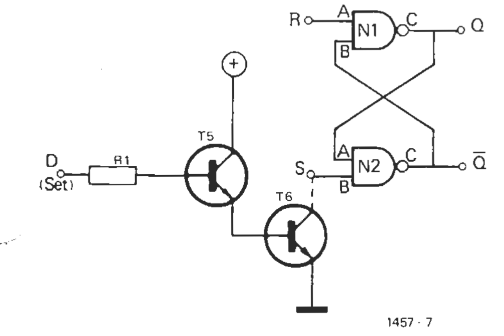

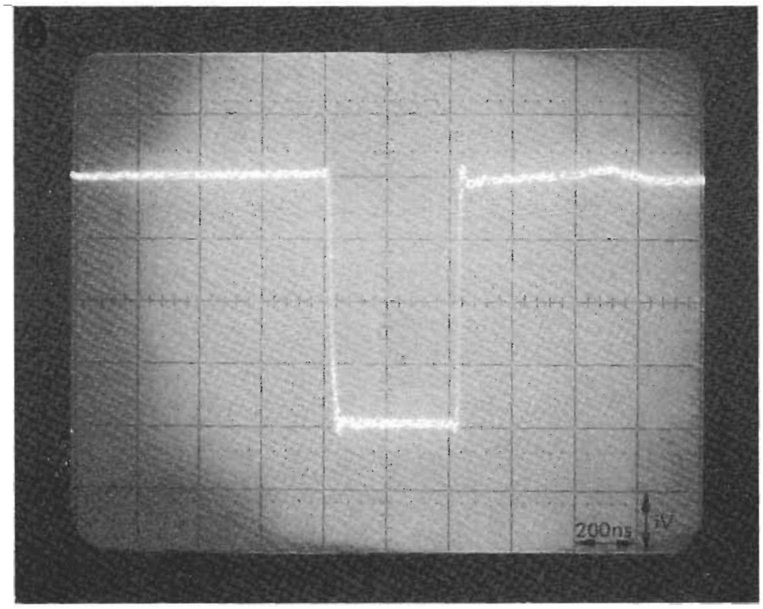

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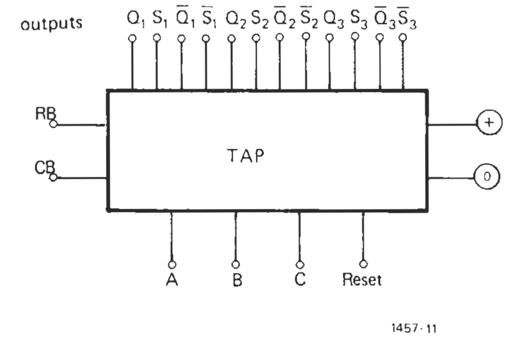

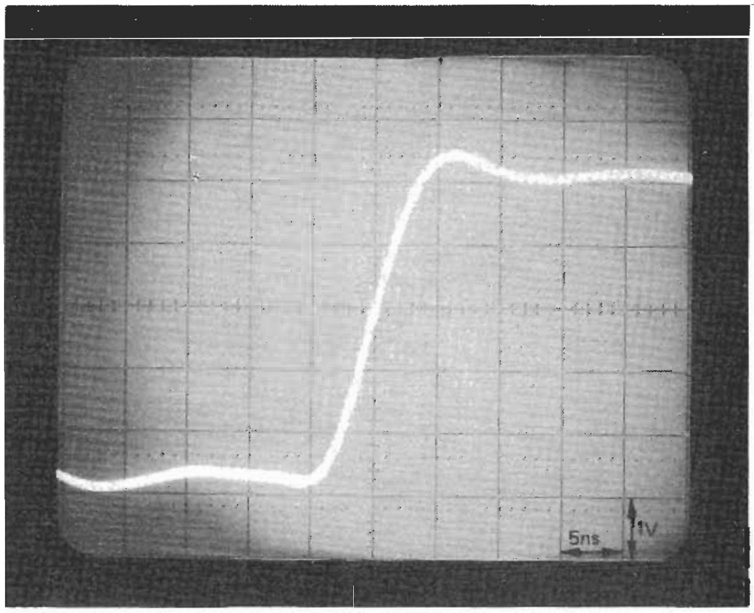

Table 2 TAP specifications

supply voltage	: +4.5 V . . . +6.4 V
input impedance (each input)	: > 10 M
response voltage (each input)	: < 1 V (RMS)
response current (each input)	: < 160 nA
maximum response delay	: 20 ms (50 Hz mains)
switching time (each output)	: < 1 µs
output voltage logic '1' (each Q and $\overline{Q}$)	: > 4.5 V p.p. (V_b = 6 V)
output voltage logic '0' (each Q and $\overline{Q}$)	: < 150 mV p.p. (V_b = 6 V)
output current logic '1' (each Q and $\overline{Q}$)	: 0.4 mA
sink current logic '0' (each Q and $\overline{Q}$)	: –16 mA
required continuous current under no-load conditions	: 16 mA (V_b = 5 V)
	: 20 mA (V_b = 6 V)

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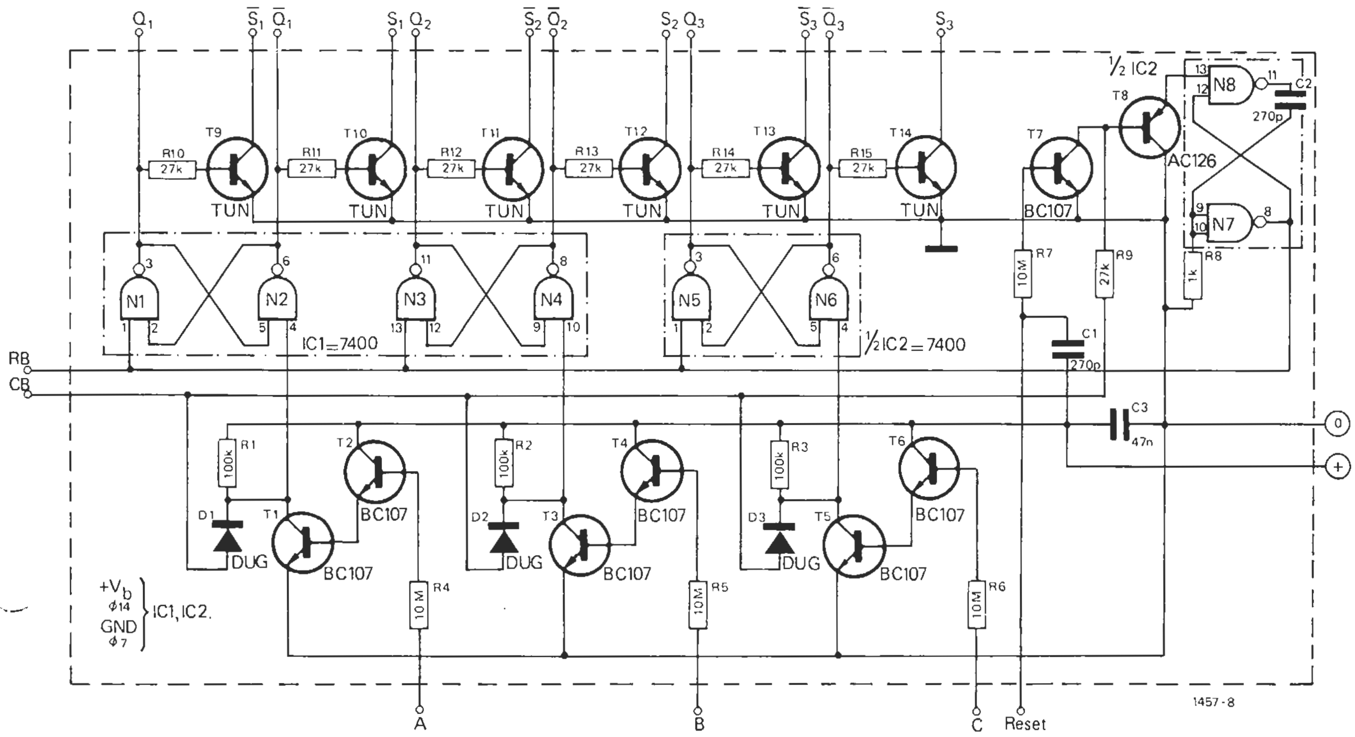

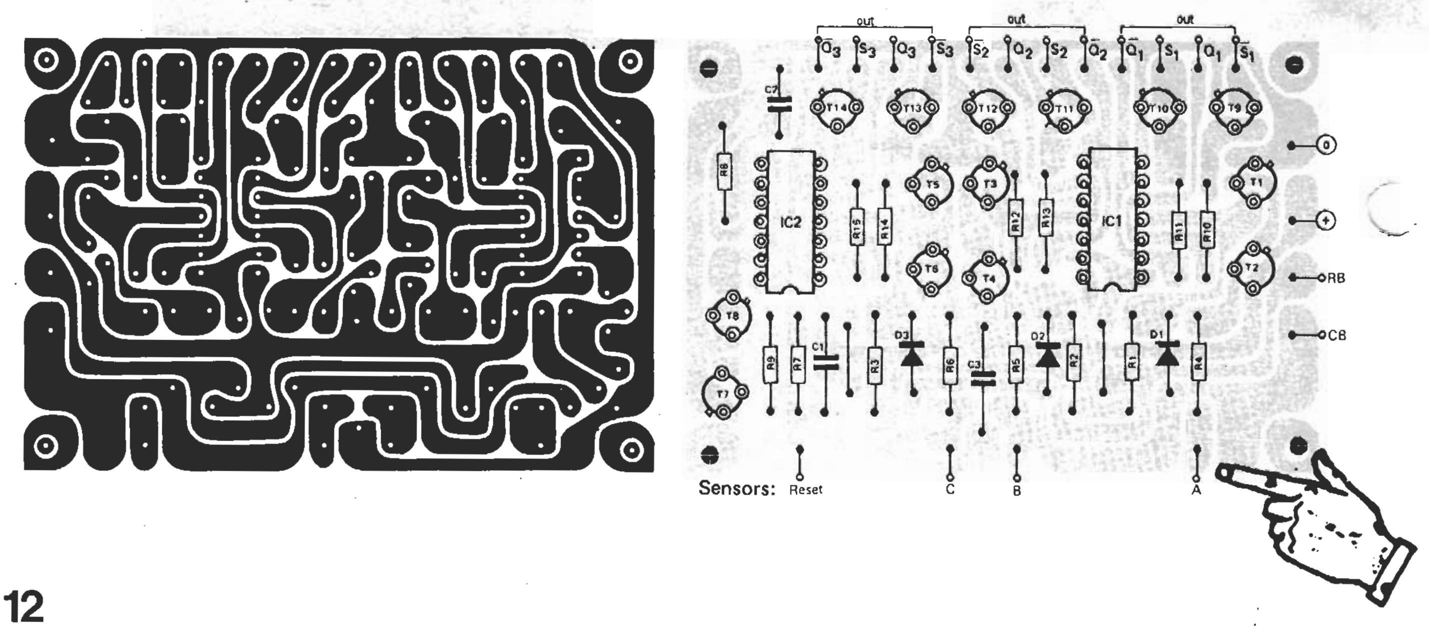

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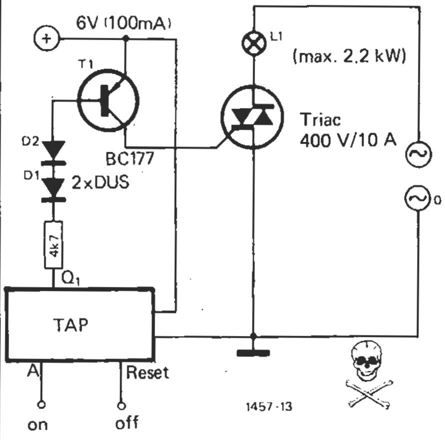

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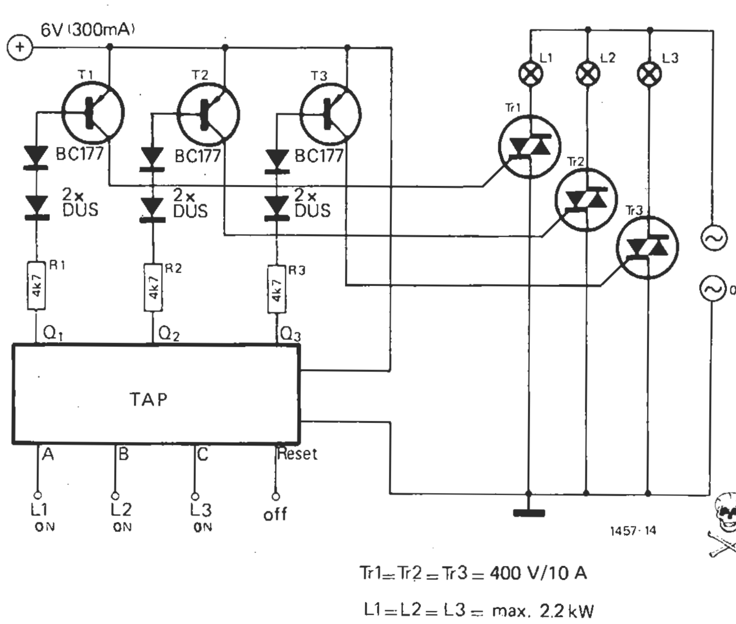

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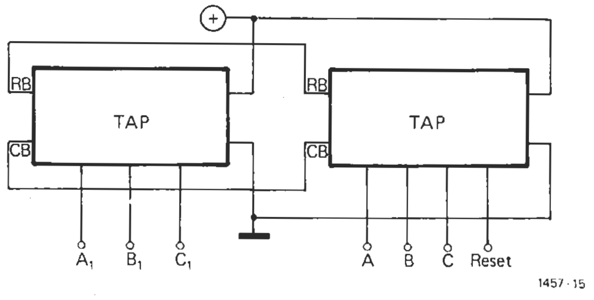
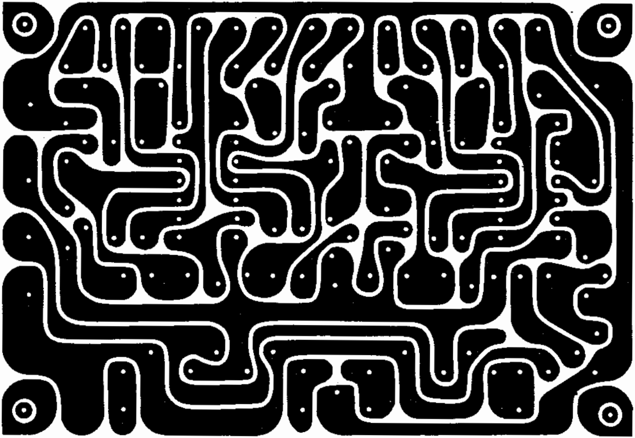


Figure 12. TAP printed circuit board with component lay-out.

Figure 13. The TAP used as a touch-controlled on/off switch for a 220 V lamp. Ensure that the live mains lead is connected to the lamp.

Figure 14. The TAP used as a triple lamp switch. If the diodes D_1, D_2 and D_3 are omitted from the TAP, the result is a triple switch with one common reset.

Figure 15. If the RB (Reset-Bar) terminals of the two TAPs and the CB (Control-Bar) terminals are interconnected, as shown, the result is a seven-position touch control switch with 6 switching positions and 1 reset. The one-shot can be left out of TAP 1 because TAP 2 already has one.



16 CHANNEL TAPs

Various circuits for Touch Activated Programme switches (TAPs) have previously been published in Elektor. However, these switches have had only three or four positions. In this article are discussed two designs for TAPs having 16 positions.

The first circuit (figure 1) makes use of a diode encoder to convert into binary the hexademical inputs from the sixteen touch contacts. The binary code is then stored in a four-bit latch circuit, the output of which is decoded back into a one-of-sixteen format.
To make the circuit easier to follow it has not been drawn in full but has been somewhat simplified. The binary code corresponding to the input from 1 to 16 is stored in four CMOS flipflops A to D. The outputs of the flip-flops are buffered by transistors T1 to T4 and are decoded by a TTL, binary to one-of-16 decoder.
Each flip-flop has a set and reset input. The 8 inputs are connected to 8 bus lines ABCD and $\overline{ABCD}$, which are normally pulled up by 8 10 M resistors.
Each of the 16 touch contacts is connected to the cathodes of four diodes. The anodes of the diodes are connected to four of the bus lines to set or reset the flip-flops in accordance with the binary code for the particular input. Each of the blocks shown with a diode symbol corresponds to four diodes, and each output line from a block corresponds to the four anodes, which are joined to the bus lines as indicated by a blob where the lines cross. For example, the first input is given the binary code 0000, so the $\overline{A}$ $\overline{B}$ $\overline{C}$ and $\overline{D}$ bus lines each have a diode connected to them from this input. At the other end of the 16th input is given the binary code 1111, so the A B C and D bus lines all have connections from this input. A complete example showing the wiring of input 13 is shown in the diagram.
The disadvantage of this circuit is that it requires a total of 64 diodes for the encoding circuits. Figure 2 shows a circuit in which the touch contacts themselves perform part of the encoding process. The latches that accept and store the touch inputs are two, four-position TAPs similar to those used in the TAP Preamp (Elektor 3 and 4, May, June 1975).
The two TAP circuits are arranged in a four-by-four matrix. When one of the inputs 1 to 4 is selected then that output goes high and applies a positive voltage to the commoned bases of one of the rows of transistors T1 - T4, T5 - T8, T9 - T12, T13 - T16. Selecting one of the inputs A to D causes that output to go high, turning on one of the transistors T17 to T20, which grounds the commoned emitters of one of the columns of transistors T1, T5, T9, T13 etc. A transistor in the matrix T1 to T16 can be turned on only if the row and column to which it belongs are both selected. Thus, if 1 A is selected a positive voltage is applied to the base of T1 and its emitter is grounded, so it turns on.
At first sight it would appear to be necessary to touch two contacts – a row and a column input – to select a particular output. However, by arranging the touch contacts as two-pole devices they can operate both a row and column input simultaneously. For example, touching the first contact activates row 1 and column A, turning on T1. Touching the second contact activates row 1 and column B, turning on T2 and so on.
In the circuit given the output transistors are shown simply switching LEDs, but of course they could be used to drive any load up to about 100 mA. ◀

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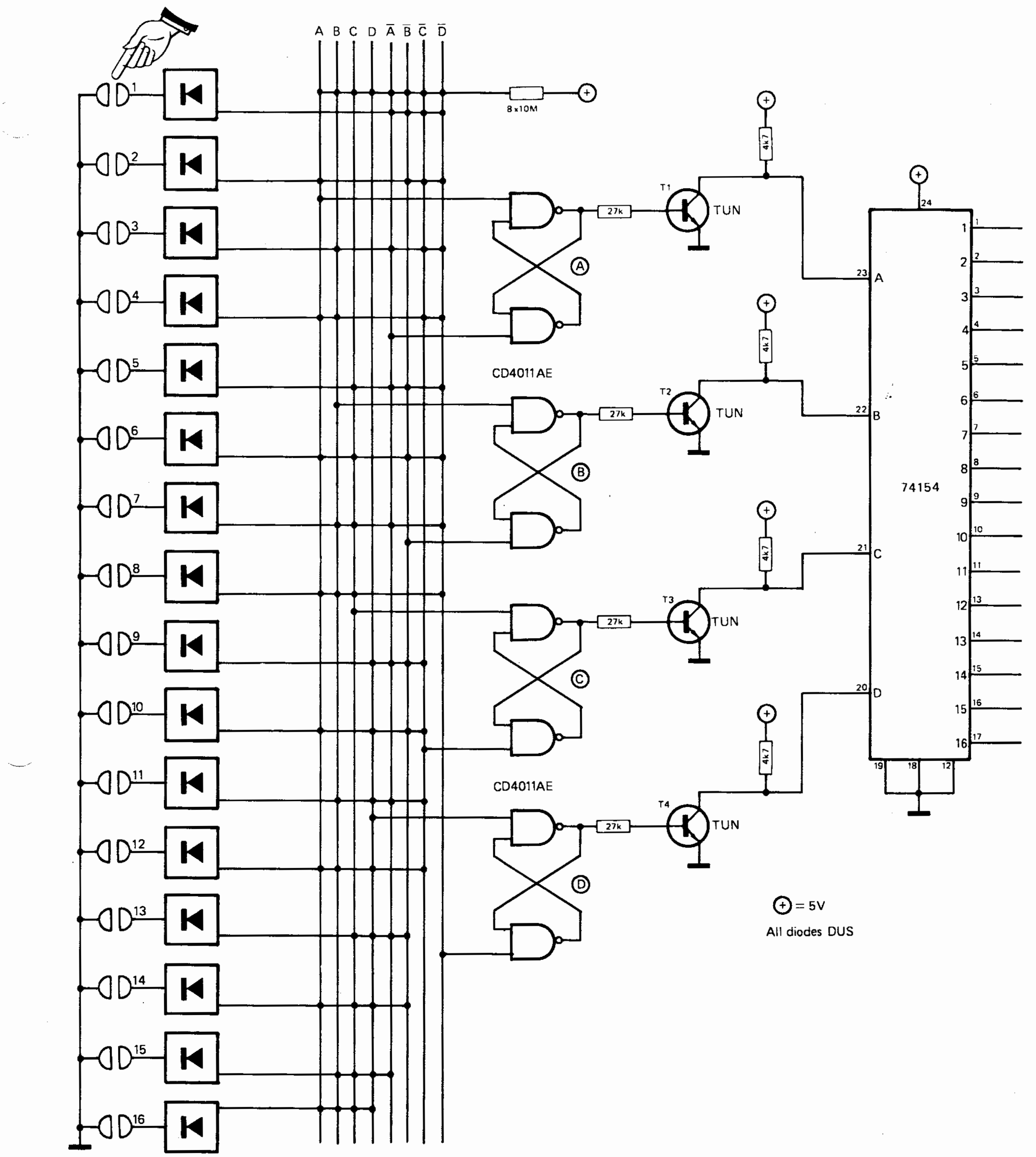
A B C D Ā B̄ C̄ D̄
8x10M
4k7
27k
T1
TUN
T2
T3
T4
A
B
C
D
CD4011AE
74154
24
23
22
21
20
19
18
12
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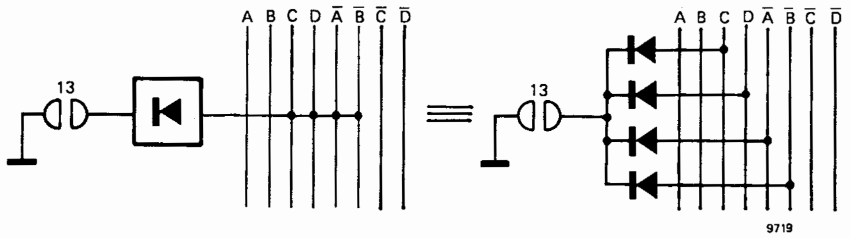
+ = 5V
All diodes DUS


A B C D Ā B̄ C̄ D̄
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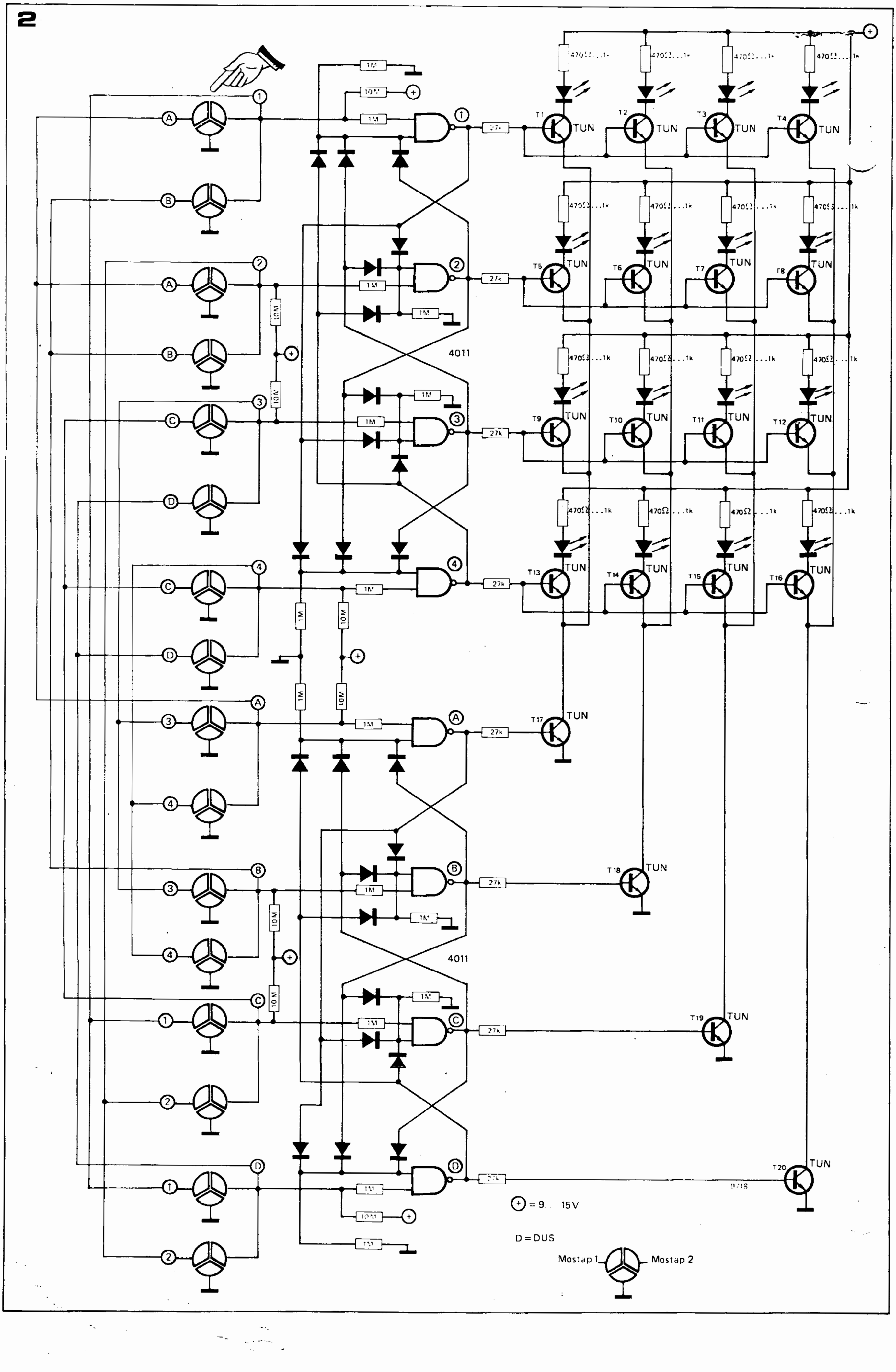
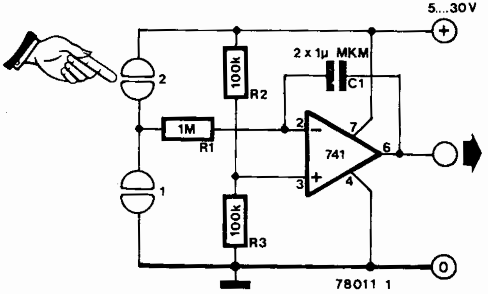


touch controller 59

H. de Grauw

This simple touch controller gives a DC output voltage which can be varied by two pairs of touch contacts and may be used to drive a variety of voltage-controlled circuits such as voltage-controlled oscillators, voltage-controlled attenuators and amplifiers.
The circuit consists of an inverting integrator based on IC1. When the circuit is switched on the non-inverting input of IC1 will be held at half supply voltage by R2 and R3. The inverting input must also be at the same potential, and since C1 is initially uncharged the output of IC1 will also be at half supply.
If the lower pair of touch contacts is bridged by a finger then current will flow through R1 to ground. Since negligible current can flow from the inverting input of IC1 this current must be provided by the output of IC1, whose voltage rises to drive charge into C1 and thus maintain the inverting input of IC1 at the same potential as the non-inverting input.
When the upper pair of touch contacts is bridged then current will flow from the positive supply through R1 into C1 and the output voltage of IC1 will fall.
The output of IC1 may be used to drive virtually any voltage-controlled circuit. A simple voltage-driven gain control for audio circuits is shown in figure 2. This consists of a lamp, driven from the output of IC1 via a transistor, whose brightness varies with the output voltage of IC1, thus changing the resistance of the LDR which forms part of an attenuator.
Due to the input bias current of IC1 the output voltage will tend to drift with time. If long-term stability of the output voltage is required then the 741 should be replaced with a FET input op-amp such as a 3130, 3140 or LF 356.

1



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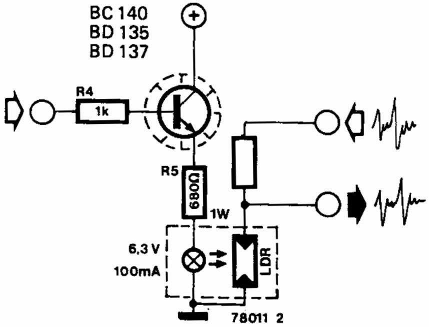
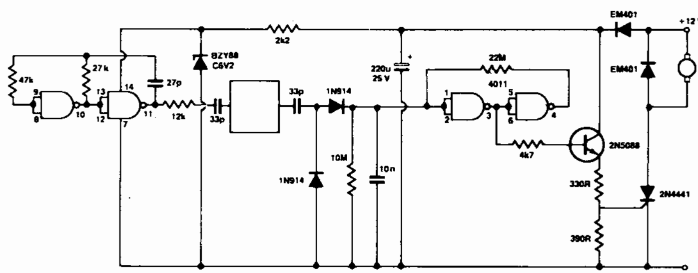


L.W. Brown designed this circuit of a touch switch suitable for operating 12 Vdc motors. He says that an excellent use for it would be to mount the touch switch on a shop window, allowing the movement of a display via a car electric fan motor.

An oscillator drives a touch plate stuck to the inside of a glass window. Anything capacitively grounding the 50 mm diameter touch plate causes the Schmitt trigger to turn on the SCR. The 10n capacitor provides several seconds extra operation once the touch plate has been released. As the SCR will latch on with a dc supply, an unregulated, unfiltered supply should be used.

For intermittent operation no heatsink is required and because of this the entire circuit will be smaller than the touch plate. The small size allows the whole switch to be mounted in a sealed plastic box for protection from environmental humidity. The double insulated power supply could enable the system to operate in hazardous locations.



TOUCH SWITCH

I'm building a touch switch and I need a way to build a bistable using two op-amps in an LM324. Have you got a simple circuit that I can use?—A. Askey, St. College, PA

Just so that we all know what we're talking about here, I'm assuming that when you say "bistable" you mean an RS flip-flop. If that's the case, the easiest way to do the job would be to use a digital flip-flop and be done with it. The circuit would be a lot simpler, much more immune to noise, and you'd be using an IC that's specifically designed with that in mind.

But I suspect that you're using half of the 324 for the touch-switch oscillator and you want to keep the parts-count down by using the rest of the IC for the flip-flop. If that's the case you're on the right track, since minimizing the parts count is a good thing. If, on the other hand, that's the only job you want to do with the 324, it makes a lot more [illegible] to use a TTL or CMOS flip-flop—believe it.

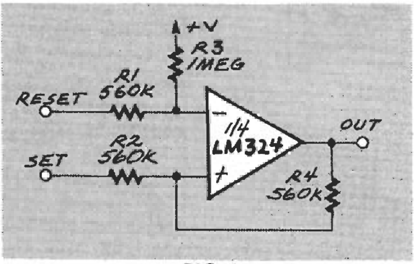
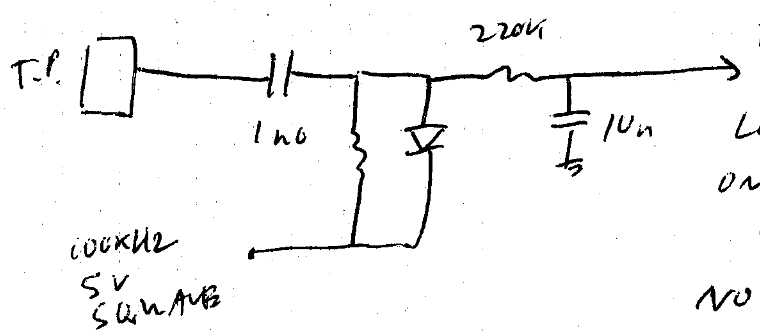


FIG. 3

Now that we understand each other, the answer is: Yes, it's not hard to build an astable around a 324. You may have two op-amps available in the IC, but if you take a look at Fig. 3, you'll see that you only need one to get the job done. A high pulse on the set input will drive the output high and it will stay that way because the resistor in the feedback loop, R4, causes the op-amp to latch up. If you put a positive pulse on the reset input, the output will drop very close to ground. How close to ground depends on the characteristics of the particular op-amp, but it will easily be within a couple of millivolts of ground level. **R-E**

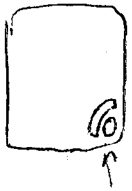
PULSAR TOUCH IN



Level sits at ≈ 2.25V
ON TOUCH IT DROPS TO 1.38V

NO INDIVIDUAL ADJUST

Drops to ~~...~~ 1.98V IF Paper Between
2.09V WITH POLY BAG Between



Small brass flat head nail soldered to contact
— Contact is plated
— used Black PCB

51

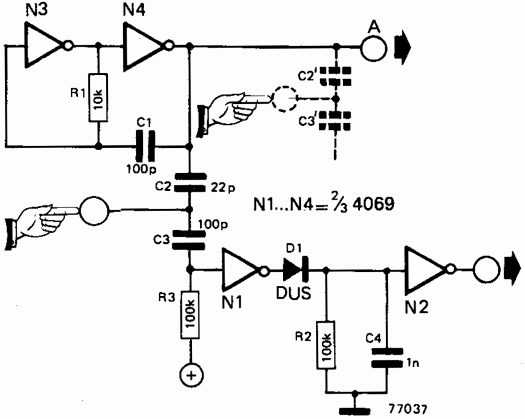
AC touchswitch

A.M. Bosschaert

Many designs for touchswitches have previously been featured in Elektor. However, most of these operated on skin resistance and thus required a double contact that could be bridged by a finger. Single contact operation is possible using a capacitive pick-up of mains hum, but this is not very reliable, and will not work at all with battery-powered equipment! The design given here overcomes these difficulties and provides a reliable single-point touch switch.

N3 and N4 form a 1 MHz oscillator. When the contact is not touched the signal from the output of N4 is fed via C2 and C3 to the input of N1, which causes the output of N1 to go high and low at a 1 MHz rate. This charges up C4 via D1, holding the input of N2 high which causes the output to remain low.

When the contact is touched, body capacitance 'shorts out' the 1 MHz signal. The input of N1 is pulled high by R3 and the output goes low. C4 discharges through R2



and the output of N2 goes high.

One oscillator will provide a 1 MHz signal for several touch switches, which may be connected to point A.

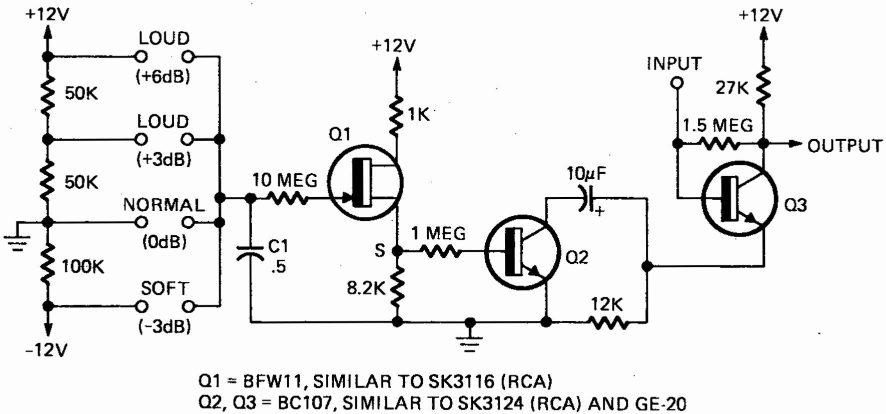
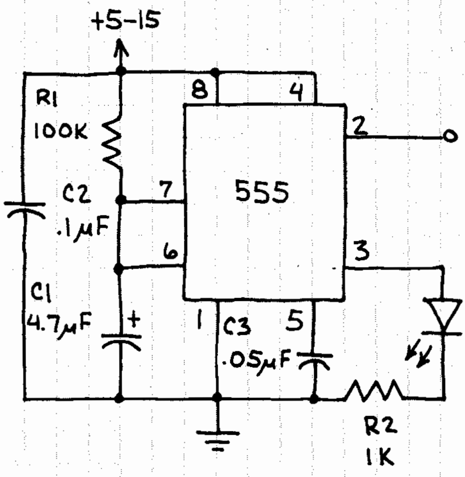


FIG. 6—TOUCH-OPERATED VOLUME CONTROL. Volume is determined by charge on C1.

TOUCH SWITCH



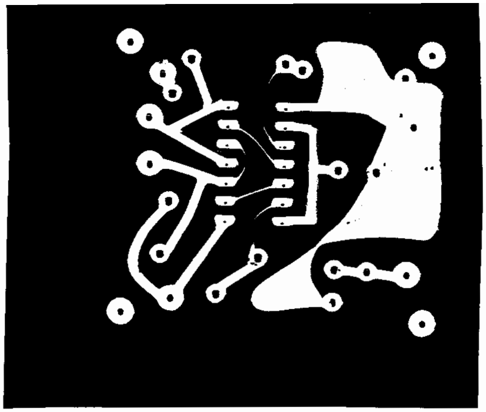
TOUCH WIRE (TOUCH AND LED WILL GLOW 1 SECOND)

WORKS BEST INDOORS DUE TO STRAY AC FIELD. ELSE-WHERE TRY TOUCHING PINS 1 AND 2.

The 555 gives you fingertip switching

If you need an inexpensive and reliable touch-controlled switch, try building one with the 555 integrated-circuit timer, suggests Howard Berlin, a technical consultant in Wilmington, Del. The basic switch is obtained by wiring the 555 in its standard one-shot mode, with the reset line (pin 4) tied to the supply, and then connecting a touchplate to the trigger input (pin 2). **This plate may be of copper or aluminum, and touching it momentarily with a finger** causes the timer's output to go high for a period of 1.1 times the RC time constant. If you hold your finger on the plate, the output will stay high. Usually a time constant of 1 second or so is enough. For latching operation, you remove the timing resistor altogether and connect a normally open push-button switch between the timer's reset pin and ground. Now by touching the plate you will latch the timer on indefinitely—until you push the reset button.

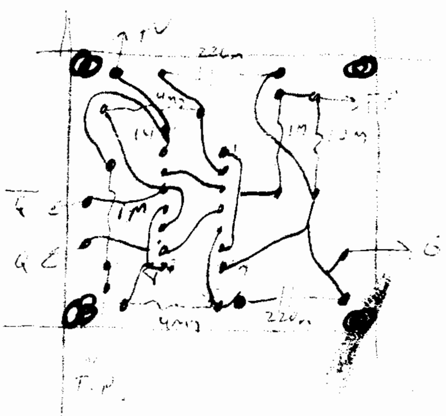
Or—to make a touch-controlled on/off switch, you just add a 7473-type J-K flip-flop at the output of the basic switch circuit. Wire the circuit's output to the flip-flop's clock input, tie both the J and K inputs to a 5-v supply line, and run the Q output to the load. Now, touching the plate once turns the load on, and touching it again turns it off. If you add a solid-state relay, **you can control household appliances.**

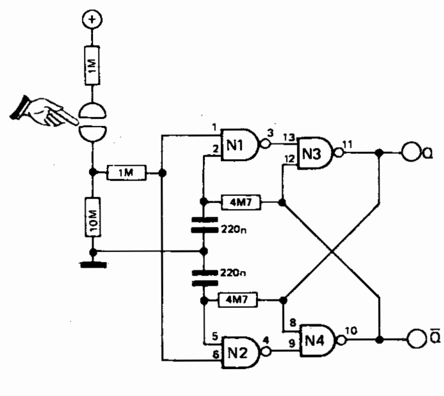


59 on-off-TAP J.
60 speech shiftel
61 piano tuner E

59 This circuit can be used for controlling CMOS analog switches of the types 4016 or 4066. The special thing about it is that the switch can be repeatedly turned on and off via only one touch contact. The gates N3 and N4 form an SR flipflop which is set and reset by negative pulses on point 13 and point 9, respectively. By touching the contact, a logic 1 is produced on points 1 and 6. This results in a reset pulse on point 9 if the flipflop is set (Q = 1), or a set pulse on point 13 if the flipflop is reset (Q = 0). Each time the contact is touched, the flipflop changes state. The Q- and /or $\overline{Q}$-output of the flipflop can be used to drive the CMOS-switch(es).

59





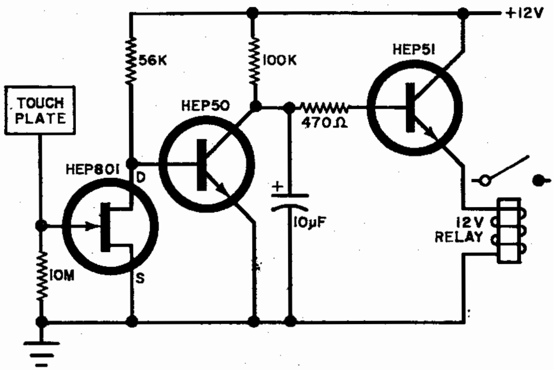
N1...N4 = CD4011 9701

Note:

The contact should be touched very briefly (shorter than about 1 s) as otherwise the circuit will function as an astable multivibrator with the output of the flipflop changing state every second.

NOTE - Correction Below

Hobby Scene



Touch Alarm Circuit

Q. ***Do you have a circuit for a simple touch alarm to activate a relay when a small metal plate is touched?***

A. This circuit should do the job. If you have any troubles with the operation, try using an ac power supply (delivering dc to the circuit, of course) and reversing the line plug to get proper operation.

Correction

In this column, in the March issue, the Touch Alarm Circuit should show the emitter of the HEP51 connected to the positive and the relay between the collector and ground.

C-MOS gates make good, low-cost touch switches

Utilizing the high-input impedance of a complementary-MOS inverter, Steve Newman of Los Angeles, Calif., finds they are ideally suited for use as low-power, low-cost touch switches having greater reliability than their mechanical cousins. He also observes their contacts can be made very large, and they can be built without protruding parts, thus aiding the handicapped person or protecting the young child.

Noting the C-MOS gate is a voltage-controlled device, Newman designs the fingertip resistance (about 1 MΩ) into a voltage-divider circuit, with a 10-MΩ resistor used between the gate input and a positive voltage, and the fingertip applied between the gate and ground. If an inverter is used, **touching the contacts brings the gate output high.** If debouncing is required, the position of the contacts and of the 10-MΩ resistor are reversed, and a 0.01-μF capacitor placed across the contacts. Two inverters placed in series are then required to bring the output high when the contacts are touched. Making a toggle switch is easily done by using a D flip-flop, such as the 74C74. With its $\overline{Q}$ output wired to the data (D) input, the clock input is driven by the output of the momentary touch switch or the debounced version as described previously.

Deaf Touch Switch

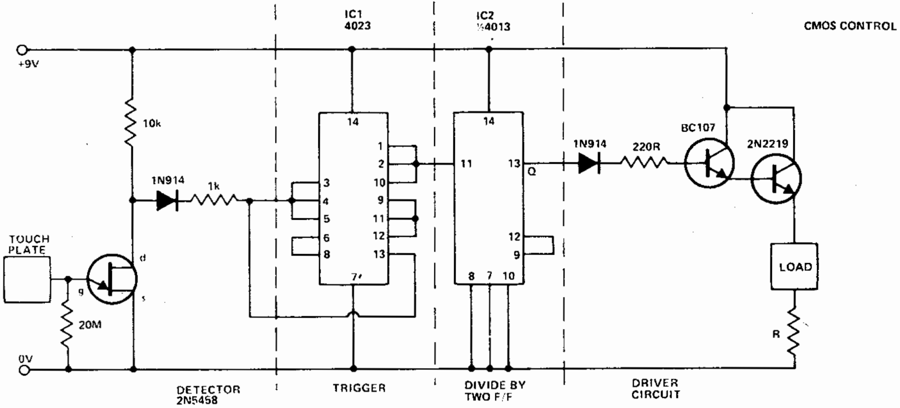
P. Reynolds.

Many designs for touch controls suffer from the disadvantage of low noise immunity, and this circuit was designed seeking to rectify this fault.

AC voltage from, for example, the hand is applied to the gate of the FET buffer. The resultant positive signal is applied via the diode, to the input of IC1. This IC is made up from three triple gates connected in a Schmidt trigger configuration. At the threshold voltage, a positive pulse is fed to the clock input of IC2, a D-type flip-flop. Connection is made between Q and the D input, so as to cause the flip-flop to run in the 'triggered' mode. Thus the input signals are divided by two and the output appears at the Q terminal.

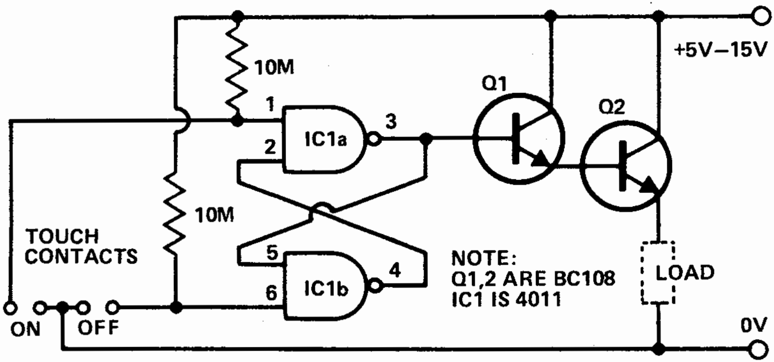
In operation, a single positive pulse sets the Schmidt trigger to its low level. (Removal of the hand causes reversion to the 'high' state). This, in turn, feeds the clock input of IC2, which changes the state of the Q output. When this is high, the output stage is driven on, enabling current to flow in the external load and the current limiting resistor, R.

A second positive pulse changes the state of Q to its low level, causing the output stage to be biased off.



Low Current Touch Switch

D. Ian



The cost of many CMOS ICs is now lower than a mechanical on/off switch. Using only one half of a 4011, plus a couple of general purpose transistors, a touch operated switch can be constructed which is ideal for many battery powered projects.

Assuming that the inputs to the remaining half of the 4011 are tied low, the current drawn in the off state is almost negligible and battery life is hardly affected.

Touching the 'on' contacts with a finger brings pin 3 high, turning on the darlington pair and supplying power to the load (transistor radio etc). Q1 must be a high gain transistor, and Q2 chosen for the current required by the load circuit.